

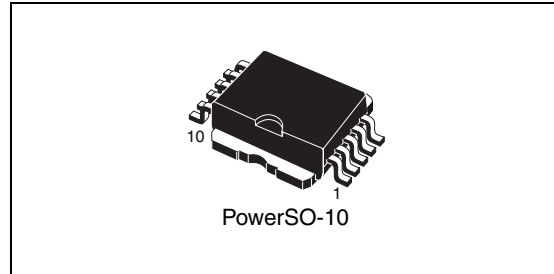
## Double channel high-side driver

### Features

Type	$R_{DS(on)}$	$I_{OUT}$	$V_{CC}$
VND830LSP-E	60 m $\Omega$	18 A <sup>(1)</sup>	36 V <sup>(1)</sup>

1. Per channel

- 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 VND830LSP-E is a monolithic device made using STMicroelectronics<sup>™</sup> VIPower<sup>™</sup> M0-3 technology. It is intended for driving any kind of load with one side connected to ground. 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 open-load condition both in on-state and off-state. The open-load threshold is aimed at detecting the 5 W/12 V standard bulb as an open-load fault in the on-state.

Device automatically turns off in case of ground pin disconnection.

**Table 1. Device summary**

Package	Order codes	
	Tube	Tape and reel
Power-SO-10 <sup>™</sup>	VND830LSP-E	VND830LSPTR-E

# Contents

<b>1</b>	<b>Block diagram and pin description</b>	<b>5</b>
<b>2</b>	<b>Electrical specifications</b>	<b>6</b>
2.1	Absolute maximum ratings	6
2.2	Thermal data	7
2.3	Electrical characteristics	8
2.4	Electrical characteristics curves	13
<b>3</b>	<b>Application information</b>	<b>16</b>
3.1	GND protection network against reverse battery	16
3.1.1	Solution 1: resistor in the ground line (RGND only)	16
3.1.2	Solution 2: diode (DGND) in the ground line	17
3.2	Load dump protection	17
3.3	MCU I/Os protection	17
3.4	Open-load detection in off-state	17
3.5	PowerSO-10 maximum demagnetization energy ( $V_{CC} = 13.5\text{ V}$ )	19
<b>4</b>	<b>Package and PCB thermal data</b>	<b>20</b>
4.1	PowerSO-10 thermal data	20
<b>5</b>	<b>Package and packing information</b>	<b>23</b>
5.1	ECOPACK® packages	23
5.2	PowerSO-10 mechanical data	23
5.3	PowerSO-10 packing information	25
<b>6</b>	<b>Revision history</b>	<b>26</b>

## List of tables

Table 1.	Device summary . . . . .	1
Table 2.	Suggested connections for unused and not connected pins . . . . .	5
Table 3.	Absolute maximum ratings . . . . .	6
Table 4.	Thermal data. . . . .	7
Table 5.	Power output. . . . .	8
Table 6.	Protection . . . . .	8
Table 7.	V <sub>CC</sub> - output diode. . . . .	8
Table 8.	Status pin . . . . .	9
Table 9.	Switching (V <sub>CC</sub> = 13 V). . . . .	9
Table 10.	Open-load detection . . . . .	9
Table 11.	Logic input . . . . .	9
Table 12.	Truth table. . . . .	10
Table 13.	Electrical transient requirements on V <sub>CC</sub> pin (part 1) . . . . .	11
Table 14.	Electrical transient requirements on V <sub>CC</sub> pin (part 2) . . . . .	11
Table 15.	Electrical transient requirements on V <sub>CC</sub> pin (part 3) . . . . .	11
Table 16.	Thermal parameter . . . . .	22
Table 17.	PowerSO-10 mechanical data . . . . .	24
Table 18.	Document revision history . . . . .	26

## List of figures

Figure 1.	Block diagram . . . . .	5
Figure 2.	Configuration diagram (top view) . . . . .	5
Figure 3.	Current and voltage conventions . . . . .	6
Figure 4.	Status timings . . . . .	10
Figure 5.	Switching time waveforms . . . . .	10
Figure 6.	Waveforms . . . . .	12
Figure 7.	Off-state output current . . . . .	13
Figure 8.	High level input current . . . . .	13
Figure 9.	Input clamp voltage . . . . .	13
Figure 10.	Status leakage current . . . . .	13
Figure 11.	Status low output current . . . . .	13
Figure 12.	Status clamp voltage . . . . .	13
Figure 13.	On-state resistance vs $T_{case}$ . . . . .	14
Figure 14.	On-state resistance vs $V_{CC}$ . . . . .	14
Figure 15.	Open-load on-state detection threshold . . . . .	14
Figure 16.	Open-load off-state detection threshold . . . . .	14
Figure 17.	Input high level . . . . .	14
Figure 18.	Input low level . . . . .	14
Figure 19.	Input hysteresis voltage . . . . .	15
Figure 20.	Overvoltage shutdown . . . . .	15
Figure 21.	Turn-on voltage slope . . . . .	15
Figure 22.	Turn-off voltage slope . . . . .	15
Figure 23.	$I_{LIM}$ vs $T_{case}$ . . . . .	15
Figure 24.	Application schematic . . . . .	16
Figure 25.	Open-load detection in off-state . . . . .	18
Figure 26.	Maximum turn- off current versus load inductance <sup>(1)</sup> . . . . .	19
Figure 27.	PowerSO-10 PC board <sup>(1)</sup> . . . . .	20
Figure 28.	$R_{thj-amb}$ vs PCB copper area in open box free air condition . . . . .	20
Figure 29.	PowerSO-10 thermal impedance junction ambient single pulse . . . . .	21
Figure 30.	Thermal fitting model of a double channel HSD in PowerSO-10 . . . . .	21
Figure 31.	PowerSO-10 package dimensions . . . . .	23
Figure 32.	PowerSO-10 suggested pad layout and tube shipment (no suffix) . . . . .	25
Figure 33.	Tape and reel shipment (suffix "TR") . . . . .	25

# 1 Block diagram and pin description

Figure 1. Block diagram

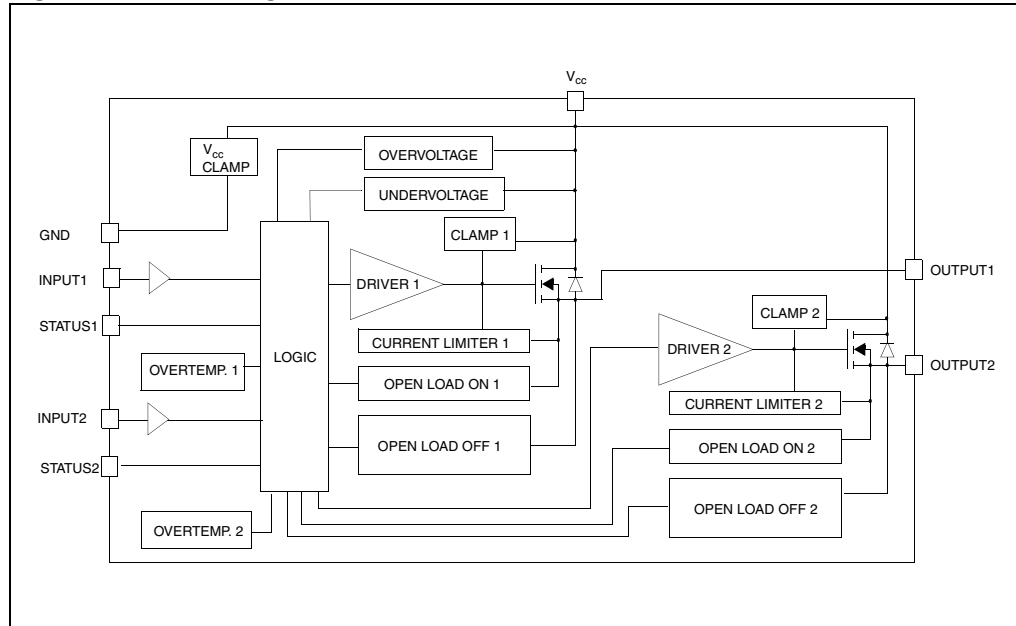


Figure 2. Configuration diagram (top view)

