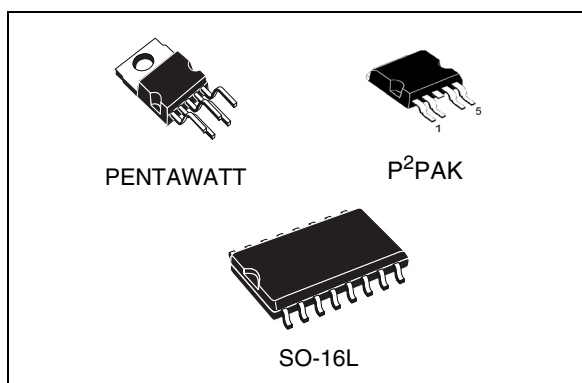


## Single channel high-side solid-state relay

### Features

| Type                         | $R_{DS(on)}$ | $I_{OUT}$ | $V_{CC}$ |
|------------------------------|--------------|-----------|----------|
| VN920<br>VN920-B5<br>VN920SO | 16 mΩ        | 30 A      | 36 V     |

- CMOS compatible input
- Proportional load current sense
- Shorted load protection
- Under-voltage and over-voltage shutdown
- Over-voltage clamp
- Thermal shutdown
- Current limitation
- Protection against loss of ground and loss of  $V_{CC}$
- Very low standby power dissipation
- Reverse battery protected (see [Application schematic](#))



### Description

The VN920 is a monolithic device designed in STMicroelectronics VIPower M0-3 technology. The VN920 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 (see ISO7637 transient compatibility table). Active current limitation combined with thermal shutdown and automatic restart protects the device against over-load.

The device integrates an analog current sense output which delivers a current proportional to the load current. The device automatically turns off in the case where the ground pin becomes disconnected.

**Table 1. Device summary**

| Package   | Order codes |               |
|-----------|-------------|---------------|
|           | Tube        | Tape and reel |
| PENTAWATT | VN920       | -             |
| P²PAK     | VN920-B5    | VN920-B513TR  |
| SO-16L    | VN920SO     | VN920SO13TR   |

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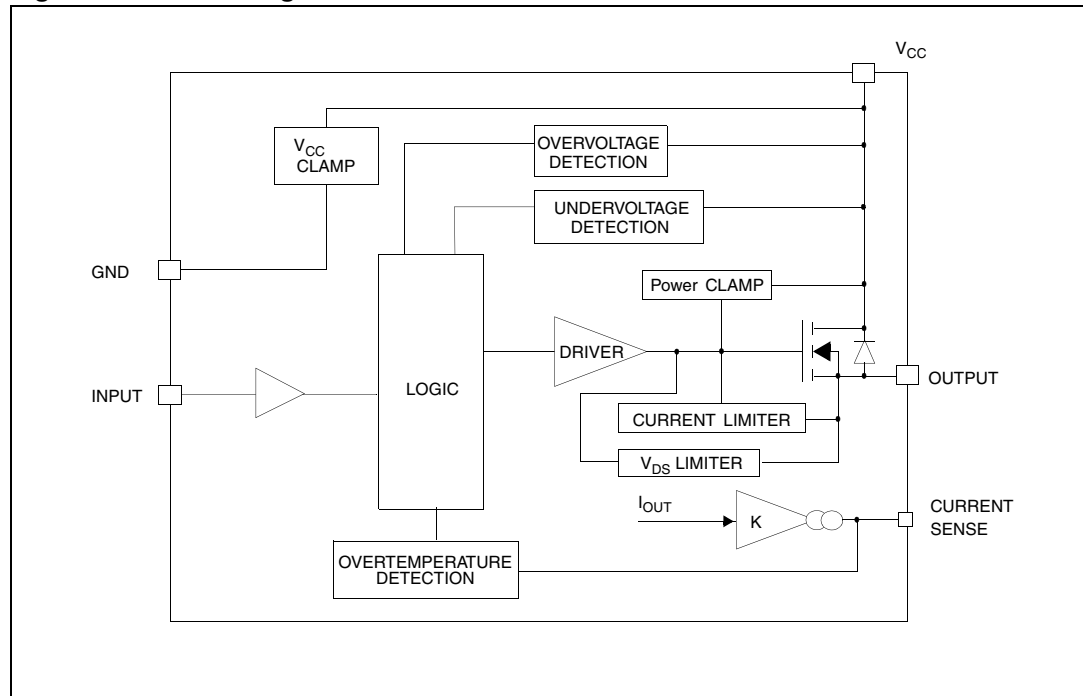
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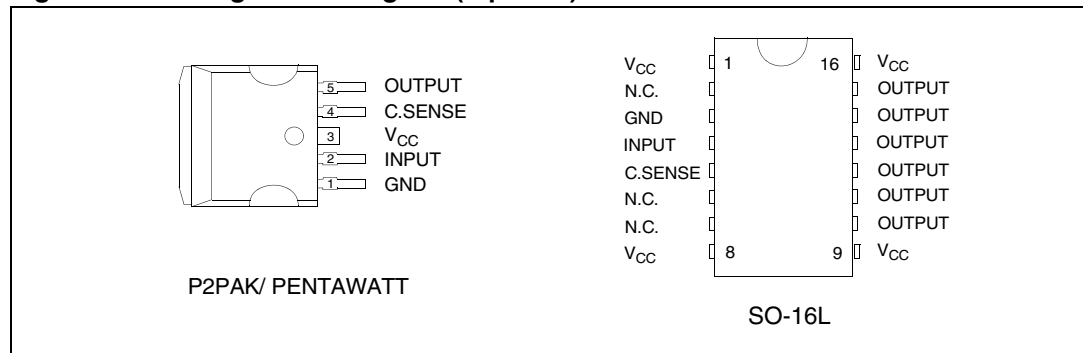
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## 1 Block diagram and pin description

**Figure 1. Block diagram**



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

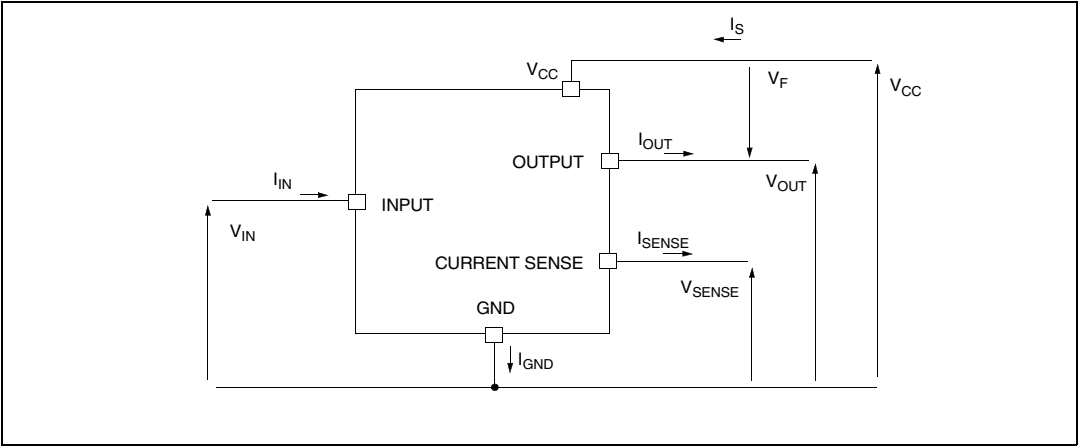


**Table 2. Suggested connections for unused and not connected pins**

| Connection / pin | Current Sense                | N.C. | Output | Input                         |
|------------------|------------------------------|------|--------|-------------------------------|
| Floating         |                              | X    | X      | X                             |
| To ground        | Through 1K $\Omega$ resistor | X    |        | Through 10K $\Omega$ resistor |

# 2 Electrical specifications

Figure 3. Current and voltage conventions



## 2.1 Absolute maximum ratings

Stressing the device above the rating listed in the “Absolute maximum ratings” table 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. Refer also to the STMicroelectronics sure program and other relevant quality document.

Table 3. Absolute maximum ratings

| Symbol       | Parameter                                                                       | Value              |           |                    | Unit   |
|--------------|---------------------------------------------------------------------------------|--------------------|-----------|--------------------|--------|
|              |                                                                                 | SO-16L             | PENTAWATT | P <sup>2</sup> PAK |        |
| $V_{CC}$     | 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                                                       | - 21               |           |                    | A      |
| $I_{IN}$     | DC input current                                                                | +/- 10             |           |                    | mA     |
| $V_{CSENSE}$ | Current sense maximum voltage                                                   | - 3<br>+ 15        |           |                    | V<br>V |
| $V_{ESD}$    | Electrostatic discharge<br>(human body model: $R = 1.5K\Omega$<br>$C = 100pF$ ) |                    |           |                    |        |
|              | INPUT                                                                           | 4000               |           |                    | V      |
|              | CURRENT SENSE                                                                   | 2000               |           |                    | V      |
|              | OUTPUT                                                                          | 5000               |           |                    | V      |
|              | $V_{CC}$                                                                        | 5000               |           |                    | V      |

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

| Symbol    | Parameter                                                                                                                                                      | Value              |           |                    | Unit             |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|-----------|--------------------|------------------|
|           |                                                                                                                                                                | SO-16L             | PENTAWATT | P <sup>2</sup> PAK |                  |
| $E_{MAX}$ | Maximum switching energy<br>( $L = 0.25\text{mH}$ ; $R_L = 0\Omega$ ;<br>$V_{bat} = 13.5\text{V}$ ; $T_{jstart} = 150^\circ\text{C}$ ;<br>$I_L = 45\text{A}$ ) | 352                |           | 364                | mJ               |
| $P_{tot}$ | Power dissipation $T_C \leq 25^\circ\text{C}$                                                                                                                  | 8.3                | 96.1      | 96.1               | 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               |
|----------------|---------------------------------------|-------------------|-----------|---------------------|--------------------|
|                |                                       | SO-16L            | PENTAWATT | P <sup>2</sup> PAK  |                    |
| $R_{thj-case}$ | Thermalresistance<br>junction-case    | -                 | 1.3       | 1.3                 | $^\circ\text{C/W}$ |
| $R_{thj-lead}$ | Thermalresistance<br>junction-lead    | 15                | -         |                     | $^\circ\text{C/W}$ |
| $R_{thj-amb}$  | Thermalresistance<br>junction-ambient | 65 <sup>(1)</sup> | 61.3      | 51.3 <sup>(2)</sup> | $^\circ\text{C/W}$ |
|                |                                       | 48 <sup>(3)</sup> |           | 37 <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) connected to all VCC pins.
2. When mounted on a standard single-sided FR-4 board with 0.5cm<sup>2</sup> of Cu (at least 35μm thick).
3. When mounted on a standard single-sided FR-4 board with 6cm<sup>2</sup> of Cu (at least 35μm thick) connected to all VCC pins.
4. 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  $8V < V_{CC} < 36V$ ;  $-40^{\circ}C < T_j < 150^{\circ}C$ , unless otherwise stated.

