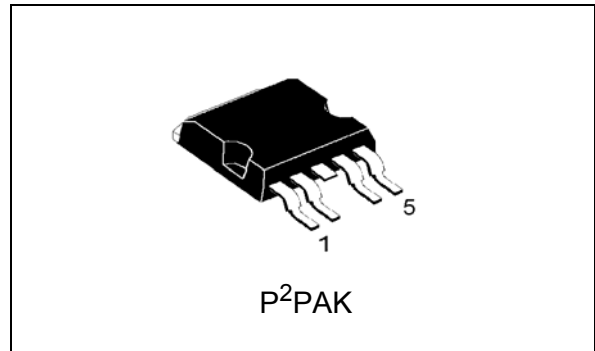


### Features

Type	$R_{DS(on)}$	$I_{OUT}$	$V_{CC}$
VN920DB5-E	18 m $\Omega$	30 A	36 V

- ECOPACK<sup>®</sup>: 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 VN920DB5-E is a monolithic device designed using STMicroelectronics<sup>™</sup> VIPower<sup>™</sup> M0-3 technology. The VN920DB5-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 (see ISO7637 transient compatibility table).

Active current limitation combined with thermal shutdown and automatic restart protects the device against overload. The device detects the open-load condition in both the on-state and off-state. In the off-state the device detects if the output is shorted to  $V_{CC}$ . 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
P <sup>2</sup> PAK	VN920DB5-E	VN920DB5TR-E

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# 1 Block diagram and pin description

Figure 1. Block diagram

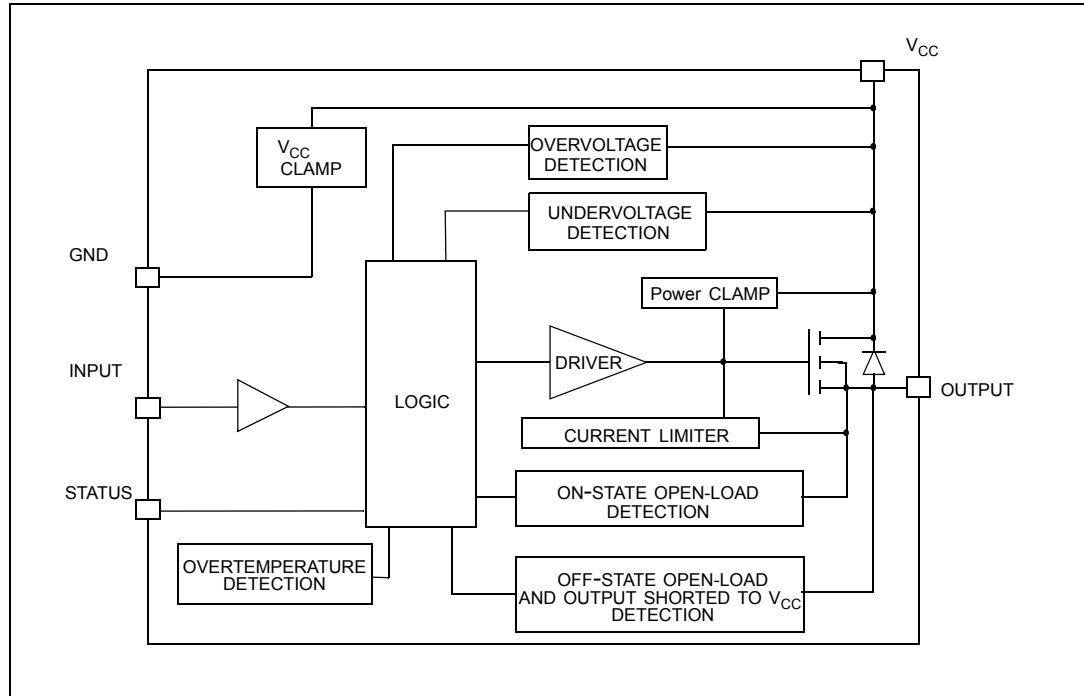


Figure 2. Configuration diagram (top view)

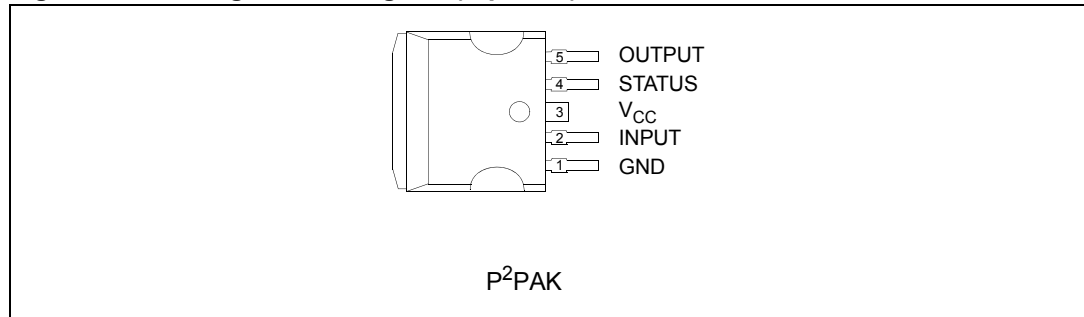
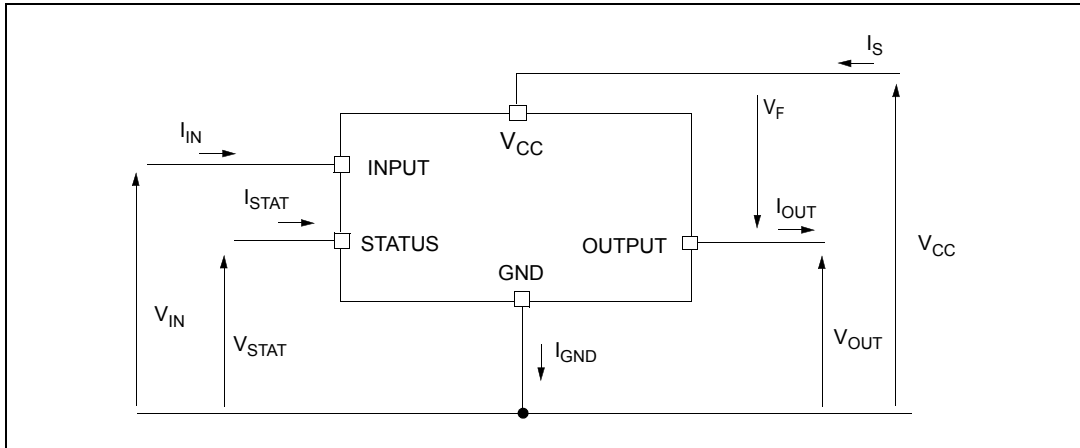


Table 2. Suggested connections for unused and not connected pins

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. Refer also to the STMicroelectronics sure program and other relevant quality document.