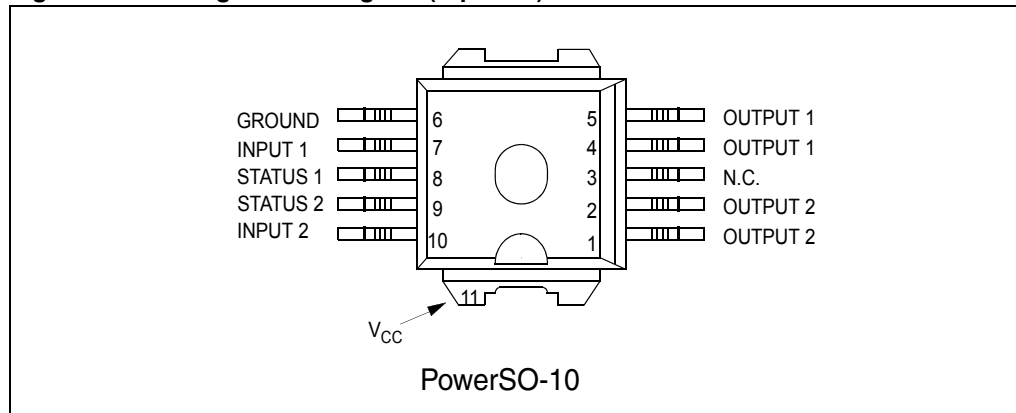
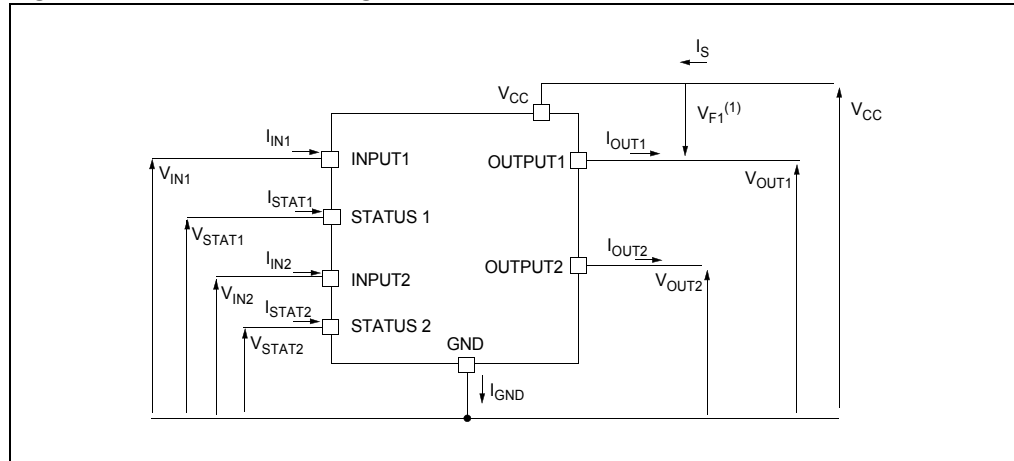


Table 2. Suggested connections for unused and not connected pins

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

## 2 Electrical specifications

Figure 3. Current and voltage conventions



1.  $V_{Fn} = V_{CCn} - V_{OUTn}$  during reverse battery condition.

### 2.1 Absolute maximum ratings

Stressing the device above the rating listed in [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	-6	A
$I_{IN}$	DC input current	+/- 10	mA
$I_{STAT}$	CD 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
$P_{tot}$	Power dissipation at $T_c = 25 \text{ }^\circ\text{C}$	74	W

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

Symbol	Parameter	Value	Unit
$E_{MAX}$	Maximum switching energy ( $L = 0.14 \text{ mH}$ ; $R_L = 0 \text{ }\Omega$ ; $V_{bat} = 13.5 \text{ V}$ ; $T_{jstart} = 150 \text{ }^\circ\text{C}$ ; $I_L = 14 \text{ A}$ )	52	mJ
$T_j$	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	Value		Unit
$R_{thj-case}$	Thermal resistance junction-case	2		$^\circ\text{C}/\text{W}$
$R_{thj-amb}$	Thermal resistance junction-ambient	52 <sup>(1)</sup>	37 <sup>(2)</sup>	$^\circ\text{C}/\text{W}$

- When mounted on a standard single sided FR-4 board with 0.5 cm<sup>2</sup> of Cu (at least 35  $\mu\text{m}$  thick). Horizontal mounting and no artificial air flow.
- When mounted on a standard single sided FR-4 board with 6 cm<sup>2</sup> of Cu (at least 35  $\mu\text{m}$  thick). Horizontal mounting and no artificial air flow.

## 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 specified. (Per each channel).

**Table 5. Power output**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{CC}^{(1)}$	Operating supply voltage		5.5	13	36	V
$V_{USD}^{(1)}$	Undervoltage shutdown		3	4	5.5	V
$V_{OV}^{(1)}$	Overvoltage shutdown		36			V
$R_{ON}$	On-state resistance	$I_{OUT} = 2\text{ A}$ ; $T_j = 25\text{ °C}$			60	mΩ
		$I_{OUT} = 2\text{ A}$ ; $V_{CC} > 8\text{ V}$			120	mΩ
$I_S^{(1)}$	Supply current	Off-state; $V_{CC} = 13\text{ V}$ ; $V_{IN} = V_{OUT} = 0\text{ V}$		12	40	μA
		Off-state; $V_{CC} = 13\text{ V}$ ; $V_{IN} = V_{OUT} = 0\text{ V}$ ; $T_j = 25\text{ °C}$		12	25	μA
		On-state; $V_{CC} = 13\text{ V}$		5	7	mA
$I_{L(off1)}$	Off-state output current	$V_{IN} = V_{OUT} = 0\text{ V}$ ; $V_{CC} = 36\text{ V}$ ; $T_j = 125\text{ °C}$	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

1. Per device.

**Table 6. Protection<sup>(1)</sup>**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$T_{TSD}$	Shutdown temperature		150	175	200	°C
$T_R$	Reset temperature		135			°C
$T_{hyst}$	Thermal hysteresis		7	15		°C
$I_{lim}$	Current limitation	$V_{CC} = 13\text{ V}$	18	23	29	A
		$5.5\text{ V} < V_{CC} < 36\text{ V}$			29	A
$V_{demag}$	Turn-off output clamp voltage	$I_{OUT} = 2\text{ A}$ ; $L = 6\text{ mH}$	$V_{CC}-41$	$V_{CC}-48$	$V_{CC}-55$	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 is subjected to abnormal conditions, this software must limit the duration and number of activation cycles.

**Table 7.  $V_{CC}$  - output diode**

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
$V_F$	Forward on voltage	$-I_{OUT} = 1.3\text{ A}$ ; $T_j = 150\text{ °C}$	—	—	0.6	V



**Table 8. Status pin**

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
V <sub>STAT</sub>	Status low output voltage	I <sub>STAT</sub> = 1.6 mA			0.5	V
I <sub>LSTAT</sub>	Status leakage current	Normal operation; V <sub>STAT</sub> = 5 V			10	mA
C <sub>STAT</sub>	Status pin input capacitance	Normal operation; V <sub>STAT</sub> = 5 V			100	pF
V <sub>SCL</sub>	Status clamp voltage	I <sub>STAT</sub> = 1 mA	6	6.8	8	V
		I <sub>STAT</sub> = -1 mA		-0.7		V

**Table 9. Switching (V<sub>CC</sub> = 13 V)**

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
t <sub>d(on)</sub>	Turn-on delay time	R <sub>L</sub> = 13 Ω from V <sub>IN</sub> rising edge to V <sub>OUT</sub> = 1.3 V	—	30	—	μs
t <sub>d(off)</sub>	Turn-on delay time	R <sub>L</sub> = 13 Ω from V <sub>IN</sub> falling edge to V <sub>OUT</sub> = 11.7 V	—	30	—	μs
(dV <sub>OUT</sub> /dt) <sub>on</sub>	Turn-on voltage slope	R <sub>L</sub> = 13 Ω from V <sub>OUT</sub> = 1.3 V to V <sub>OUT</sub> = 10.4 V	—	See Figure 21	—	V/μs
(dV <sub>OUT</sub> /dt) <sub>off</sub>	Turn-off voltage slope	R <sub>L</sub> = 13 Ω from V <sub>OUT</sub> = 11.7 V to V <sub>OUT</sub> = 1.3 V	—	See Figure 22	—	V/μs

