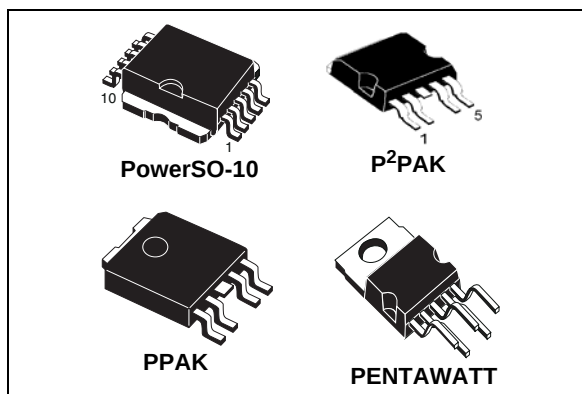


### Features

| Type                                                                       | $R_{DS(on)}$  | $I_{OUT}$ | $V_{CC}$ |
|----------------------------------------------------------------------------|---------------|-----------|----------|
| VN820-E<br>VN820SP-E<br>VN820B5-E<br>VN820PT-E<br>VN820-12-E<br>VN820-11-E | 40 m $\Omega$ | 9 A       | 36 V     |

- ECOPACK®: lead free and RoHS compliant
- Automotive Grade: compliance with AEC guidelines
- Very low standby current
- CMOS compatible input
- On-state open-load detection
- Off-state open-load detection
- Thermal shutdown protection and diagnosis
- Undervoltage shutdown
- Overvoltage clamp
- Output stuck to  $V_{CC}$  detection
- Load current limitation
- Reverse battery protection
- Electrostatic discharge protection



### Description

The VN820-E is a monolithic device designed in STMicroelectronics' VIPower® M0-3 technology. The VN820-E is intended for driving any type of load with one side connected to ground. The active  $V_{CC}$  pin voltage clamp protects the device against low energy spikes.

Active current limitation combined with thermal shutdown and automatic restart protect the device against overload. The device detects the open-load condition in both on- and off-state mode. In the off-state the device detects if the output is shorted to  $V_{CC}$ . The device automatically turns off where the ground pin becomes disconnected.

**Table 1. Device summary**

| Package            | Order codes                         |               |
|--------------------|-------------------------------------|---------------|
|                    | Tube                                | Tape and reel |
| PENTAWATT          | VN820-E<br>VN820-12-E<br>VN820-11-E | -             |
| PowerSO-10         | VN820SP-E                           | VN820SPTR-E   |
| P <sup>2</sup> PAK | VN820B5-E                           | VN820B5TR-E   |
| PPAK               | VN820PT-E                           | VN820PTTR-E   |

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1 Block diagram and pin description

Figure 1. Block diagram

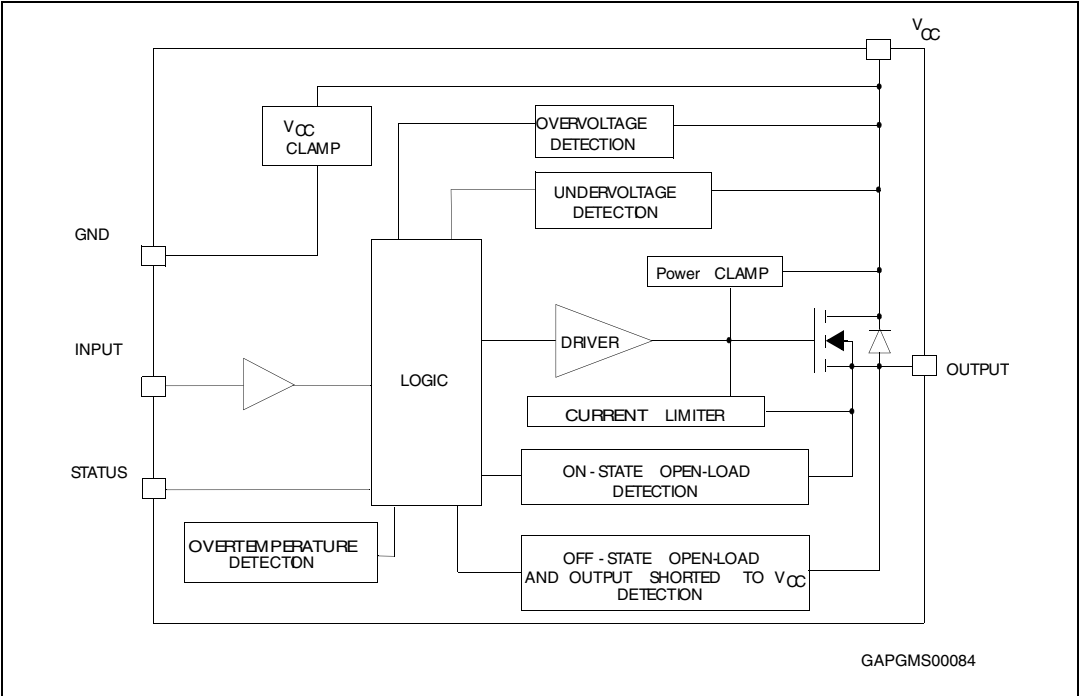


Figure 2. Configuration diagram (top view)

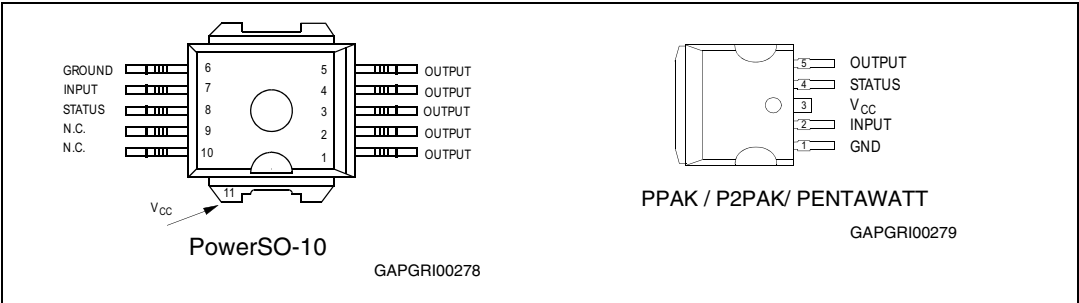
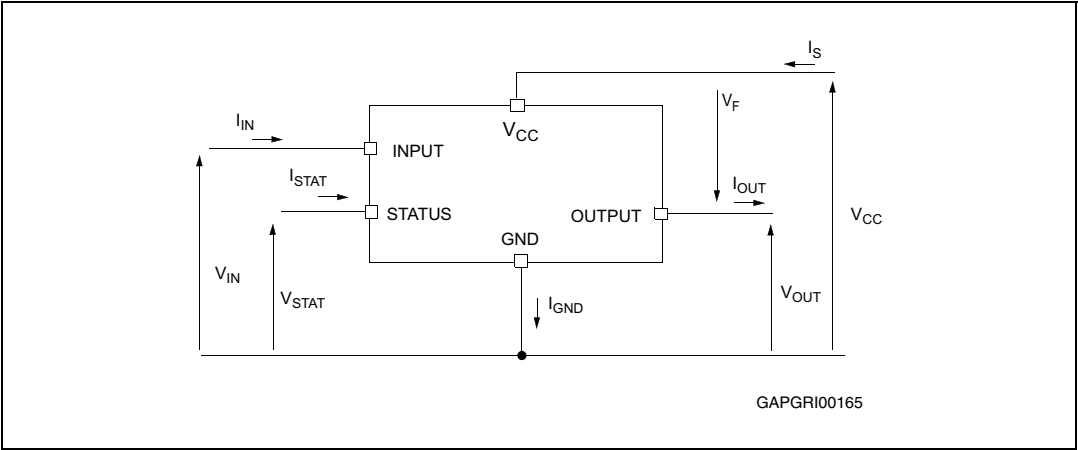


Table 2. Suggested connections for unused and not connected pins

| 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

Stressing the device above the rating listed in the [Table 3](#) may cause permanent damage to the device. These are stress ratings only and operation of the device at these or any other conditions above those indicated in the operating sections of this specification is not implied. Exposure to Absolute maximum rating conditions for extended periods may affect device reliability.

Table 3. Absolute maximum ratings

| Symbol     | Parameter                                                                                         | Value              |           |                    |      | Unit |
|------------|---------------------------------------------------------------------------------------------------|--------------------|-----------|--------------------|------|------|
|            |                                                                                                   | PowerSO-10         | PENTAWATT | P <sup>2</sup> PAK | PPAK |      |
| $V_{CC}$   | 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                                                                         | - 9                |           |                    |      | A    |
| $I_{IN}$   | DC input current                                                                                  | +/- 10             |           |                    |      | mA   |
| $I_{STAT}$ | DC Status current                                                                                 | +/- 10             |           |                    |      | mA   |
| $V_{ESD}$  | Electrostatic discharge<br>(human body model:<br>$R = 1.5\text{ K}\Omega$ ; $C = 100\text{ pF}$ ) |                    |           |                    |      |      |
|            | – INPUT                                                                                           | 4000               |           |                    |      | V    |
|            | – STATUS                                                                                          | 4000               |           |                    |      | V    |
|            | – OUTPUT                                                                                          | 5000               |           |                    |      | V    |
|            | – $V_{CC}$                                                                                        | 5000               |           |                    |      | V    |

**Table 3. Absolute maximum ratings (continued)**

| Symbol    | Parameter                                                                                                                                                                               | Value              |           |                    |      | Unit             |
|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|-----------|--------------------|------|------------------|
|           |                                                                                                                                                                                         | PowerSO-10         | PENTAWATT | P <sup>2</sup> PAK | PPAK |                  |
| $E_{MAX}$ | Maximum switching energy<br>( $L = 1.4 \text{ mH}$ ; $R_L = 0 \text{ } \Omega$ ;<br>$V_{bat} = 13.5 \text{ V}$ ; $T_{jstart} = 150 \text{ } ^\circ\text{C}$ ;<br>$I_L = 13 \text{ A}$ ) | 156                |           |                    |      | mJ               |
| $P_{tot}$ | Power dissipation $T_C = 25 \text{ } ^\circ\text{C}$                                                                                                                                    | 65.8               |           |                    |      | W                |
| $T_j$     | Junction operating temperature                                                                                                                                                          | Internally limited |           |                    |      | $^\circ\text{C}$ |
| $T_C$     | Case operating temperature                                                                                                                                                              | - 40 to 150        |           |                    |      | $^\circ\text{C}$ |
| $T_{stg}$ | Storage temperature                                                                                                                                                                     | - 55 to 150        |           |                    |      | $^\circ\text{C}$ |

## 2.2 Thermal data

**Table 4. Thermal data**

| Symbol         | Parameter                             | Max. value          |                     |                     |                     | Unit               |
|----------------|---------------------------------------|---------------------|---------------------|---------------------|---------------------|--------------------|
|                |                                       | PowerSO-10          | PENTAWATT           | P <sup>2</sup> PAK  | PPAK                |                    |
| $R_{thj-case}$ | Thermalresistance<br>junction-case    | 1.9                 | 1.9                 | 1.9                 | 1.9                 | $^\circ\text{C/W}$ |
| $R_{thj-lead}$ | Thermalresistance<br>junction-lead    | -                   | -                   | -                   | -                   | $^\circ\text{C/W}$ |
| $R_{thj-amb}$  | Thermalresistance<br>junction-ambient | 51.9 <sup>(1)</sup> | 61.9 <sup>(2)</sup> | 51.9 <sup>(2)</sup> | 76.9 <sup>(2)</sup> | $^\circ\text{C/W}$ |
|                |                                       | 37 <sup>(2)</sup>   | -                   | 37 <sup>(4)</sup>   | 45 <sup>(4)</sup>   | $^\circ\text{C/W}$ |

1. When mounted on a standard single-sided FR-4 board with 0.5cm<sup>2</sup> of Cu (at least 35μm thick).

2. When mounted on a standard single-sided FR-4 board with 6cm<sup>2</sup> of Cu (at least 35μm thick).

## 2.3 Electrical characteristics

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

**Table 5. Power**

| Symbol        | Parameter                        | Test conditions                                                                                                         | Min. | Typ. | Max.     | Unit     |
|---------------|----------------------------------|-------------------------------------------------------------------------------------------------------------------------|------|------|----------|----------|
| $V_{CC}$      | Operating supply voltage         |                                                                                                                         | 5.5  | 13   | 36       | V        |
| $V_{USD}$     | Undervoltage shutdown            |                                                                                                                         | 3    | 4    | 5.5      | V        |
| $V_{USDhyst}$ | Undervoltage shutdown hysteresis |                                                                                                                         |      | 0.5  |          | V        |
| $V_{OV}$      | Overvoltage shutdown             |                                                                                                                         | 36   |      |          | V        |
| $R_{ON}$      | On-state resistance              | $I_{OUT} = 3\text{ A}$ ; $T_j = 25\text{ °C}$ ; $V_{CC} > 8\text{ V}$<br>$I_{OUT} = 3\text{ A}$ ; $V_{CC} > 8\text{ V}$ |      |      | 40<br>80 | mΩ<br>mΩ |
| $I_S$         | Supply current                   | Off-state; $V_{CC} = 13\text{ V}$ ;<br>$V_{IN} = V_{OUT} = 0\text{ V}$                                                  |      | 10   | 25       | μA       |
|               |                                  | Off-state; $V_{CC} = 13\text{ V}$ ;<br>$V_{IN} = V_{OUT} = 0\text{ V}$ ; $T_j = 25\text{ °C}$                           |      | 10   | 20       | μA       |
|               |                                  | On-state; $V_{CC} = 13\text{ V}$ ; $V_{IN} = 5\text{ V}$ ;<br>$I_{OUT} = 0\text{ A}$                                    |      | 2    | 3.5      | mA       |
| $I_{L(off1)}$ | Off-state output current         | $V_{IN} = V_{OUT} = 0\text{ V}$                                                                                         | 0    |      | 50       | μA       |
| $I_{L(off2)}$ | Off-state output current         | $V_{IN} = 0\text{ V}$ ; $V_{OUT} = 3.5\text{ V}$                                                                        | -75  |      | 0        | μA       |
| $I_{L(off3)}$ | Off-state output current         | $V_{IN} = V_{OUT} = 0\text{ V}$ ; $V_{CC} = 13\text{ V}$ ;<br>$T_j = 125\text{ °C}$                                     |      |      | 5        | μA       |
| $I_{L(off4)}$ | Off-state output current         | $V_{IN} = V_{OUT} = 0\text{ V}$ ; $V_{CC} = 13\text{ V}$ ;<br>$T_j = 25\text{ °C}$                                      |      |      | 3        | μA       |

**Table 6. Switching ( $V_{CC} = 13\text{ V}$ )**

| Symbol                | Parameter              | Test conditions                                                                    | Min.                          | Typ. | Max. | Unit |
|-----------------------|------------------------|------------------------------------------------------------------------------------|-------------------------------|------|------|------|
| $t_{d(on)}$           | Turn-on delay time     | $R_L = 4.3\text{ Ω}$ from $V_{IN}$ rising edge to<br>$V_{OUT} = 1.3\text{ V}$      |                               | 30   |      | μs   |
| $t_{d(off)}$          | Turn-off delay time    | $R_L = 4.3\text{ Ω}$ from $V_{IN}$ falling edge to<br>$V_{OUT} = 11.7\text{ V}$    |                               | 30   |      | μs   |
| $dV_{OUT}/dt_{(on)}$  | Turn-on voltage slope  | $R_L = 4.3\text{ Ω}$ from $V_{OUT} = 1.3\text{ V}$ to<br>$V_{OUT} = 10.4\text{ V}$ | See <a href="#">Figure 21</a> |      |      | V/μs |
| $dV_{OUT}/dt_{(off)}$ | Turn-off voltage slope | $R_L = 4.3\text{ Ω}$ from $V_{OUT} = 11.7\text{ V}$ to<br>$V_{OUT} = 1.3\text{ V}$ | See <a href="#">Figure 22</a> |      |      | V/μs |