Table 3. Absolute maximum ratings

Symbol	Parameter	Value	Unit
$V_{CC}$	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	- 25	A
$I_{IN}$	DC input current	+/- 10	mA
$I_{STAT}$	DC Status current	+/- 10	mA
$V_{ESD}$	Electrostatic discharge (Human Body Model: $R = 1.5\text{ K}\Omega$ ; $C = 100\text{ pF}$ )		
	- INPUT	4000	V
	- STATUS	4000	V
	- OUTPUT	5000	V
	- $V_{CC}$	5000	V
$E_{MAX}$	Maximum switching energy ( $L = 0.25\text{ mH}$ ; $R_L = 0\ \Omega$ ; $V_{bat} = 13.5\text{ V}$ ; $T_{jstart} = 150\text{ }^\circ\text{C}$ ; $I_L = 45\text{ A}$ )	364	mJ

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

Symbol	Parameter	Value	Unit
$P_{tot}$	Power dissipation $T_C = 25\text{ °C}$	96.1	W
$T_j$	Junction operating temperature	Internally limited	°C
$T_c$	Case operating temperature	- 40 to 150	°C
$T_{stg}$	Storage temperature	- 55 to 150	°C

## 2.2 Thermal data

**Table 4. Thermal data**

Symbol	Parameter	Maximum value	Unit
$R_{thj-case}$	Thermal resistance junction-case	1.3	°C/W
$R_{thj-amb}$	Thermal resistance junction-ambient	51.3 <sup>(1)</sup>	°C/W

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

## 2.3 Electrical characteristics

Values specified in this section are for  $8\text{ V} < V_{CC} < 36\text{ V}$ ;  $-40\text{ °C} < T_j < 150\text{ °C}$ , 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	$I_{OUT} = 10\text{ A}$ ; $T_j = 25\text{ °C}$ ;			18	mΩ
		$I_{OUT} = 10\text{ A}$ ;			36	mΩ
		$I_{OUT} = 3\text{ A}$ ; $V_{CC} = 6\text{ V}$			50	mΩ
$I_S$	Supply current	Off-state; $V_{CC} = 13\text{ V}$ ; $V_{IN} = V_{OUT} = 0\text{ V}$		10	25	μA
		Off-state; $V_{CC} = 13\text{ V}$ ; $V_{IN} = V_{OUT} = 0\text{ V}$ ; $T_j = 25\text{ °C}$		10	20	μA
		On-state; $V_{CC} = 13\text{ V}$ ; $V_{IN} = 5\text{ V}$ ; $I_{OUT} = 0\text{ A}$			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	$V_{IN} = V_{OUT} = 0\text{ V}$ ; $V_{CC} = 13\text{ V}$ ; $T_j = 125\text{ °C}$			5	μA
$I_{L(off4)}$	Off-state output current	$V_{IN} = V_{OUT} = 0\text{ V}$ ; $V_{CC} = 13\text{ V}$ ; $T_j = 25\text{ °C}$			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	$R_L = 1.3\text{ Ω}$		50		μs
$t_{d(off)}$	Turn-off delay time	$R_L = 1.3\text{ Ω}$		50		μs
$dV_{OUT}/dt_{(on)}$	Turn-on voltage slope	$R_L = 1.3\text{ Ω}$	See <a href="#">Figure 20</a>			V/μs
$dV_{OUT}/dt_{(off)}$	Turn-off voltage slope	$R_L = 1.3\text{ Ω}$	See <a href="#">Figure 21</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	$I_{IN} = 1\text{ mA}$ $I_{IN} = -1\text{ mA}$	6	6.8 - 0.7	8	V V

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

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_F$	Forward on voltage	$-I_{OUT} = 5.5\text{ A}; T_j = 150\text{ }^\circ\text{C}$	-	-	0.7	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	$I_{STAT} = 1\text{ mA}$ $I_{STAT} = -1\text{ mA}$	6	6.8 - 0.7	8	V V

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

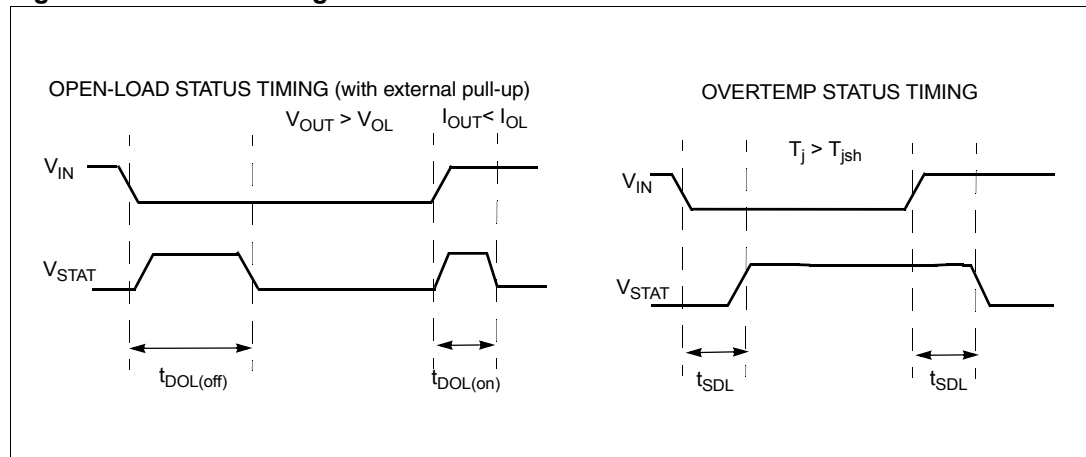
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$T_{TSD}$	Shutdown temperature		150	175	200	$^\circ\text{C}$
$T_R$	Reset temperature		135			$^\circ\text{C}$
$T_{hyst}$	Thermal hysteresis		7	15		$^\circ\text{C}$
$t_{SDL}$	Status delay in overload condition	$T_j > T_{jsh}$			20	ms
$I_{lim}$	Current limitation	$V_{CC} = 13\text{ V}$ $5.5\text{ V} < V_{CC} < 36\text{ V}$	30	45	75 75	A A
$V_{demag}$	Turn-off output clamp voltage	$I_{OUT} = 2\text{ A};$ $V_{IN} = 0\text{ V};$ $L = 6\text{ mH}$	$V_{CC} - 41$	$V_{CC} - 48$	$V_{CC} - 55$	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	$V_{IN} = 5\text{ V}$	300	500	700	mA
$t_{DOL(on)}$	Open-load on-state detection delay	$I_{OUT} = 0\text{ A}$			250	$\mu\text{s}$
$V_{OL}$	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**