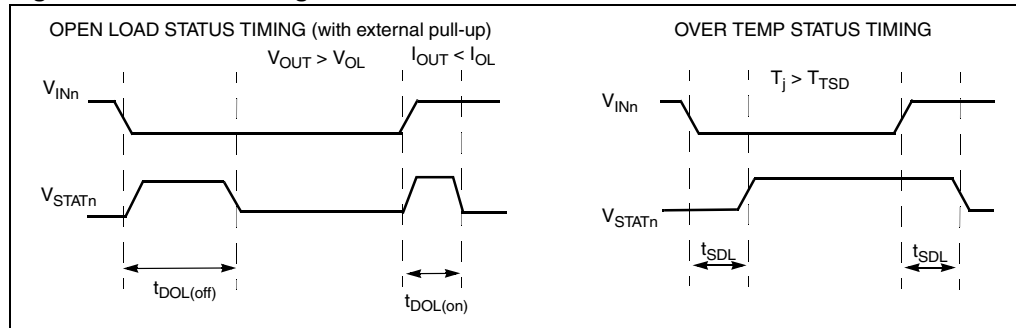
**Table 10. Open-load detection**

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
I <sub>OL</sub>	Open-load on-state detection threshold	V <sub>IN</sub> = 5 V	0.6	0.9	1.2	A
t <sub>DOL(on)</sub>	Open-load on-state detection delay	I <sub>OUT</sub> = 0 A			200	μs
V <sub>OL</sub>	Openload off-state voltage detection threshold	V <sub>IN</sub> = 0 V	1.5	2.5	3.5	V
T <sub>DOL(off)</sub>	Open-load detection delay at turn-off				1000	μs

**Table 11. Logic input**

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
V <sub>IL</sub>	Input low level				1.25	V
I <sub>IL</sub>	Low level input current	V <sub>IN</sub> = 1.25 V	1			μA
V <sub>IH</sub>	Input high level		3.25			V
I <sub>IH</sub>	High level input current	V <sub>IN</sub> = 3.25 V			10	μA
V <sub>I(hyst)</sub>	Input hysteresis voltage		0.5			V
V <sub>ICL</sub>	Input clamp voltage	I <sub>IN</sub> = 1 mA	6	6.8	8	V
		I <sub>IN</sub> = -1 mA		-0.7		V

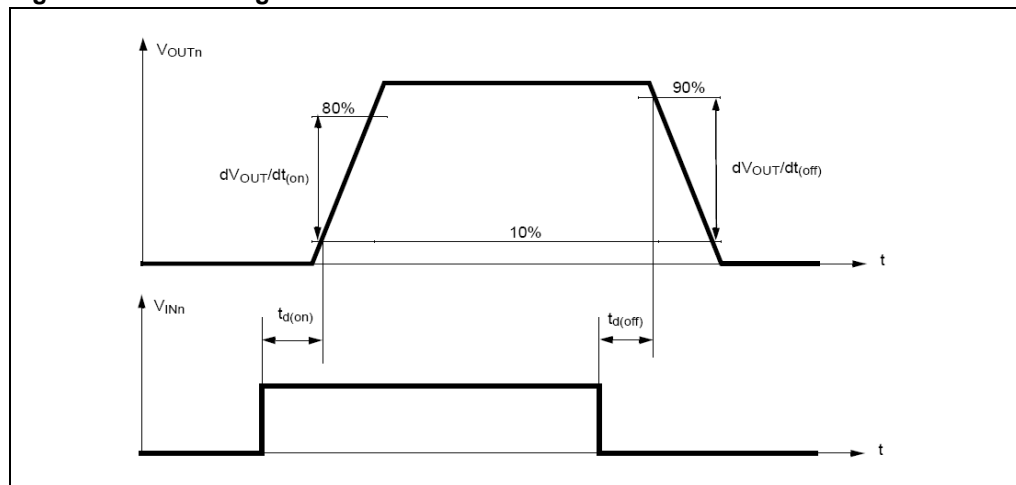
**Figure 4. Status timings**



**Table 12. Truth table**

Conditions	Input	Output	Sense
Normal operation	L	L	H
	H	H	H
Current limitation	L	L	H
	H	X	( $T_j < T_{TSD}$ ) H ( $T_j > T_{TSD}$ ) 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

**Figure 5. Switching time waveforms**



**Table 13. Electrical transient requirements on V<sub>CC</sub> pin (part 1)**

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

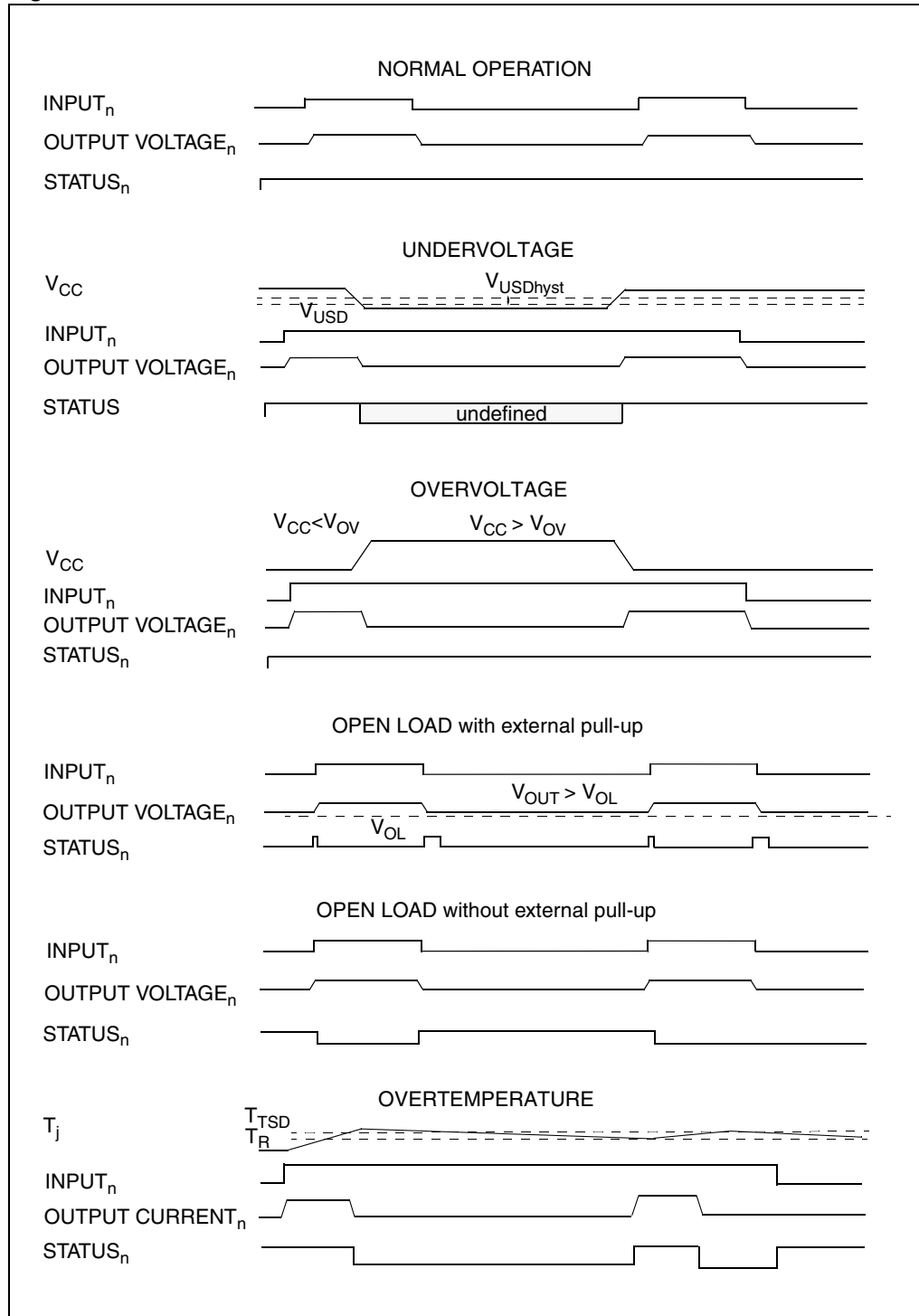
**Table 14. Electrical transient requirements on V<sub>CC</sub> pin (part 2)**