**Table 5. Power**

| Symbol        | Parameter                | Test conditions                                                                                | Min. | Typ. | Max.           | Unit                                |
|---------------|--------------------------|------------------------------------------------------------------------------------------------|------|------|----------------|-------------------------------------|
| $V_{CC}$      | Operating supply voltage |                                                                                                | 5.5  | 13   | 36             | V                                   |
| $V_{USD}$     | Under-voltage shutdown   |                                                                                                | 3    | 4    | 5.5            | V                                   |
| $V_{OV}$      | Over-voltage shutdown    |                                                                                                | 36   |      |                | V                                   |
| $R_{ON}$      | On-state resistance      | $I_{OUT} = 10A$ ; $T_j = 25^{\circ}C$ ;<br>$I_{OUT} = 10A$ ;<br>$I_{OUT} = 3A$ ; $V_{CC} = 6V$ |      |      | 16<br>32<br>55 | $m\Omega$<br>$m\Omega$<br>$m\Omega$ |
| $V_{CLAMP}$   | Clamp voltage            | $I_{CC} = 20mA$                                                                                | 41   | 48   | 55             | V                                   |
| $I_S$         | Supply current           | Off-state; $V_{CC} = 13V$ ;<br>$V_{IN} = V_{OUT} = 0V$                                         |      | 10   | 25             | $\mu A$                             |
|               |                          | Off-state; $V_{CC} = 13V$ ;<br>$V_{IN} = V_{OUT} = 0V$ ; $T_j = 25^{\circ}C$                   |      | 10   | 20             | $\mu A$                             |
|               |                          | On-state; $V_{CC} = 13V$ ; $V_{IN} = 5V$ ;<br>$I_{OUT} = 0A$ ; $R_{SENSE} = 3.9 k\Omega$       |      |      | 5              | mA                                  |
| $I_{L(off1)}$ | Off-state output current | $V_{IN} = V_{OUT} = 0V$                                                                        | 0    |      | 50             | $\mu A$                             |
| $I_{L(off2)}$ | Off-state output current | $V_{IN} = 0V$ ; $V_{OUT} = 3.5V$                                                               | -75  |      | 0              | $\mu A$                             |
| $I_{L(off3)}$ | Off-state output current | $V_{IN} = V_{OUT} = 0V$ ; $V_{CC} = 13V$ ;<br>$T_j = 125^{\circ}C$                             |      |      | 5              | $\mu A$                             |
| $I_{L(off4)}$ | Off-state output current | $V_{IN} = V_{OUT} = 0V$ ; $V_{CC} = 13V$ ;<br>$T_j = 25^{\circ}C$                              |      |      | 3              | $\mu A$                             |

Note:  $V_{CLAMP}$  and  $V_{OV}$  are correlated. Typical difference is 5V.

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

| Symbol                | Parameter              | Test conditions                                    | Min.                           | Typ. | Max. | Unit       |
|-----------------------|------------------------|----------------------------------------------------|--------------------------------|------|------|------------|
| $t_{d(on)}$           | Turn-on delay time     | $R_L = 1.3\Omega$ (see <a href="#">Figure 4.</a> ) |                                | 50   |      | $\mu s$    |
| $t_{d(off)}$          | Turn-off delay time    | $R_L = 1.3\Omega$ (see <a href="#">Figure 4.</a> ) |                                | 50   |      | $\mu s$    |
| $dV_{OUT}/dt_{(on)}$  | Turn-on voltage slope  | $R_L = 1.3\Omega$ (see <a href="#">Figure 4.</a> ) | See <a href="#">Figure 10.</a> |      |      | V/ $\mu s$ |
| $dV_{OUT}/dt_{(off)}$ | Turn-off voltage slope | $R_L = 1.3\Omega$ (see <a href="#">Figure 4.</a> ) | See <a href="#">Figure 12.</a> |      |      | V/ $\mu s$ |

**Table 7. Logic inputs**

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

**Table 8. Current sense ( $9V \leq V_{CC} \leq 16V$ )**

| Symbol       | Parameter                                   | Test conditions                                                                                                               | Min.         | Typ.         | Max.         | Unit    |
|--------------|---------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|--------------|--------------|--------------|---------|
| $K_1$        | $I_{OUT}/I_{SENSE}$                         | $I_{OUT} = 1A$ ; $V_{SENSE} = 0.5V$ ;<br>$T_j = -40^\circ C \dots 150^\circ C$                                                | 3300         | 4400         | 6000         |         |
| $dK_1/K_1$   | Current sense ratio drift                   | $I_{OUT} = 1A$ ; $V_{SENSE} = 0.5V$ ;<br>$T_j = -40^\circ C \dots 150^\circ C$                                                | -10          |              | +10          | %       |
| $K_2$        | $I_{OUT}/I_{SENSE}$                         | $I_{OUT} = 10A$ ; $V_{SENSE} = 4V$ ;<br>$T_j = -40^\circ C$<br>$T_j = 25^\circ C \dots 150^\circ C$                           | 4200<br>4400 | 4900<br>4900 | 6000<br>5750 |         |
| $dK_2/K_2$   | Current sense ratio drift                   | $I_{OUT} = 10A$ ; $V_{SENSE} = 4V$ ;<br>$T_j = -40^\circ C \dots 150^\circ C$                                                 | -8           |              | +8           | %       |
| $K_3$        | $I_{OUT}/I_{SENSE}$                         | $I_{OUT} = 30A$ ; $V_{SENSE} = 4V$ ;<br>$T_j = -40^\circ C$<br>$T_j = 25^\circ C \dots 150^\circ C$                           | 4200<br>4400 | 4900<br>4900 | 5500<br>5250 |         |
| $dK_3/K_3$   | Current sense ratio drift                   | $I_{OUT} = 30A$ ; $V_{SENSE} = 4V$ ;<br>$T_j = -40^\circ C \dots 150^\circ C$                                                 | -6           |              | +6           | %       |
| $I_{SENSE0}$ | Analog sense current                        | $V_{CC} = 6 \dots 16V$ ; $I_{OUT} = 0A$ ;<br>$V_{SENSE} = 0V$ ;<br>$T_j = -40^\circ C \dots 150^\circ C$                      | 0            |              | 10           | $\mu A$ |
| $V_{SENSE}$  | Max analog sense output voltage             | $V_{CC} = 5.5V$ ; $I_{OUT} = 5A$ ;<br>$R_{SENSE} = 10k\Omega$<br>$V_{CC} > 8V$ , $I_{OUT} = 10A$ ;<br>$R_{SENSE} = 10k\Omega$ | 2<br>4       |              |              | V<br>V  |
| $V_{SENSEH}$ | Sense voltage in over-temperature condition | $V_{CC} = 13V$ ; $R_{SENSE} = 3.9k\Omega$                                                                                     |              | 5.5          |              | V       |

**Table 8. Current sense ( $9V \leq V_{CC} \leq 16V$ ) (continued)**

| Symbol        | Parameter                                                   | Test conditions                                | Min. | Typ. | Max. | Unit     |
|---------------|-------------------------------------------------------------|------------------------------------------------|------|------|------|----------|
| $R_{VSENSEH}$ | Analog sense output impedance in over-temperature condition | $V_{CC} = 13V$ ; $T_j > T_{TSD}$ ; output open |      | 400  |      | $\Omega$ |
| $t_{DSENSE}$  | Current sense delay response                                | To 90% $I_{SENSE}^{(1)}$                       |      |      | 500  | $\mu s$  |

1. Current sense signal delay after positive input slope.

**Table 9.  $V_{CC}$  output diode**

| Symbol | Parameter          | Test conditions                       | Min. | Typ. | Max. | Unit |
|--------|--------------------|---------------------------------------|------|------|------|------|
| $V_F$  | Forward on voltage | $-I_{OUT} = 5A$ ; $T_j = 150^\circ C$ |      |      | 0.6  | V    |

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

| Symbol      | Parameter                      | Test conditions                                            | Min.          | Typ.          | Max.          | Unit       |
|-------------|--------------------------------|------------------------------------------------------------|---------------|---------------|---------------|------------|
| $T_{TSD}$   | Shutdown temperature           |                                                            | 150           | 175           | 200           | $^\circ C$ |
| $T_R$       | Reset temperature              |                                                            | 135           |               |               | $^\circ C$ |
| $T_{hyst}$  | Thermal hysteresis             |                                                            | 7             | 15            |               | $^\circ C$ |
| $I_{lim}$   | Current limitation             | $V_{CC} = 13V$<br>$5V < V_{CC} < 36V$                      | 30            | 45            | 75<br>75      | A<br>A     |
| $V_{demag}$ | Turn-off output clamp voltage  | $I_{OUT} = 2 A$ ;<br>$V_{IN} = 0V$ ;<br>$L = 6mH$          | $V_{CC} - 41$ | $V_{CC} - 48$ | $V_{CC} - 55$ | V          |
| $V_{ON}$    | Output voltage drop limitation | $I_{OUT} = 1 A$ ;<br>$T_j = -40^\circ C \dots 150^\circ C$ |               | 50            |               | mV         |

1. To ensure long term reliability under heavy over-load 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. Truth table

| Conditions                    | Input       | Output      | Sense                                                          |
|-------------------------------|-------------|-------------|----------------------------------------------------------------|
| Normal operation              | L<br>H      | L<br>H      | 0<br>Nominal                                                   |
| Over-temperature              | L<br>H      | L<br>L      | 0<br>$V_{SENSEH}$                                              |
| Under-voltage                 | L<br>H      | L<br>L      | 0<br>0                                                         |
| Over-voltage                  | L<br>H      | L<br>L      | 0<br>0                                                         |
| Short circuit to GND          | L<br>H<br>H | L<br>L<br>L | 0<br>( $T_j < T_{TSD}$ ) 0<br>( $T_j > T_{TSD}$ ) $V_{SENSEH}$ |
| Short circuit to $V_{CC}$     | L<br>H      | H<br>H      | 0<br>< Nominal                                                 |
| Negative output voltage clamp | L           | L           | 0                                                              |

Table 12. 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 4. Switching characteristics