**Table 7. Input pin**

| Symbol     | Parameter                | Test conditions                                     | Min. | Typ.         | Max. | Unit          |
|------------|--------------------------|-----------------------------------------------------|------|--------------|------|---------------|
| $V_{IL}$   | Input low-level          |                                                     |      |              | 1.25 | V             |
| $I_{IL}$   | Low-level input current  | $V_{IN} = 1.25\text{ V}$                            | 1    |              |      | $\mu\text{A}$ |
| $V_{IH}$   | Input high-level         |                                                     | 3.25 |              |      | V             |
| $I_{IH}$   | High-level input current | $V_{IN} = 3.25\text{ V}$                            |      |              | 10   | $\mu\text{A}$ |
| $V_{hyst}$ | Input hysteresis voltage |                                                     | 0.5  |              |      | V             |
| $V_{ICL}$  | Input clamp voltage      | $I_{IN} = 1\text{ m A}$<br>$I_{IN} = -1\text{ m A}$ | 6    | 6.8<br>- 0.7 | 8    | V<br>V        |

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

| Symbol | Parameter          | Test conditions                                             | Min. | Typ. | Max. | Unit |
|--------|--------------------|-------------------------------------------------------------|------|------|------|------|
| $V_F$  | Forward on voltage | $-I_{OUT} = 2\text{ A}$ ; $T_j = 150\text{ }^\circ\text{C}$ | -    | -    | 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; $V_{STAT} = 5\text{ V}$               |      |              | 10   | $\mu\text{A}$ |
| $C_{STAT}$  | Status pin input capacitance | Normal operation; $V_{STAT} = 5\text{ V}$               |      |              | 100  | pF            |
| $V_{SCL}$   | Status clamp voltage         | $I_{STAT} = 1\text{ m A}$<br>$I_{STAT} = -1\text{ m A}$ | 6    | 6.8<br>- 0.7 | 8    | V<br>V        |

**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            | ms               |
| $I_{lim}$   | Current limitation                 | $9\text{ V} < V_{CC} < 36\text{ V}$<br>$5.5\text{ V} < V_{CC} < 36\text{ V}$ | 9             | 13            | 20<br>20      | A<br>A           |
| $V_{demag}$ | Turn-off output clamp voltage      | $I_{OUT} = 3\text{ A}$ ;<br>$V_{IN} = 0\text{ V}$ ;<br>$L = 6\text{ mH}$     | $V_{CC} - 41$ | $V_{CC} - 48$ | $V_{CC} - 55$ | 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 operates under abnormal conditions this software must limit the duration and number of activation cycles.

Table 11. Open-load detection

| Symbol         | Parameter                                       | Test conditions        | Min. | Typ. | Max. | Unit          |
|----------------|-------------------------------------------------|------------------------|------|------|------|---------------|
| $I_{OL}$       | Open-load on-state detection threshold          | $V_{IN} = 5\text{ V}$  | 70   | 150  | 300  | mA            |
| $t_{DOL(on)}$  | Open-load on-state detection delay              | $I_{OUT} = 0\text{ A}$ |      |      | 200  | $\mu\text{s}$ |
| $V_{OL}$       | Open-load off-state voltage detection threshold | $V_{IN} = 0\text{ V}$  | 1.5  | 2.5  | 3.5  | V             |
| $t_{DOL(off)}$ | Open-load detection delay at turn-off           |                        |      |      | 1000 | $\mu\text{s}$ |

Figure 4. Status timings

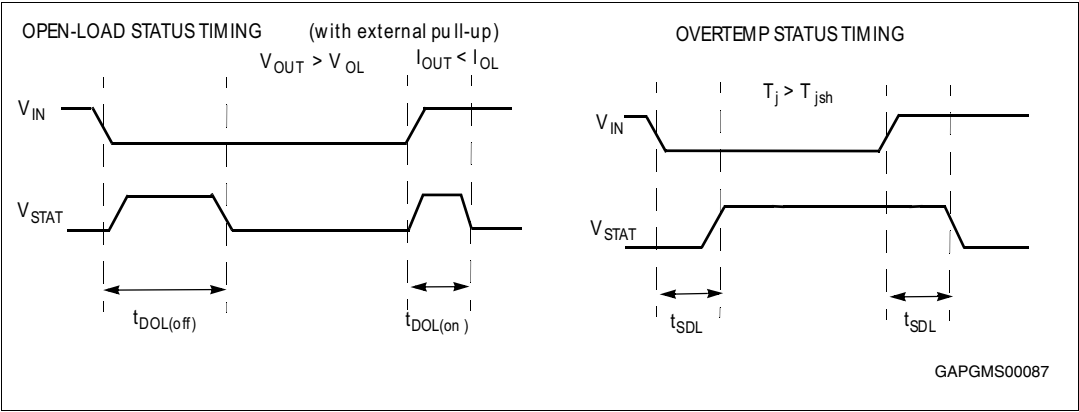


Figure 5. Switching time waveforms

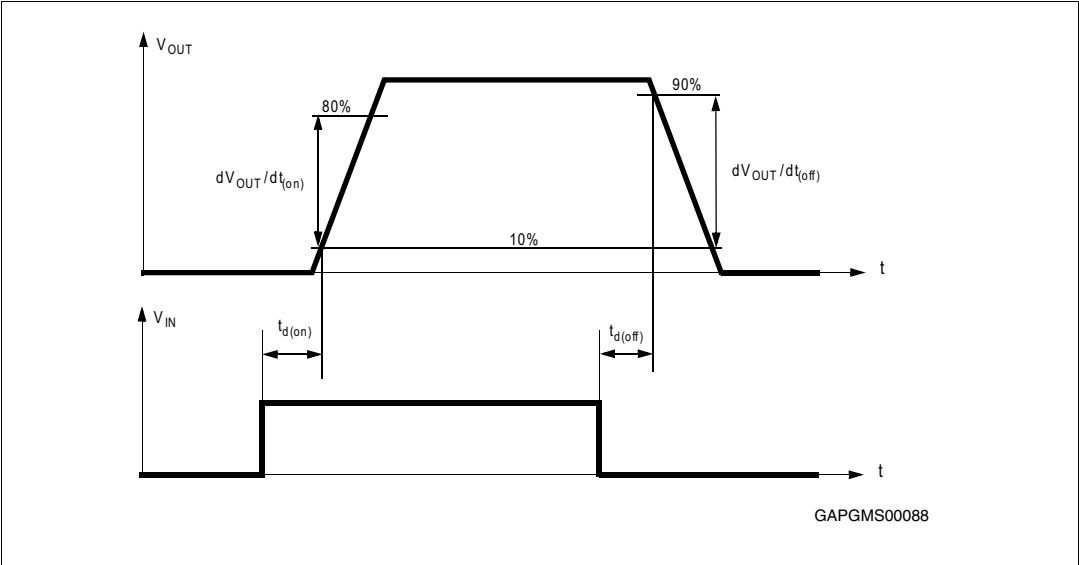


Table 12. Truth table

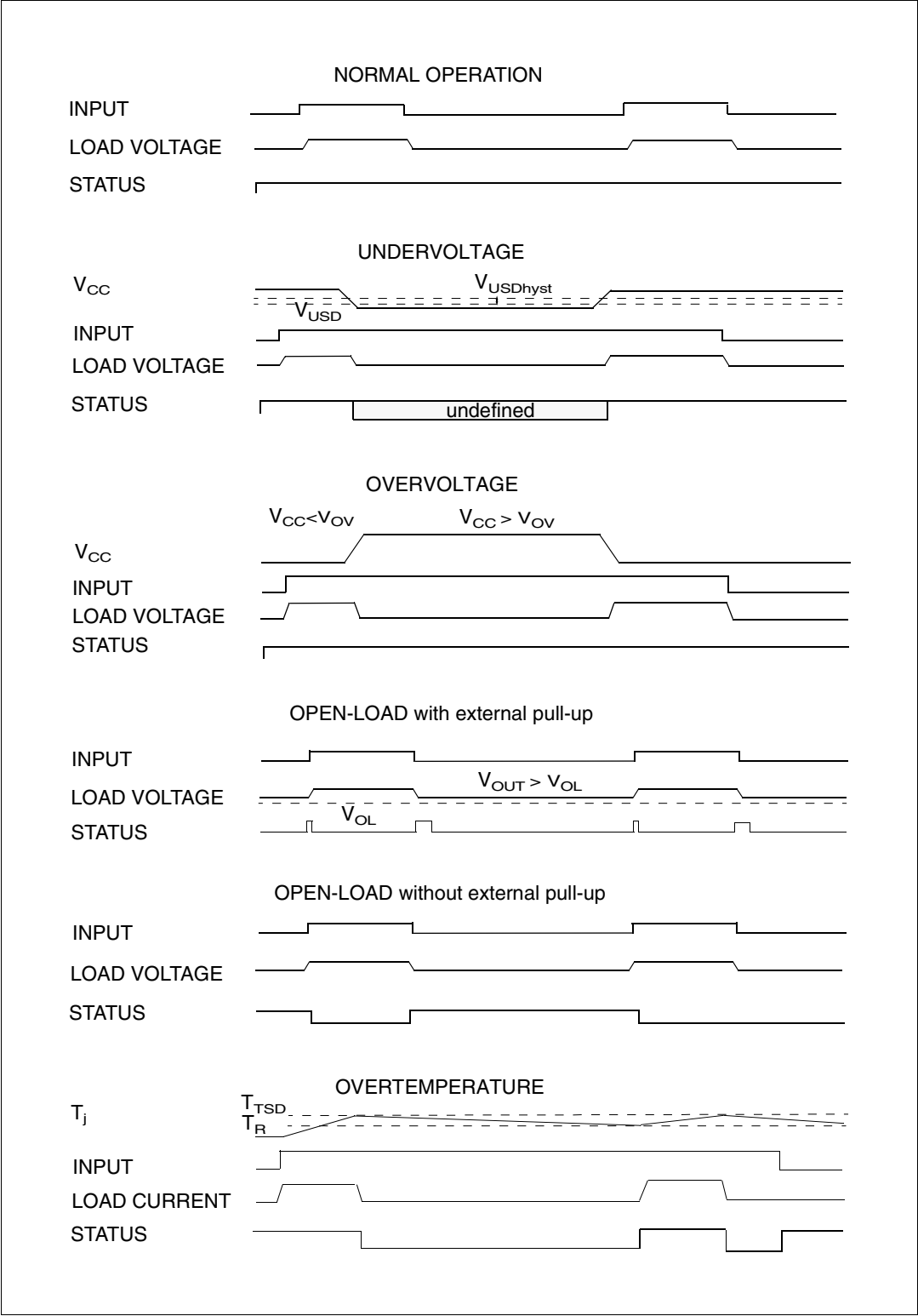
| Conditions                | Input | Output | Status              |
|---------------------------|-------|--------|---------------------|
| Normal operation          | L     | L      | H                   |
|                           | H     | H      | H                   |
| Current limitation        | L     | L      | H                   |
|                           | H     | X      | $(T_j < T_{TSD})$ H |
|                           | H     | X      | $(T_j > T_{TSD})$ L |
| Overtemperature           | L     | L      | H                   |
|                           | H     | L      | L                   |
| Undervoltage              | L     | L      | X                   |
|                           | H     | L      | X                   |
| Overvoltage               | L     | L      | H                   |
|                           | H     | L      | H                   |
| Output voltage > $V_{OL}$ | L     | H      | L                   |
|                           | H     | H      | H                   |
| Output current < $I_{OL}$ | L     | L      | H                   |
|                           | H     | H      | L                   |

Table 13. Electrical transient requirements

| ISO T/R<br>7637/1<br>Test pulse | Test level             |                        |                        |                        |                      |
|---------------------------------|------------------------|------------------------|------------------------|------------------------|----------------------|
|                                 | I                      | II                     | III                    | IV                     | Delays and impedance |
| 1                               | - 25V <sup>(1)</sup>   | - 50V <sup>(1)</sup>   | - 75V <sup>(1)</sup>   | - 100V <sup>(1)</sup>  | 2ms, 10Ω             |
| 2                               | + 25V <sup>(1)</sup>   | + 50V <sup>(1)</sup>   | + 75V <sup>(1)</sup>   | + 100V <sup>(1)</sup>  | 0.2ms, 10Ω           |
| 3a                              | - 25V <sup>(1)</sup>   | - 50V <sup>(1)</sup>   | - 100V <sup>(1)</sup>  | - 150V <sup>(1)</sup>  | 0.1μs, 50Ω           |
| 3b                              | + 25V <sup>(1)</sup>   | + 50V <sup>(1)</sup>   | + 75V <sup>(1)</sup>   | + 100V <sup>(1)</sup>  | 0.1μs, 50Ω           |
| 4                               | - 4V <sup>(1)</sup>    | - 5V <sup>(1)</sup>    | - 6V <sup>(1)</sup>    | - 7V <sup>(1)</sup>    | 100ms, 0.01Ω         |
| 5                               | + 26.5V <sup>(1)</sup> | + 46.5V <sup>(2)</sup> | + 66.5V <sup>(2)</sup> | + 86.5V <sup>(2)</sup> | 400ms, 2Ω            |

1. All functions of the device are performed as designed after exposure to disturbance.
2. One or more functions of the device is not performed as designed after exposure and cannot be returned to proper operation without replacing the device.

