

## 3 mΩ reverse battery protection switch

Datasheet – production data

### Features

Max supply voltage	$V_{CC}$	-16 to 41 V
Operating voltage range	$V_{CC}$	-16 to 28 V
On-state resistance	$R_{ON}$	3 mΩ

- General
  - Optimized electromagnetic emissions
  - Very low electromagnetic susceptibility
  - Compliant with European directive 2002/95/EC
- Protections
  - Automatic switch off in case of negative input voltage
  - Electrostatic discharge protection

### Application

- Reverse battery protection of an electronic control unit



### Description

The VN5R003H-E is a device made using STMicroelectronics® VIPower® technology. It is intended for providing reverse battery protection to an electronic module.

This device has two power pins (Drain and Source) and a control pin  $\overline{IN}$ . If the  $\overline{IN}$  voltage versus Drain is negative the device is turned on.

A negative voltage of Drain pin versus  $\overline{IN}$  automatically turns off the device. When  $\overline{IN}$  is left open, device is in OFF-state and behaves like a power diode between Source and Drain pins.

Table 1. Device summary

Package	Order codes	
	Tube	Tape and reel
HPAK	VN5R003H-E	VN5R003HTR-E

# Contents

- 1      Block diagram and pin description ..... 5**
- 2      Electrical specifications ..... 7**
  - 2.1 Absolute maximum ratings ..... 7
  - 2.2 Thermal data ..... 8
  - 2.3 Electrical characteristics ..... 8
- 3      Application information ..... 11**
- 4      Package and PC board thermal data ..... 12**
  - 4.1 HPAK thermal data ..... 12
- 5      Package and packing information ..... 15**
  - 5.1 ECOPACK® ..... 15
  - 5.2 HPAK mechanical data ..... 15
  - 5.3 HPAK suggested land pattern ..... 17
  - 5.4 Packing information ..... 17
- 6      Revision history ..... 19**

## List of tables

Table 1.	Device summary . . . . .	1
Table 2.	Pin function . . . . .	5
Table 3.	Absolute maximum ratings . . . . .	7
Table 4.	Thermal data . . . . .	8
Table 5.	Power section for reverse battery mode . . . . .	8
Table 6.	Electrical transient requirements (part 1) . . . . .	9
Table 7.	Electrical transient requirements (part 2) . . . . .	9
Table 8.	Electrical transient requirements (part 3) . . . . .	9
Table 9.	Thermal parameter . . . . .	14
Table 10.	HPAK mechanical data . . . . .	16
Table 11.	Document revision history . . . . .	19

## List of figures

Figure 1.	Block diagram . . . . .	5
Figure 2.	Configuration diagram (top view) . . . . .	6
Figure 3.	Current and voltage conventions . . . . .	7
Figure 4.	Maximum pulsed drain current ( $V_{BATT} = 13\text{ V}$ ). . . . .	10
Figure 5.	Battery supplied systems . . . . .	11
Figure 6.	Switched systems . . . . .	11
Figure 7.	PC board. . . . .	12
Figure 8.	$R_{thj-amb}$ vs PCB copper area in open box free air condition. . . . .	12
Figure 9.	HPAK thermal impedance junction ambient single pulse . . . . .	13
Figure 10.	Thermal fitting model of a single-channel HSD in HPAK . . . . .	13
Figure 11.	HPAK package dimension . . . . .	15
Figure 12.	HPAK suggested pad layout. . . . .	17
Figure 13.	HPAK tube shipment (no suffix) . . . . .	17
Figure 14.	HPAK tape and reel (suffix "TR") . . . . .	18