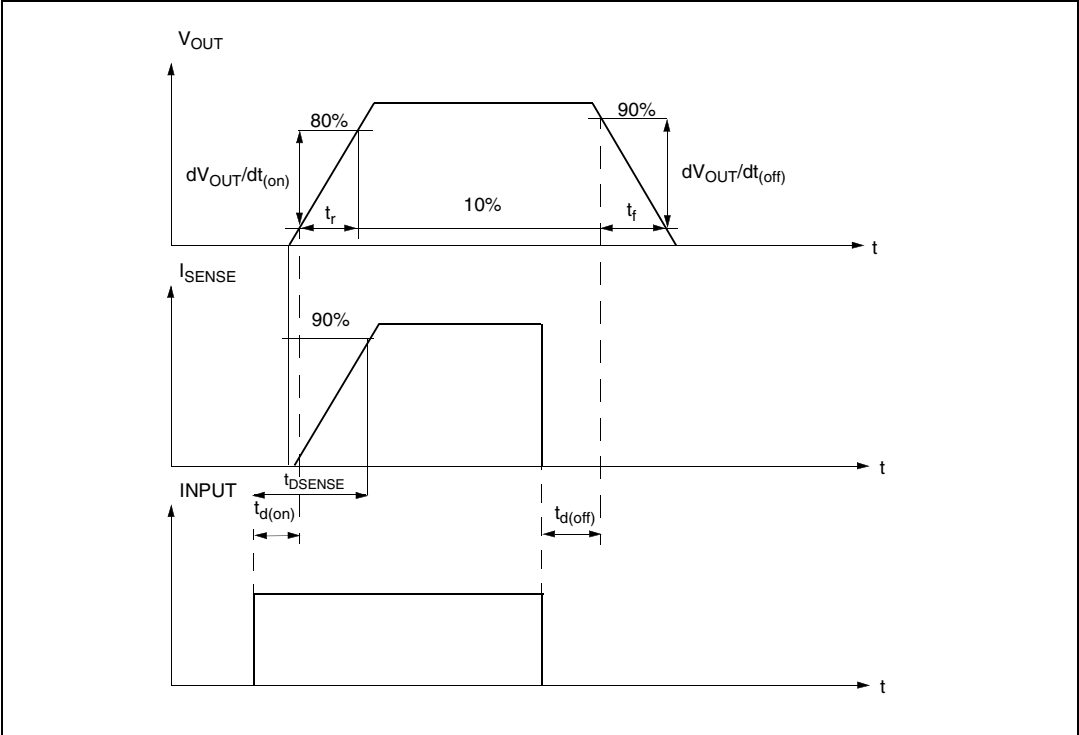


Figure 5.  $I_{OUT}/I_{SENSE}$  versus  $I_{OUT}$

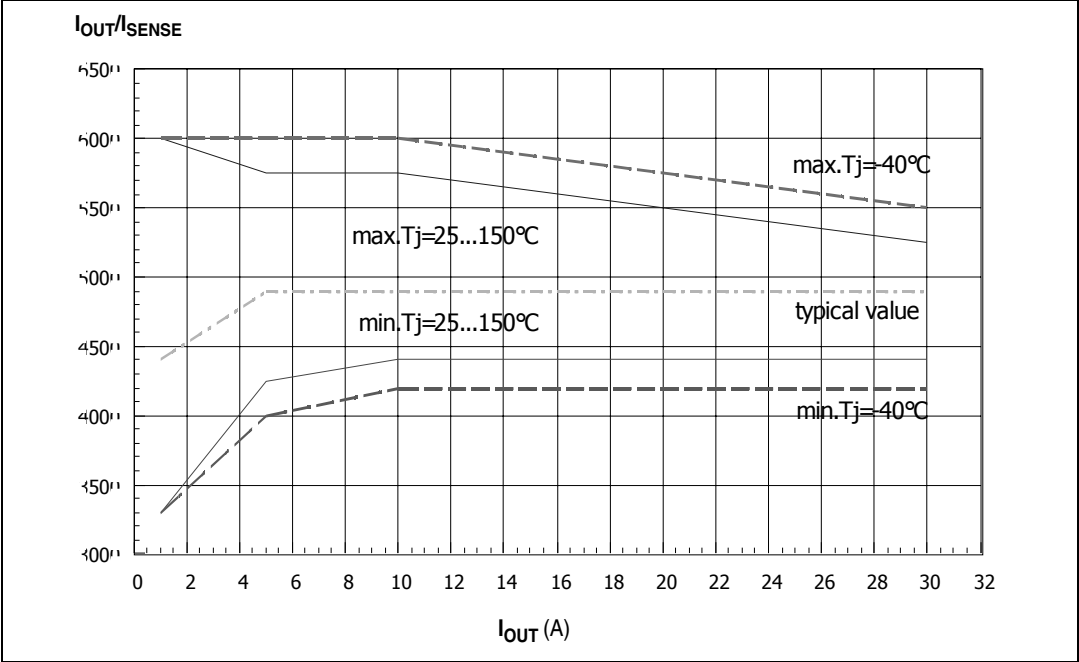
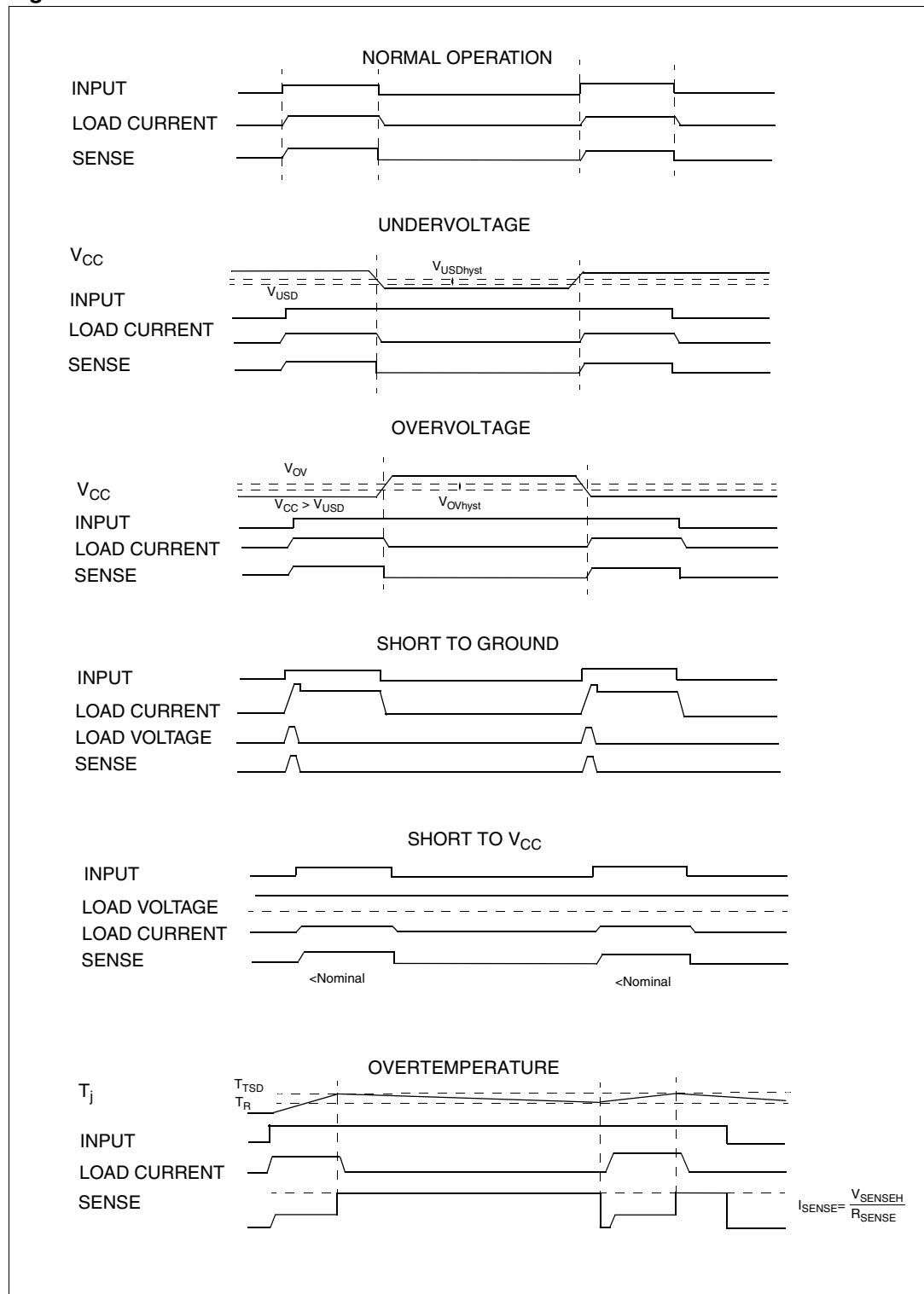