Figure 6. Waveforms



2.4 Electrical characteristics curves

Figure 7. Off-state output current

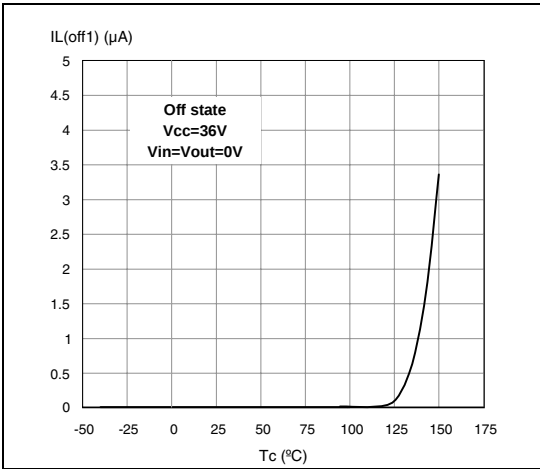


Figure 8. High-level input current

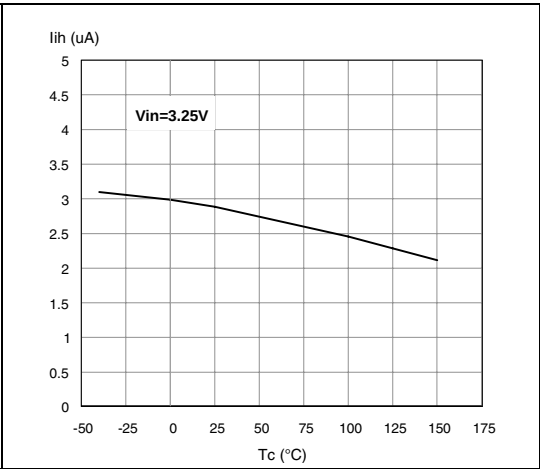


Figure 9. Input clamp voltage

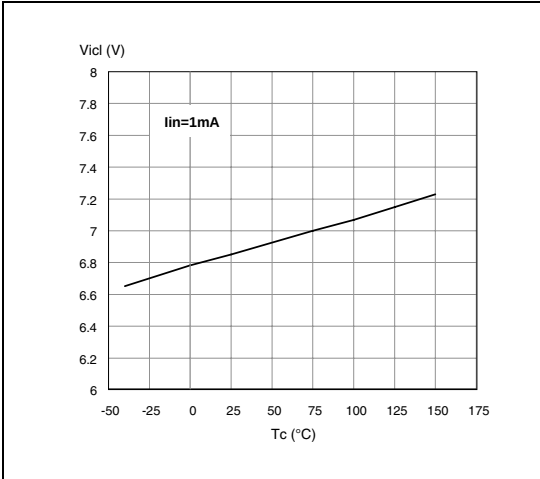


Figure 10. Status leakage current

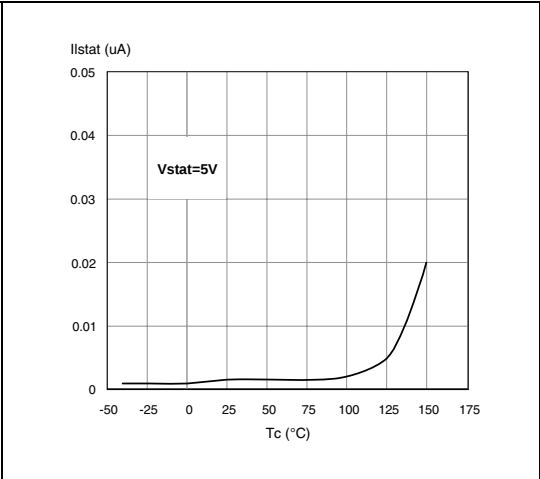


Figure 11. Status low output voltage

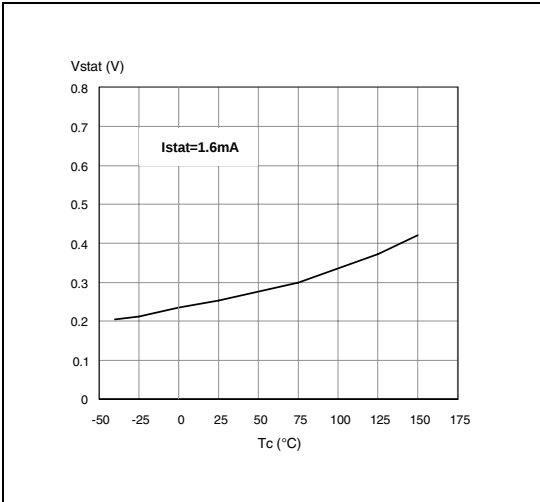


Figure 12. Status clamp voltage

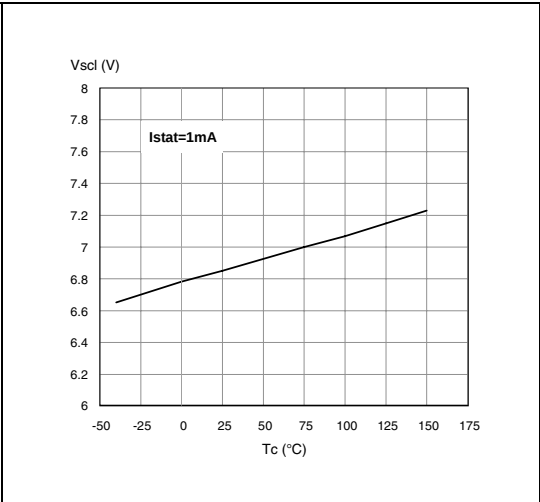


Figure 13. On-state resistance vs  $T_{case}$

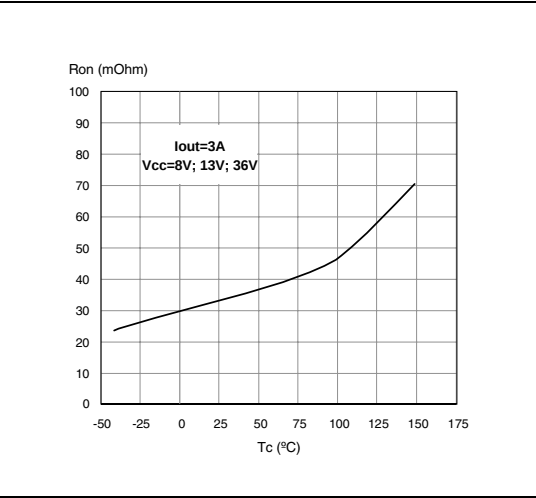


Figure 14. On-state resistance vs  $V_{CC}$

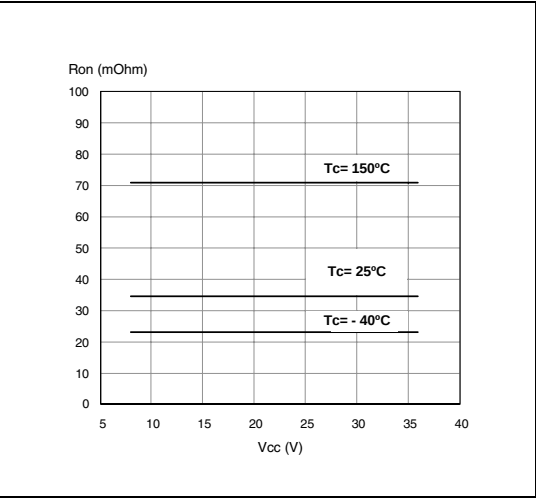


Figure 15. Open-load on-state detection threshold

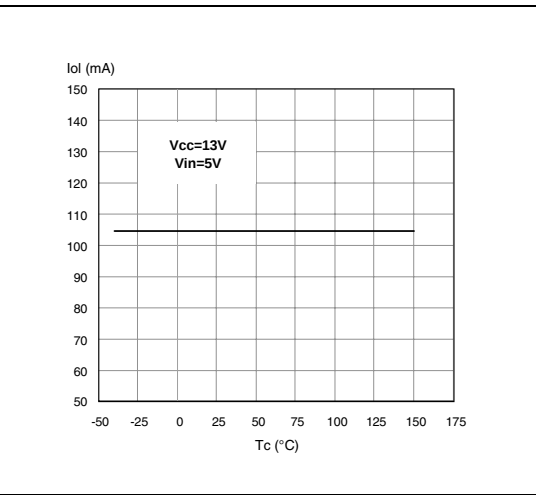


Figure 16. Input high-level threshold

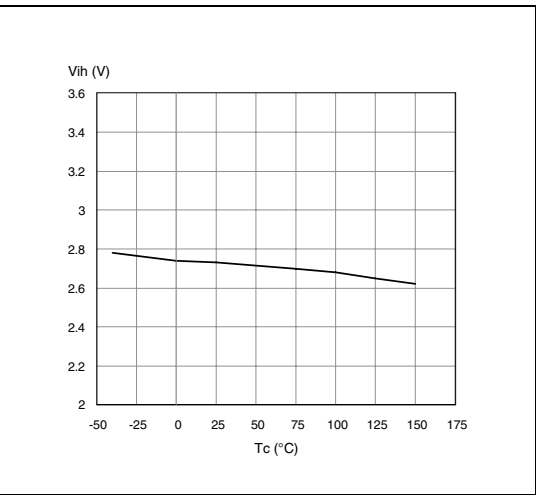


Figure 17. Input low-level

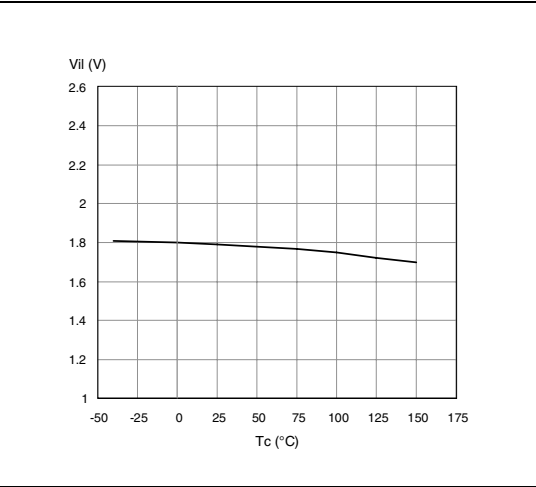


Figure 18. Input hysteresis voltage

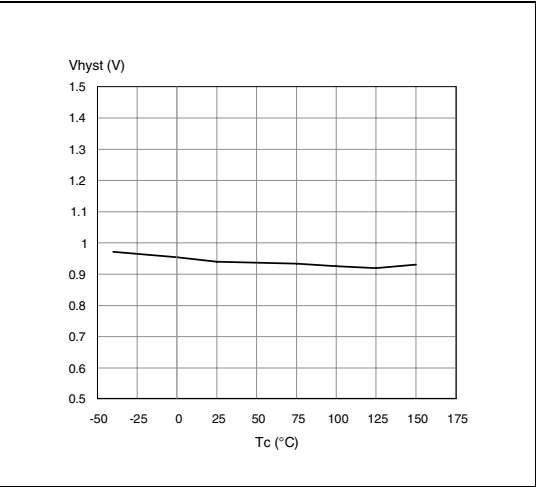


Figure 19. Overvoltage shutdown

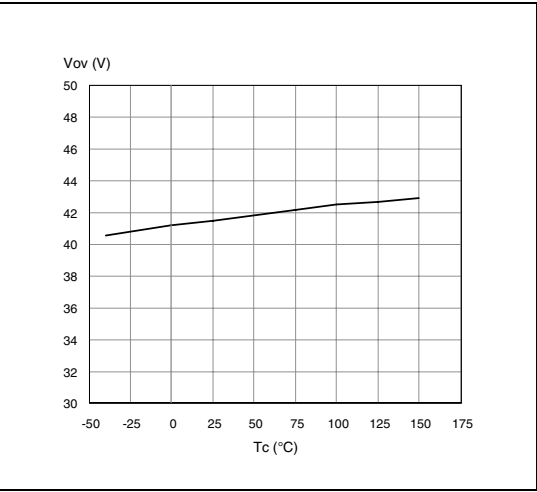


Figure 20. Open-load off-state voltage detection threshold

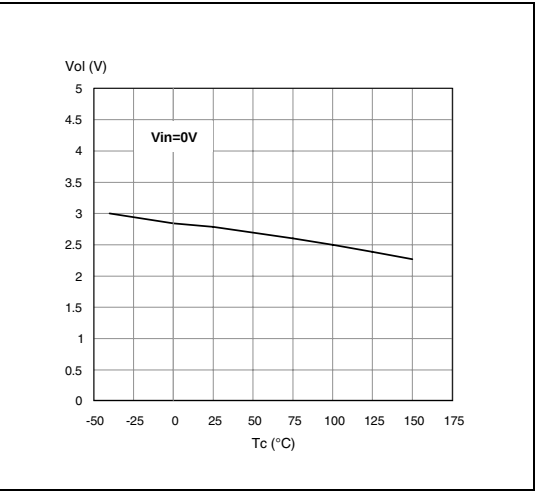


Figure 21. Turn-on voltage slope

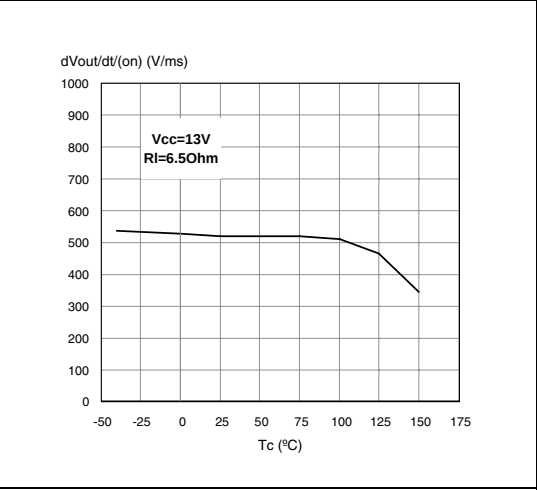


Figure 22. Turn-off voltage slope

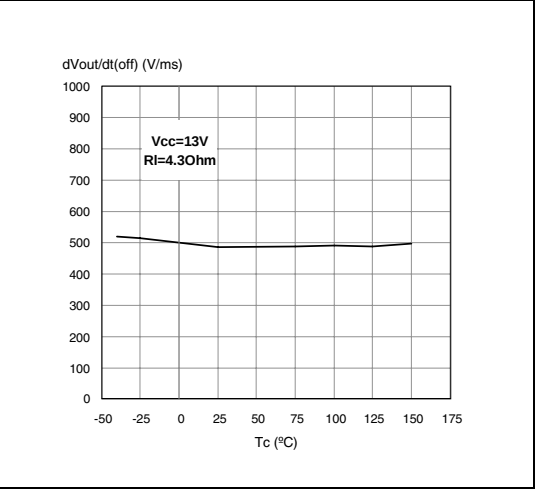
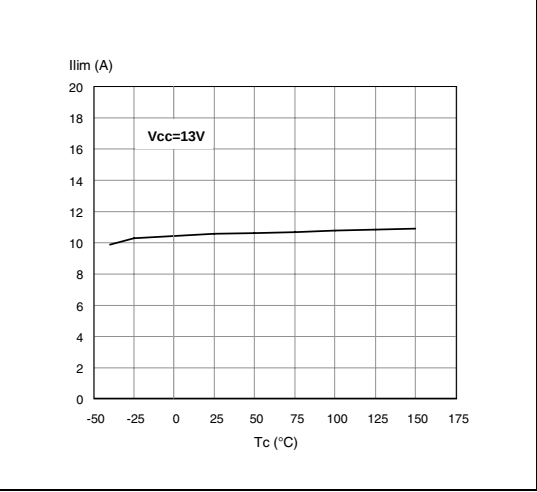
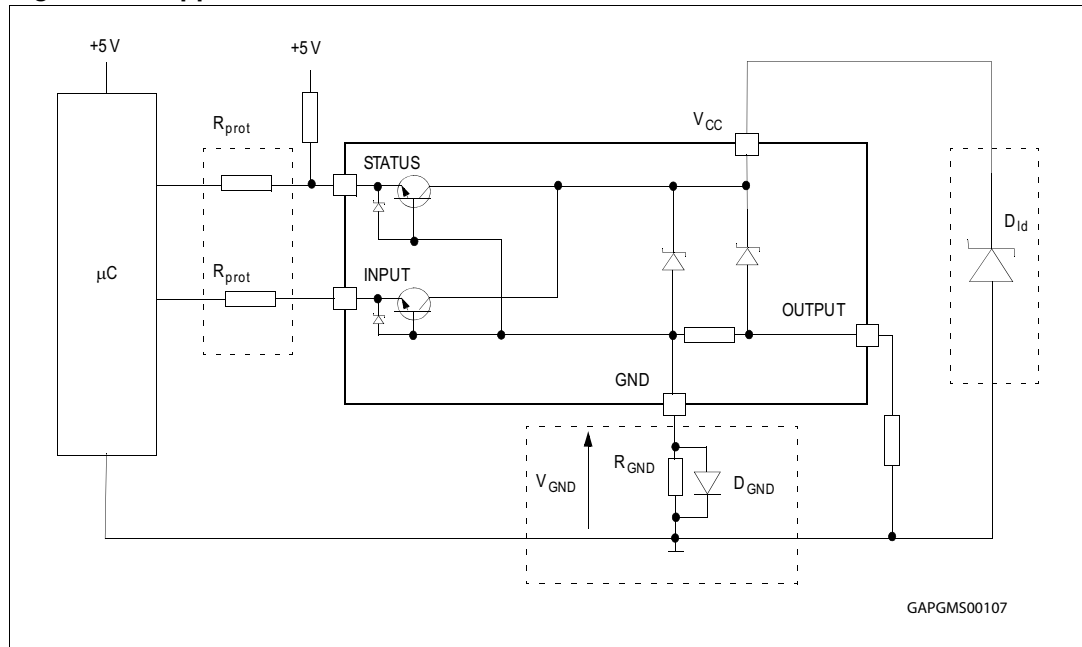


Figure 23.  $I_{lim}$  vs  $T_{case}$



### 3 Application information

Figure 24. Application schematic



#### 3.1 GND protection network against reverse battery

##### 3.1.1 Solution 1: resistor in the ground line (R<sub>GND</sub> only)

This can be used with any type of load.