# 1 Block diagram and pin description

Figure 1. Block diagram

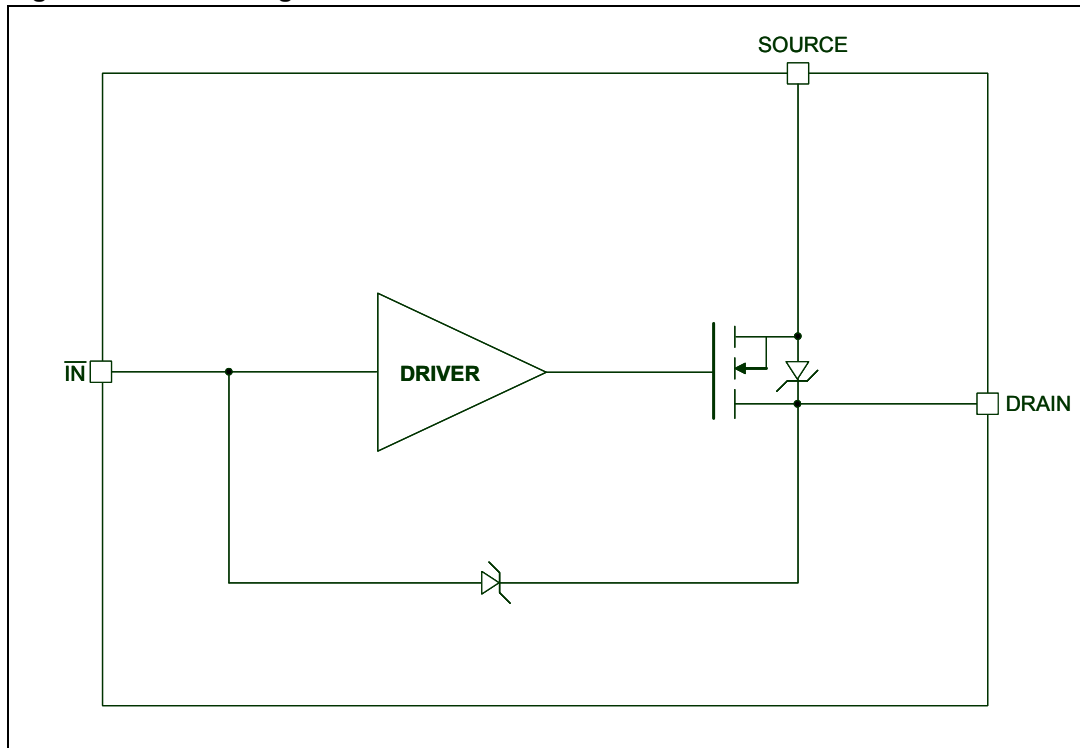
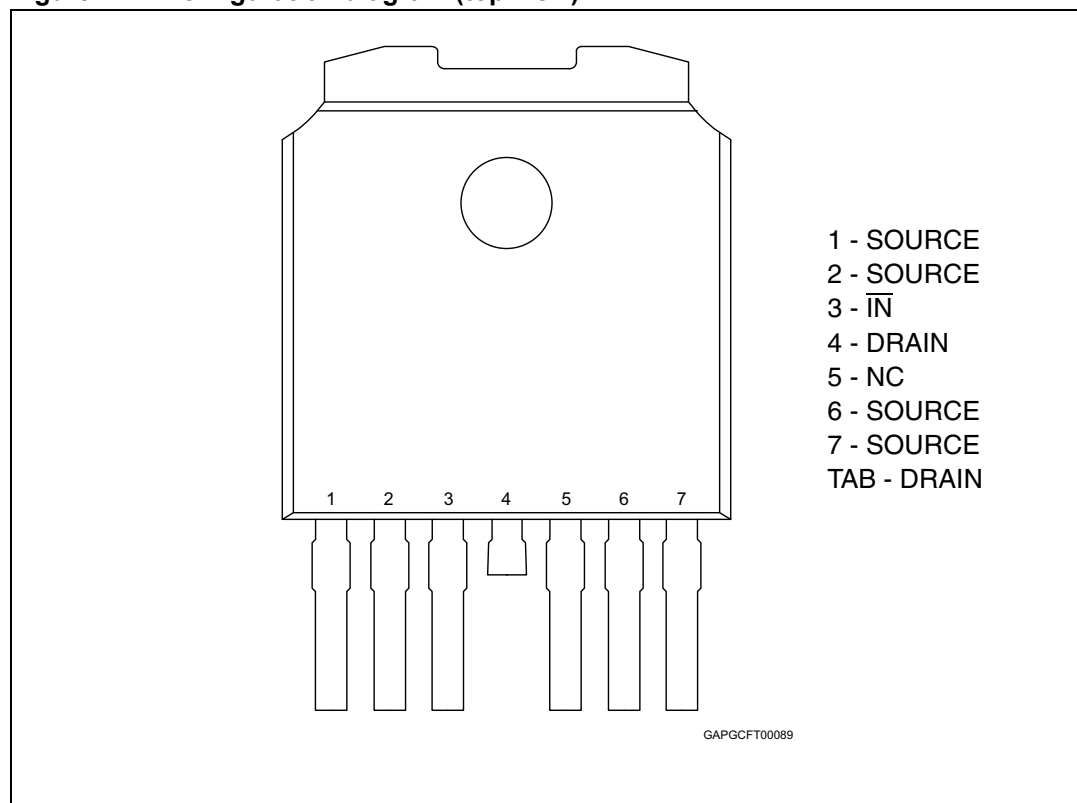


Table 2. Pin function

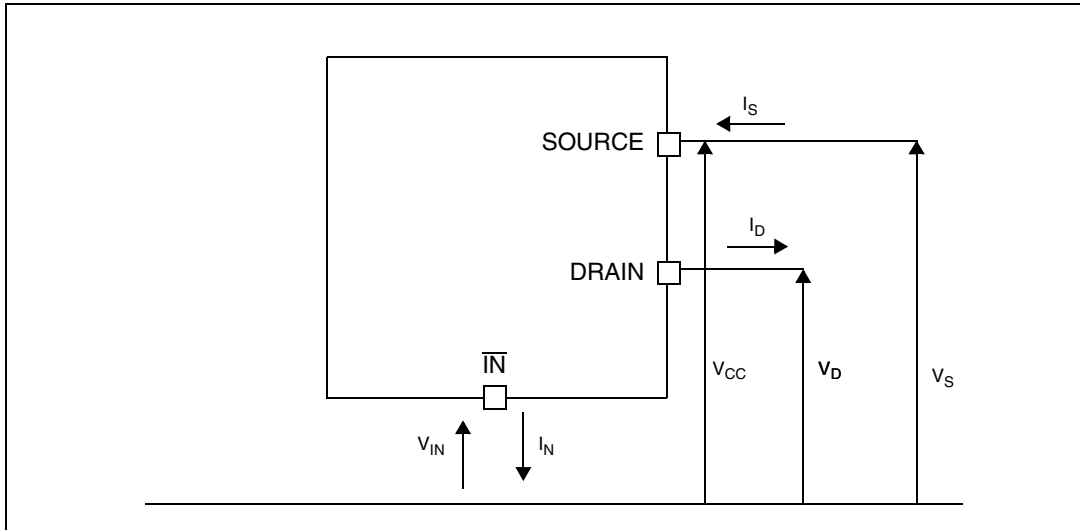
Name	Function
Drain	Power MOS drain
Source	Power MOS source
$\overline{\text{IN}}$	Control pin

Figure 2. Configuration diagram (top view)



## 2 Electrical specifications

Figure 3. Current and voltage conventions



### 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 the conditions in table below for extended periods may affect device reliability.

Table 3. Absolute maximum ratings

Symbol	Parameter	Value	Unit
$V_S$	Source power terminal DC voltage (reverse battery mode)	-16 to 41	V
$I_S, I_D$	Source or Drain current	60	A
$-I_S, -I_D$	Reverse currents	60	A
$E_{MAX}$	Inductive clamp energy $L = 2 \text{ mH}, V_D = 0 \text{ V}, \overline{IN}$ open, $I_S < 0, T_{jstart} = 25^\circ\text{C}$	0.9	J
$V_{ESD}$	Electrostatic discharge (Human Body Model: $R = 1.5 \text{ K}\Omega; C = 100 \text{ pF}$ ) - All terminals	5000	V
$V_{ESD}$	Charge device model (CDM-AEC-Q100-011)	1000	V
$T_j$	Junction 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.	Unit
$R_{thj-case}$	Thermal resistance junction-case	0.5	°C/W
$R_{thj-amb}$	Thermal resistance junction-ambient (mounted on FR4 using 6 cm <sup>2</sup> copper pad)	42	°C/W