Figure 6. Waveforms



2.4 Electrical characteristics curves

Figure 7. Off-state output current

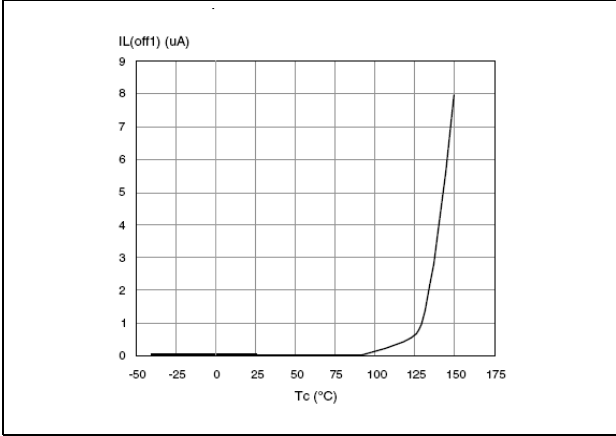


Figure 8. High-level input current

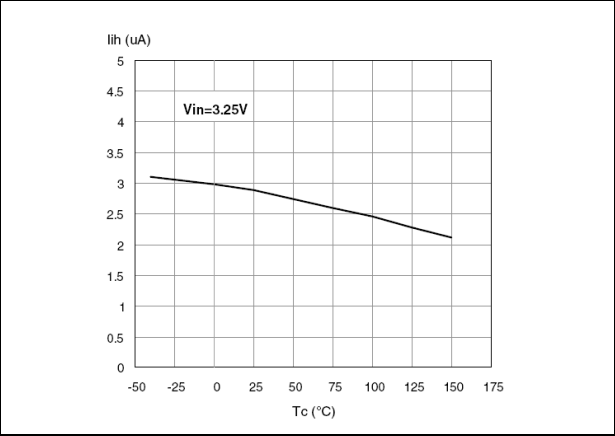


Figure 9. Input clamp voltage

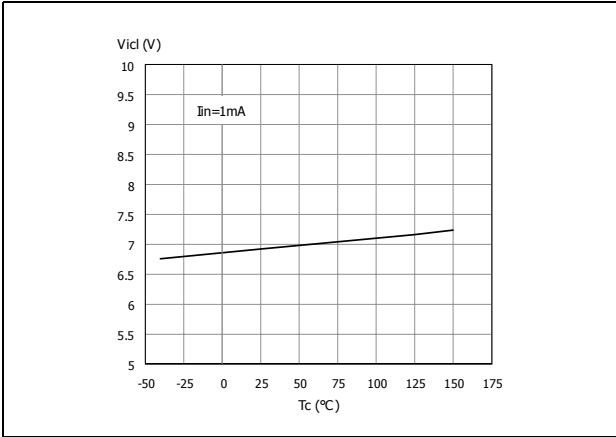


Figure 10. Turn-on voltage slope

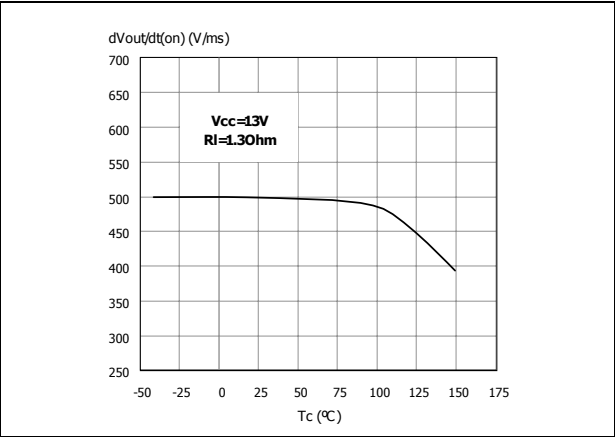


Figure 11. Over-voltage shutdown

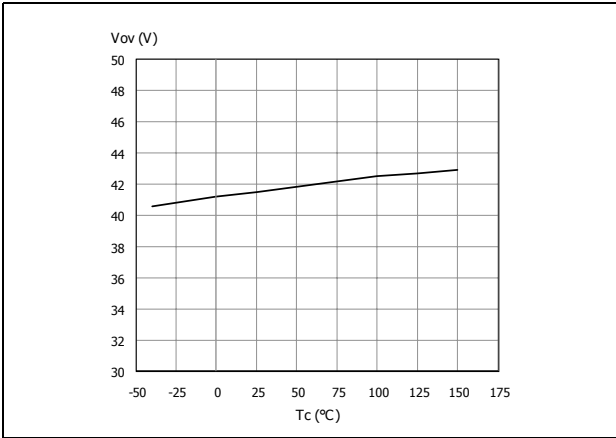


Figure 12. Turn-off voltage slope

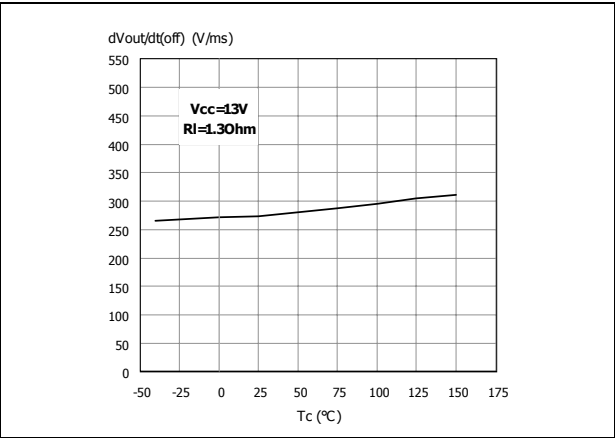


Figure 13.  $I_{LIM}$  vs  $T_{case}$

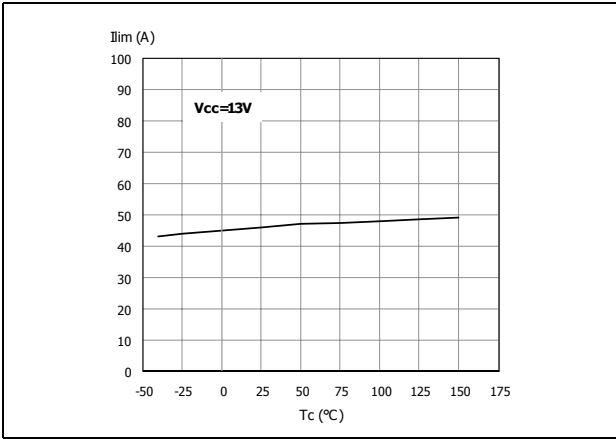


Figure 14. On-state resistance vs  $V_{CC}$

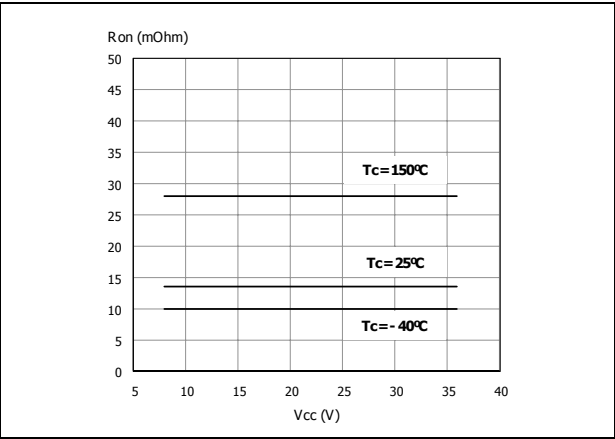


Figure 15. Input high-level

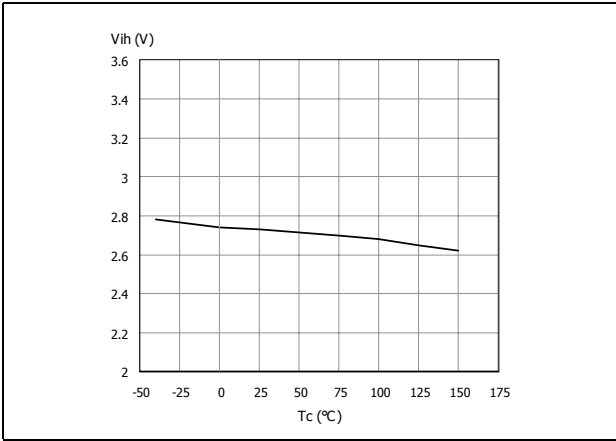


Figure 16. Input hysteresis voltage

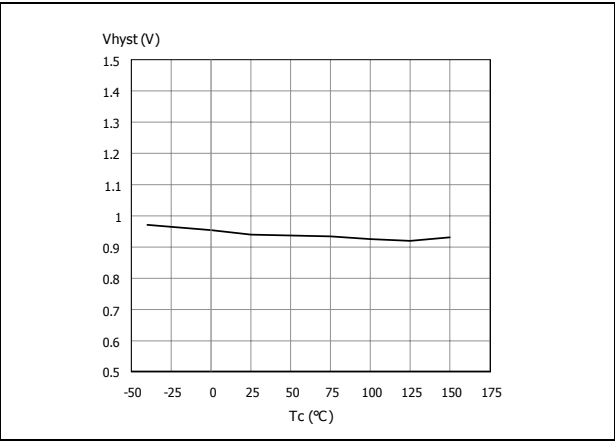


Figure 17. On-state resistance vs  $T_{case}$

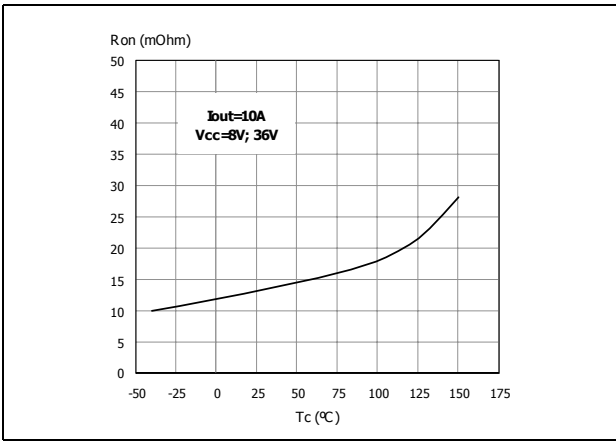
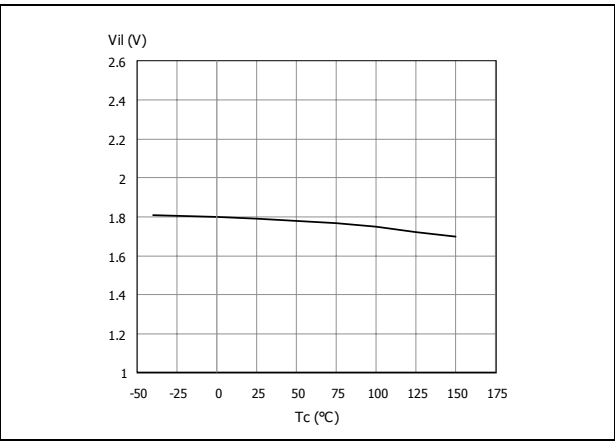
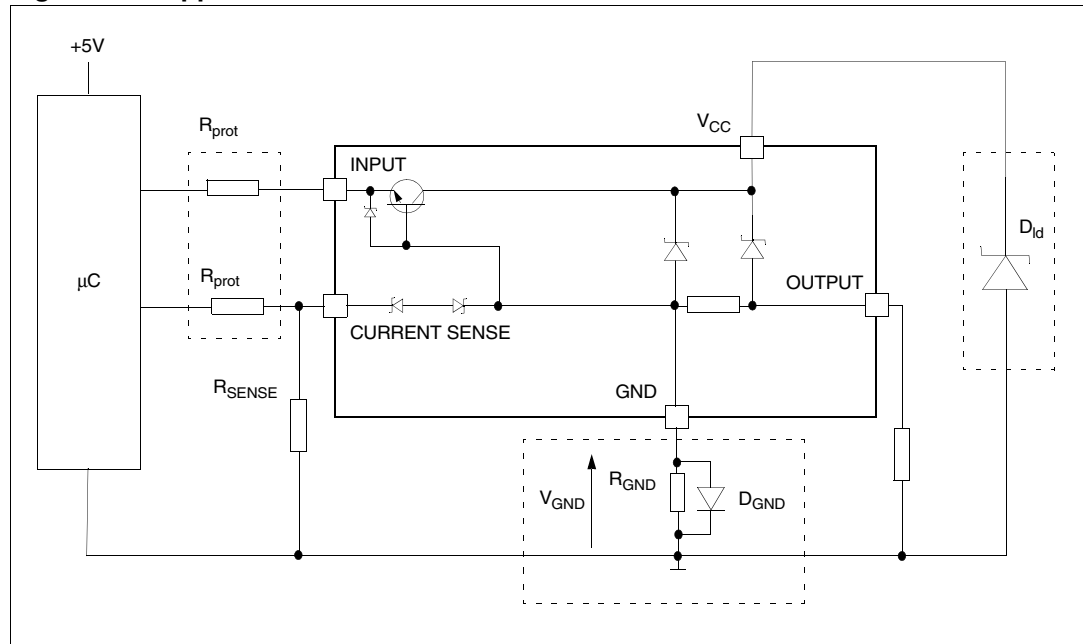


Figure 18. Input low level



### 3 Application information

**Figure 19. 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.  $R_{GND} \leq 600mV / (I_{S(on)max})$ .
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  $R_{GND}$  (when  $V_{CC} < 0$ : during reverse battery situations) is:

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

This resistor can be shared amongst several different 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  $R_{GND}$  will produce a shift ( $I_{S(on)max} * R_{GND}$ ) in the input thresholds and the status output values. This shift will vary depending on how 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 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 will produce a shift ( $\approx 600mV$ ) in the input threshold and in the status output values if the microprocessor ground is not common to the device ground. This shift will not vary 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 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 transient are present on the  $V_{CC}$  line, the control pins will be pulled negative. ST suggests to insert a resistor ( $R_{prot}$ ) in line to prevent the  $\mu C$  I/Os pins to latch-up.

The value of these resistors is a compromise between the leakage current of  $\mu C$  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:

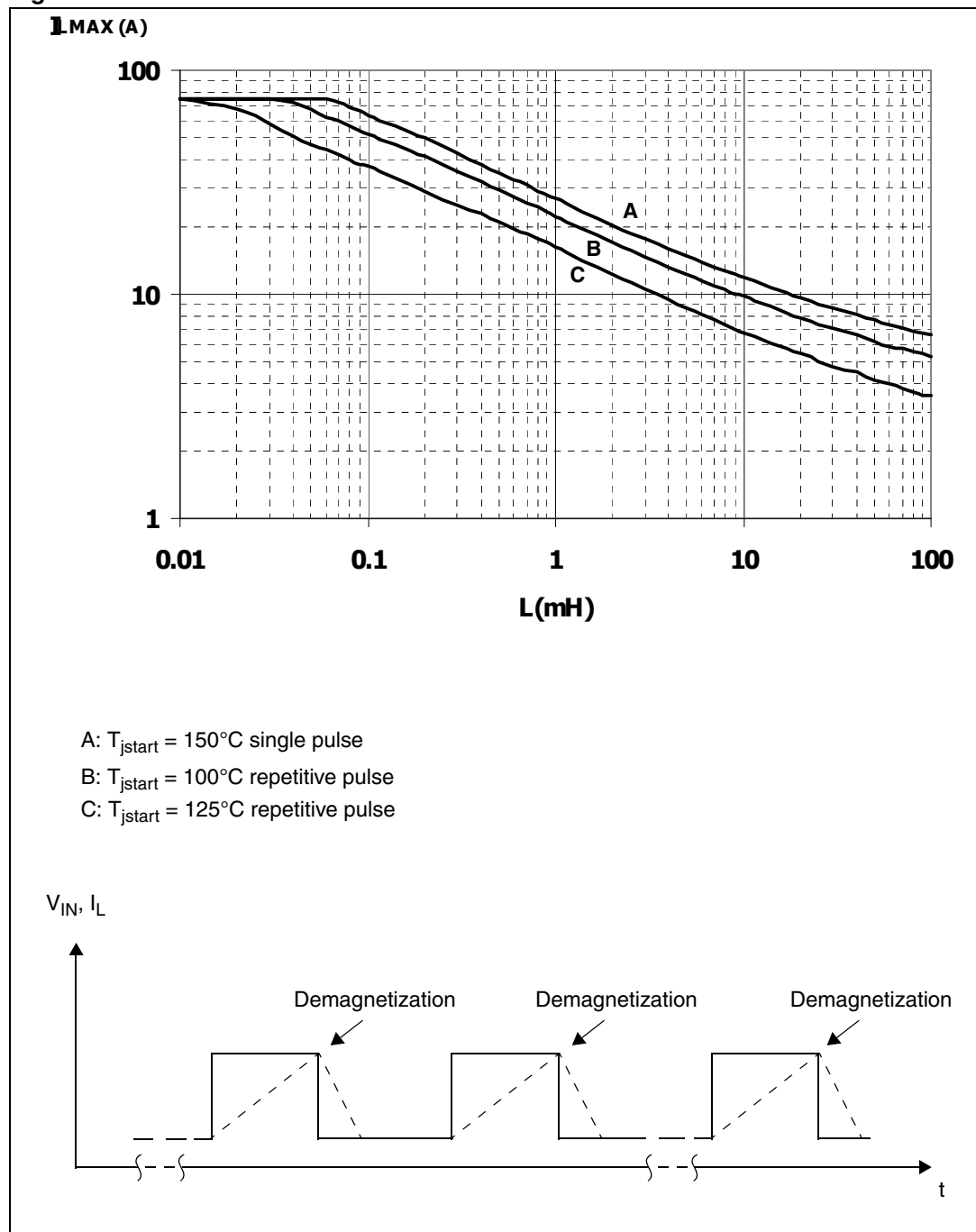
For  $V_{CCpeak} = -100V$  and  $I_{latchup} \geq 20mA$ ;  $V_{OH\mu C} \geq 4.5V$