The following is an indication on how to set a dimension the R<sub>GND</sub> resistor.

1.  $R_{GND} \leq 600 \text{ mV} / (I_{S(on)max})$ .
2.  $R_{GND} \geq (-V_{CC}) / (-I_{GND})$

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

Power Dissipation in R<sub>GND</sub> (when  $V_{CC} < 0$ : during reverse battery situations) is:

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

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

Please note that if the microprocessor ground is not shared by the device ground then the R<sub>GND</sub> produces a shift ( $I_{S(on)max} * R_{GND}$ ) in the input thresholds and the status output values. This shift does not vary depending on how many devices are ON in case of several high-side drivers sharing the same R<sub>GND</sub>.

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

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

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

This small signal diode can be safely shared amongst several different HSDs. Also in this case, the presence of the ground network produces a shift ( $\approx 600$  mV) in the input threshold and in the status output values if the microprocessor ground is not common to 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.

The safest configuration for unused INPUT and STATUS pin is to leave them unconnected.

## 3.2 Load dump protection

$D_{ld}$  is necessary (Voltage Transient Suppressor) if the load dump peak voltage exceeds the  $V_{CC}$  max DC rating. The same applies if the device is subject to transients on the  $V_{CC}$  line that are greater than the ones shown in the ISO 7637-2: 2004(E) table.

## 3.3 MCU I/Os protection

If a ground protection network is used and negative 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 from latching-up.

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

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

Calculation example:

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

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

Recommended values:  $R_{prot} = 10\text{ k}\Omega$ .

## 3.4 Open-load detection in off-state

Off-state open-load detection requires an external pull-up resistor ( $R_{PU}$ ) connected between OUTPUT pin and a positive supply voltage ( $V_{PU}$ ) like the +5 V line used to supply the microprocessor.

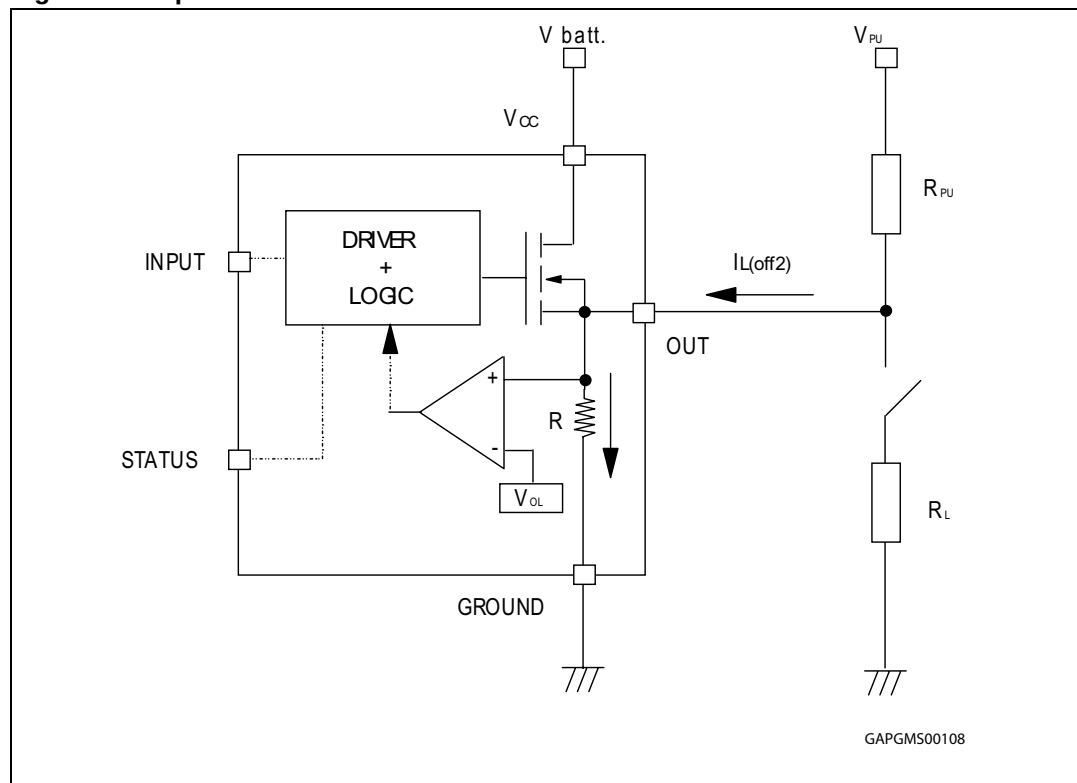
The external resistor has to be selected according to the following requirements:

1. no false open-load indication when load is connected: in this case we have to avoid  $V_{OUT}$  to be higher than  $V_{OLmin}$ ; this results in the following condition  

$$V_{OUT} = (V_{PU} / (R_L + R_{PU})) R_L < V_{OLmin}$$
2. no misdetection when load is disconnected: in this case the  $V_{OUT}$  has to be higher than  $V_{OLmax}$ ; this results in the following condition  $R_{PU} < (V_{PU} - V_{OLmax}) / I_{L(off2)}$ .

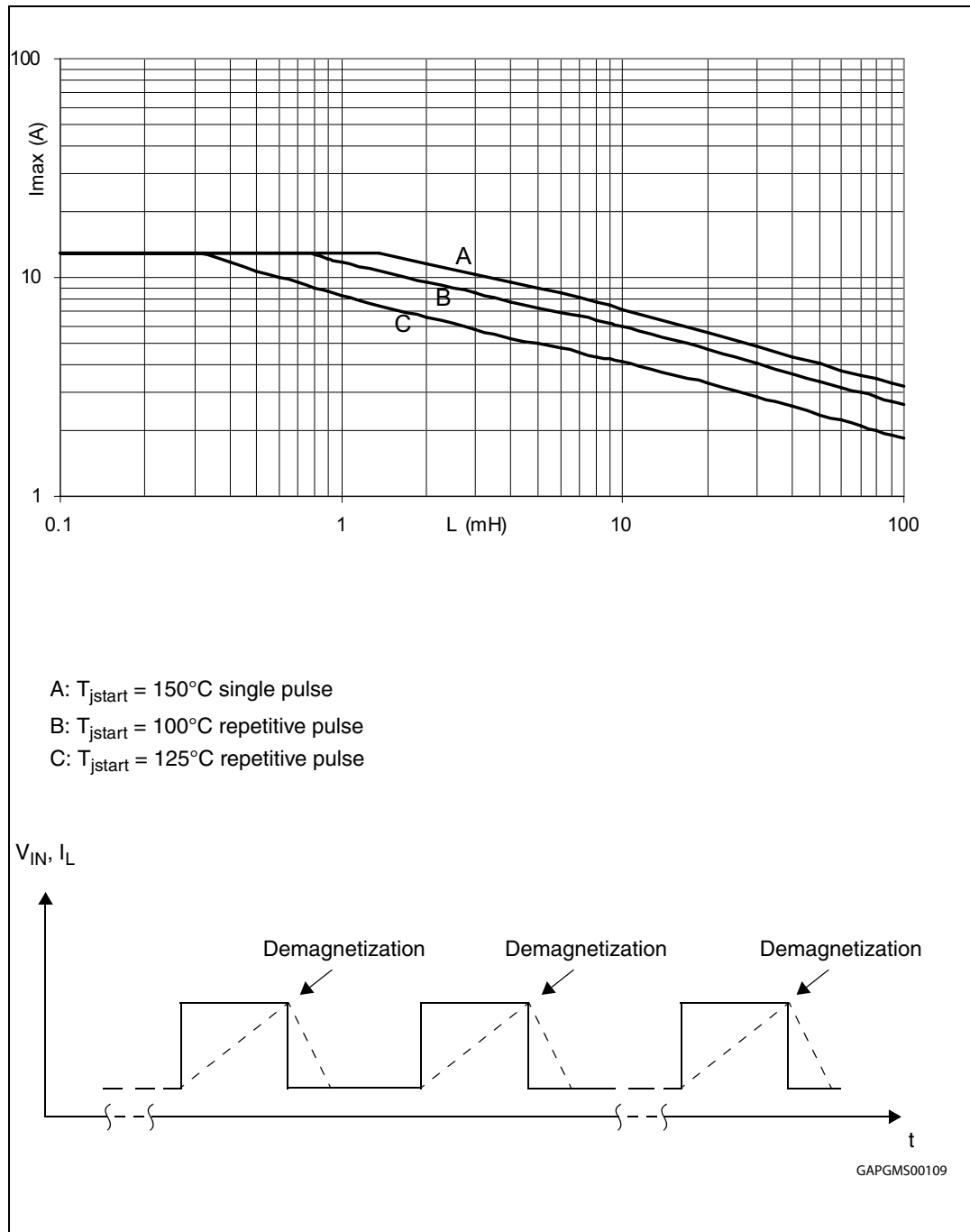
The values of  $V_{OLmin}$ ,  $V_{OLmax}$  and  $I_{L(off2)}$  are available in the electrical characteristics section.

**Figure 25. Open-load detection in off-state**



### 3.5 PowerSO-10, P<sup>2</sup>PAK, PPAK, PENTAWATT maximum demagnetization energy ( $V_{CC} = 13.5V$ )

Figure 26. PowerSO-10, P<sup>2</sup>PAK, PPAK, PENTAWATT maximum turn-off current versus inductance

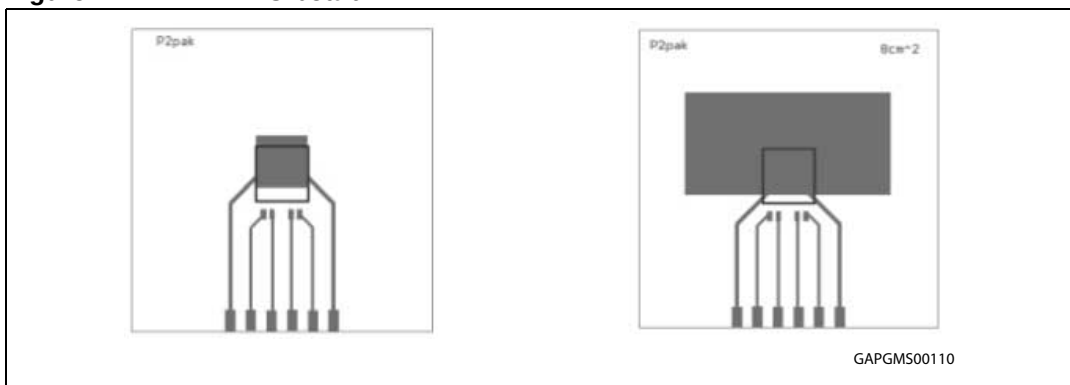


Note: Values are generated with  $R_L = 0 \Omega$ . In case of repetitive pulses,  $T_{jstart}$  (at beginning of each demagnetization) of every pulse must not exceed the temperature specified above for curves A and B.

## 4 Package and PCB thermal data

### 4.1 P<sup>2</sup>PAK thermal data

Figure 27. P<sup>2</sup>PAK PC board



Note: Layout condition of  $R_{th}$  and  $Z_{th}$  measurements (PCB FR4 area = 60 mm x 60 mm, PCB thickness = 2 mm, Cu thickness = 35  $\mu$ m, Copper areas: 0.97 cm<sup>2</sup>, 8 cm<sup>2</sup>).

Figure 28. P<sup>2</sup>PAK  $R_{thj-amb}$  vs PCB copper area in open box free air conditions

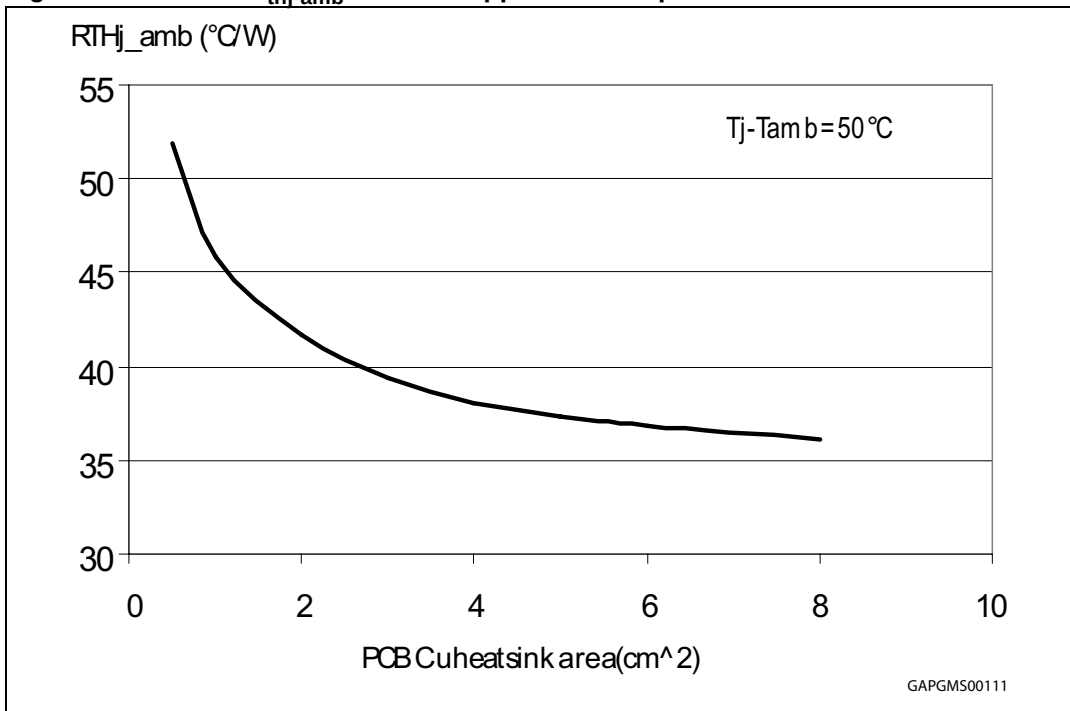
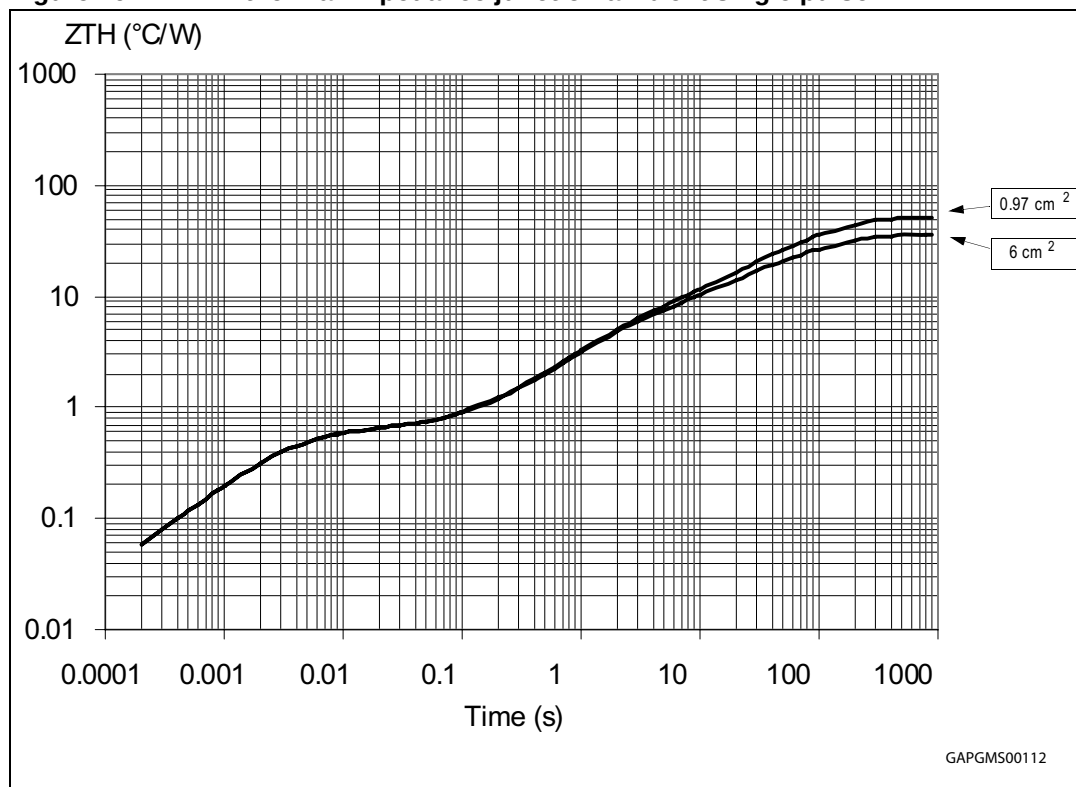
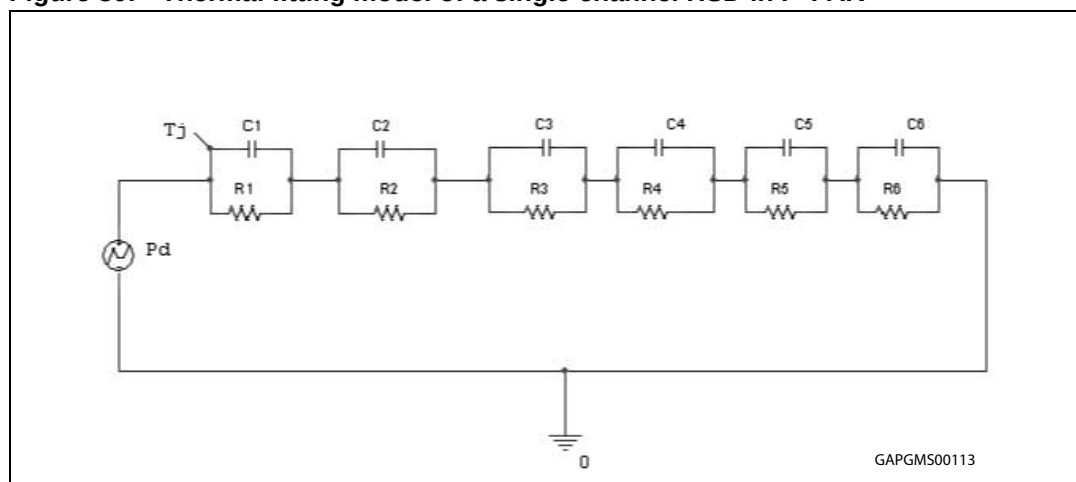