## 2.3 Electrical characteristics

**Table 5. Power section for reverse battery mode<sup>(1)</sup>**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_S$	Operating supply voltage	—	-16	13	28	V
$V_{CLPDS}$	Drain-Source clamp voltage	$V_D = 0\text{ V}$ , $\overline{IN}$ open, $I_S = -5\text{ A}$	17		23	V
$V_{CLPDIN}$	Drain input clamp voltage	$V_{IN} = 0\text{ V}$ , $I_D = 20\text{ mA}$	41		52	V
$V_F$	Source drain voltage	$\overline{IN} = \text{open}$ , $I_S = 10\text{ A}$ ; $T_j = 25^\circ\text{C}$		0.85		V
$R_{ON}$	On state resistance between SOURCE and Drain terminals	$I_S = 10\text{ A}$ ; $T_j = 25^\circ\text{C}$ ; $8\text{ V} < V_{CC} < 28\text{ V}$		3		mΩ
		$I_S = 10\text{ A}$ ; $T_j = 150^\circ\text{C}$ ; $8\text{ V} < V_{CC} < 28\text{ V}$			5.5	
$I_{\overline{IN}}$	Input current	$V_S = 13\text{ V}$ , $V_{\overline{IN}} = 0\text{ V}$		2	3	mA
$I_{\overline{IN}(REV)}$	Reverse input current	$V_S = -16\text{ V}$ , $V_{\overline{IN}} = 0\text{ V}$	-2		0	mA
$I_{OUT\_rev}$	Output reverse current	$V_S = -16\text{ V}$ , $V_D = 0\text{ V}$ , $\overline{IN}$ open	-1.5		-0.5	mA

1. Operating conditions:  $40^\circ\text{C} < T_j < 150^\circ\text{C}$



**Table 6. Electrical transient requirements (part 1)**

ISO 7637-2: 2004(E) Test pulse	Test levels <sup>(1)</sup>		Number of pulses or test times	Burst cycle/pulse repetition time		Delays and Impedance
	III	IV		Min.	Max.	
1 <sup>(2)</sup>	-75 V	-100 V	5000 pulses	0.5 s	5 s	2 ms, 10 Ω
2a	+37 V	+50 V	5000 pulses	0.2 s	5 s	50 μs, 2 Ω
3a	-100 V	-150 V	1h	90 ms	100 ms	0.1 μs, 50 Ω
3b	+75 V	+100 V	1h	90 ms	100 ms	0.1 μs, 50 Ω
4	-6 V	-7 V	1 pulse	—		100 ms, 0.01 Ω
5b <sup>(3)</sup>	+65 V	+87 V	1 pulse	—		400 ms, 2 Ω

1. The above test levels must be considered referred to  $V_{CC} = 13.5$  V except for pulse 5b.
2. The device does not turn Off once the ISO pulse is applied.
3. Valid in case of external load dump clamp: 40 V maximum referred to ground.

**Table 7. Electrical transient requirements (part 2)**

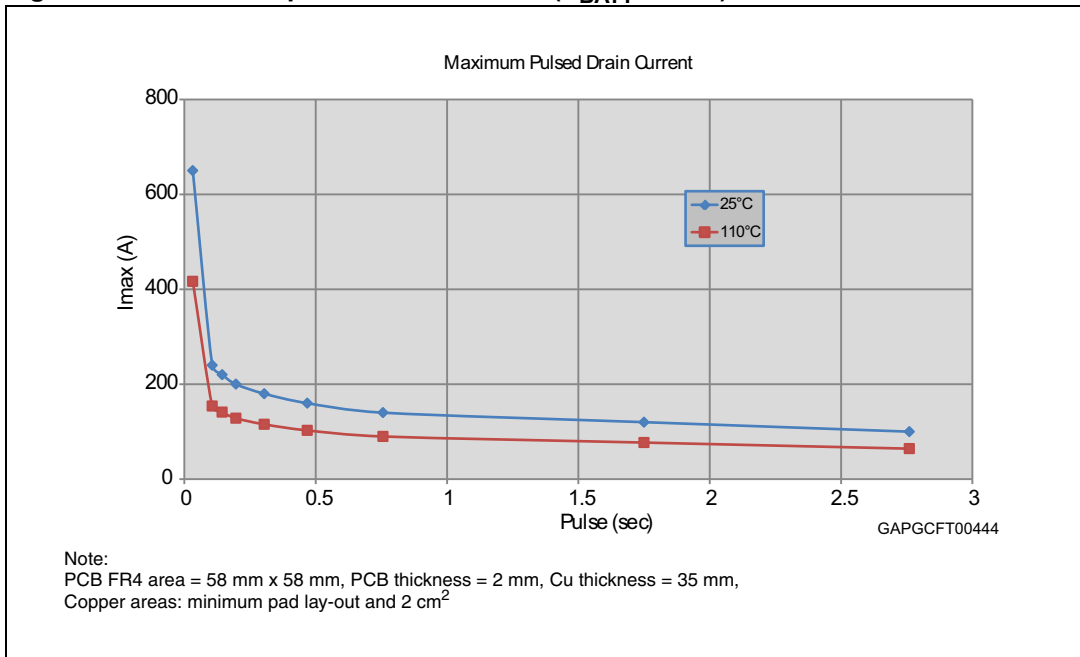
ISO 7637-2: 2004(E) Test pulse	Test level results <sup>(1)</sup>	
	III	IV
1	C	C
2a	C	C
3a	C	C
3b	C	C
4	C	C
5b <sup>(2)</sup>	C	C

1. Transient pulses have been applied with the INPUT pin grounded with  $R1 > 5\Omega$ .
2. Valid in case of external load dump clamp: 40V maximum referred to ground.

**Table 8. Electrical transient requirements (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 are not performed as designed after exposure to disturbance and cannot be returned to proper operation without replacing the device.

Figure 4. Maximum pulsed drain current ( $V_{BATT} = 13\text{ V}$ )



### 3 Application information

Figure 5 shows the solution for systems supplied directly from the battery. If the system goes into *Stand-by* mode, the transistor T1 is switched off by the microcontroller with zero quiescent current. System is still supplied through the PowerMOS body diode.