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

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

### 3.4 P<sup>2</sup>PAK maximum demagnetization energy ( $V_{CC} = 13.5V$ )

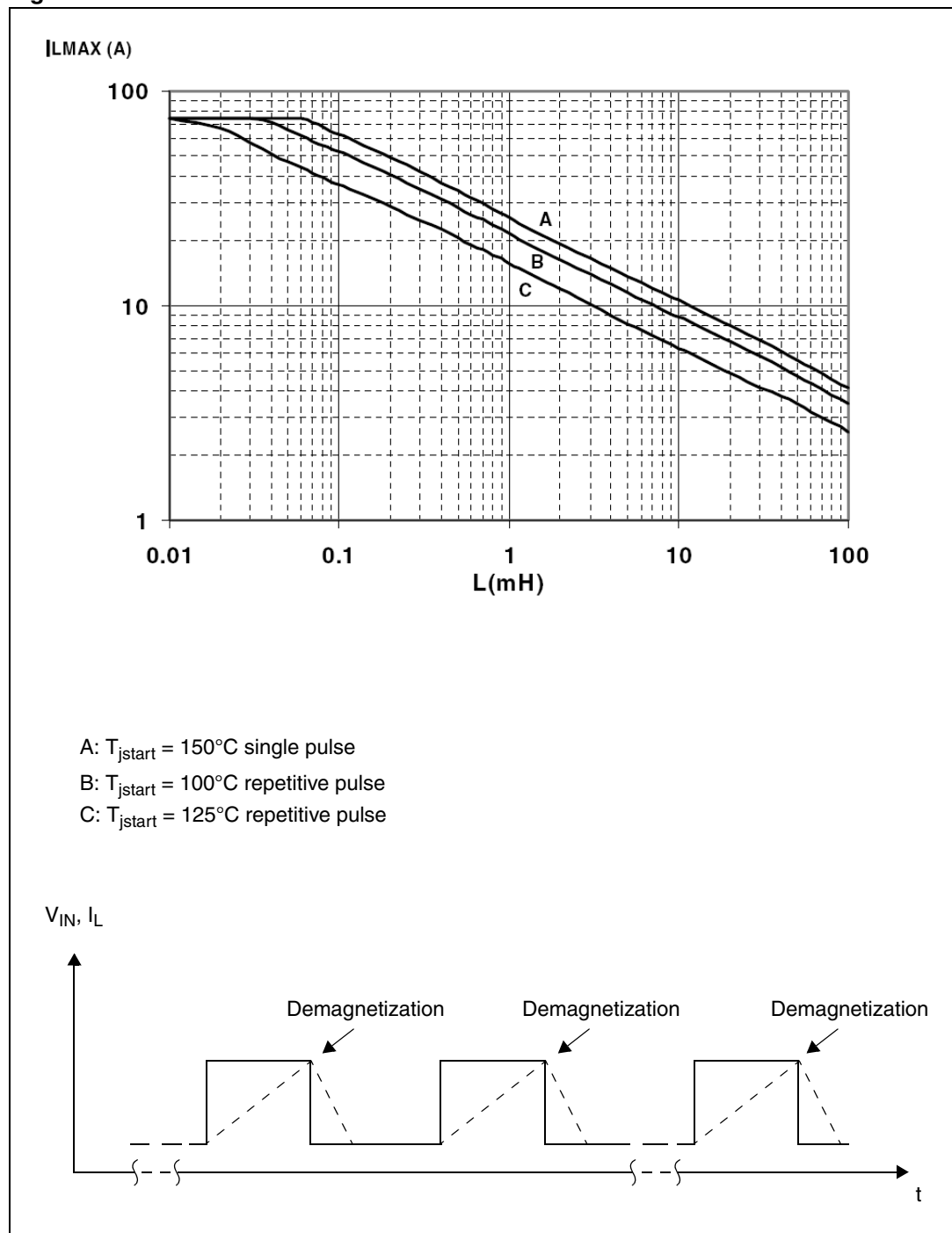
Figure 20. P<sup>2</sup>PAK maximum turn-off current versus inductance



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.

### 3.5 SO-16L maximum demagnetization energy ( $V_{CC} = 13.5V$ )

Figure 21. SO-16L maximum turn-off current versus inductance

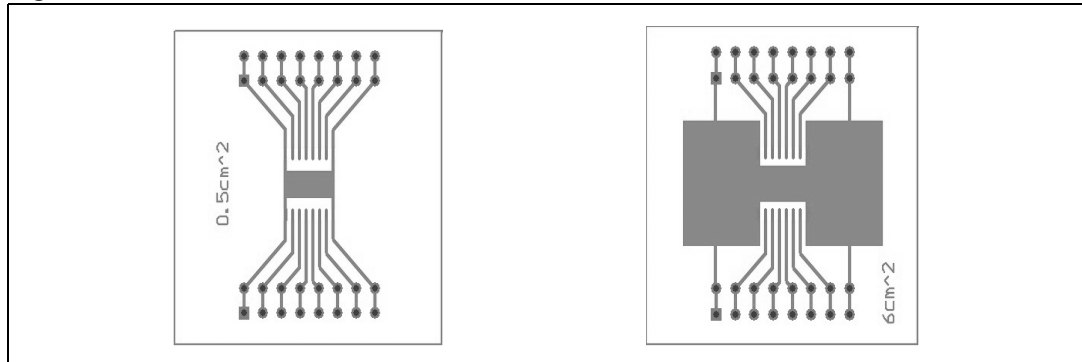


Note: Values are generated with  $R_L = 0 \Omega$ . In case of repetitive pulses,  $T_{jstart}$  (at beginning of each demagnetization) of every pulse must not exceed the temperature specified above for curves A and B.

## 4 Package and PCB thermal data

### 4.1 SO-16L thermal data

Figure 22. SO-16L PC board



Note: Layout condition of  $R_{th}$  and  $Z_{th}$  measurements (PCB FR4 area = 41mm x 48mm, PCB thickness = 2mm, Cu thickness = 35 $\mu$ m, Copper areas: 0.5cm<sup>2</sup>, 6cm<sup>2</sup>).

Figure 23. SO-16L  $R_{thj-amb}$  Vs PCB copper area in open box free air condition

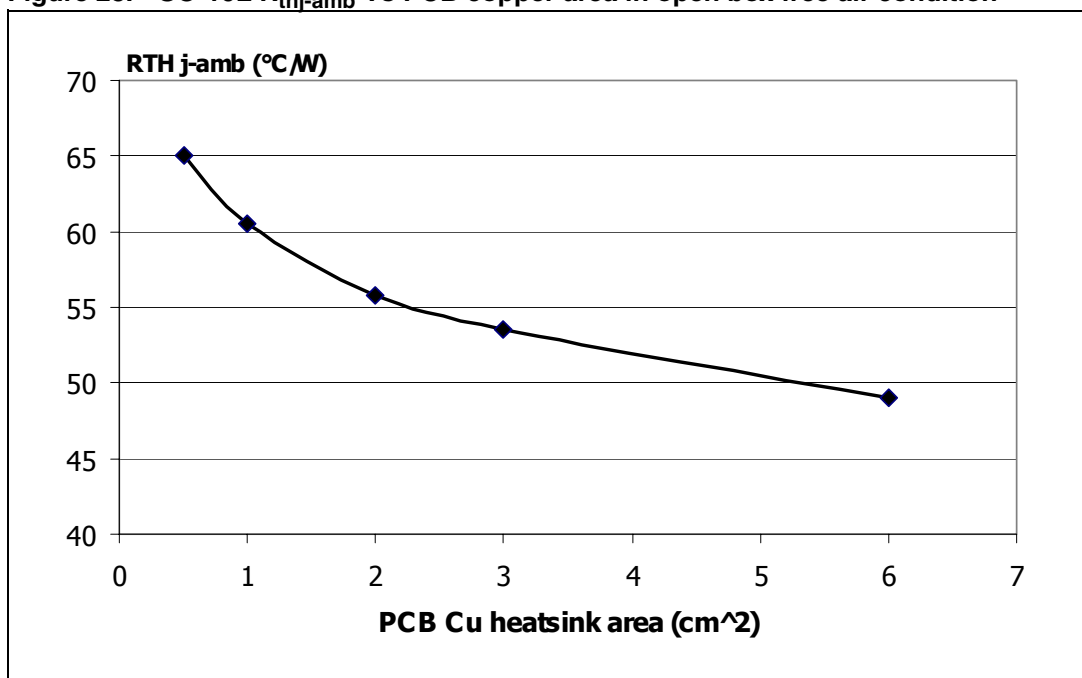
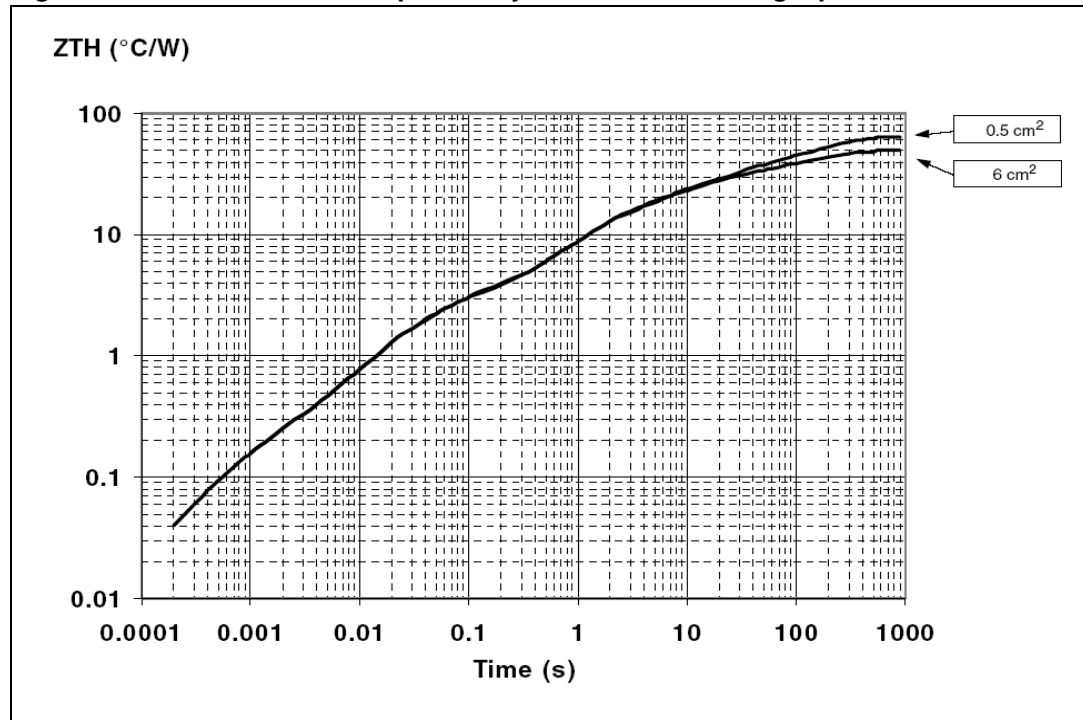