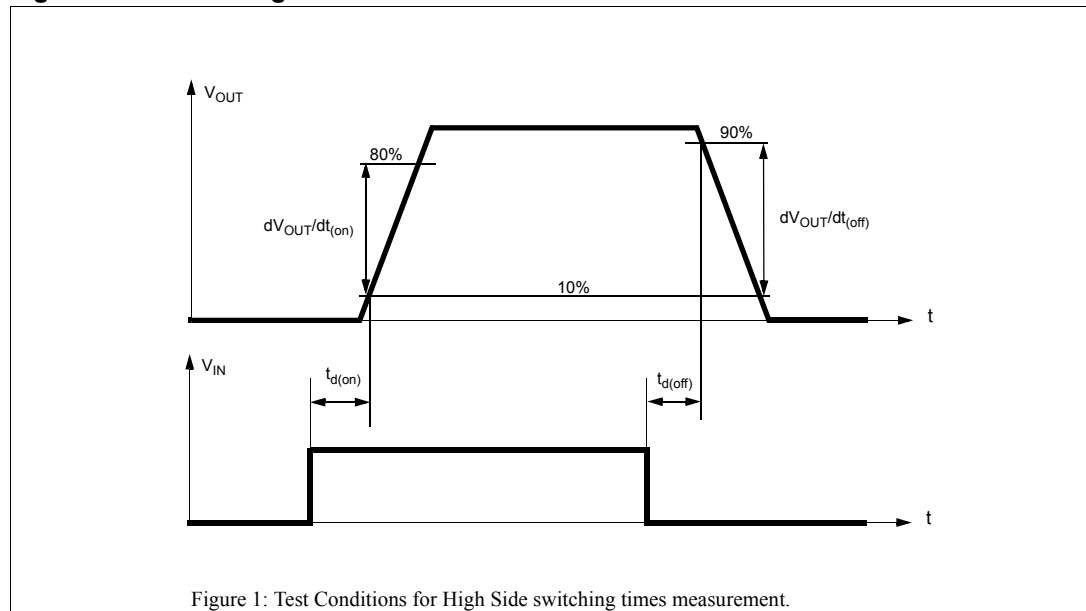


Table 12. Truth table

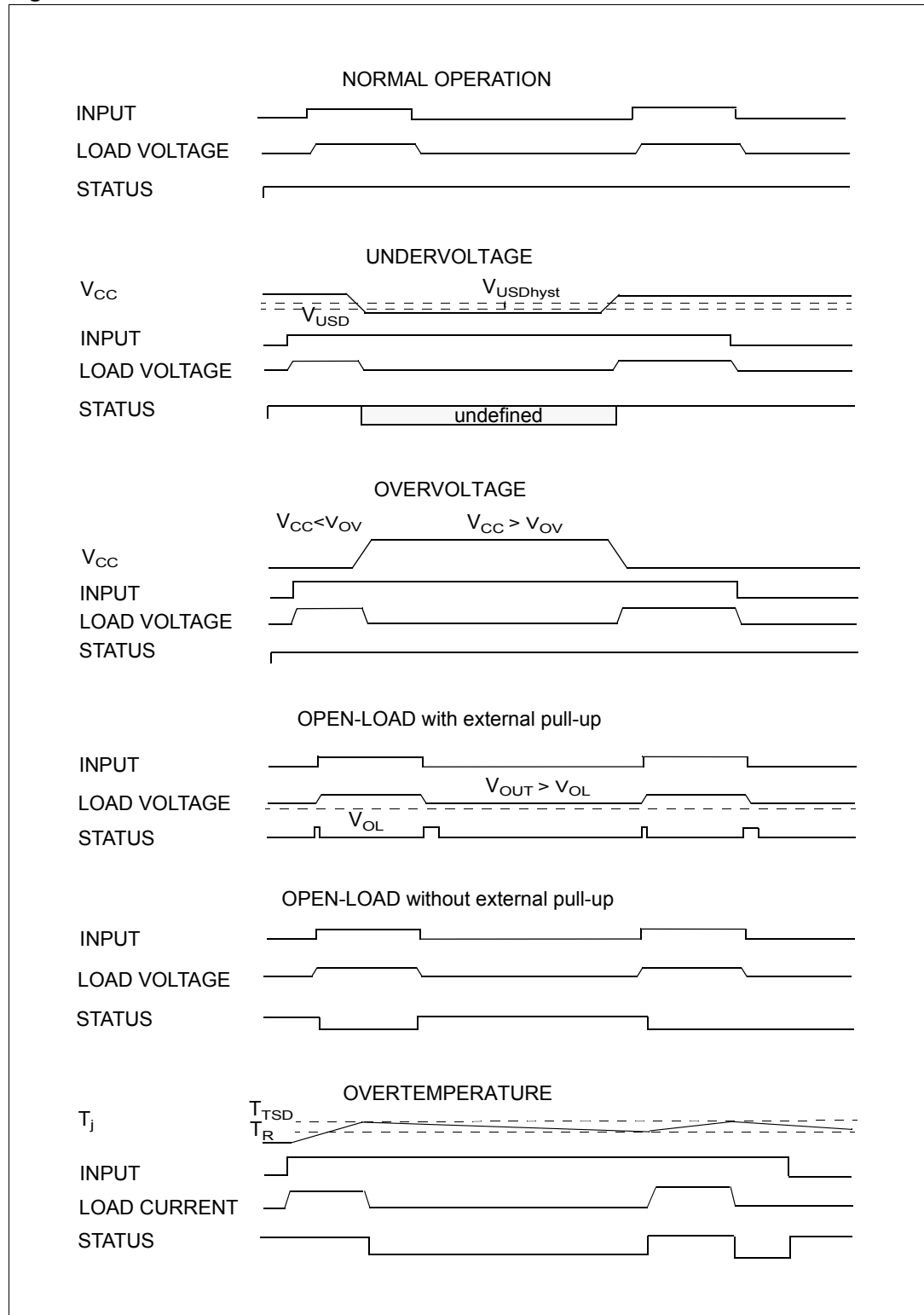
Conditions	Input	Output	Status
Normal operation	L	L	H
	H	H	H
Current limitation	L	L	H
	H	X	( $T_j < T_{TSD}$ ) H
	H	X	( $T_j > T_{TSD}$ ) L
Overtemperature	L	L	H
	H	L	L
Undervoltage	L	L	X
	H	L	X
Overvoltage	L	L	H
	H	L	H
Output voltage $> V_{OL}$	L	H	L
	H	H	H
Output current $< I_{OL}$	L	L	H
	H	H	L

Table 13. Electrical transient requirements

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

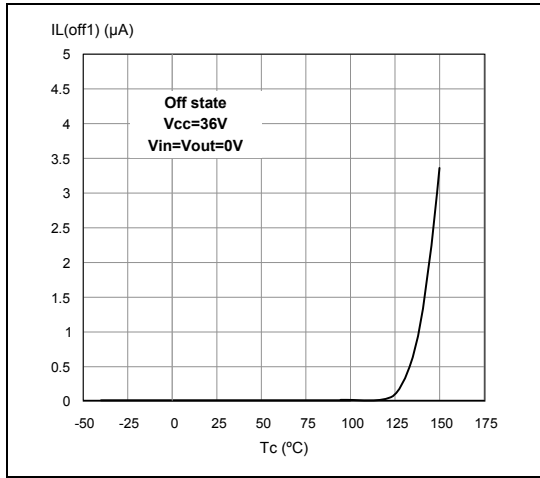
1. All functions of the device are performed as designed after exposure to disturbance.
2. One or more functions of the device is not performed as designed after exposure and cannot be returned to proper operation without replacing the device.