**Figure 5. Battery supplied systems**

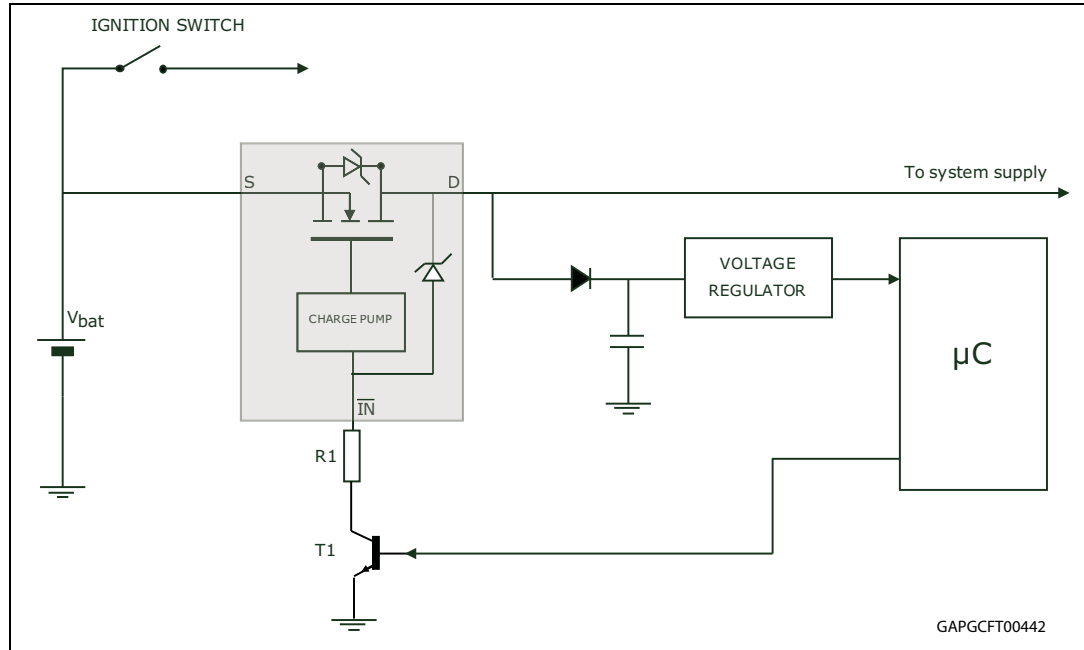
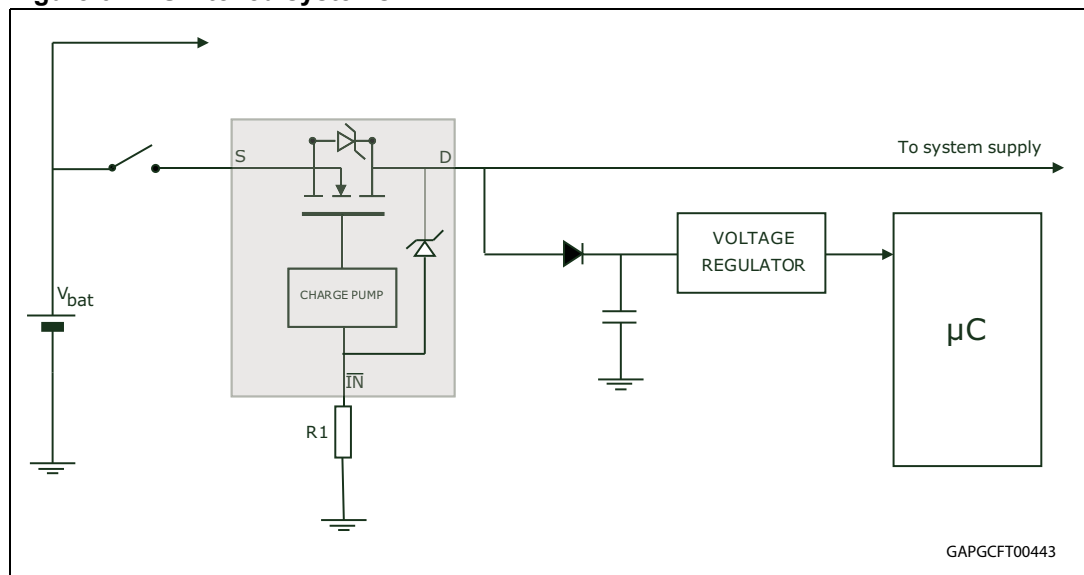


Figure 6 refers to a solution for systems supplied after the ignition switch. Low quiescent currents are not strictly required, so resistor R1 can be directly connected to ground.