Figure 24. SO-16L thermal impedance junction ambient single pulse



Equation 1: pulse calculation formula

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

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

Figure 25. Thermal fitting model of a single channel HSD in SO-16L

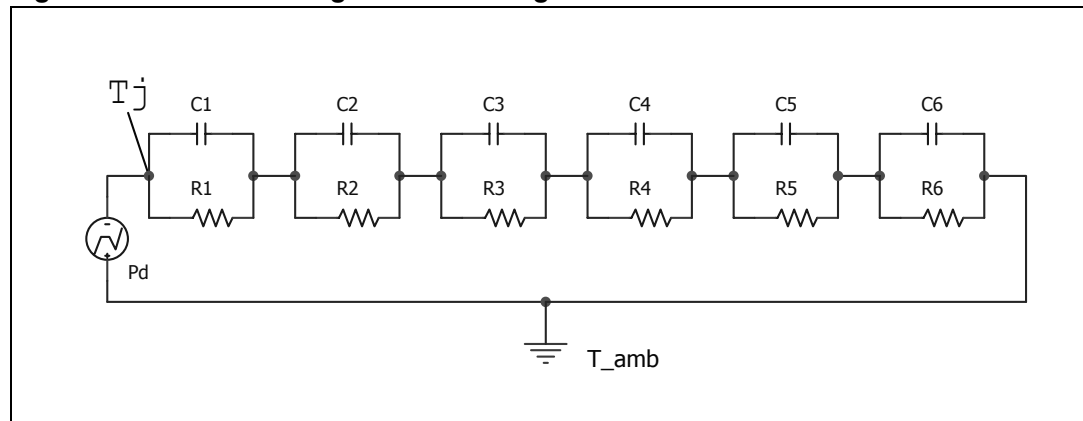
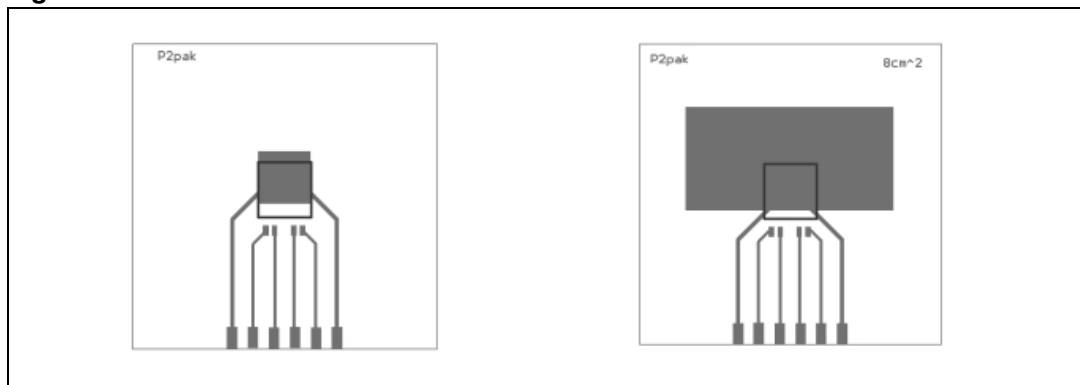


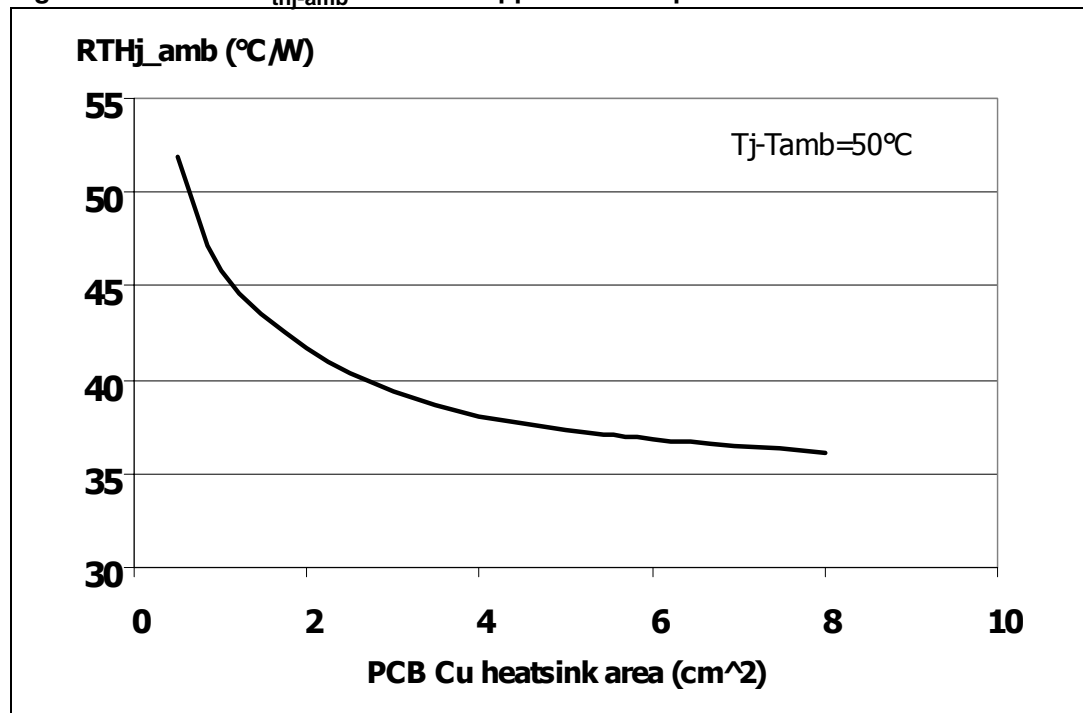
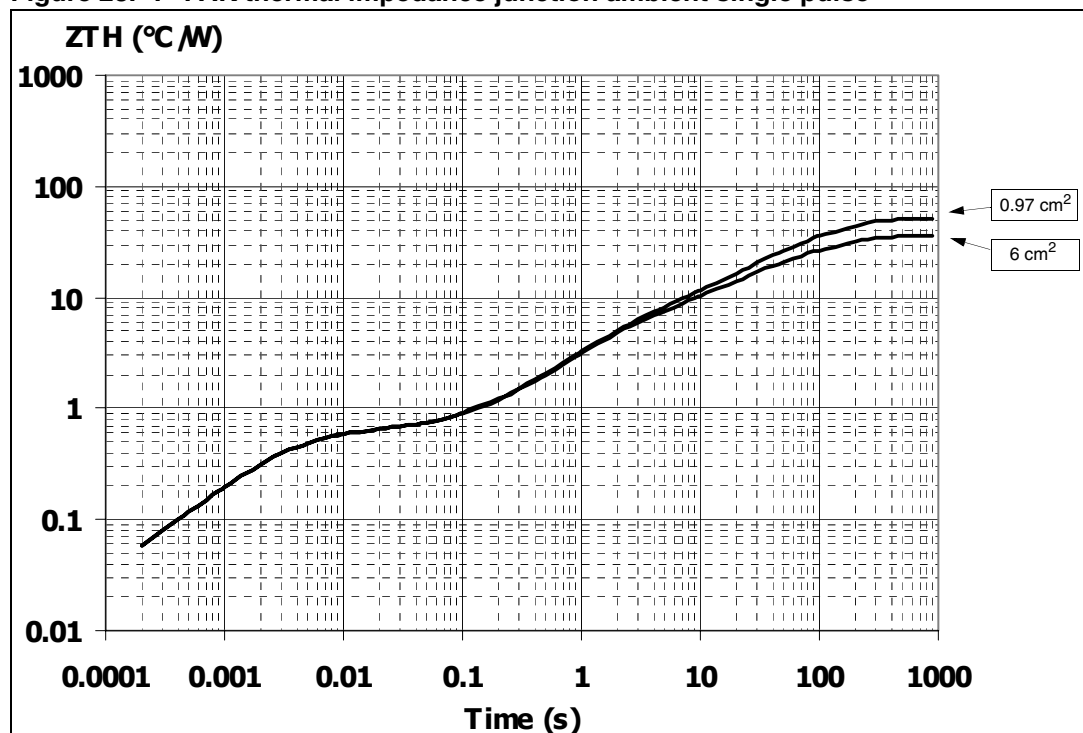
Table 13. SO-16L thermal parameters

| Area / island (cm <sup>2</sup> ) | Footprint | 6  |
|----------------------------------|-----------|----|
| R1 (°C/W)                        | 0.02      |    |
| R2 (°C/W)                        | 0.1       |    |
| R3 (°C/W)                        | 2.2       |    |
| R4 (°C/W)                        | 12        |    |
| R5 (°C/W)                        | 15        |    |
| R6 (°C/W)                        | 35        | 20 |
| C1 (W.s/°C)                      | 0.0015    |    |
| C2 (W.s/°C)                      | 7E-03     |    |
| C3 (W.s/°C)                      | 1.5E-02   |    |
| C4 (W.s/°C)                      | 0.14      |    |
| C5 (W.s/°C)                      | 1         |    |
| C6 (W.s/°C)                      | 5         | 8  |

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

Figure 26. P<sup>2</sup>PAK PC board

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

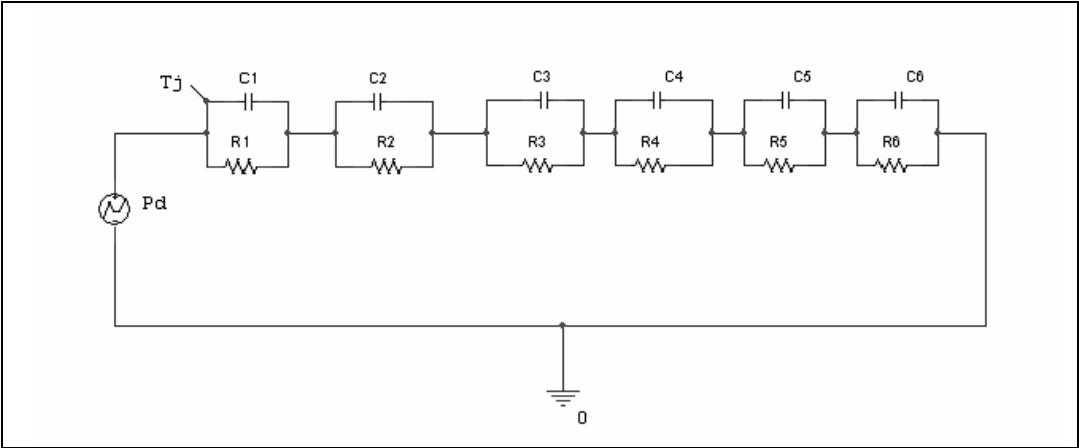
Figure 27. P<sup>2</sup>PAK  $R_{thj-amb}$  Vs. PCB copper area in open box free air conditionFigure 28. P<sup>2</sup>PAK thermal impedance junction ambient single pulse

**Equation 2: pulse calculation formula**

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

where  $\delta = t_p/T$

**Figure 29. Thermal fitting model of a single channel HSD in P<sup>2</sup>PAK**



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

| Area/island (cm <sup>2</sup> ) | 0.97   | 6  |
|--------------------------------|--------|----|
| R1 (°C/W)                      | 0.02   |    |
| R2 (°C/W)                      | 0.1    |    |
| R3 (°C/W)                      | 0.22   |    |
| R4 (°C/W)                      | 4      |    |
| R5 (°C/W)                      | 9      |    |
| R6 (°C/W)                      | 37     | 22 |
| C1 (W·s/°C)                    | 0.0015 |    |
| 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  |