Figure 6. Waveforms

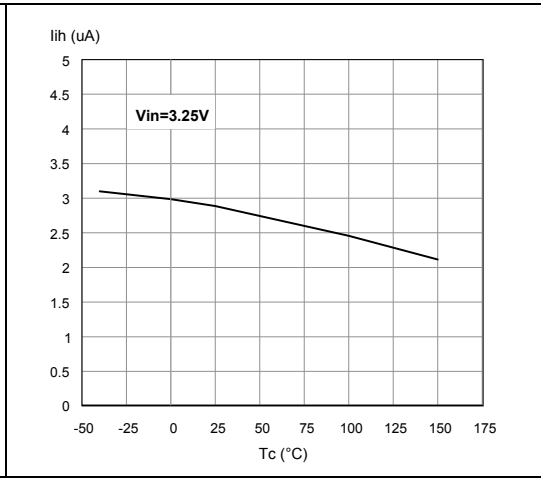


## 2.4 Electrical characteristics curves

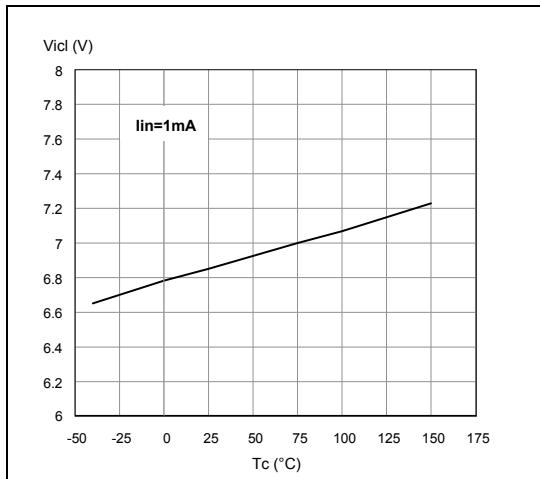
**Figure 7. Off-state output current**



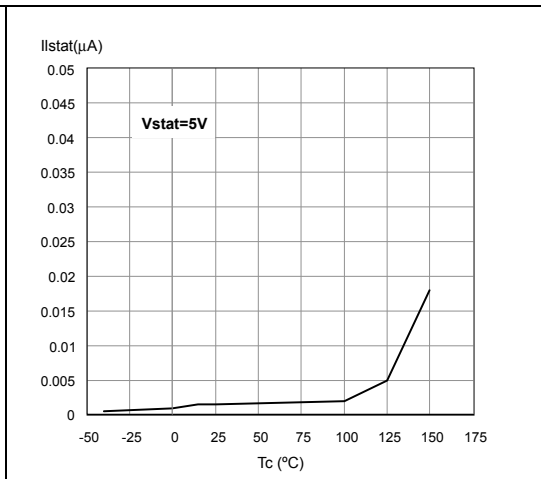
**Figure 8. High level input current**



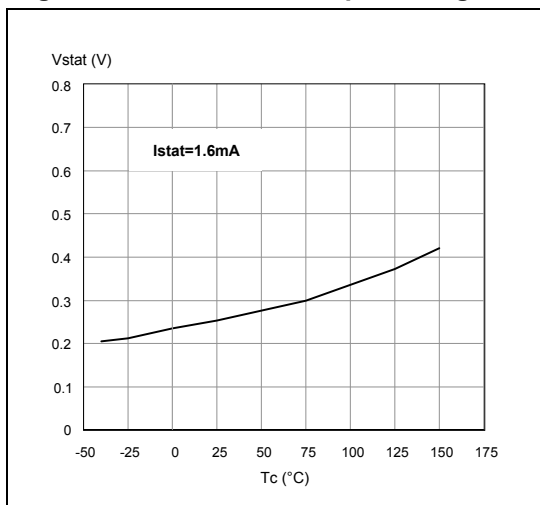
**Figure 9. Input clamp voltage**



**Figure 10. Status leakage current**



**Figure 11. Status low output voltage**



**Figure 12. Status clamp voltage**

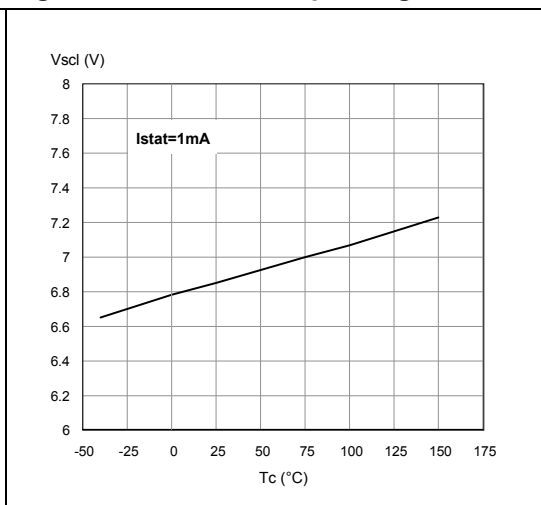


Figure 13. On-state resistance vs  $T_{case}$

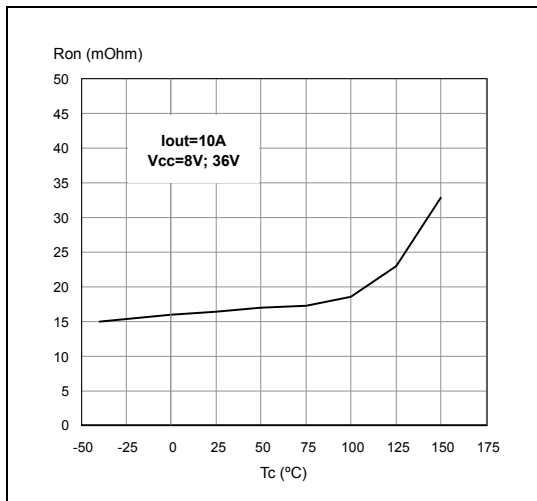


Figure 14. On-state resistance vs  $V_{CC}$

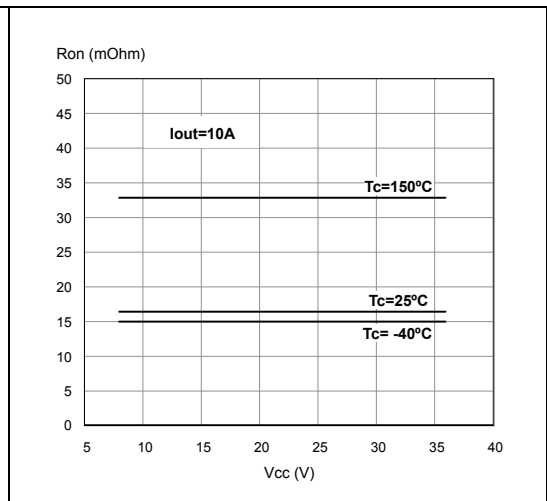


Figure 15. Overtolerance shutdown

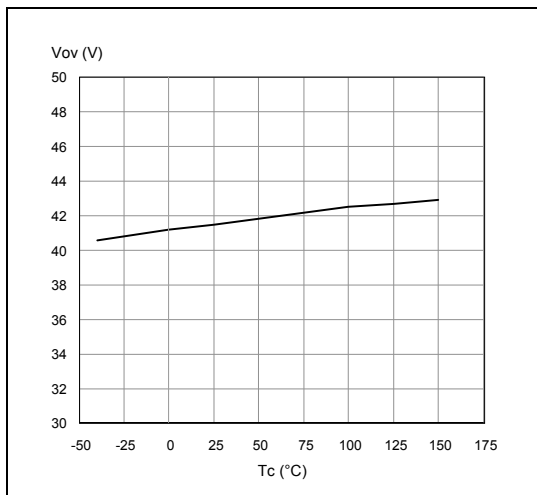


Figure 16. Input high level

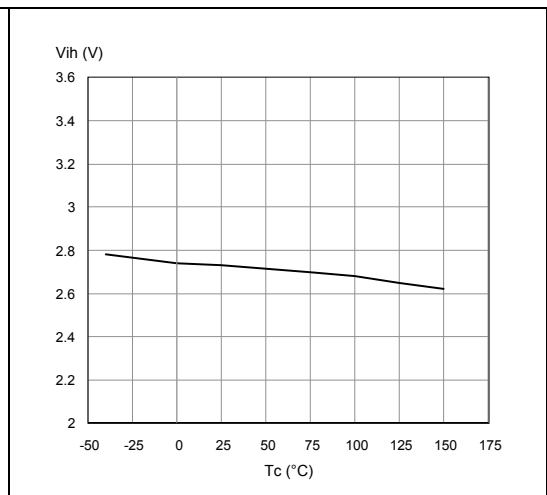


Figure 17. Input low level

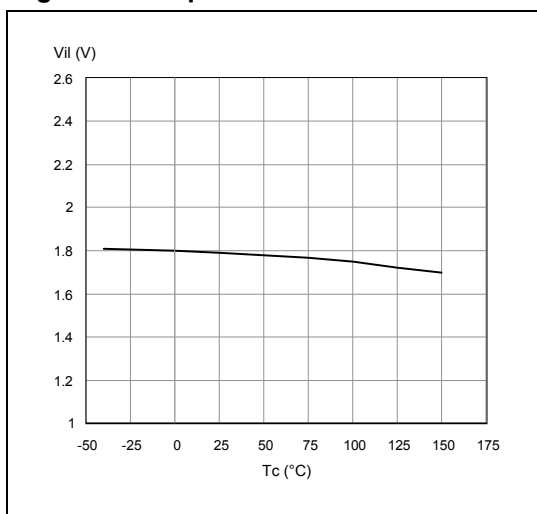


Figure 18. Input hysteresis voltage

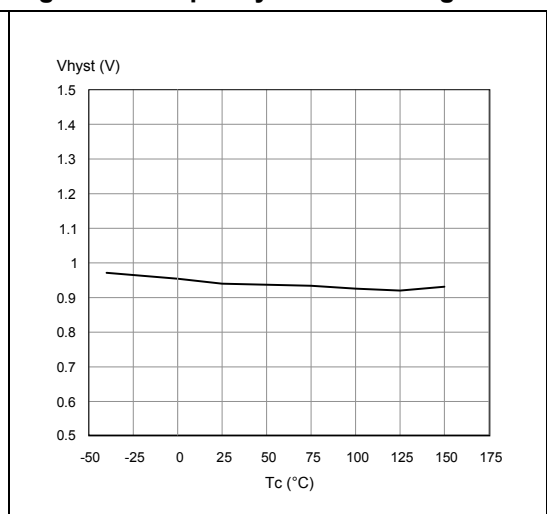


Figure 19.  $I_{lim}$  vs  $T_{case}$

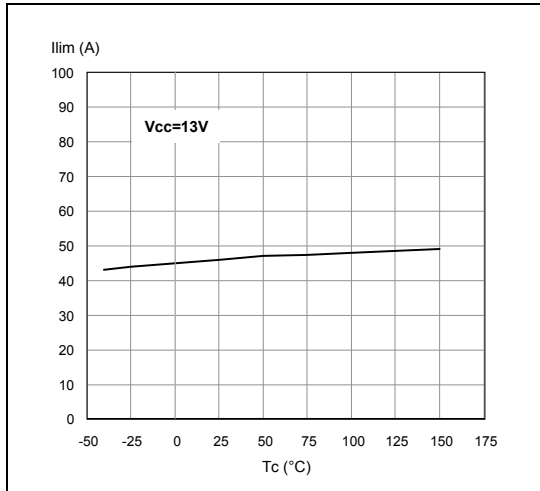


Figure 20. Turn-on voltage slope

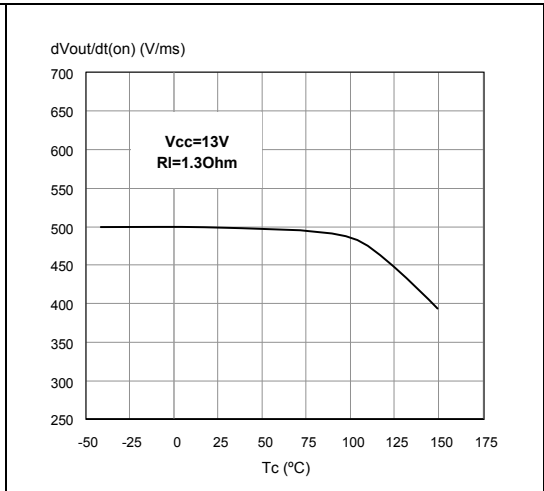