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

**Table 15. Electrical transient requirements on V<sub>CC</sub> pin (part 3)**

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

Figure 6. Waveforms



## 2.4 Electrical characteristics curves

Figure 7. Off-state output current

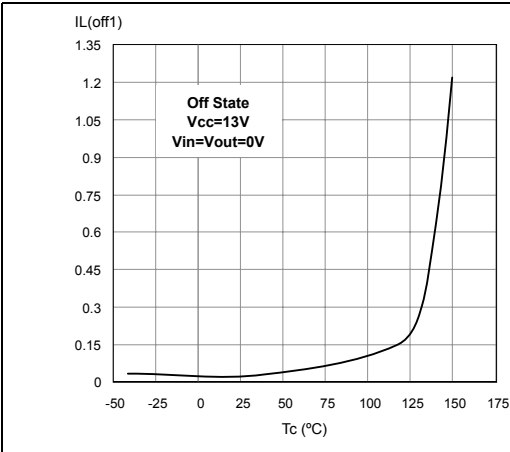


Figure 8. High level input current

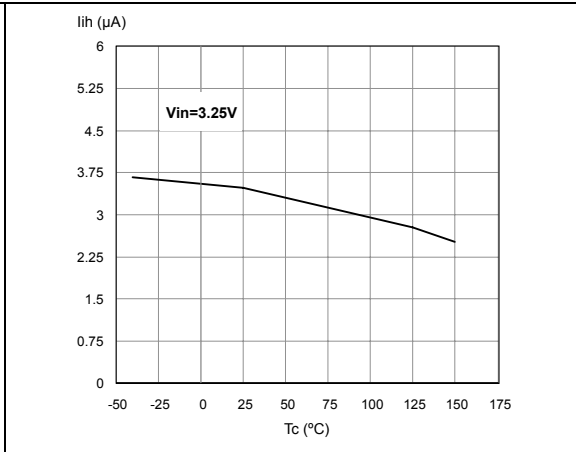


Figure 9. Input clamp voltage

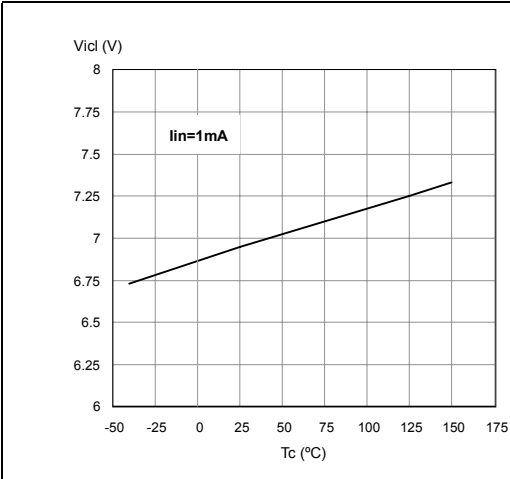


Figure 10. Status leakage current

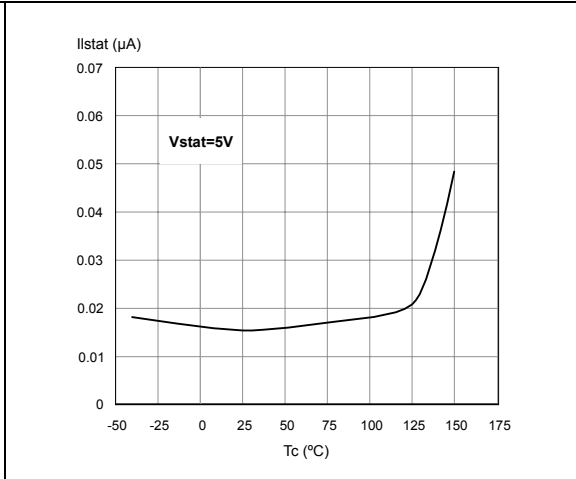


Figure 11. Status low output current

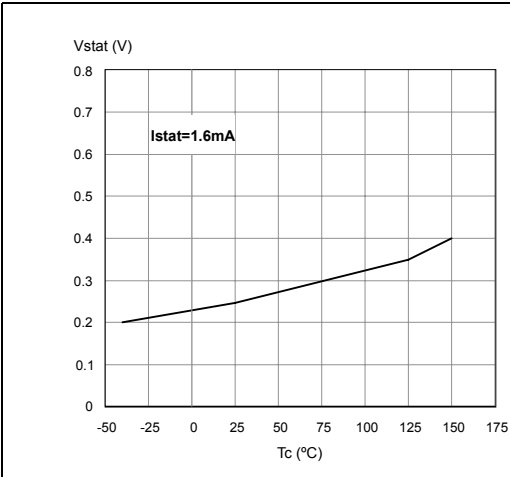


Figure 12. Satus clamp voltage

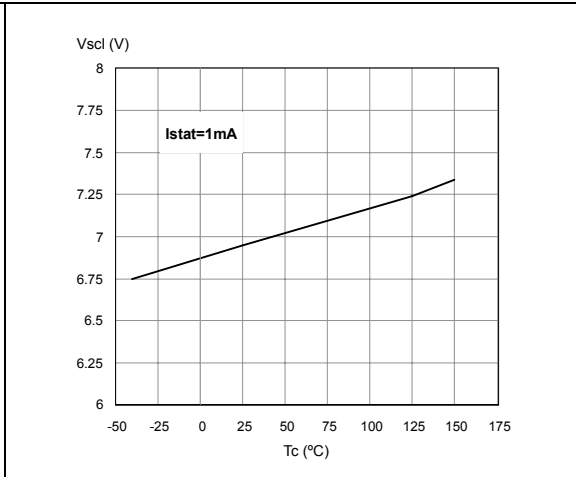


Figure 13. On-state resistance vs  $T_{case}$

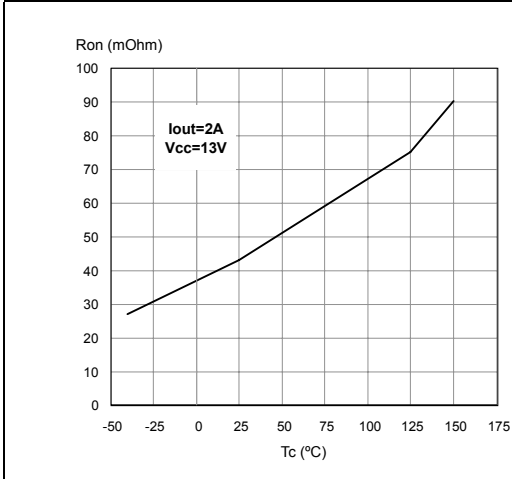


Figure 14. On-state resistance vs  $V_{CC}$

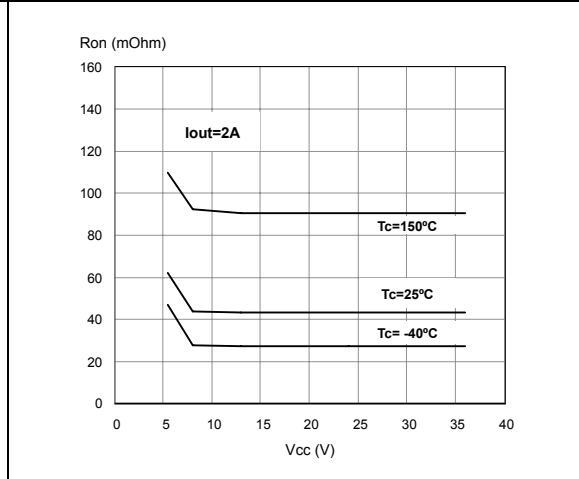