## 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.

Figure 30. SO-16L package dimensions

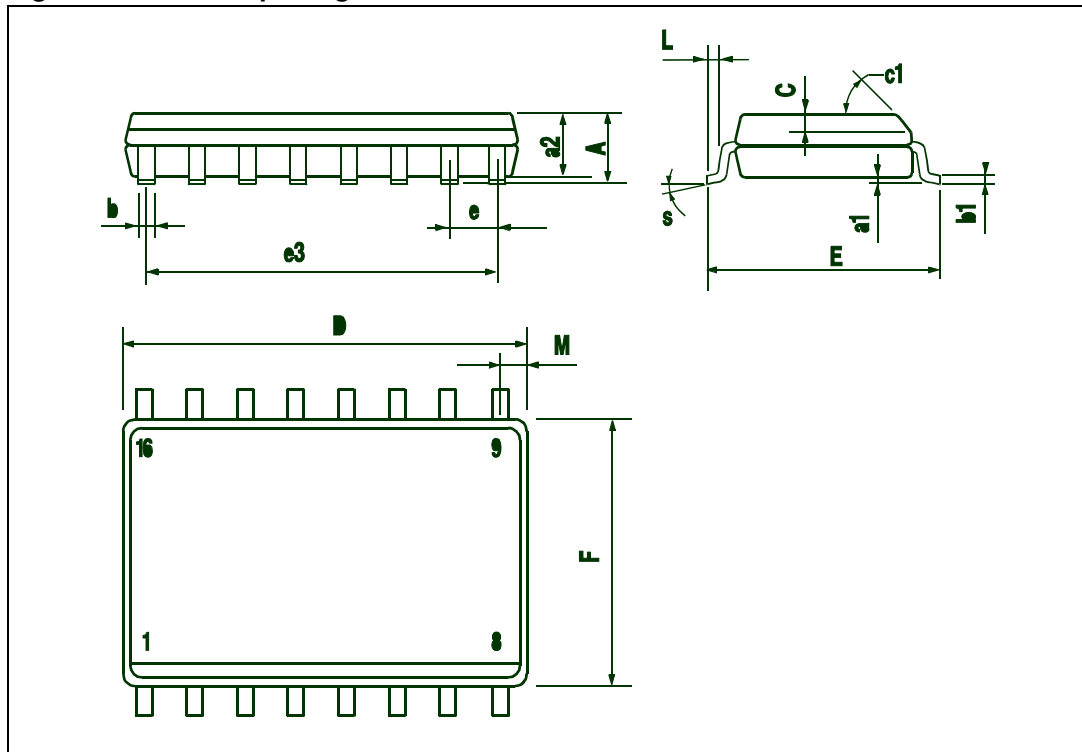


Table 15. SO-16L mechanical data

| DIM. | mm.        |      |      |
|------|------------|------|------|
|      | Min.       | Typ. | Max. |
| A    |            |      | 2.65 |
| a1   | 0.1        |      | 0.2  |
| a2   |            |      | 2.45 |
| b    | 0.35       |      | 0.49 |
| b1   | 0.23       |      | 0.32 |
| C    |            | 0.5  |      |
| c1   | 45° (typ.) |      |      |

**Table 15. SO-16L mechanical data (continued)**

| DIM. | mm.       |      |       |
|------|-----------|------|-------|
|      | Min.      | Typ. | Max.  |
| D    | 10.1      |      | 10.5  |
| E    | 10.0      |      | 10.65 |
| e    |           | 1.27 |       |
| e3   |           | 8.89 |       |
| F    | 7.4       |      | 7.6   |
| L    | 0.5       |      | 1.27  |
| M    |           |      | 0.75  |
| S    | 8° (max.) |      |       |

## 5.2 PENTAWATT mechanical data

**Figure 31. PENTAWATT package dimensions**

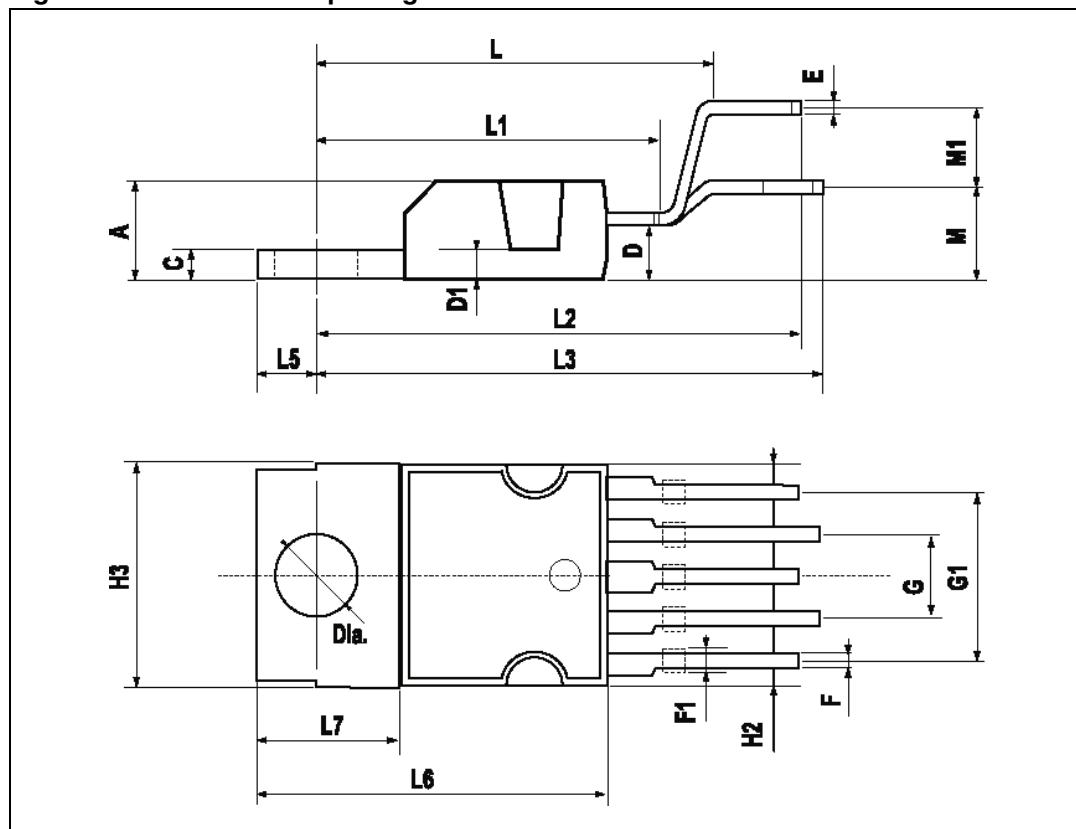


Table 16. PENTAWATT mechanical data

| 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 32. P<sup>2</sup>PAK package dimensions

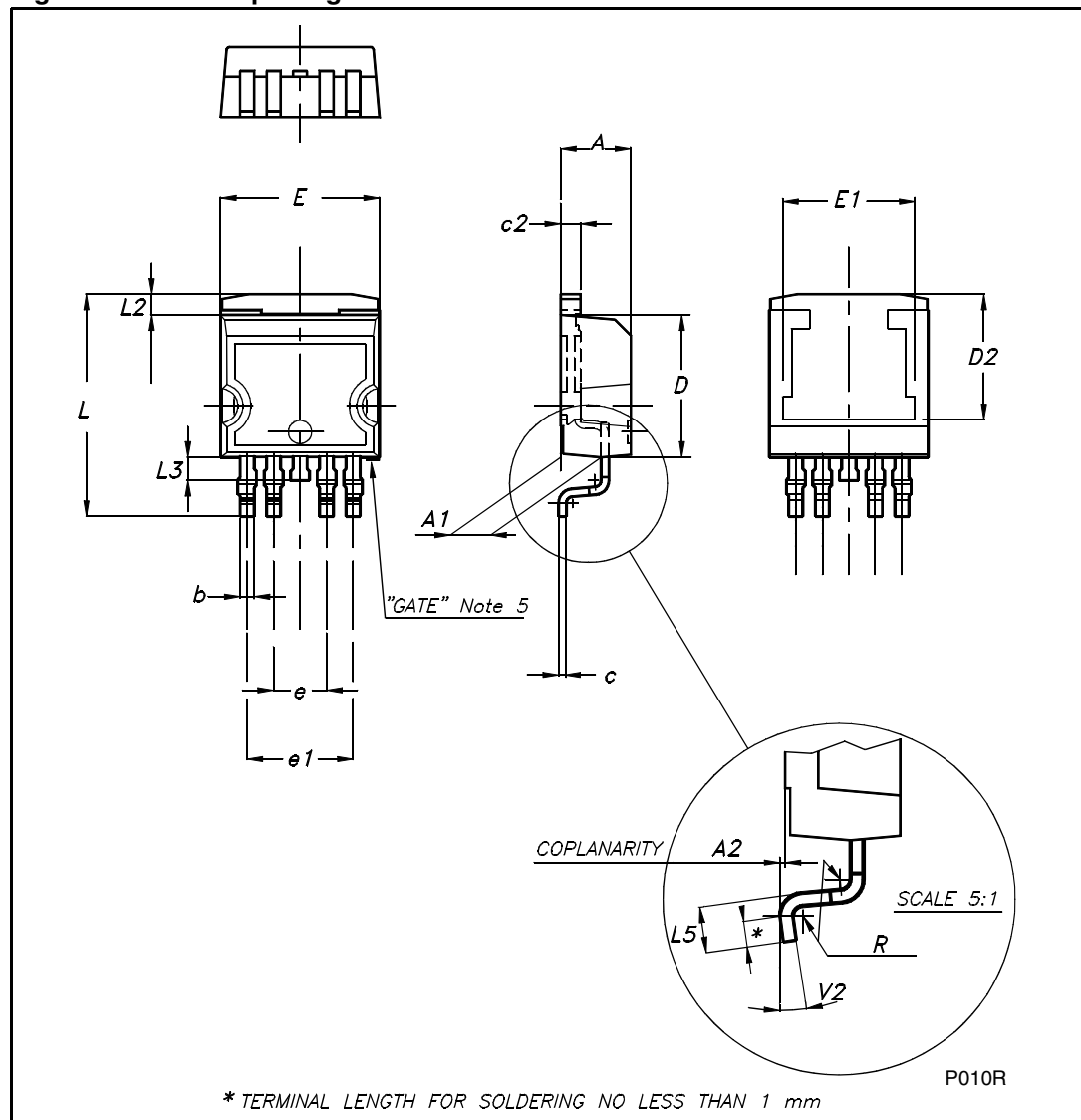


Table 17. P<sup>2</sup>PAK mechanical data

| 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 SO-16L packing information

Figure 33. SO-16L tube shipment (no suffix)