Figure 29. P<sup>2</sup>PAK thermal impedance junction ambient single pulse

Equation 1: pulse calculation formula

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

where  $\delta = t_p/T$

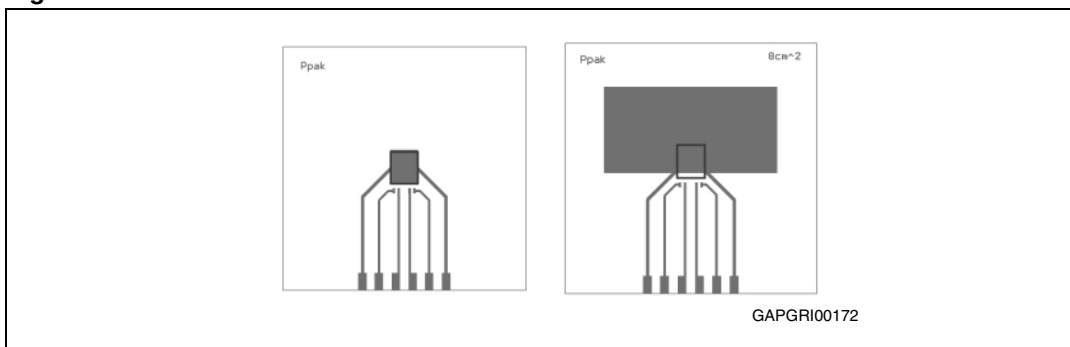
Figure 30. Thermal fitting model of a single channel HSD in P<sup>2</sup>PAK

**Table 14. P<sup>2</sup>PAK thermal parameters**

| Area/island (cm <sup>2</sup> ) | 0.97   | 6  |
|--------------------------------|--------|----|
| R1 (°C/W)                      | 0.04   |    |
| R2 (°C/W)                      | 0.25   |    |
| R3 (°C/W)                      | 0.3    |    |
| R4 (°C/W)                      | 4      |    |
| R5 (°C/W)                      | 9      |    |
| R6 (°C/W)                      | 37     | 22 |
| C1 (W·s/°C)                    | 0.0008 |    |
| C2 (W·s/°C)                    | 0.007  |    |
| C3 (W·s/°C)                    | 0.015  |    |
| C4 (W·s/°C)                    | 0.4    |    |
| C5 (W·s/°C)                    | 2      |    |
| C6 (W·s/°C)                    | 3      | 5  |

## 4.2 PPAK thermal data

Figure 31. PPAK PC board



Note: Layout condition of  $R_{th}$  and  $Z_{th}$  measurements (PCB FR4 area = 60 mm x 60 mm, PCB thickness = 2 mm, Cu thickness = 35  $\mu\text{m}$ , Copper areas: 0.44  $\text{cm}^2$ , 8  $\text{cm}^2$ ).

Figure 32. PPAK  $R_{thj-amb}$  vs PCB copper area in open box free air conditions

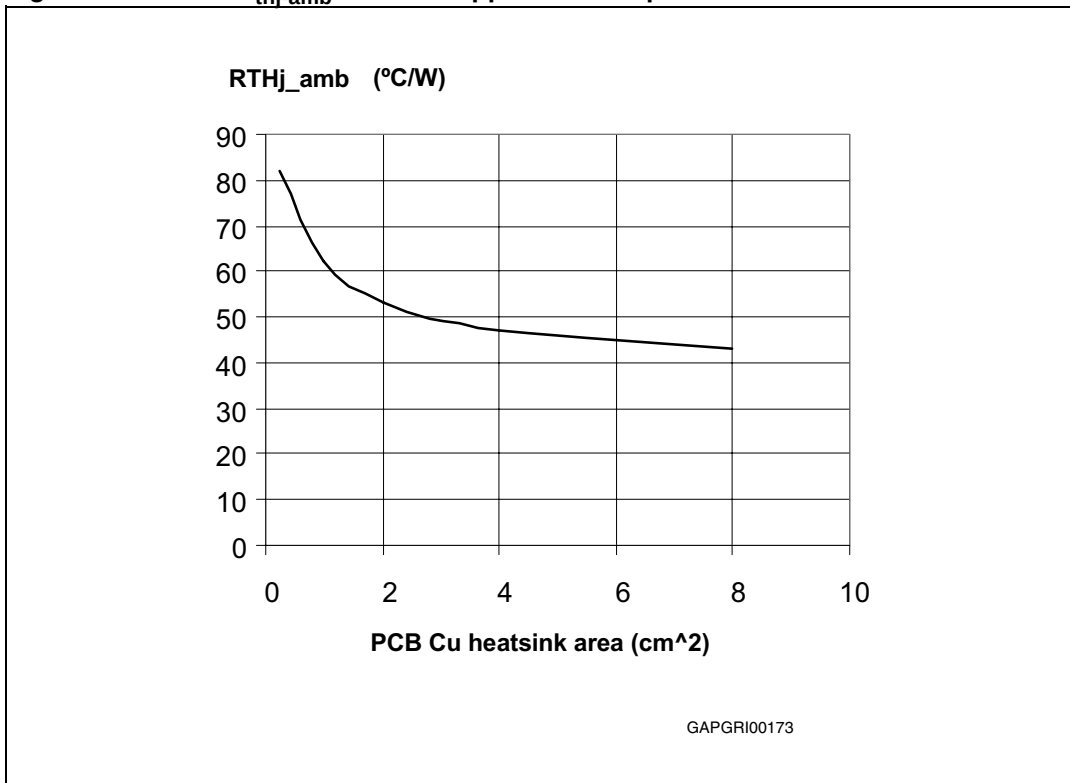
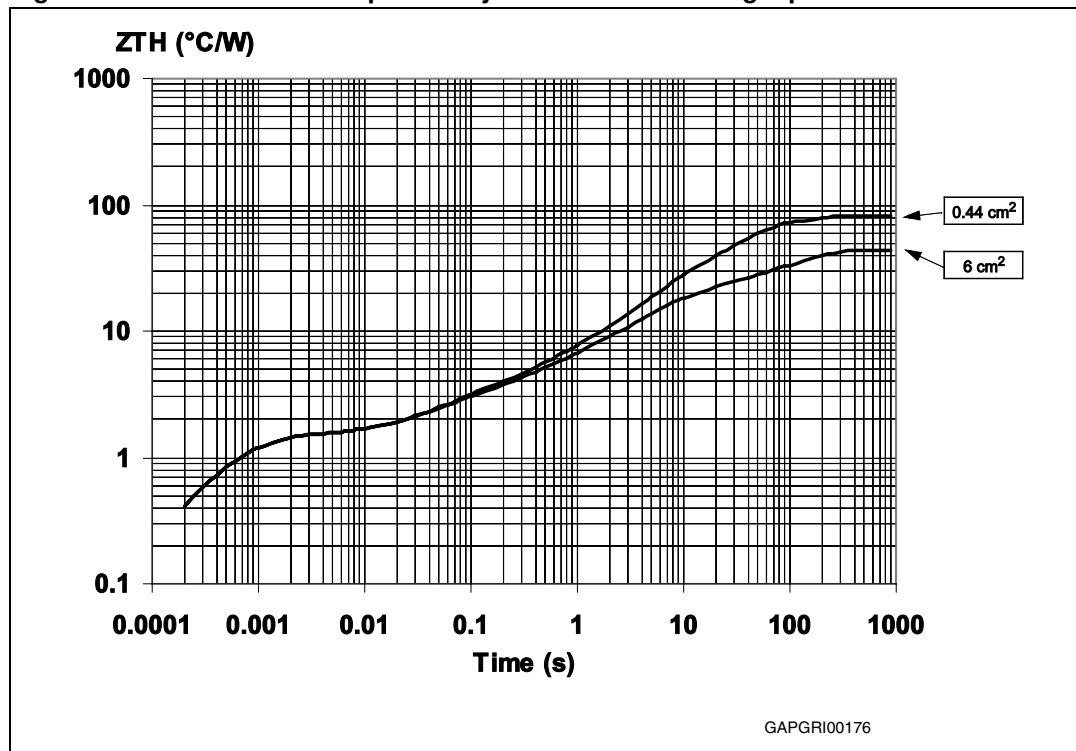


Figure 33. PPAK thermal impedance junction ambient single pulse



Equation 2: pulse calculation formula

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

where  $\delta = t_p/T$

Figure 34. Thermal fitting model of a single channel HSD in PPAK

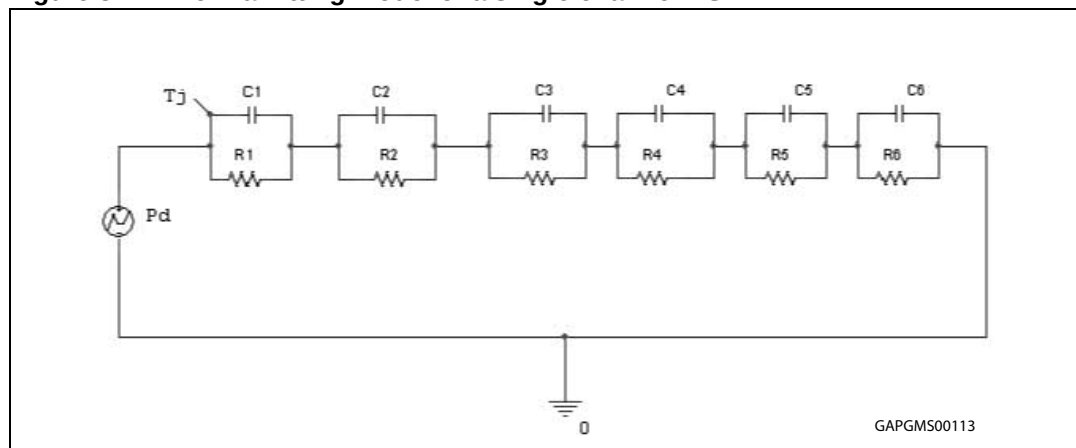
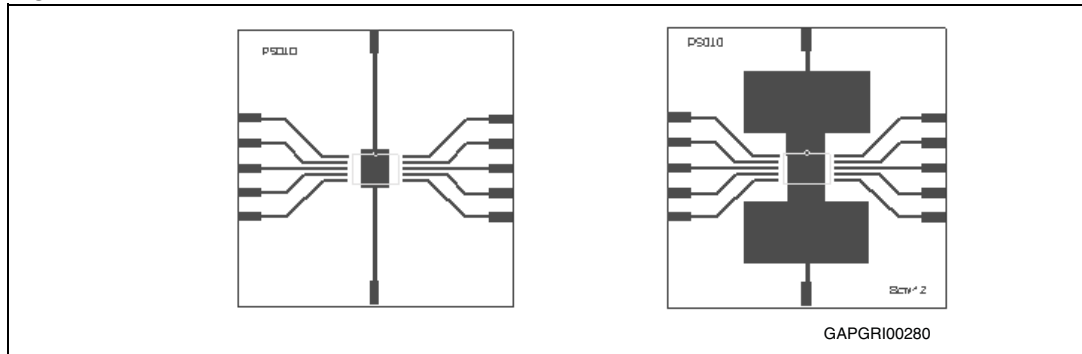


Table 15. PPAK thermal parameters

| Area/island (cm <sup>2</sup> ) | 0.44   | 6  |
|--------------------------------|--------|----|
| R1 (°C/W)                      | 0.04   |    |
| R2 (°C/W)                      | 0.25   |    |
| R3 (°C/W)                      | 0.3    |    |
| R4 (°C/W)                      | 2      |    |
| R5 (°C/W)                      | 15     |    |
| R6 (°C/W)                      | 61     | 24 |
| C1 (W·s/°C)                    | 0.0008 |    |
| C2 (W·s/°C)                    | 0.007  |    |
| C3 (W·s/°C)                    | 0.02   |    |
| C4 (W·s/°C)                    | 0.3    |    |
| C5 (W·s/°C)                    | 0.45   |    |
| C6 (W·s/°C)                    | 0.8    | 5  |

### 4.3 PowerSO-10 thermal data

Figure 35. PowerSO-10 PC board



*Note:* 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: from minimum pad lay-out to 8 cm<sup>2</sup>).