Figure 15. Open-load on-state detection threshold

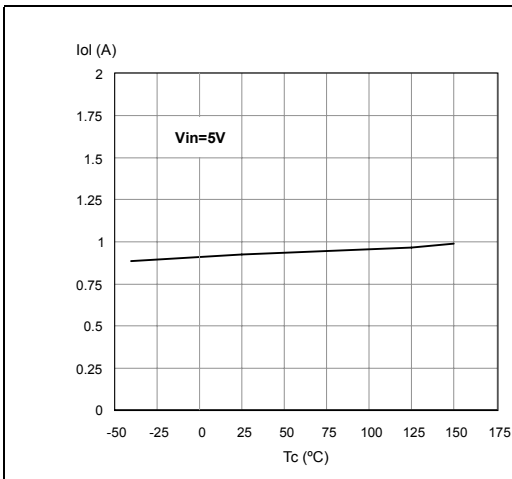


Figure 16. Open-load off-state detection threshold

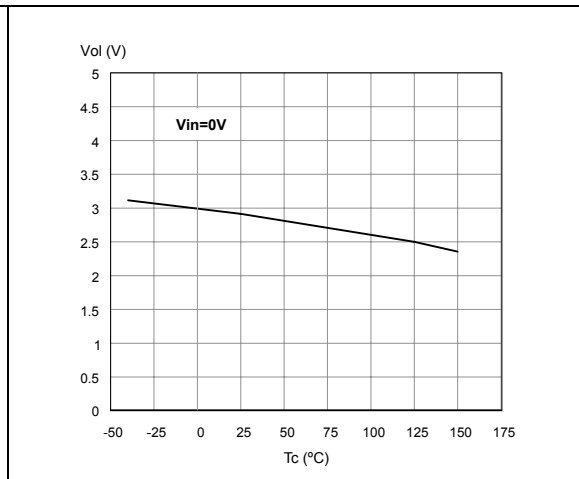


Figure 17. Input high level

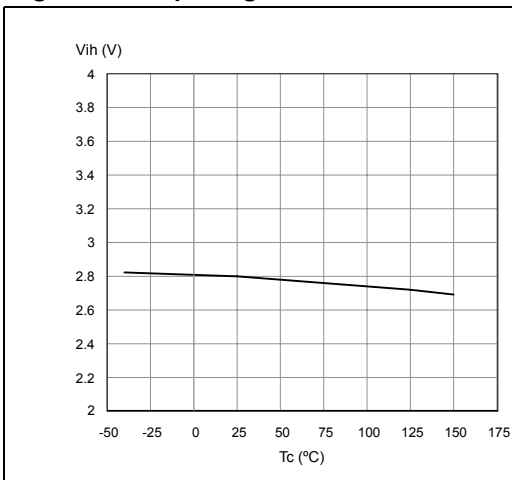


Figure 18. Input low level

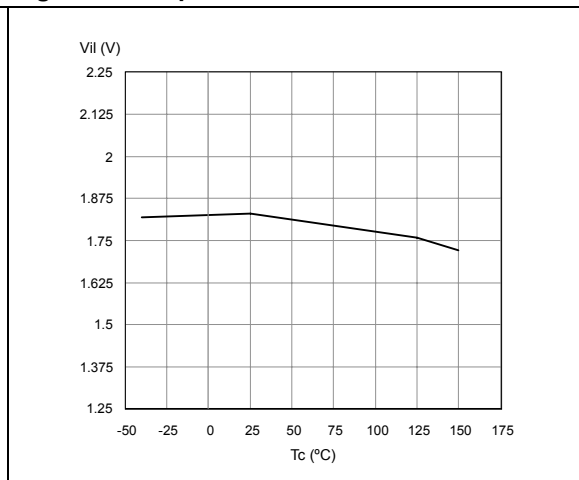


Figure 19. Input hysteresis voltage

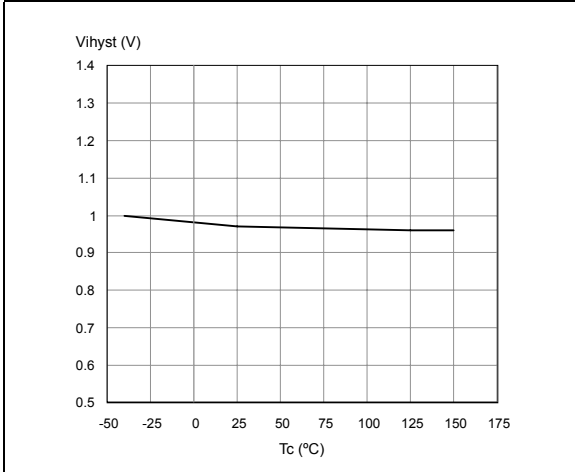


Figure 20. Overvoltage shutdown

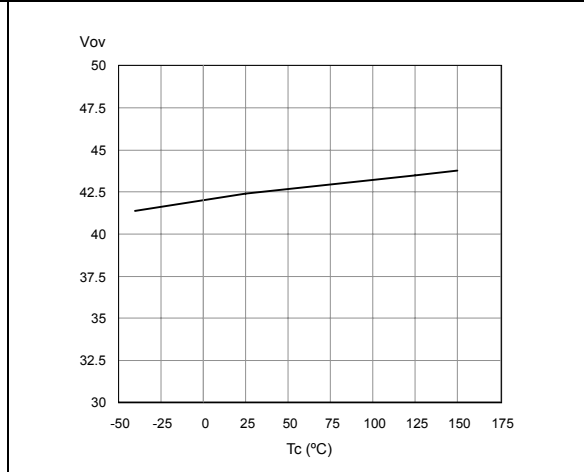


Figure 21. Turn-on voltage slope

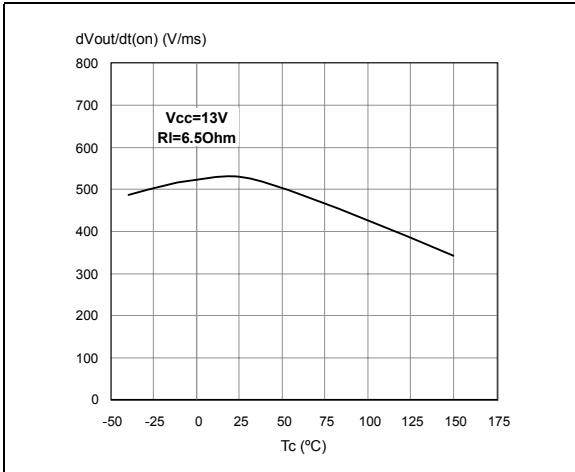


Figure 22. Turn-off voltage slope

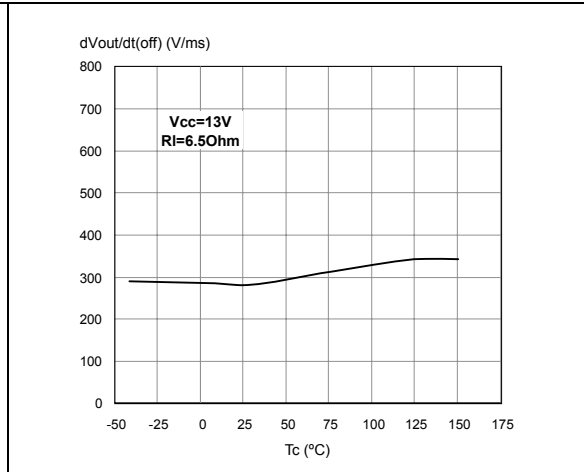
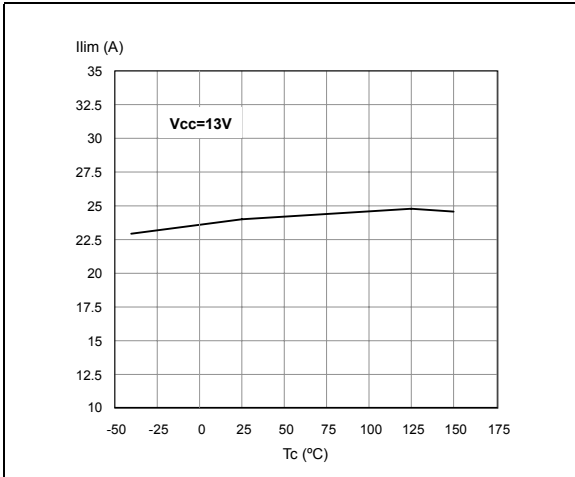
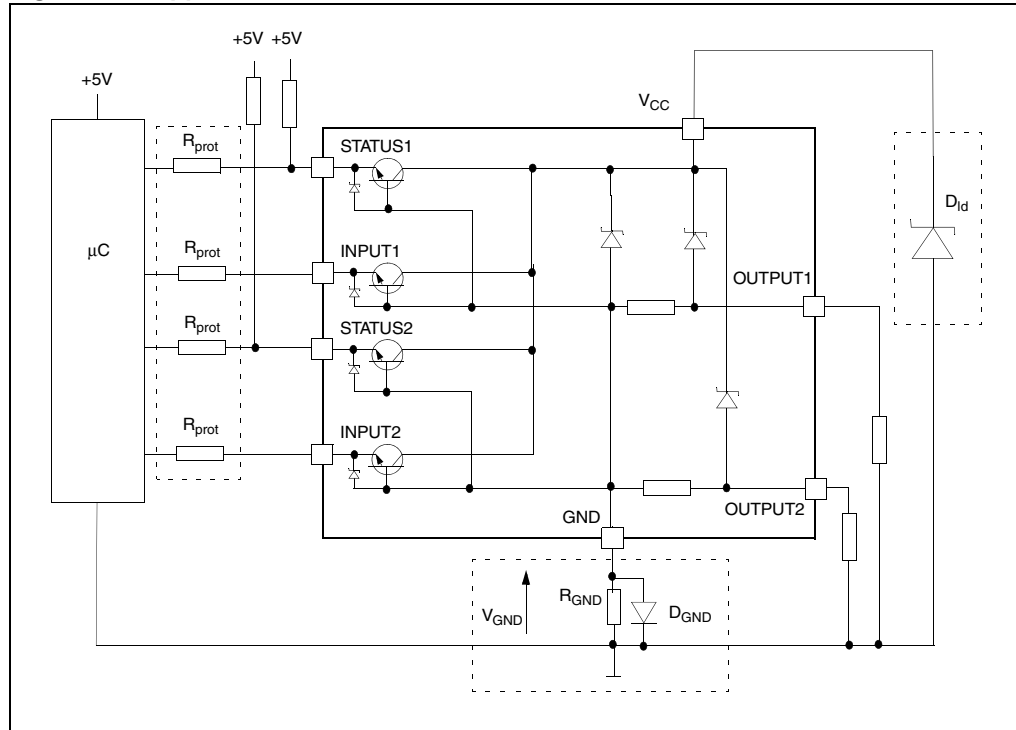


Figure 23. I<sub>LIM</sub> vs T<sub>case</sub>



### 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 ( $R_{GND}$ only)

This can be used with any type of load.