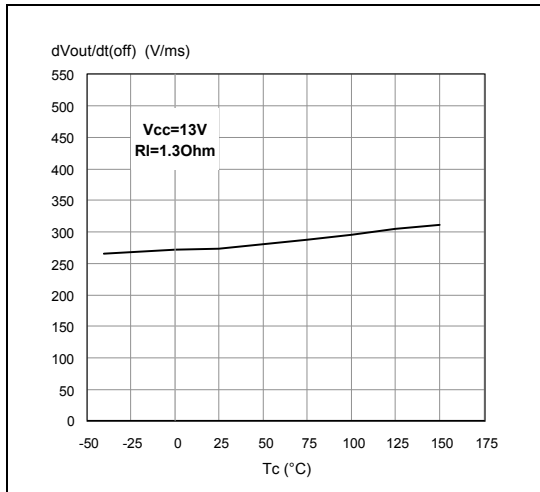
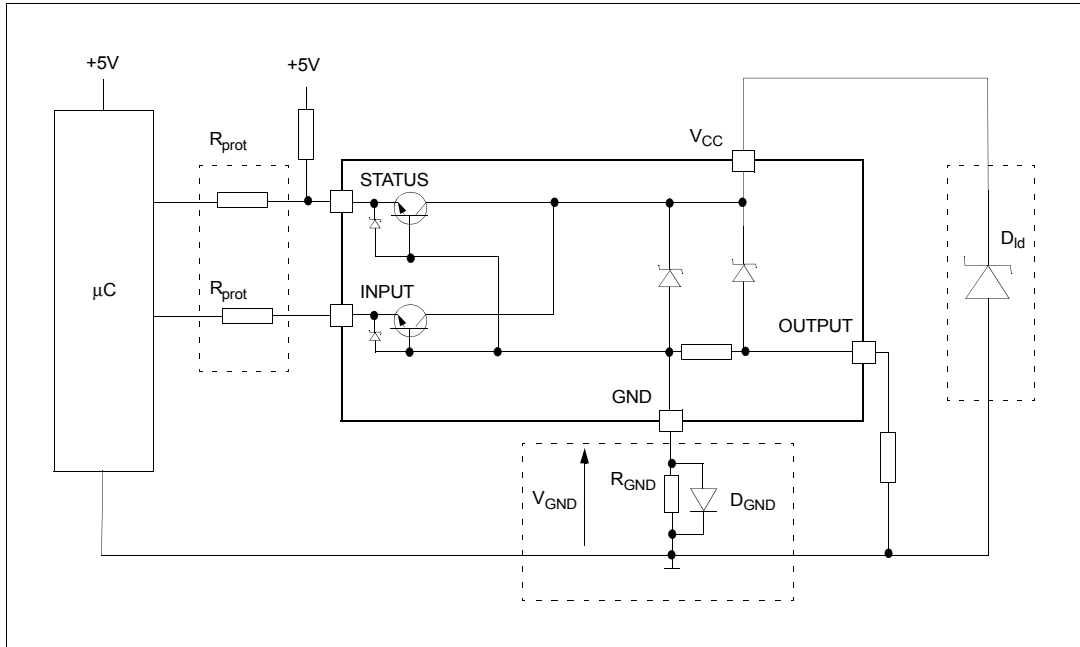


Figure 21. Turn-off voltage slope



### 3 Application information

Figure 22. 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 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's datasheet.

Power Dissipation in R<sub>GND</sub> (when V<sub>CC</sub> < 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<sub>S(on)max</sub> 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<sub>S(on)max</sub> \* R<sub>GND</sub>) in the input thresholds and the status output values. This shift varies depending on how many devices are ON in the 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 [Section 3.1.2](#)).



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

A resistor ( $R_{GND} = 1 \text{ k}\Omega$ ) should be inserted in parallel to  $D_{GND}$  if the device 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 ( $\sim 600 \text{ mV}$ ) in the input threshold and in the status output values if the microprocessor ground is not common to the device ground. This shift does 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 [Table 13](#).