**Figure 6. Switched systems**



## 4 Package and PC board thermal data

### 4.1 HPAK thermal data

Figure 7. PC board

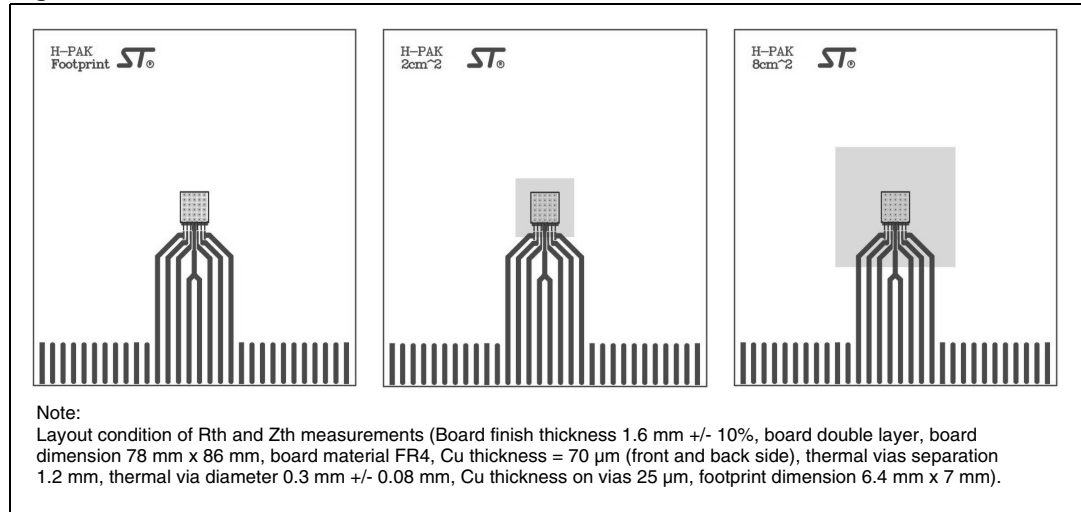


Figure 8.  $R_{thj-amb}$  vs PCB copper area in open box free air condition