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

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

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

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

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

This resistor can be shared amongst several different 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  $R_{GND}$  produces a shift ( $I_{S(on)max} * R_{GND}$ ) 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  $R_{GND}$ .

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 [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 Open-load detection in off-state

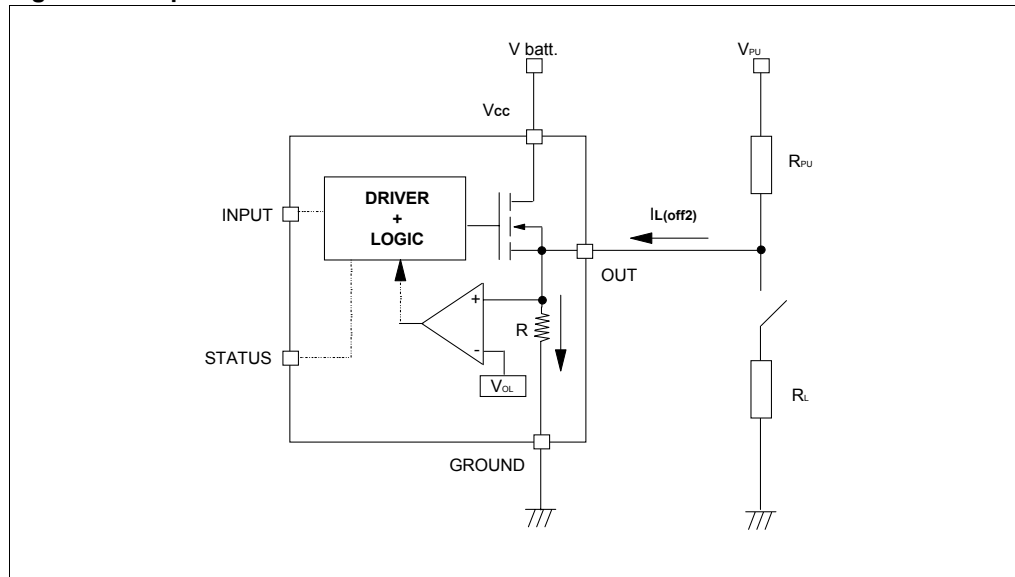
Off-state open-load detection requires an external pull-up resistor ( $R_{PU}$ ) connected between OUTPUT pin and a positive supply voltage ( $V_{PU}$ ) like the +5 V line used to supply the microprocessor.

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  $R_{PU} < (V_{PU} - V_{OLmax})/I_{L(off2)}$ .

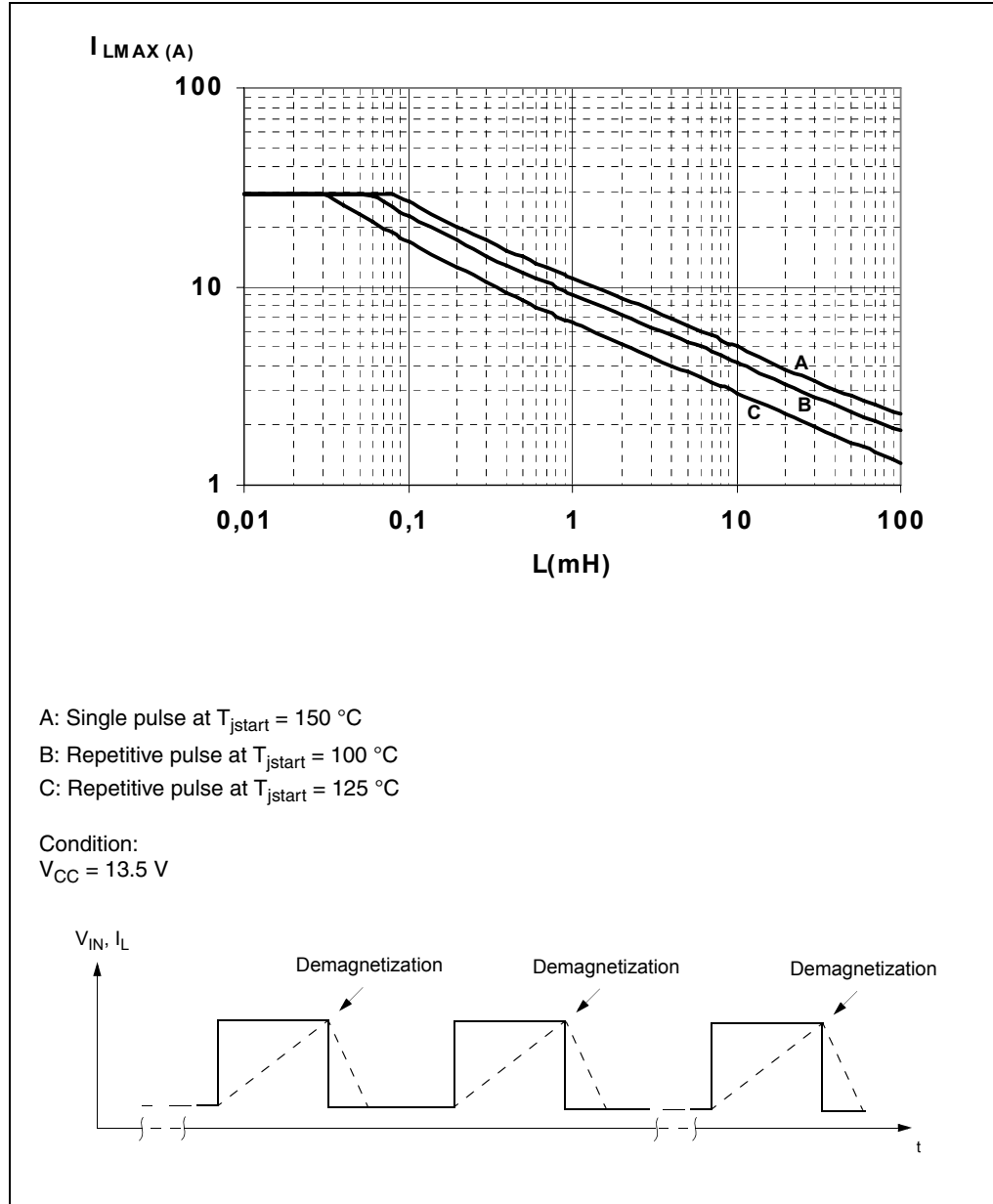
Because  $I_{S(OFF)}$  may significantly increase if  $V_{OUT}$  is pulled high (up to several mA), the pull-up resistor  $R_{PU}$  should be connected to a supply that is switched OFF when the module is in standby. The values of  $V_{OLmin}$ ,  $V_{OLmax}$  and  $I_{L(off2)}$  are available in [Section 2.3: Electrical characteristics](#).

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



### 3.5 PowerSO-10 maximum demagnetization energy ( $V_{CC} = 13.5\text{ V}$ )

Figure 26. Maximum turn-off current versus load inductance<sup>(1)</sup>

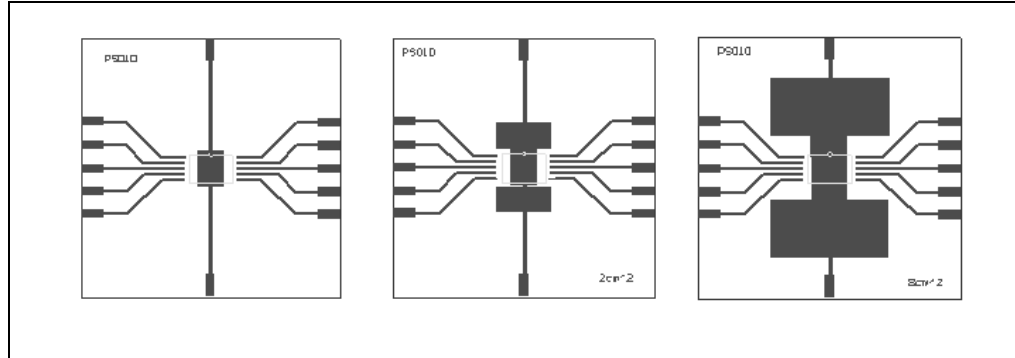


1. Values are generated with  $R_L = 0\ \Omega$   
 In case of repetitive pulses,  $T_{jstart}$  (at beginning of each demagnetization) of every pulse must not exceed the temperature specified above for curves B and C.