Figure 36. PowerSO-10  $R_{thj-amb}$  vs PCB copper area in open box free air conditions

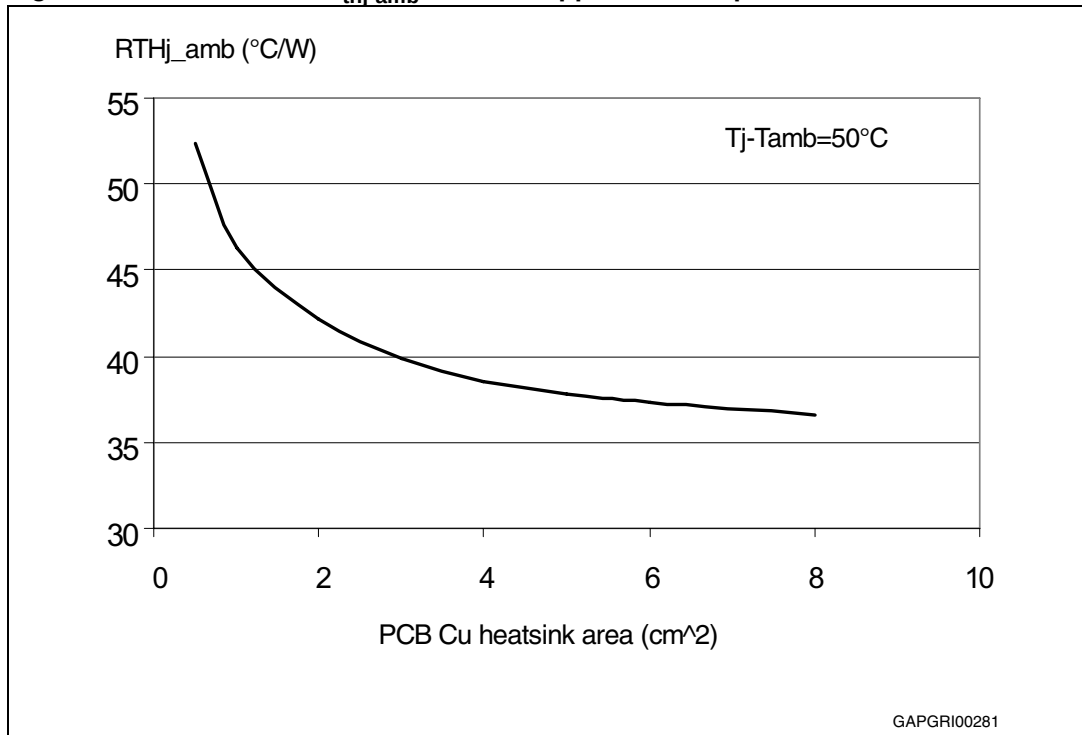
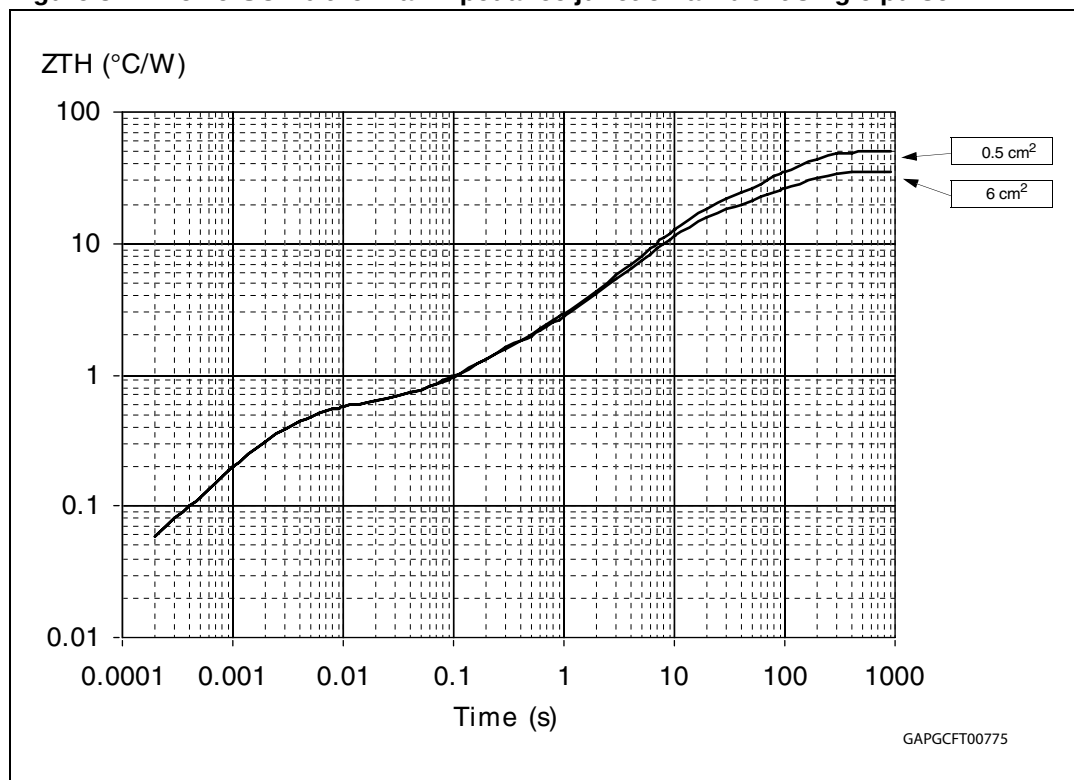


Figure 37. PowerSO-10 thermal impedance junction ambient single pulse



Equation 3: pulse calculation formula

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

$$\text{where } \delta = t_p / T$$

Figure 38. Thermal fitting model of a single channel HSD in PowerSO-10

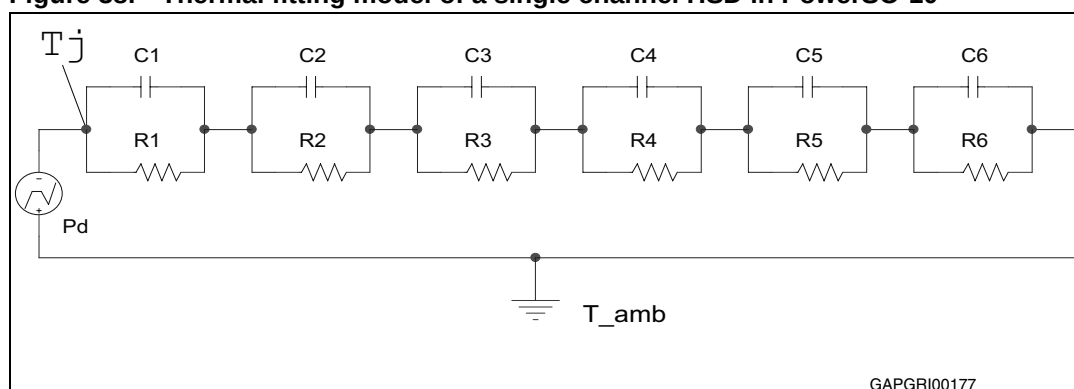


Table 16. PowerSO-10 thermal parameters

| Area / island (cm <sup>2</sup> ) | Footprint | 6  |
|----------------------------------|-----------|----|
| R1 (°C/W)                        | 0.04      |    |
| R2 (°C/W)                        | 0.25      |    |
| R3 (°C/W)                        | 0.25      |    |
| R4 (°C/W)                        | 0.8       |    |
| R5 (°C/W)                        | 12        |    |
| R6 (°C/W)                        | 37        | 22 |
| C1 (W.s/°C)                      | 0.0008    |    |
| C2 (W.s/°C)                      | 7E-03     |    |
| C3 (W.s/°C)                      | 0.015     |    |
| C4 (W.s/°C)                      | 0.3       |    |
| C5 (W.s/°C)                      | 0.75      |    |
| C6 (W.s/°C)                      | 3         | 5  |

## 5 Package and packing information

### 5.1 ECOPACK® packages

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 PENTAWATT mechanical data

Figure 39. PENTAWATT package dimensions

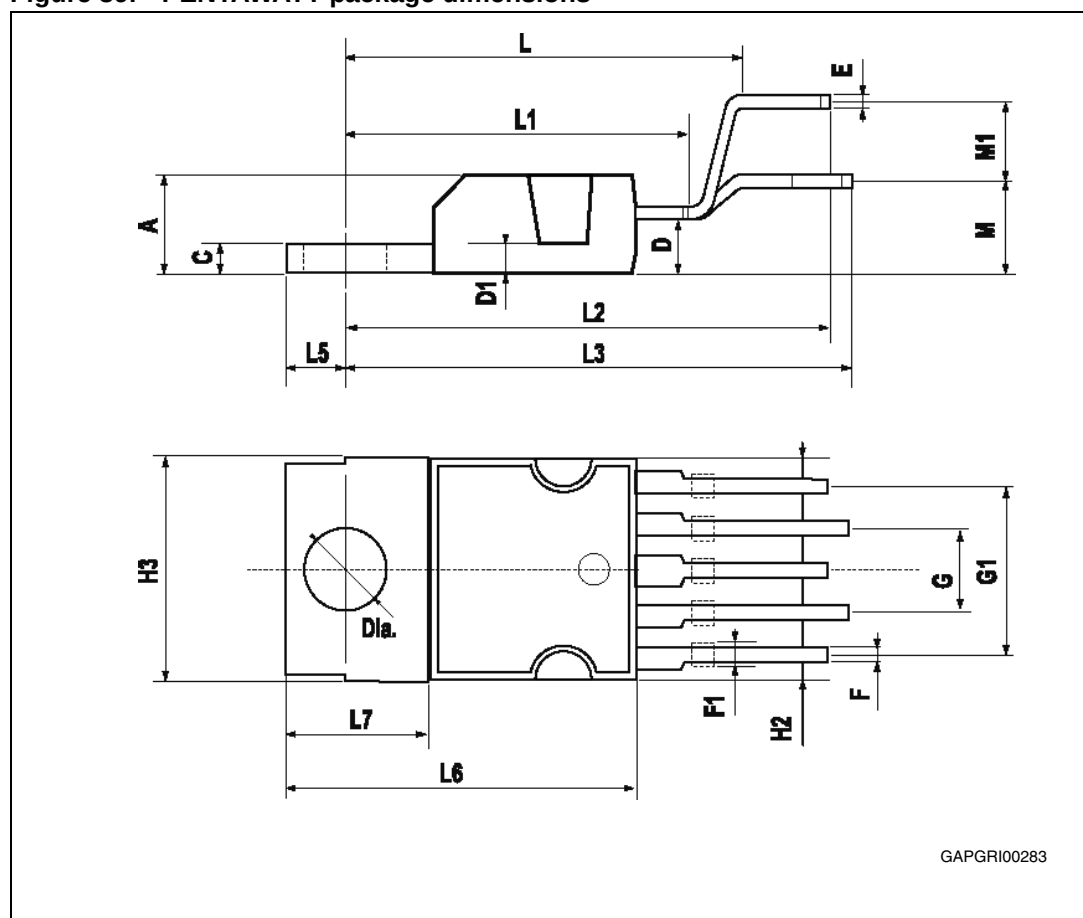


Table 17. PENTAWATT mechanical data

| Dim.  | mm    |       |      |
|-------|-------|-------|------|
|       | Min.  | Typ.  | Max. |
| A     |       |       | 4.8  |
| C     |       |       | 1.37 |
| D     | 2.4   |       | 2.8  |
| D1    | 1.2   |       | 1.35 |
| E     | 0.35  |       | 0.55 |
| F     | 0.8   |       | 1.05 |
| F1    | 1     |       | 1.4  |
| G     | 3.2   | 3.4   | 3.6  |
| G1    | 6.6   | 6.8   | 7    |
| H2    |       |       | 10.4 |
| H3    | 10.05 |       | 10.4 |
| L     |       | 17.85 |      |
| L1    |       | 15.75 |      |
| L2    |       | 21.4  |      |
| L3    |       | 22.5  |      |
| L5    | 2.6   |       | 3    |
| L6    | 15.1  |       | 15.8 |
| L7    | 6     |       | 6.6  |
| M     |       | 4.5   |      |
| M1    |       | 4     |      |
| Diam. | 3.65  |       | 3.85 |

### 5.3 P<sup>2</sup>PAK mechanical data

Figure 40. P<sup>2</sup>PAK package dimensions

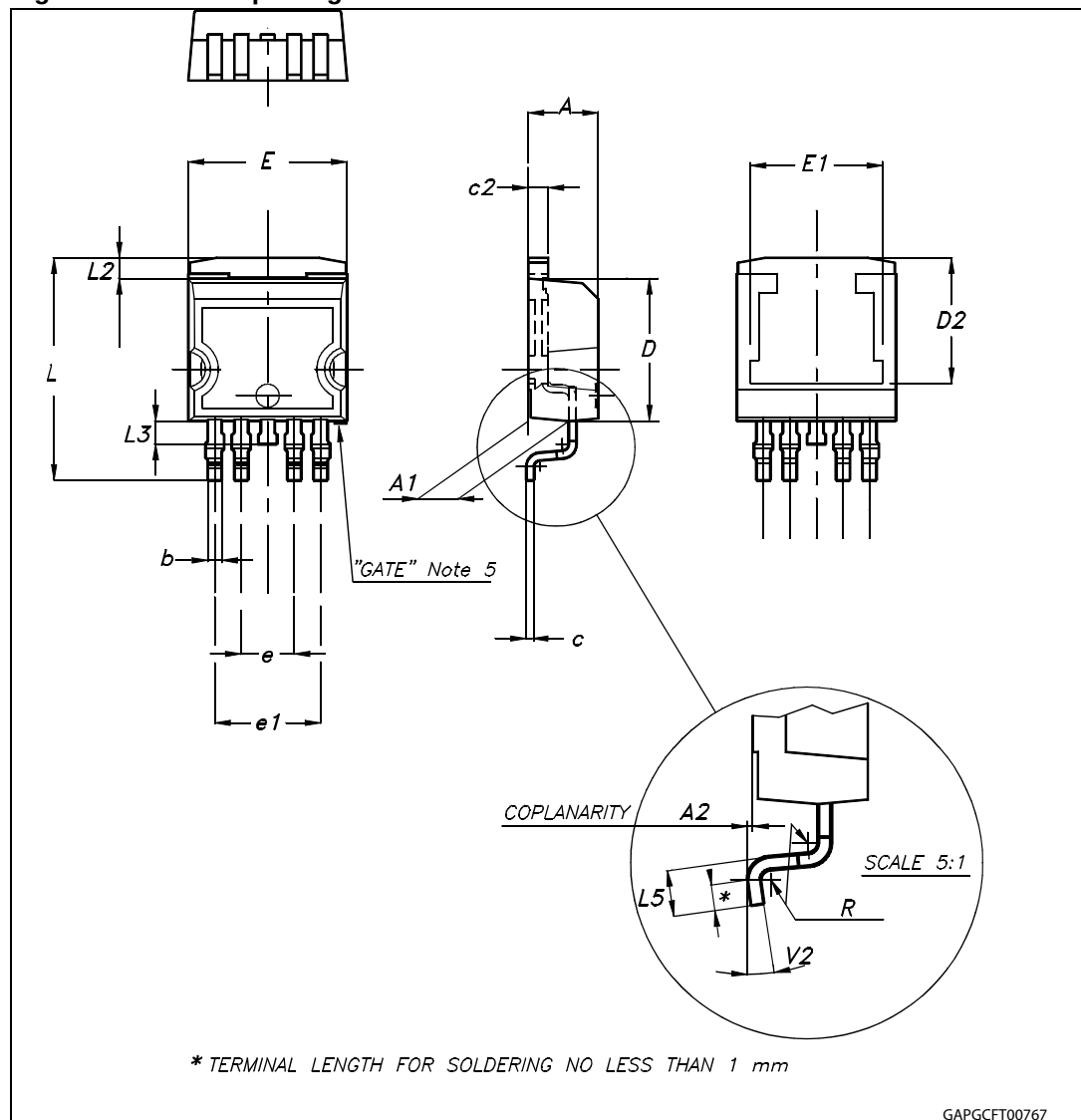


Table 18. P<sup>2</sup>PAK mechanical data

| Dim.           | mm            |      |       |
|----------------|---------------|------|-------|
|                | Min.          | Typ. | Max.  |
| A              | 4.30          |      | 4.80  |
| A1             | 2.40          |      | 2.80  |
| A2             | 0.03          |      | 0.23  |
| b              | 0.80          |      | 1.05  |
| c              | 0.45          |      | 0.60  |
| c2             | 1.17          |      | 1.37  |
| D              | 8.95          |      | 9.35  |
| D2             |               | 8.00 |       |
| E              | 10.00         |      | 10.40 |
| E1             |               | 8.50 |       |
| e              | 3.20          |      | 3.60  |
| e1             | 6.60          |      | 7.00  |
| L              | 13.70         |      | 14.50 |
| L2             | 1.25          |      | 1.40  |
| L3             | 0.90          |      | 1.70  |
| L5             | 1.55          |      | 2.40  |
| R              |               | 0.40 |       |
| V2             | 0°            |      | 8°    |
| Package weight | 1.40 Gr (typ) |      |       |