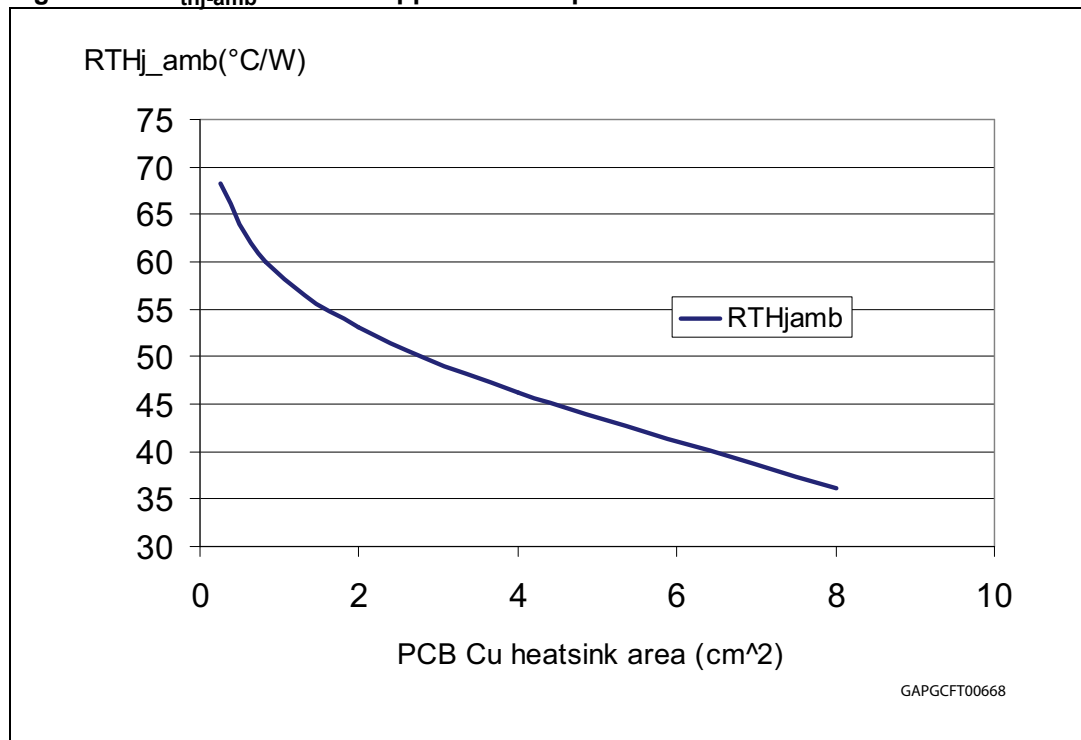


Figure 9. HPAK thermal impedance junction ambient single pulse

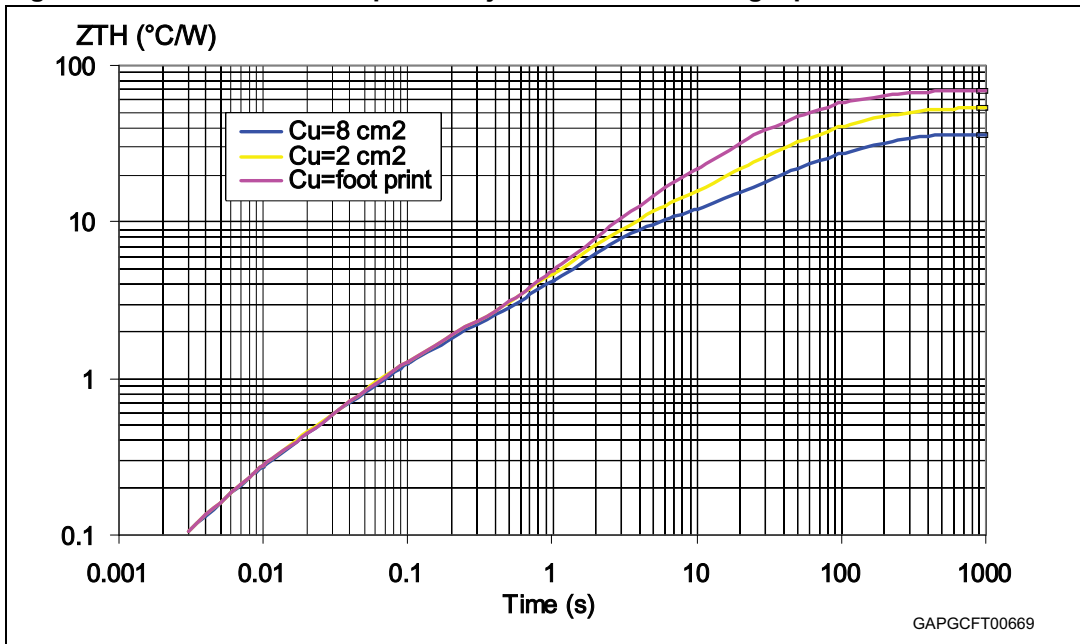
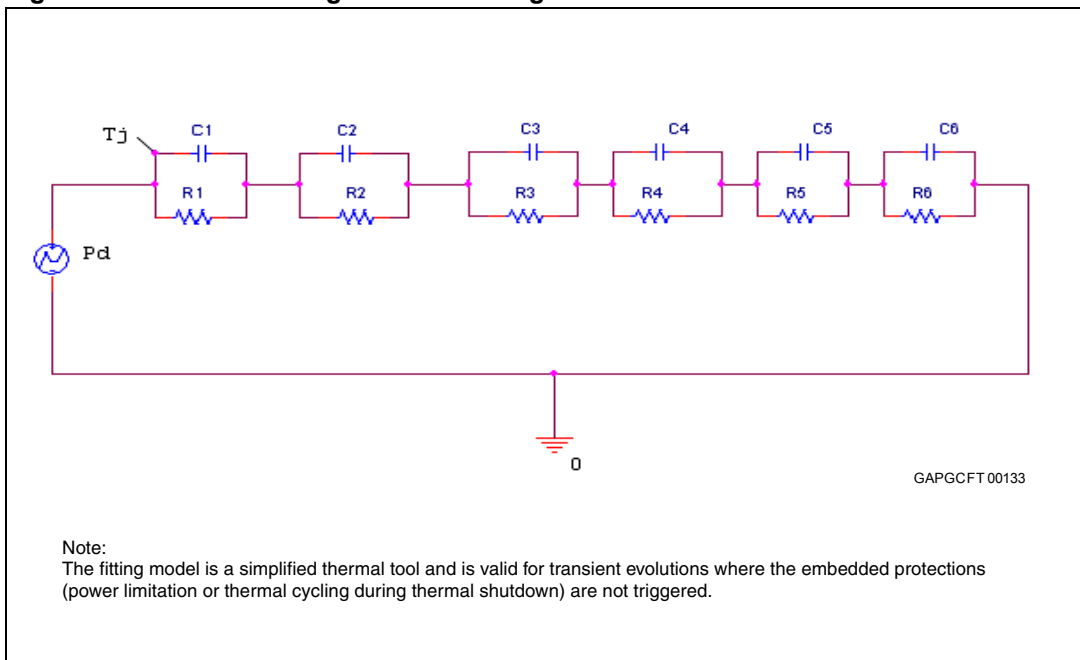