## 4 Package and PCB thermal data

### 4.1 PowerSO-10 thermal data

Figure 27. PowerSO-10 PC board<sup>(1)</sup>



1. Layout condition of  $R_{th}$  and  $Z_{th}$  measurements (PCB FR4 area = 58 mm x 58 mm, PCB thickness = 2 mm, Cu thickness = 35  $\mu$ m, Copper areas: from minimum pad lay-out to 8 cm<sup>2</sup>).

Figure 28.  $R_{thj-amb}$  vs PCB copper area in open box free air condition

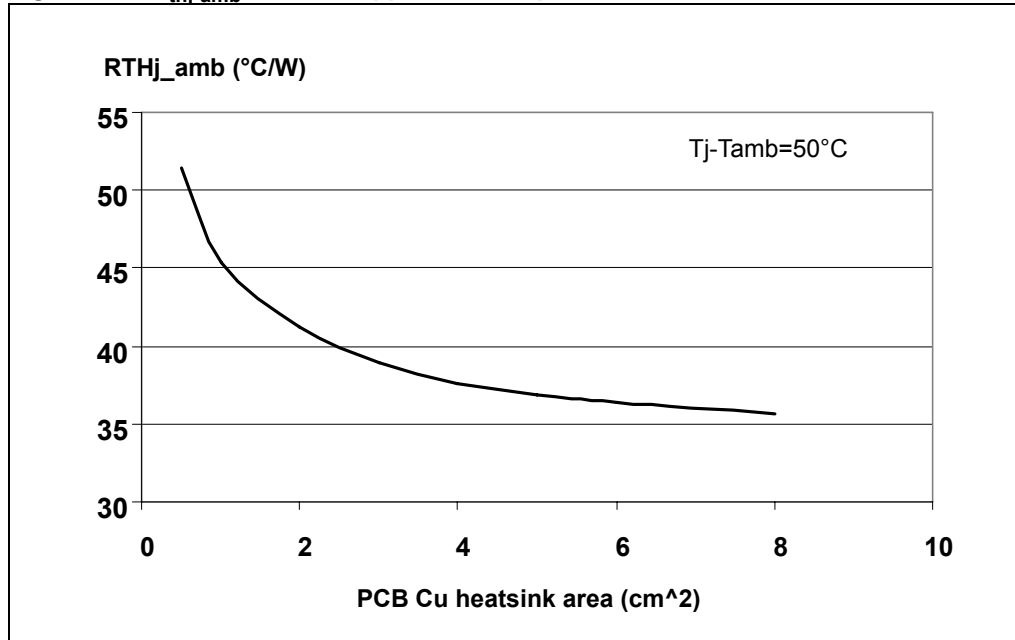
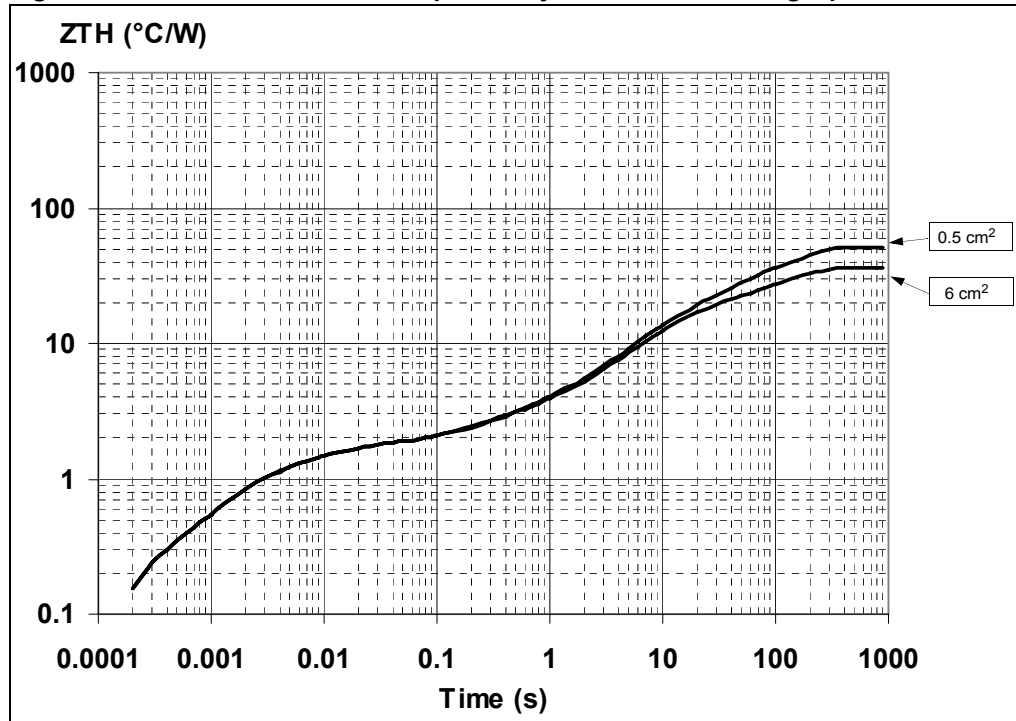


Figure 29. PowerSO-10 thermal impedance junction ambient single pulse



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 double channel HSD in PowerSO-10

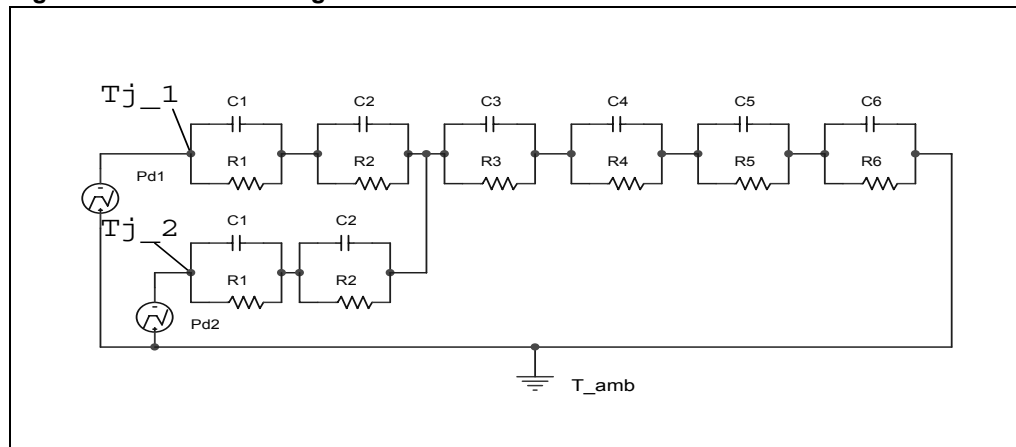


Table 16. Thermal parameter

Area/island (cm <sup>2</sup> )	Footprint	6
R1 (°C/ W)	0.15	
R2 (°C/ W)	0.8	
R3 (°C/ W)	0.7	
R4 (°C/ W)	0.8	
R5 (°C/ W)	12	
R6 (°C/ W)	37	22
C1 (W.s/ °C)	0.0006	
C2 (W.s/ °C)	2.1E-03	
C3 (W.s/ °C)	0.013	
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<sup>®</sup> packages