## 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 are pulled negative. ST suggests to insert a resistor ( $R_{prot}$ ) in line to prevent the microcontroller I/Os pins to latch-up.

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

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

Calculation example:

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

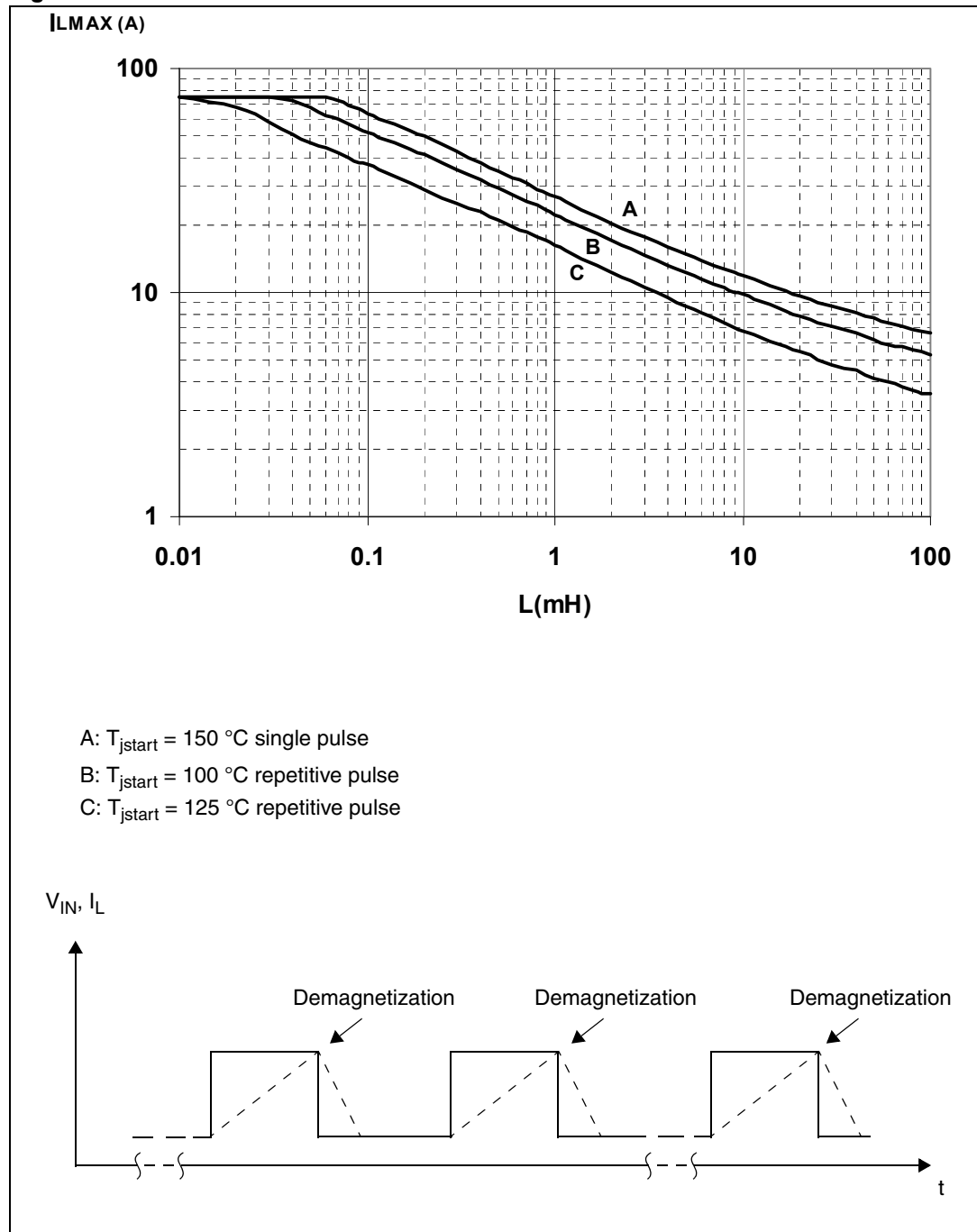
$$5 \text{ k}\Omega \leq R_{prot} \leq 65 \text{ k}\Omega$$

Recommended values:

$$R_{prot} = 10 \text{ k}\Omega$$

### 3.4 P2PAK maximum demagnetization energy ( $V_{CC} = 13.5\text{ V}$ )

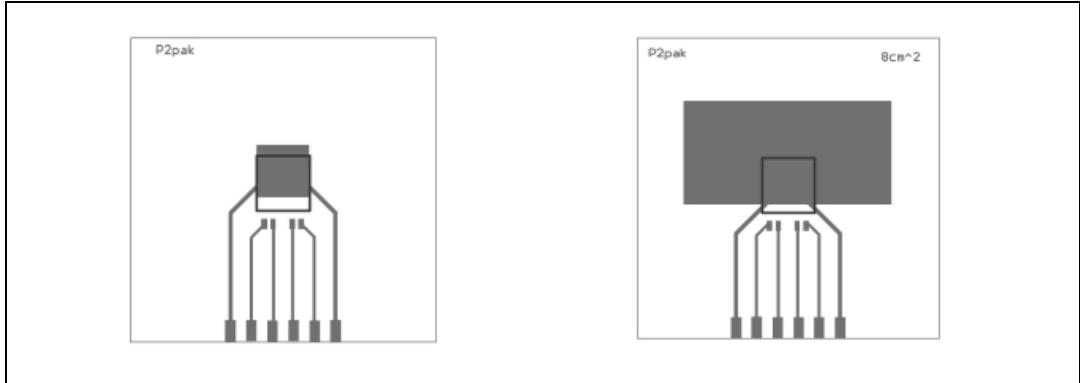
Figure 23. P<sup>2</sup>PAK maximum turn-off current versus inductance



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.

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

Figure 24. 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 25. P<sup>2</sup>PAK  $R_{thj-amb}$  vs PCB copper area in open box free air condition