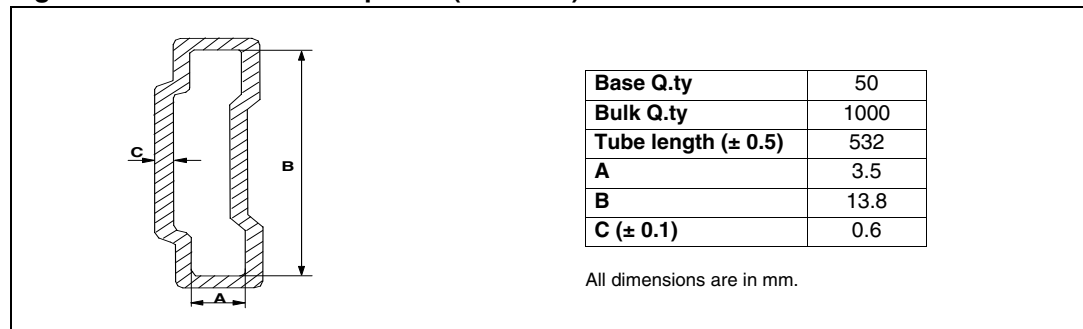
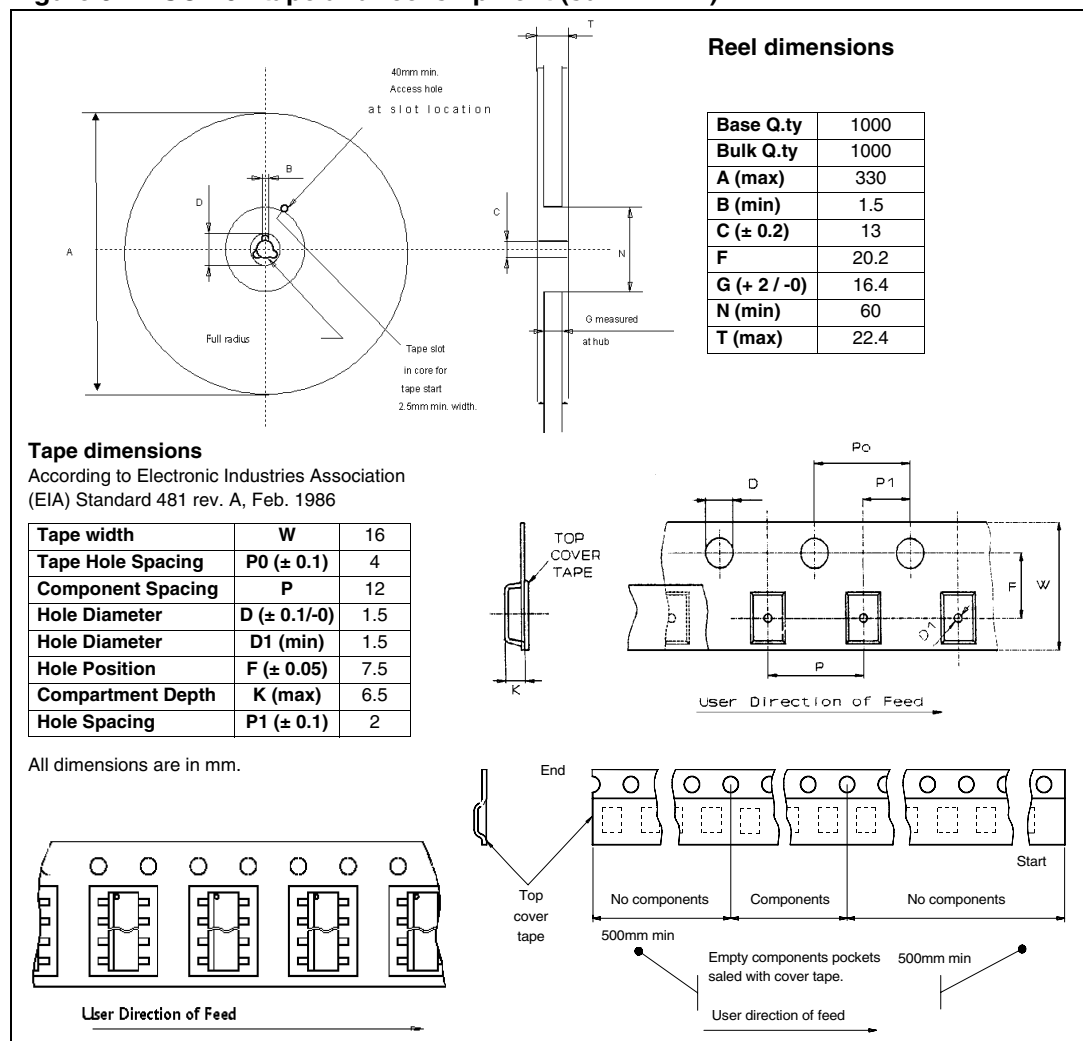
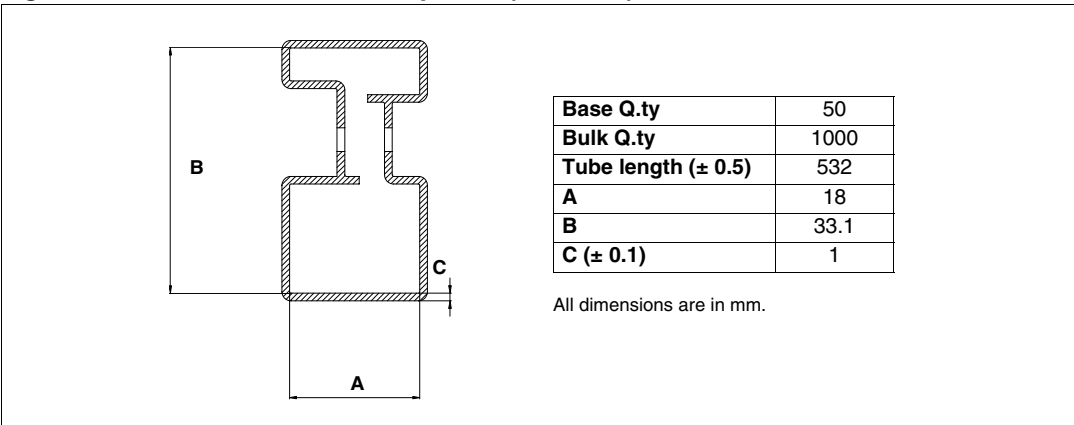


Figure 34. SO-16L tape and reel shipment (suffix "TR")



5.5 PENTAWATT packing information

Figure 35. PENTAWATT tube shipment (no suffix)



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

Figure 36. P<sup>2</sup>PAK tube shipment (no suffix)

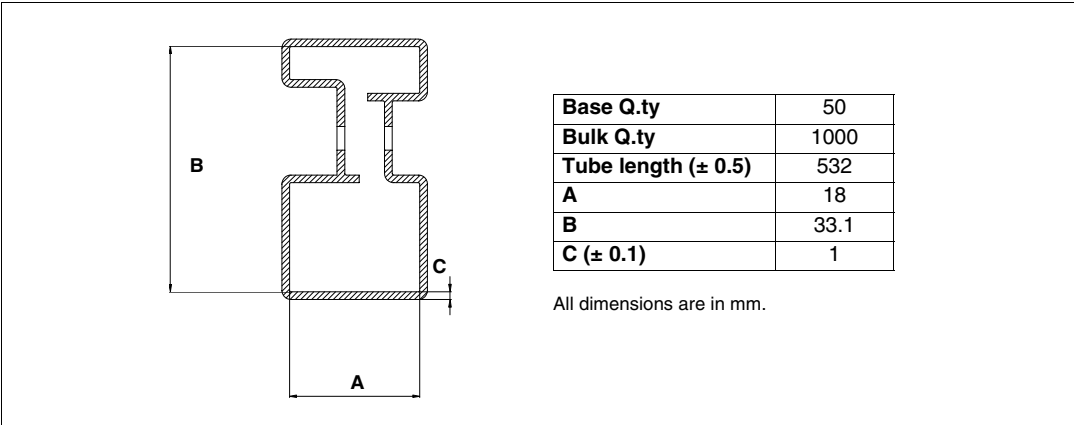
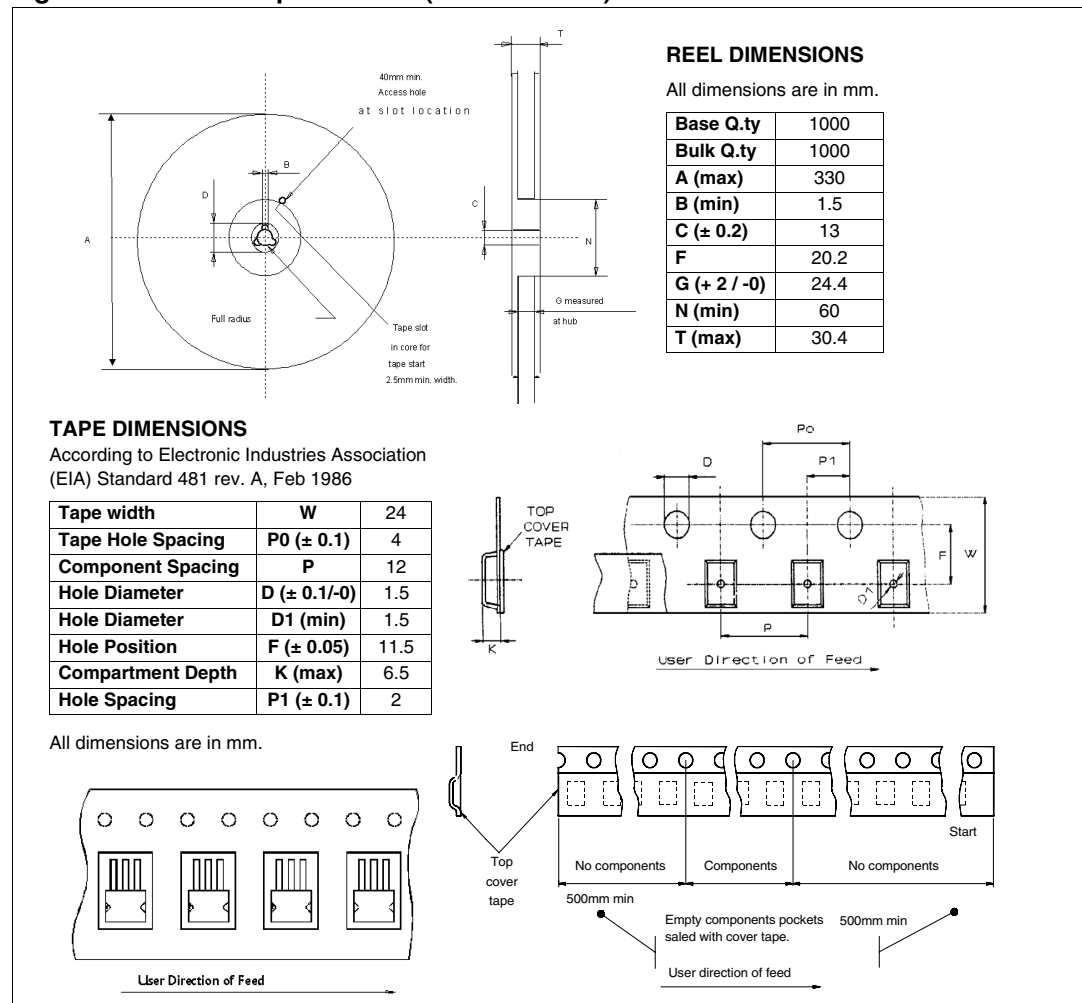


Figure 37. P<sup>2</sup>PAK tape and reel (suffix “13TR”)

## 6 Revision history

**Table 18. Document revision history**

| Date        | Revision | Changes                                                                                                                                                                                                                                                                                        |
|-------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 22-Jun-2004 | 1        | Initial release.                                                                                                                                                                                                                                                                               |
| 07-Jul-2004 | 2        | Current and voltage convention update (page 2).<br>Configuration diagram (top view) & suggested connections for unused and n.c. pins insertion (page 2).<br>6cm2 Cu condition insertion in thermal data table (page 3).                                                                        |
| 09-Jul-2004 | 3        | V <sub>CC</sub> - output diode section update (page 5).<br>Protections note insertion (page 5).<br>Revision history table insertion (page 24).<br>Disclaimers update (page 25).                                                                                                                |
| 03-May-2006 | 4        | Suggested connections for unused and n.c.pins? correction (page 2).                                                                                                                                                                                                                            |
| 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 37.: P<sup>2</sup>PAK tape and reel (suffix "13TR")</i> : changed component spacing (P) in tape dimensions table from 16 mm to 12 mm. |
| 24-Sep-2013 | 6        | Updated Disclaimer.                                                                                                                                                                                                                                                                            |

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