## 5.4 PPAK mechanical data

Figure 41. PPAK package dimensions

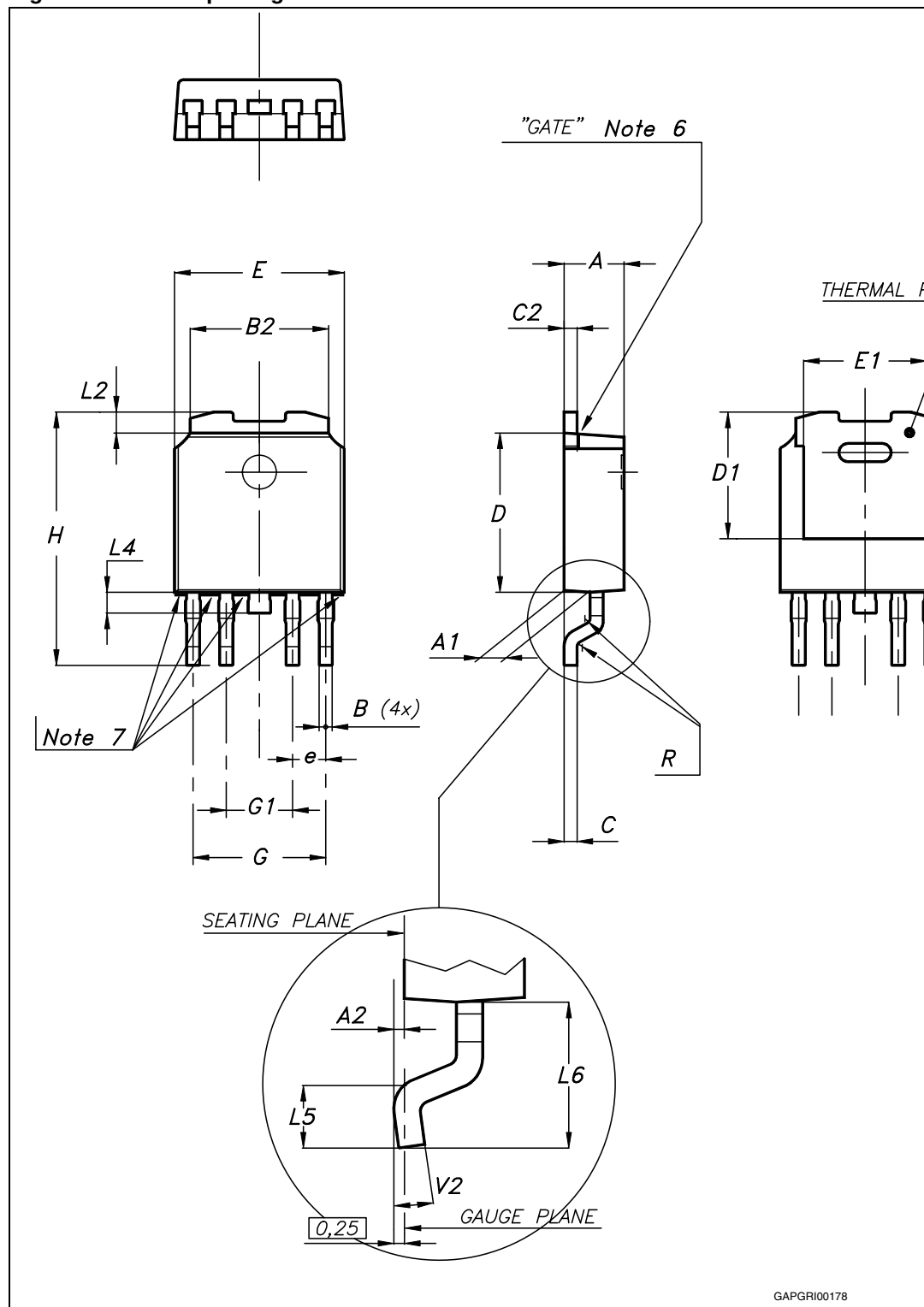


Table 19. PPAK mechanical data

| Dim.           | mm      |      |       |
|----------------|---------|------|-------|
|                | Min.    | Typ. | Max.  |
| A              | 2.20    |      | 2.40  |
| A1             | 0.90    |      | 1.10  |
| A2             | 0.03    |      | 0.23  |
| B              | 0.40    |      | 0.60  |
| B2             | 5.20    |      | 5.40  |
| C              | 0.45    |      | 0.60  |
| C2             | 0.48    |      | 0.60  |
| D1             |         | 5.1  |       |
| D              | 6.00    |      | 6.20  |
| E              | 6.40    |      | 6.60  |
| E1             |         | 4.7  |       |
| e              |         | 1.27 |       |
| G              | 4.90    |      | 5.25  |
| G1             | 2.38    |      | 2.70  |
| H              | 9.35    |      | 10.10 |
| L2             |         | 0.8  | 1.00  |
| L4             | 0.60    |      | 1.00  |
| L5             | 1       |      |       |
| L6             |         | 2.80 |       |
| R              |         | 0.2  |       |
| V2             | 0°      |      | 8°    |
| Package weight | Gr. 0.3 |      |       |

## 5.5 PowerSO-10 mechanical data

**Figure 42. PowerSO-10 package dimensions**

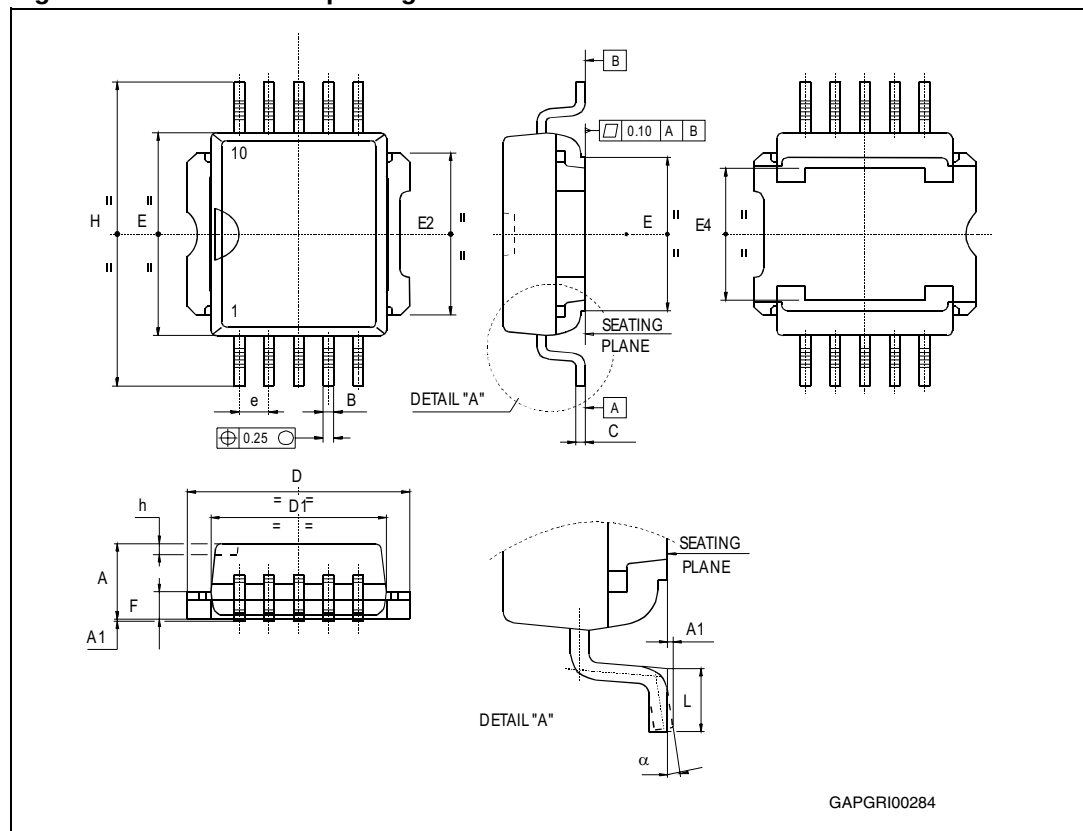


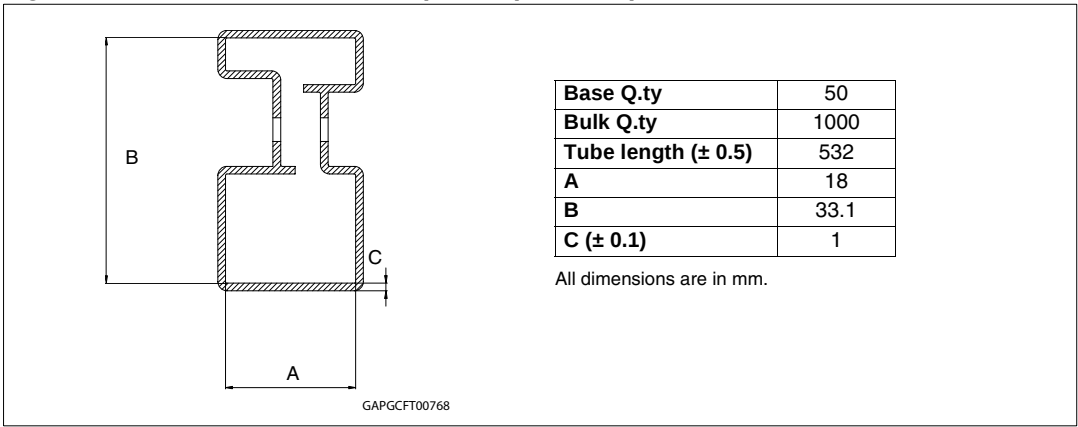
Table 20. PowerSO-10 mechanical data

| Dim.              | mm    |      |       |
|-------------------|-------|------|-------|
|                   | Min.  | Typ. | Max.  |
| A                 | 3.35  |      | 3.65  |
| A <sup>(1)</sup>  | 3.4   |      | 3.6   |
| A1                | 0     |      | 0.10  |
| B                 | 0.40  |      | 0.60  |
| B <sup>(1)</sup>  | 0.37  |      | 0.53  |
| C                 | 0.35  |      | 0.55  |
| C <sup>(1)</sup>  | 0.23  |      | 0.32  |
| D                 | 9.40  |      | 9.60  |
| D1                | 7.40  |      | 7.60  |
| E                 | 9.30  |      | 9.50  |
| E2                | 7.20  |      | 7.60  |
| E2 <sup>(1)</sup> | 7.30  |      | 7.50  |
| E4                | 5.90  |      | 6.10  |
| E4 <sup>(1)</sup> | 5.90  |      | 6.30  |
| e                 |       | 1.27 |       |
| F                 | 1.25  |      | 1.35  |
| F <sup>(1)</sup>  | 1.20  |      | 1.40  |
| H                 | 13.80 |      | 14.40 |
| H <sup>(1)</sup>  | 13.85 |      | 14.35 |
| h                 |       | 0.50 |       |
| L                 | 1.20  |      | 1.80  |
| L <sup>(1)</sup>  | 0.80  |      | 1.10  |
| $\alpha$          | 0°    |      | 8°    |
| $\alpha^{(1)}$    | 2°    |      | 8°    |

1. Muar only POA P013P.

5.6 PENTAWATT packing information

Figure 43. PENTAWATT tube shipment (no suffix)



5.7 P<sup>2</sup>PAK packing information

Figure 44. P<sup>2</sup>PAK tube shipment (no suffix)

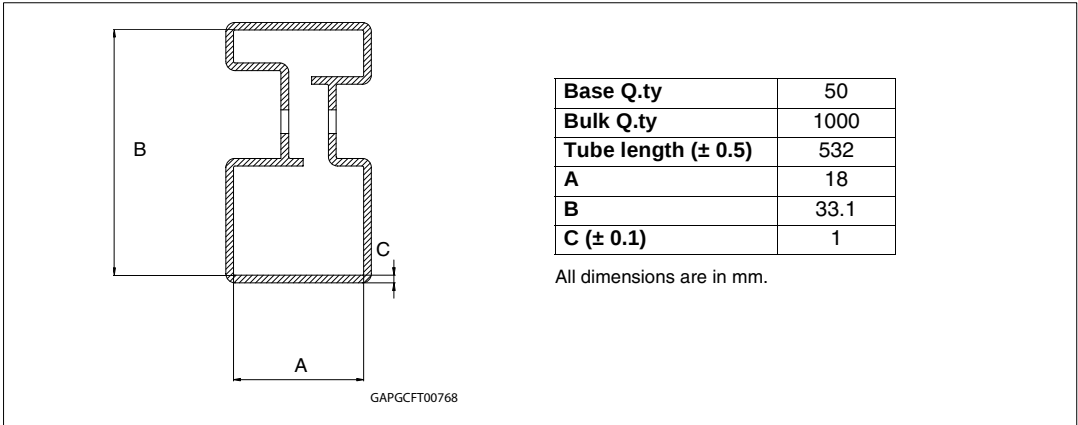
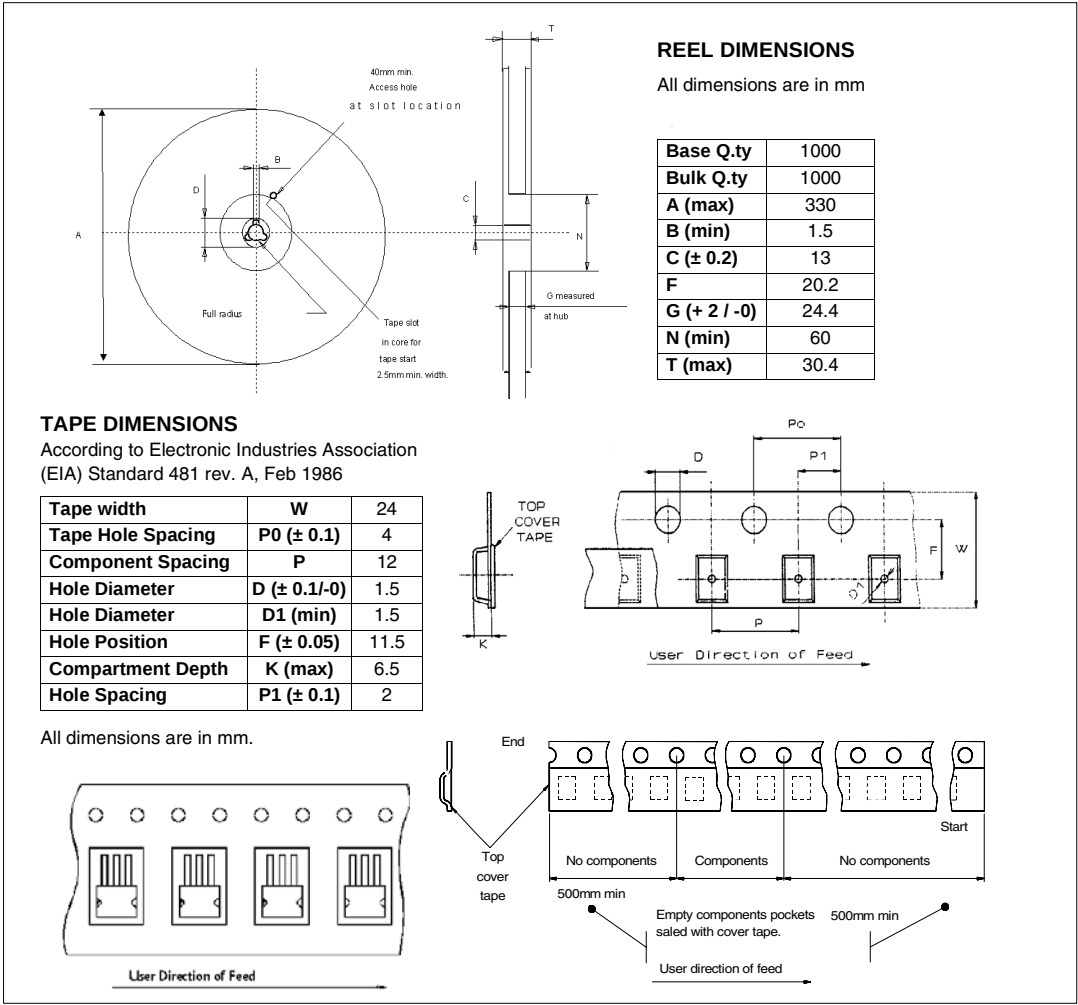