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

### 5.2 PowerSO-10 mechanical data

Figure 31. PowerSO-10 package dimensions

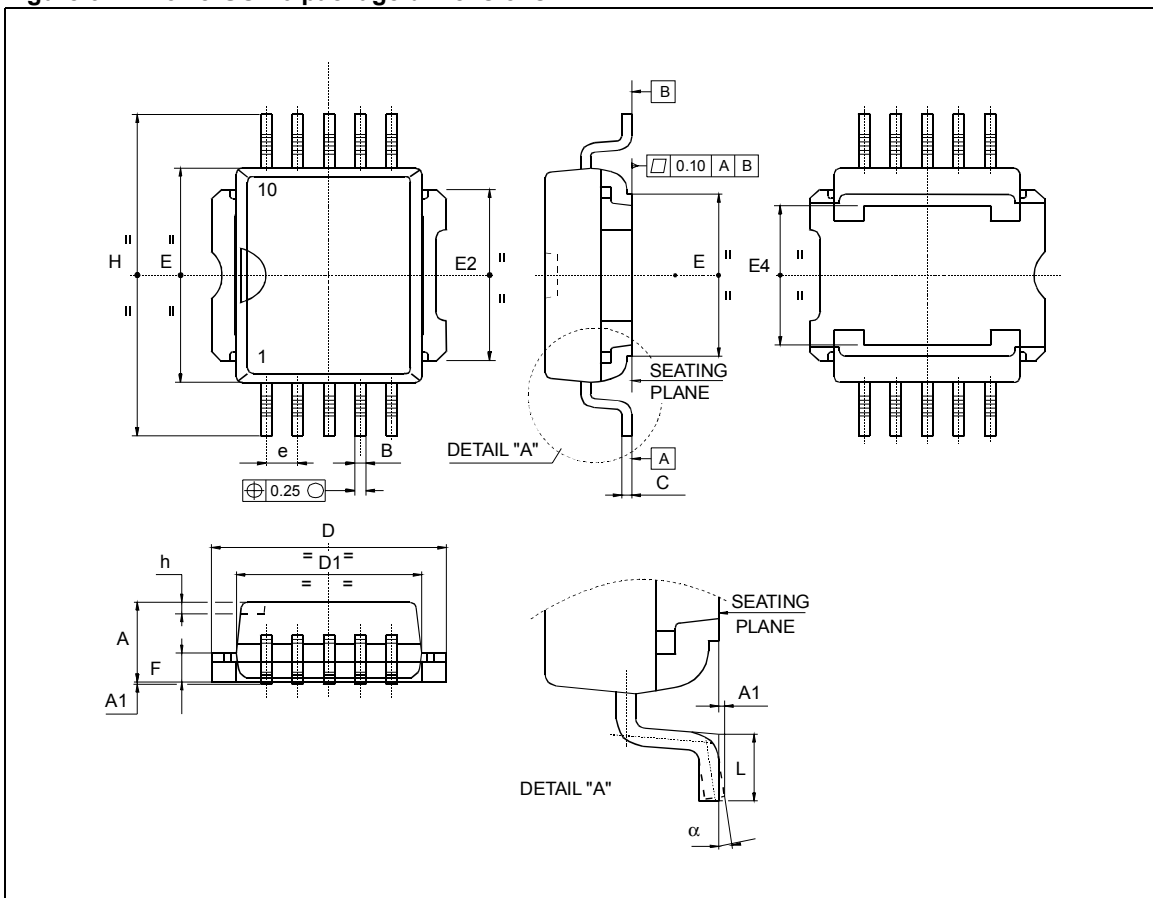


Table 17. PowerSO-10 mechanical data

Dim.	Millimeters		
	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°
$\alpha$ <sup>(1)</sup>	2°		8°

1. Muar only POA P013P.



### 5.3 PowerSO-10 packing information

Figure 32. PowerSO-10 suggested pad layout and tube shipment (no suffix)

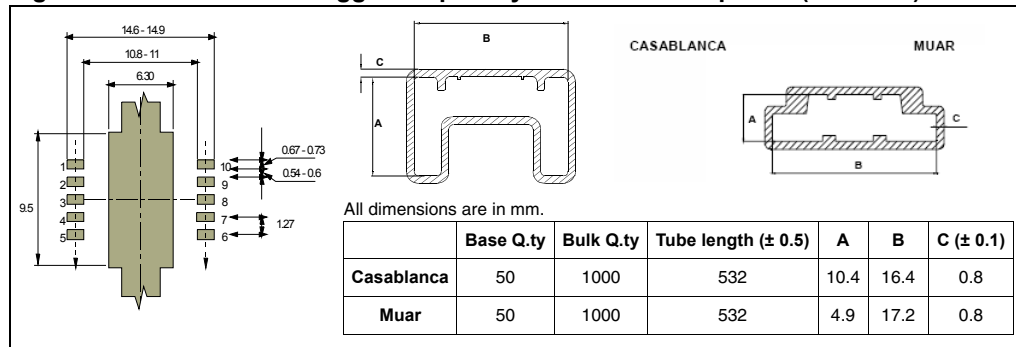
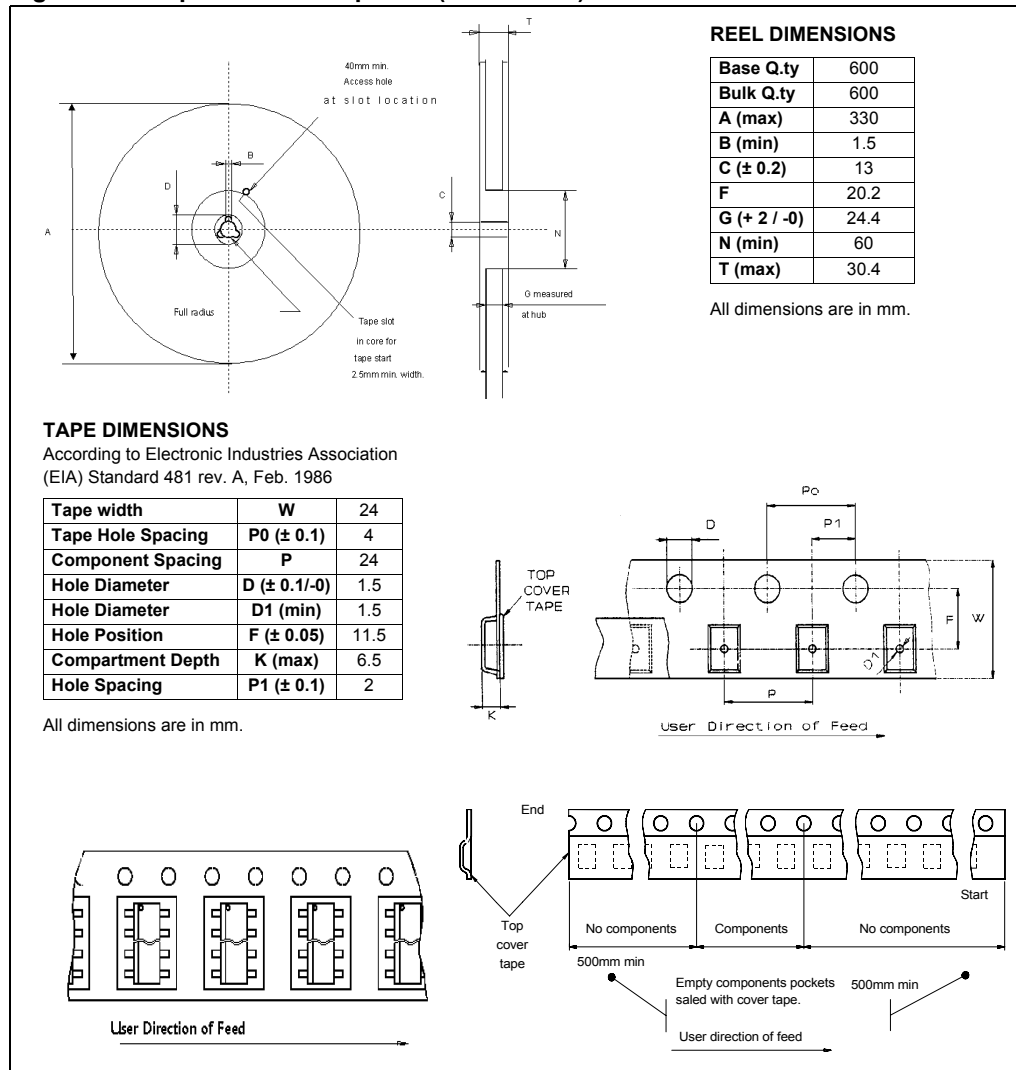


Figure 33. Tape and reel shipment (suffix “TR”)



## 6 Revision history

Table 18. Document revision history

Date	Revision	Changes
1-Oct-2004	1	Initial release.
19-Jul-2010	2	Changed <i>Features</i> list. Reformatted entire document. No content change.
25-Feb-2011	3	Updated I <sub>OUT</sub> value in <i>Features</i> list. Updated <i>Table 16: Thermal parameter</i> .

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