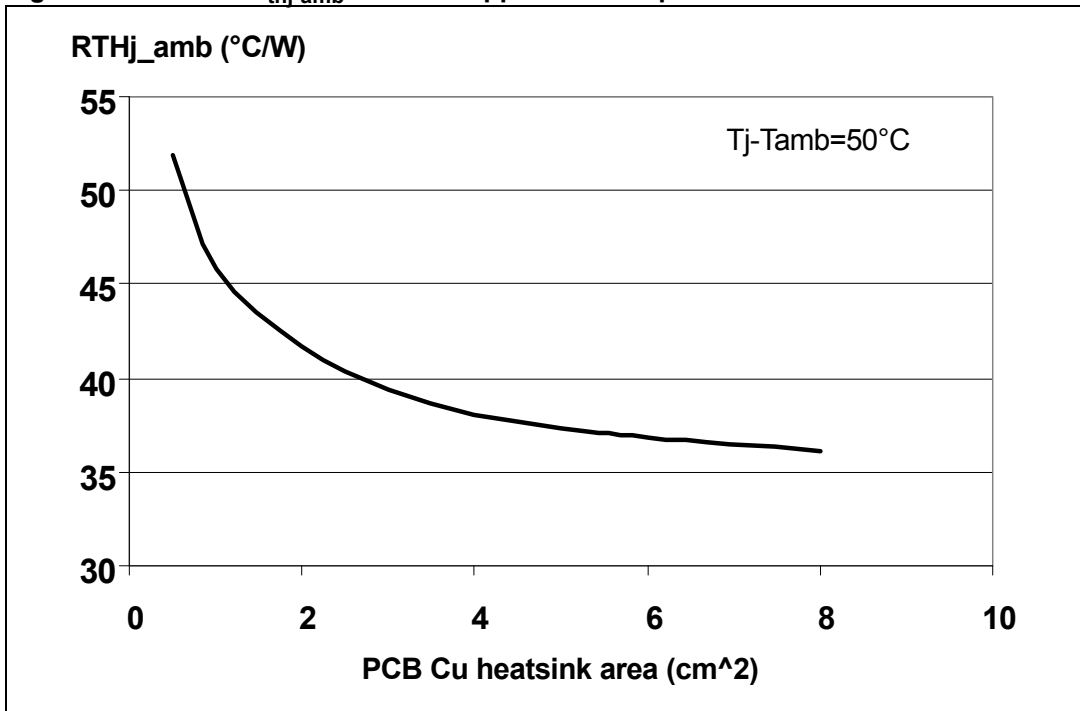
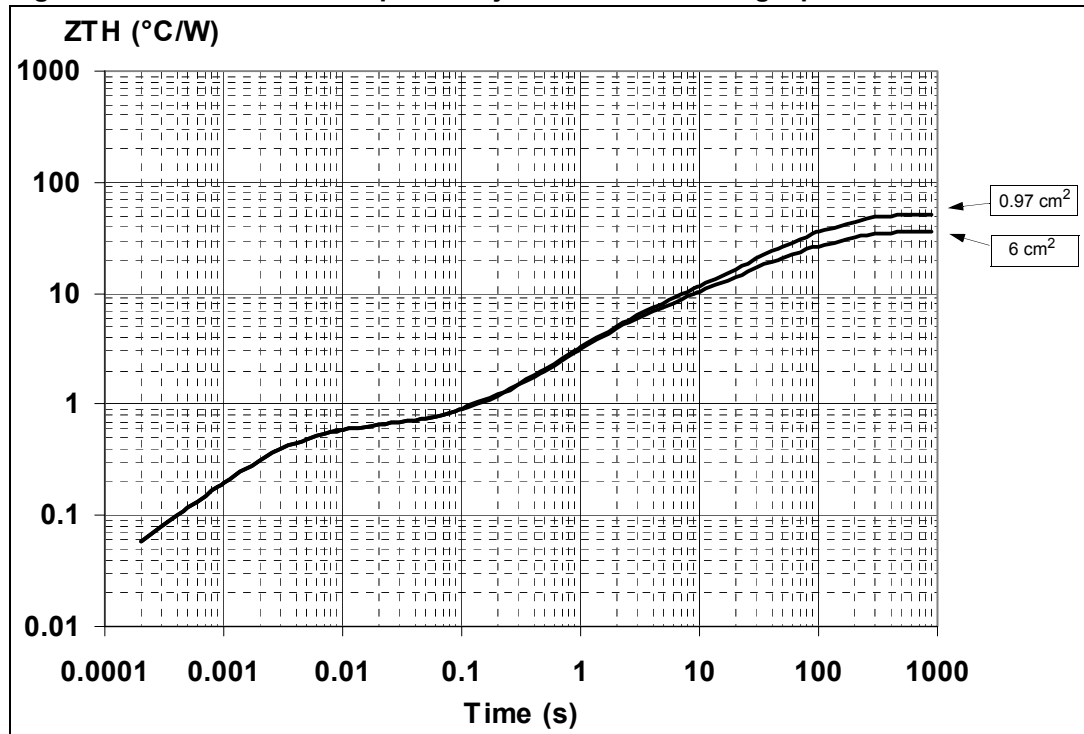


Figure 26. P<sup>2</sup>PAK thermal impedance junction ambient single pulse



Equation 1: pulse calculation formula

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

where  $\delta = t_p/T$

Figure 27. Thermal fitting model of a single channel HSD in P<sup>2</sup>PAK

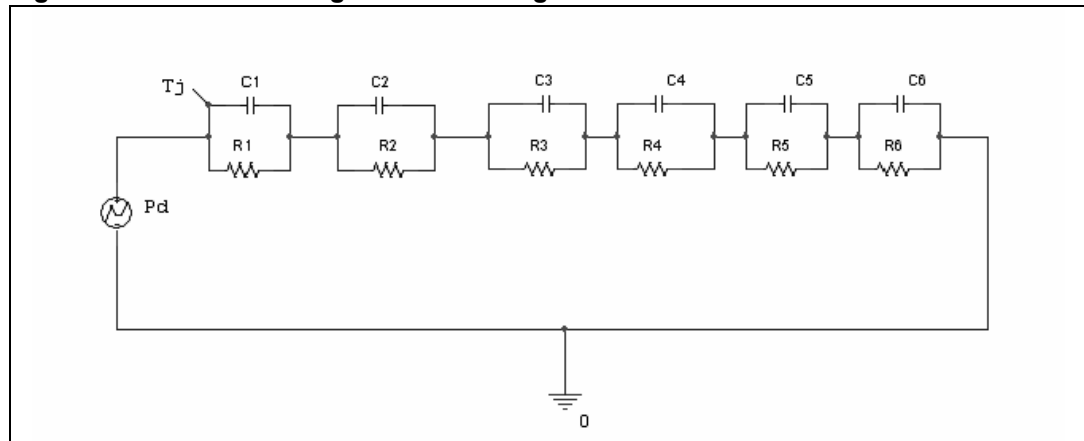


Table 14. P<sup>2</sup>PAK thermal parameters

Area/island (cm <sup>2</sup> )	0.97	6
R1 (°C/W)	0.02	
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