Figure 45. P<sup>2</sup>PAK tape and reel (suffix “TR”)



## 5.8 PPAK packing information

Figure 46. PPAK suggested pad layout

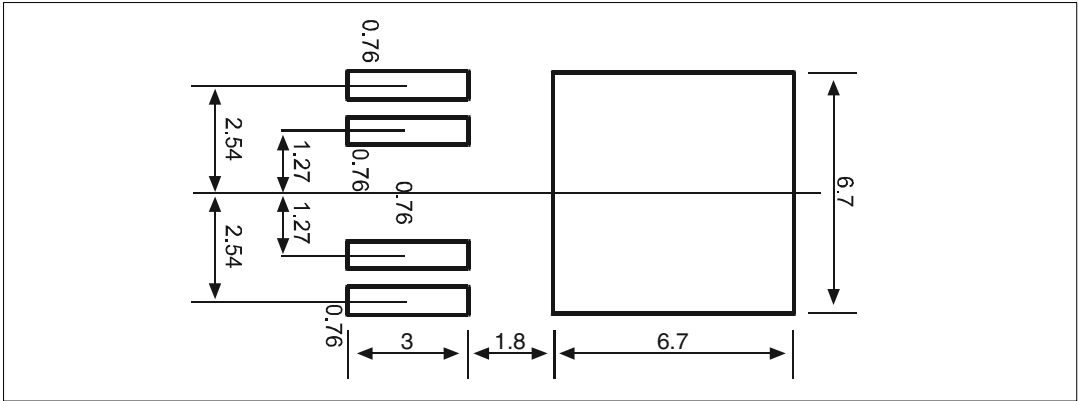


Figure 47. PPAK tube shipment (no suffix)

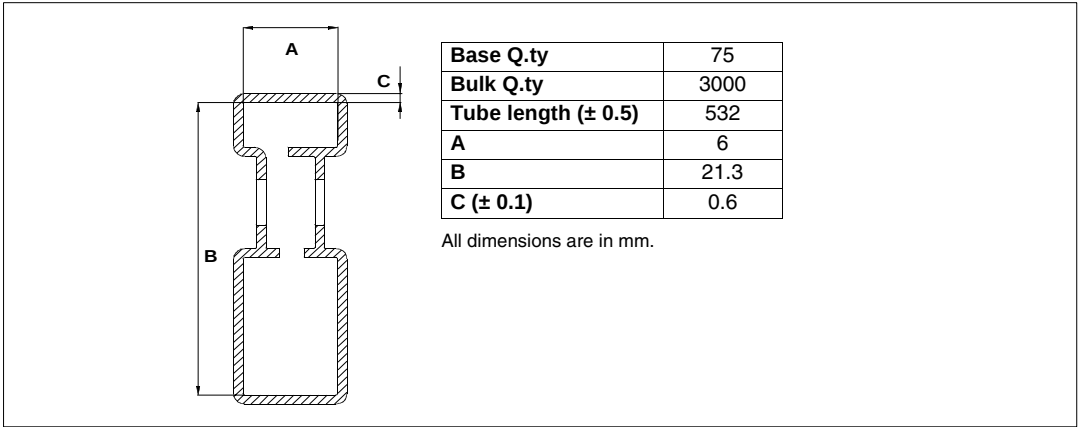
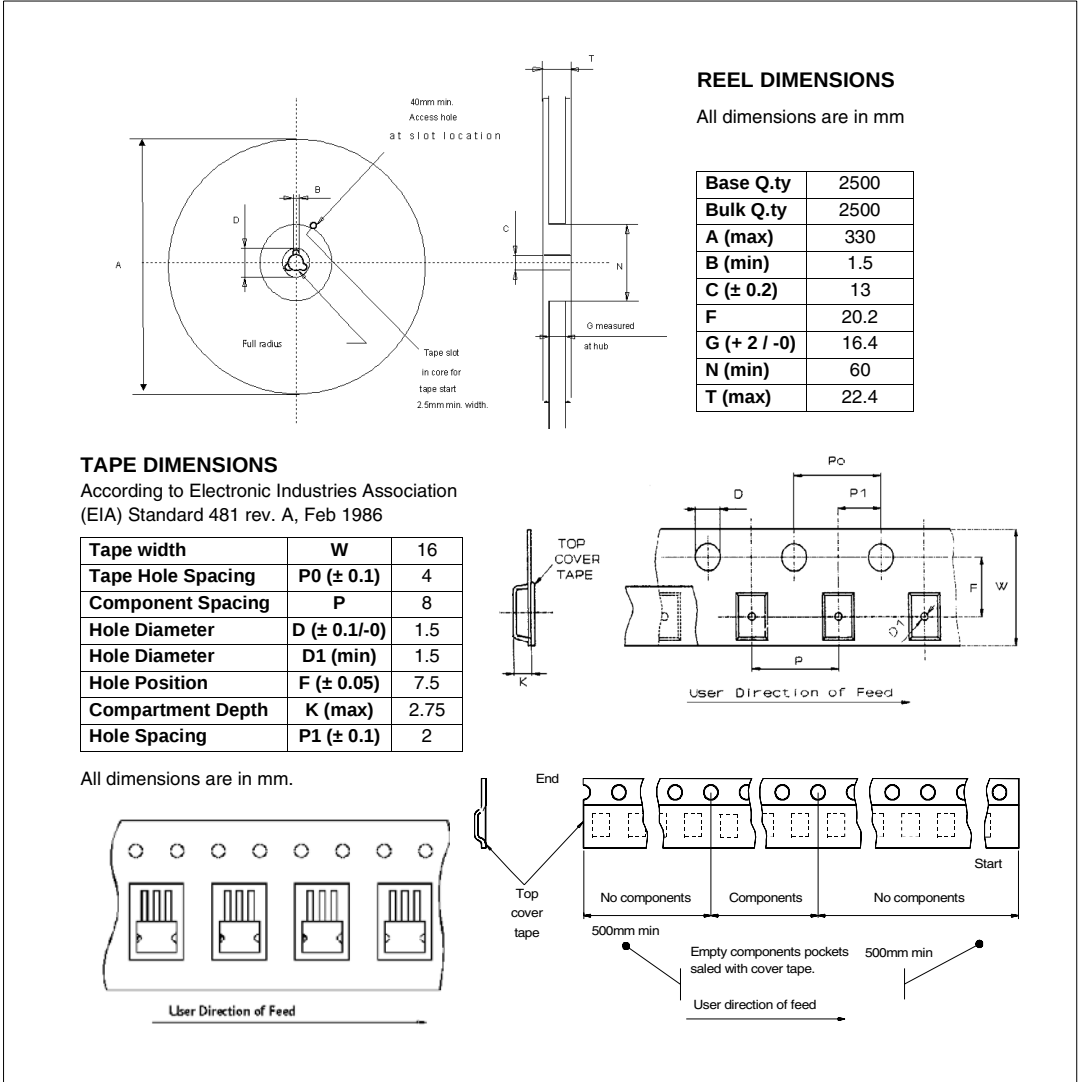
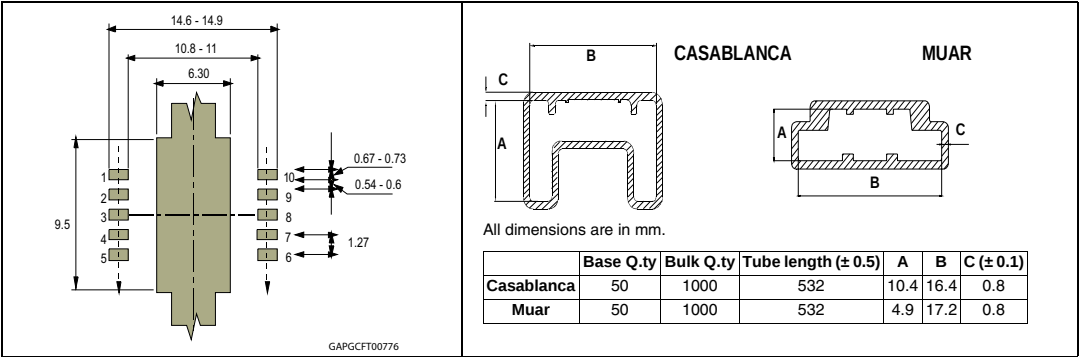


Figure 48. PPAK tape and reel (suffix "TR")

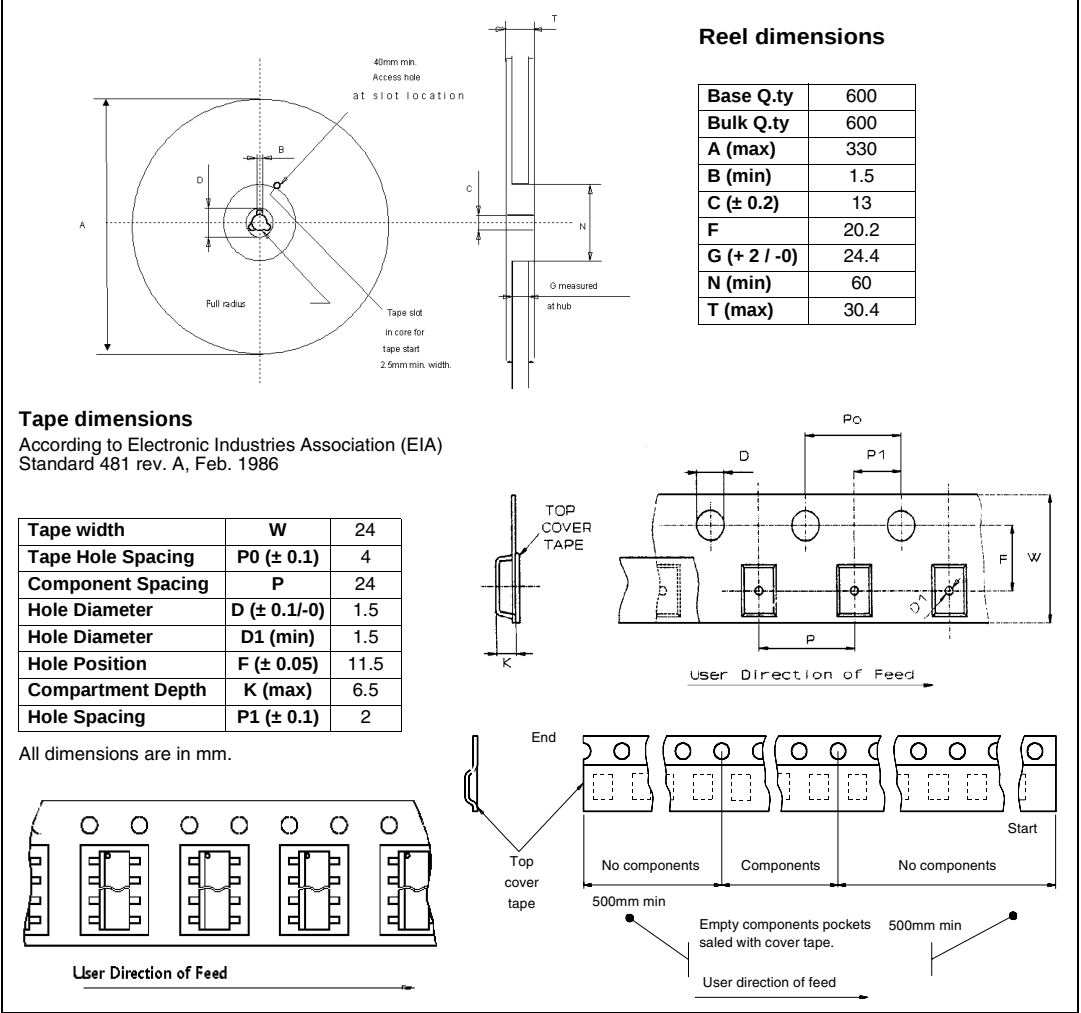


# 5.9 PowerSO-10 packing information

**Figure 49. PowerSO-10 suggested pad layout** **Figure 50. PowerSO-10 tube shipment (no suffix)**



**Figure 51. PowerSO-10 tape and reel shipment (suffix “TR”)**



## 6 Revision history

**Table 21. Document revision history**

| Date         | Revision | Changes                                                                                                                                                                                                                                                                                |
|--------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 07-Dec-2004  | 1        | Initial release.                                                                                                                                                                                                                                                                       |
| 09-Feb-2005  | 2        | Text changed.                                                                                                                                                                                                                                                                          |
| 23-Mar-2005  | 3        | Configuration diagram (PowerSO-10) modification.                                                                                                                                                                                                                                       |
| 03-May-2006  | 4        | SO-16L mechanical and shipment data insertion.                                                                                                                                                                                                                                         |
| 17-Dec-2008  | 5        | Document reformatted and restructured.<br>Added content, list of figures and tables.<br>Added <i>ECOPACK® packages</i> information.<br>Updated <i>Figure 45: P2PAK tape and reel (suffix "TR")</i> :<br>– changed component spacing (P) in tape dimensions table from 16 mm to 12 mm.  |
| 29-Mar-2010  | 6        | Updated features list.<br>Updated <i>Table 1: Device summary</i> .<br>Updated <i>Table 3: Absolute maximum ratings</i> .<br>Updated <i>Section 3.5: PowerSO-10, P2PAK, PPAK, PENTAWATT maximum demagnetization energy (VCC = 13.5V)</i> .<br>Removed SO-16L package into the document. |
| 07-June-2012 | 7        | Updated <i>Section 5.8: PPAK packing information</i> .                                                                                                                                                                                                                                 |
| 24-Sep-2013  | 8        | Updated Disclaimer.                                                                                                                                                                                                                                                                    |

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