Figure 10. Thermal fitting model of a single-channel HSD in HPAK



**Equation 1: pulse calculation formula**

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

where  $\delta = t_p/T$

**Table 9. Thermal parameter**

Area/island (cm <sup>2</sup> )	Footprint	4	8
R1 (°C/W)	0.01		
R2 (°C/W)	0.15		
R3 (°C/W)	1		
R4 (°C/W)	8		
R5 (°C/W)	28	21	12
R6 (°C/W)	31	24	16
C1 (W.s/°C)	0.005		
C2 (W.s/°C)	0.05		
C3 (W.s/°C)	0.08		
C4 (W.s/°C)	0.4		
C5 (W.s/°C)	0.8	1.4	3
C6 (W.s/°C)	3	6	9

## 5 Package and packing information

### 5.1 ECOPACK®

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

### 5.2 HPAK mechanical data

Figure 11. HPAK package dimension

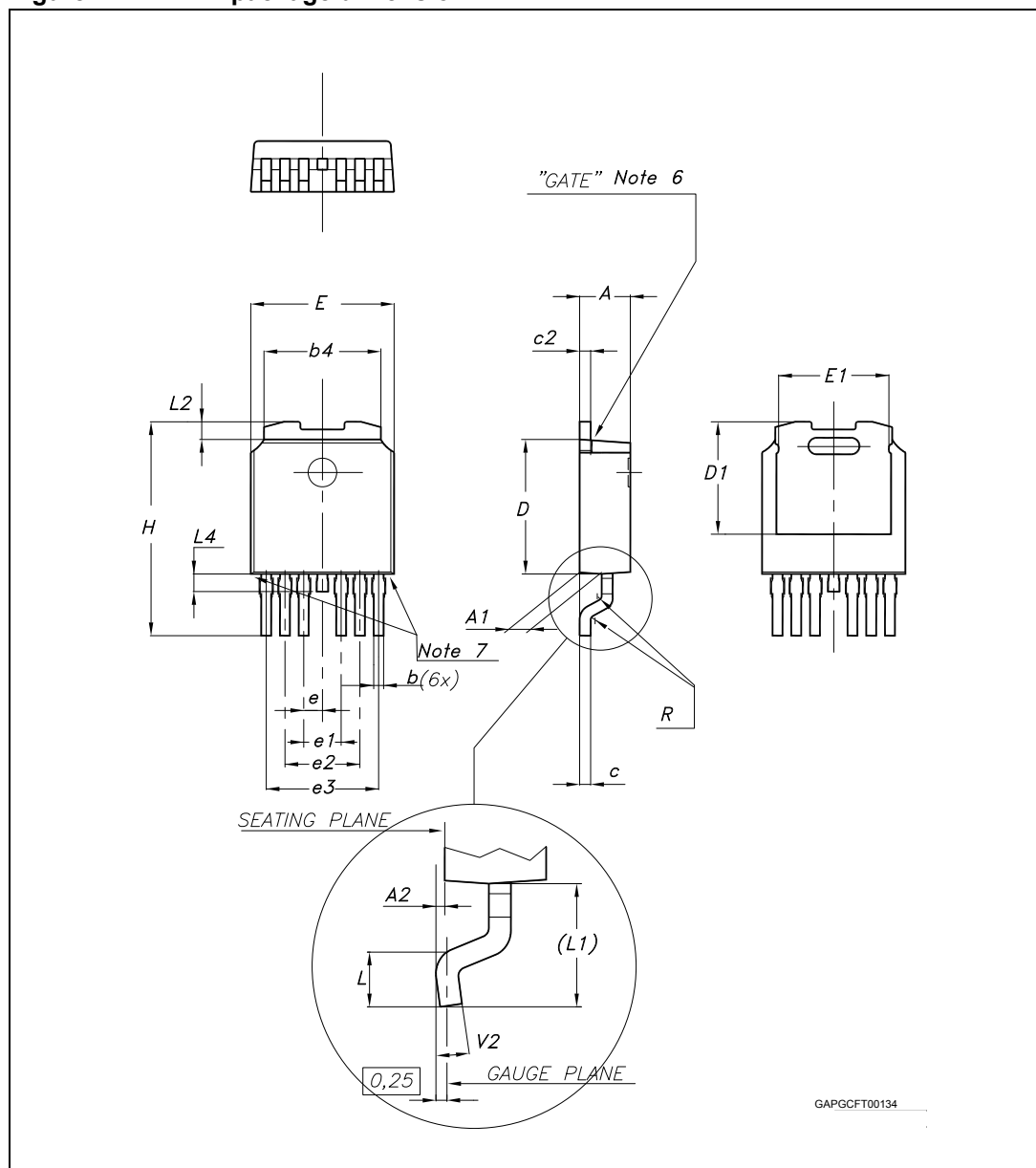


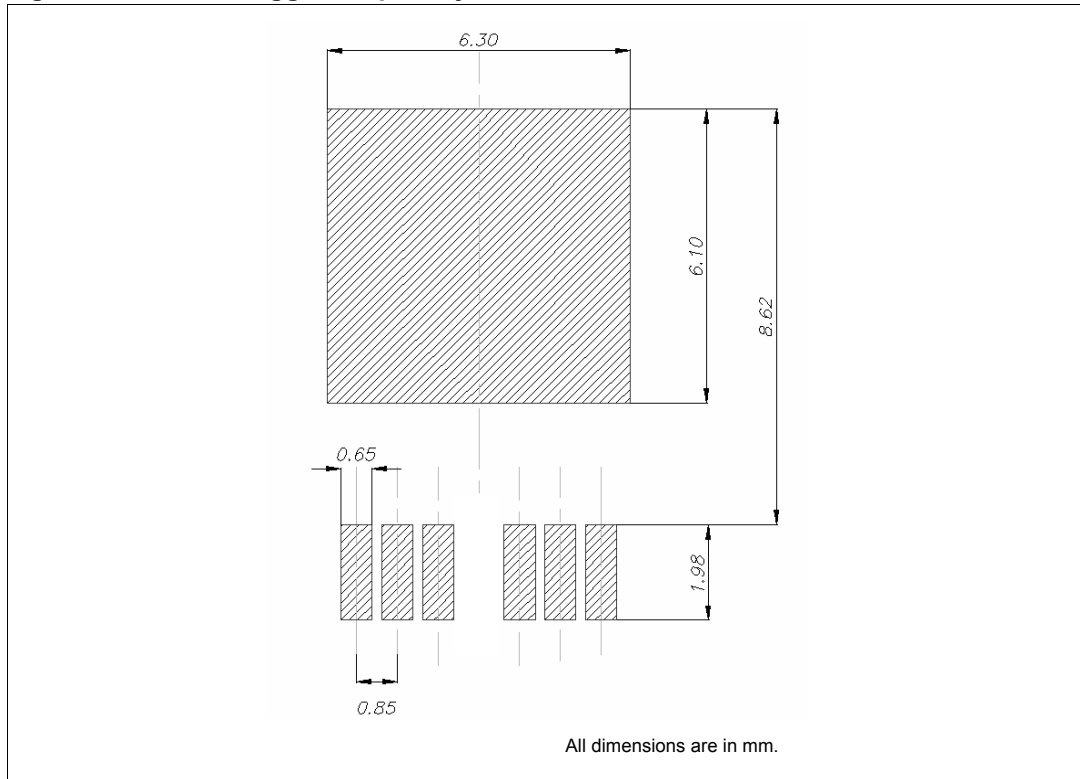
Table 10. HPAK mechanical data

Ref. dim	Data book mm		
	Typ	Min.	Max.
A	—	2.20	2.40
A1	—	0.90	1.10
A2	—	0.03	0.23
b	—	0.45	0.60
b4	—	5.20	5.40
c	—	0.45	0.60
c2	—	0.48	0.60
D	—	6.00	6.20
D1	5.10	—	—
E	—	6.40	6.60
E1	5.20	—	—
e	0.85	—	—
e1	—	1.60	1.80
e2	—	3.30	3.50
e3	—	5.00	5.20
H	—	9.35	10.10
L	—	1	—
(L1)	2.80	—	—
L2	0.80	—	—
L4	—	0.60	1.00
R	0.20	—	—
V2	—	0°	8°