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

Figure 28. P<sup>2</sup>PAK package dimensions

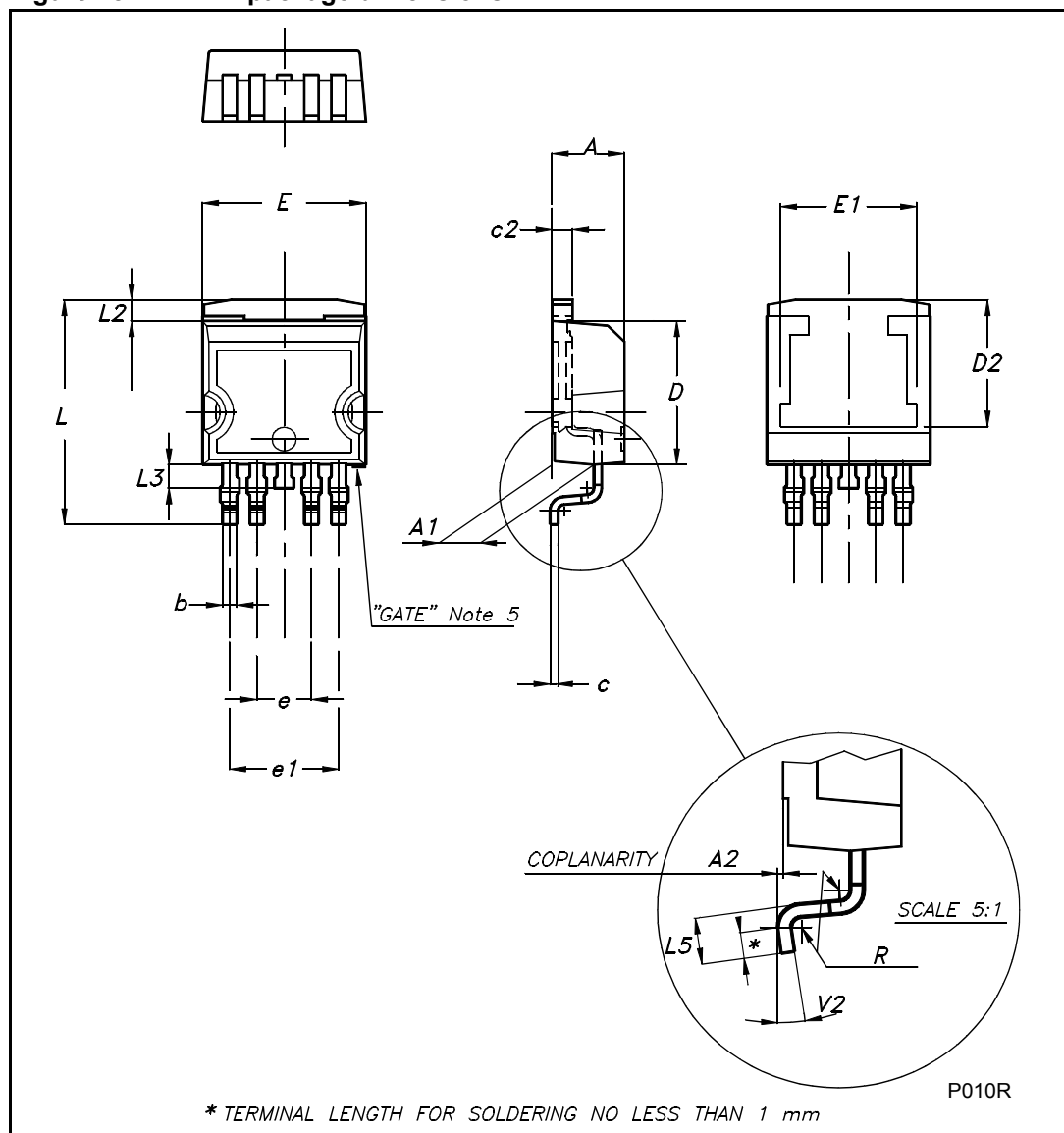


Table 15. P<sup>2</sup>PAK mechanical data

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)		

### 5.3 P<sup>2</sup>PAK packing information

Figure 29. P<sup>2</sup>PAK tube shipment (no suffix)

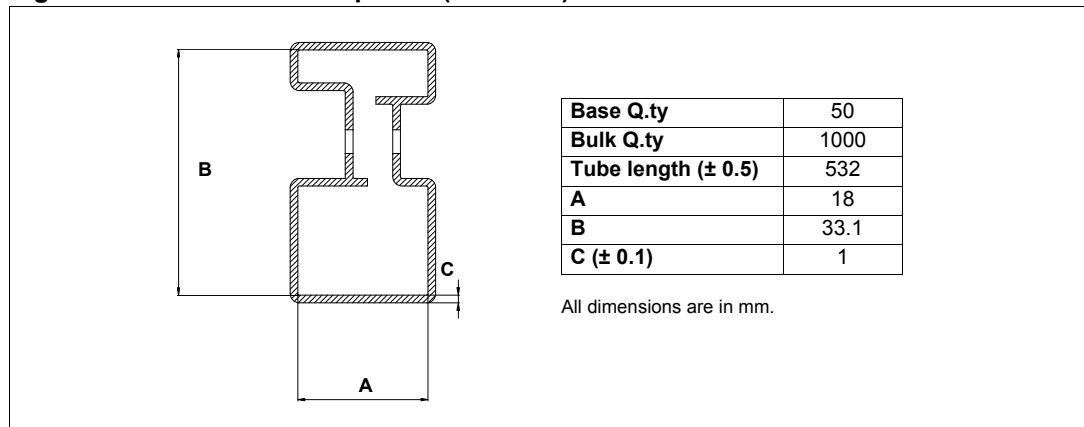
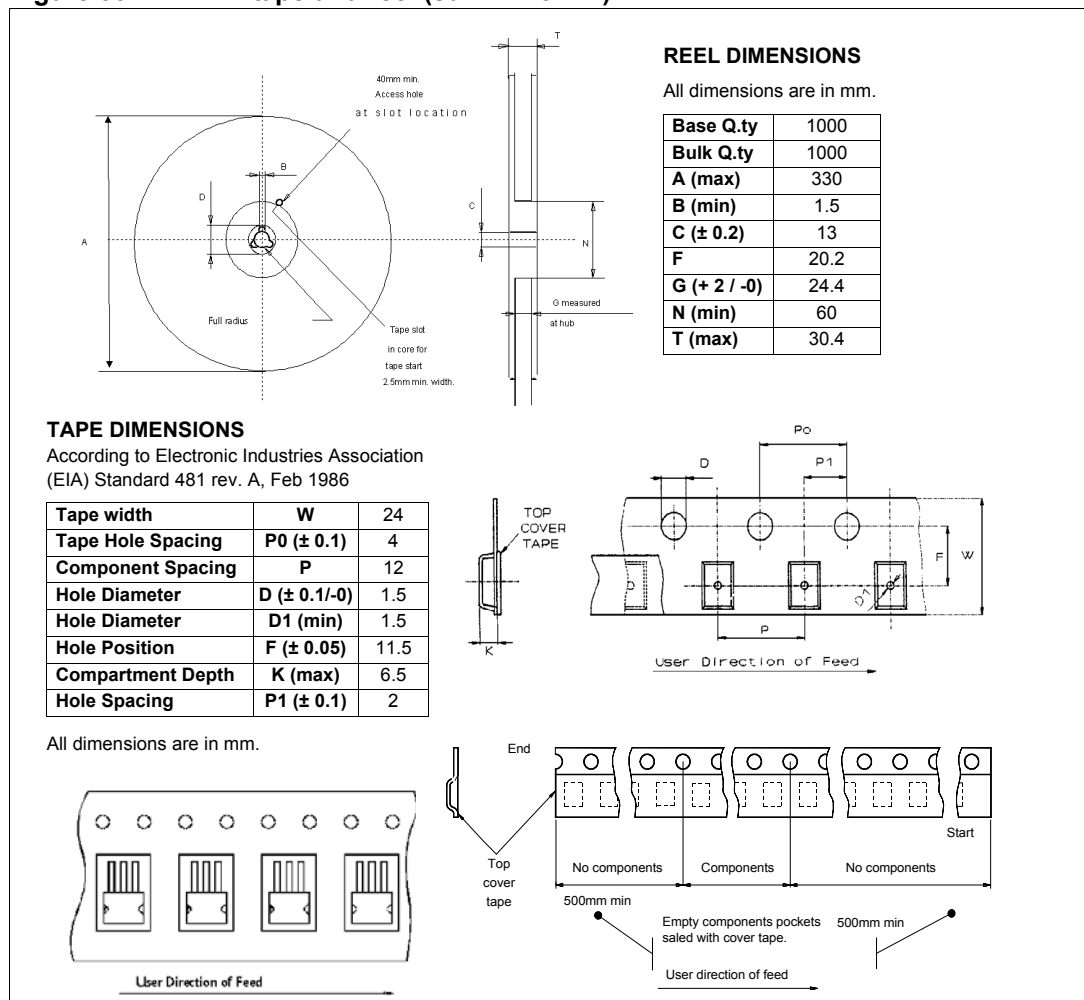


Figure 30. P<sup>2</sup>PAK tape and reel (suffix "13TR")





## 6 Revision history

**Table 16. Document revision history**

Date	Revision	Changes
17-May-2010	1	Initial release.
15-Nov-2010	2	Updated <i>Features</i> list. Updated following tables: – <i>Table 3: Absolute maximum ratings</i> – <i>Table 4: Thermal data</i>
19-Sep-2013	3	Updated Disclaimer

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