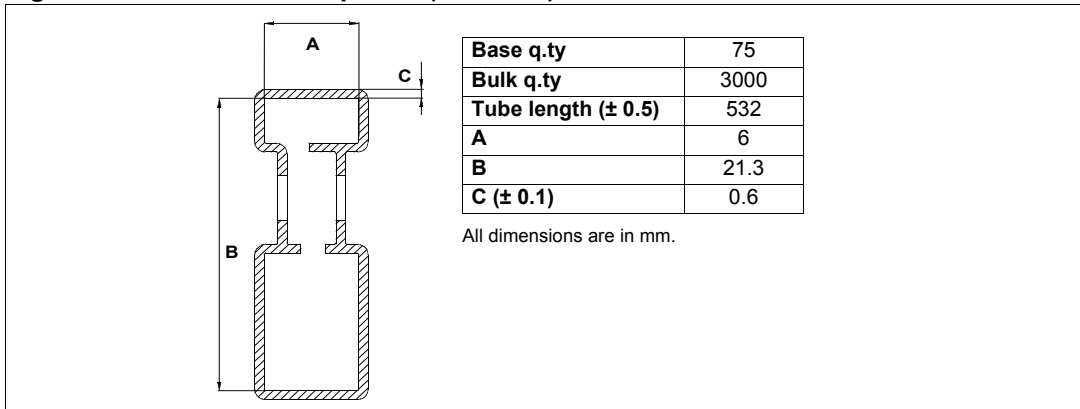
### 5.3 HPAK suggested land pattern

Figure 12. HPAK suggested pad layout<sup>(a)</sup>



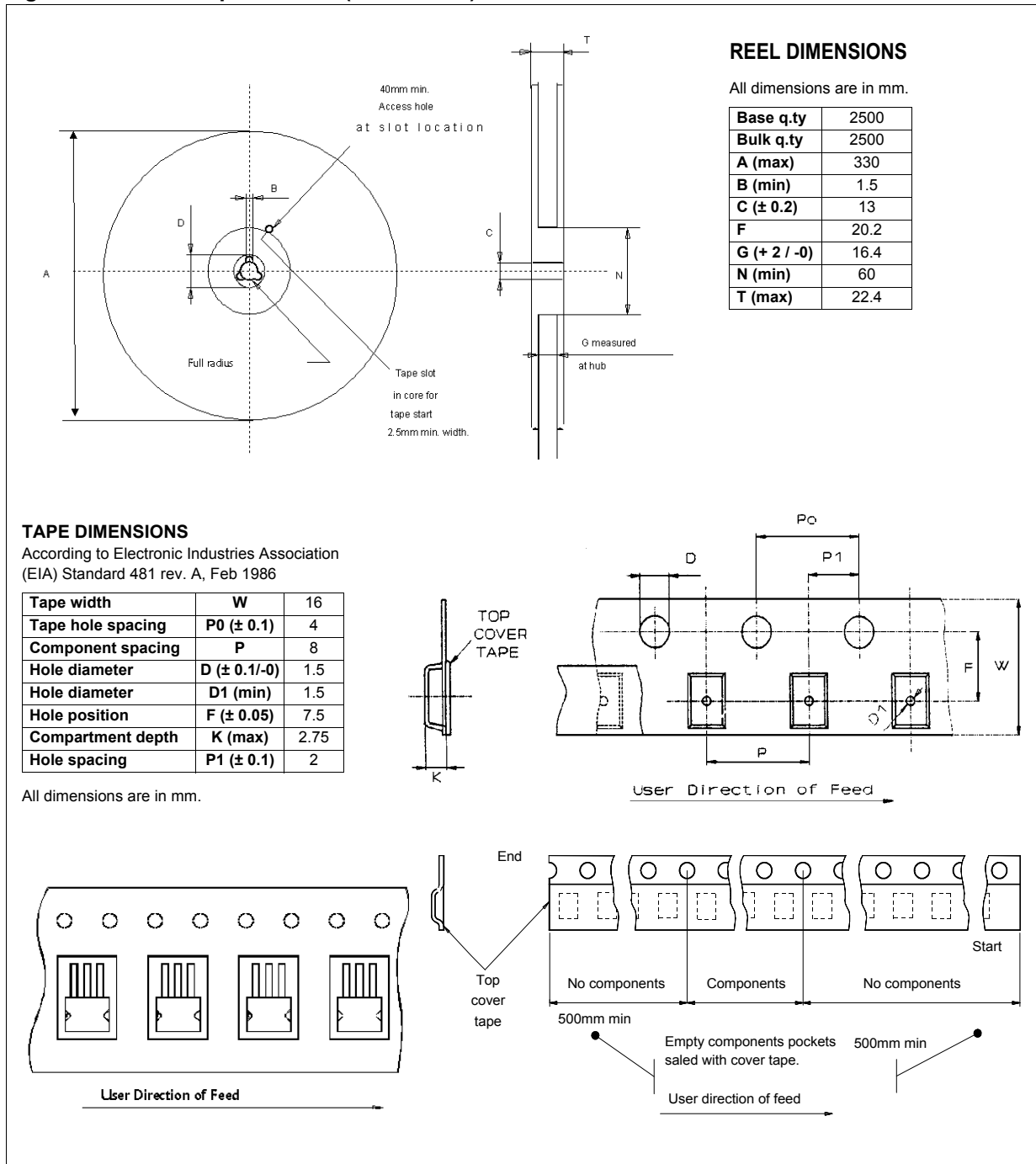
### 5.4 Packing information

Figure 13. HPAK tube shipment (no suffix)



a. The land pattern proposed is not intended to over-rule User's PCB design, manufacturing and soldering process rules

Figure 14. HPAK tape and reel (suffix "TR")



## 6 Revision history

Table 11. Document revision history

Date	Revision	Changes
23-Jun-2010	1	Initial release.
06-Jul-2010	2	Updated <a href="#">Table 4: Thermal data</a> .
06-Oct-2010	3	Added <a href="#">Figure 4: Maximum pulsed drain current (<math>V_{BATT} = 13\text{ V}</math>)</a>
18-Nov-2010	4	<p>Changed document status from target specification to datasheet.</p> <p><a href="#">Table 3: Absolute maximum ratings</a>:</p> <ul style="list-style-type: none"> <li>– Removed <math>V_D</math> row</li> </ul> <p><a href="#">Table 5: Power section for reverse battery mode</a></p> <ul style="list-style-type: none"> <li>– <math>I_{IN}</math>: added maximum value</li> </ul> <p><a href="#">Table 6: Electrical transient requirements (part 1)</a></p> <ul style="list-style-type: none"> <li>– Added <a href="#">Note 2</a></li> </ul> <p>Updated <a href="#">Figure 5: Battery supplied systems</a> and <a href="#">Figure 6: Switched systems</a></p>
17-Apr-2012	5	Updated <a href="#">Figure 4: Maximum pulsed drain current (<math>V_{BATT} = 13\text{ V}</math>)</a>
19-Sep-2013	6	Updated Disclaimer

**Please Read Carefully:**

Information in this document is provided solely in connection with ST products. STMicroelectronics NV and its subsidiaries ("ST") reserve the right to make changes, corrections, modifications or improvements, to this document, and the products and services described herein at any time, without notice.

All ST products are sold pursuant to ST's terms and conditions of sale.

Purchasers are solely responsible for the choice, selection and use of the ST products and services described herein, and ST assumes no liability whatsoever relating to the choice, selection or use of the ST products and services described herein.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted under this document. If any part of this document refers to any third party products or services it shall not be deemed a license grant by ST for the use of such third party products or services, or any intellectual property contained therein or considered as a warranty covering the use in any manner whatsoever of such third party products or services or any intellectual property contained therein.

**UNLESS OTHERWISE SET FORTH IN ST'S TERMS AND CONDITIONS OF SALE ST DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY WITH RESPECT TO THE USE AND/OR SALE OF ST PRODUCTS INCLUDING WITHOUT LIMITATION IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION), OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.**

**ST PRODUCTS ARE NOT DESIGNED OR AUTHORIZED FOR USE IN: (A) SAFETY CRITICAL APPLICATIONS SUCH AS LIFE SUPPORTING, ACTIVE IMPLANTED DEVICES OR SYSTEMS WITH PRODUCT FUNCTIONAL SAFETY REQUIREMENTS; (B) AERONAUTIC APPLICATIONS; (C) AUTOMOTIVE APPLICATIONS OR ENVIRONMENTS, AND/OR (D) AEROSPACE APPLICATIONS OR ENVIRONMENTS. WHERE ST PRODUCTS ARE NOT DESIGNED FOR SUCH USE, THE PURCHASER SHALL USE PRODUCTS AT PURCHASER'S SOLE RISK, EVEN IF ST HAS BEEN INFORMED IN WRITING OF SUCH USAGE, UNLESS A PRODUCT IS EXPRESSLY DESIGNATED BY ST AS BEING INTENDED FOR "AUTOMOTIVE, AUTOMOTIVE SAFETY OR MEDICAL" INDUSTRY DOMAINS ACCORDING TO ST PRODUCT DESIGN SPECIFICATIONS. PRODUCTS FORMALLY ESCC, QML OR JAN QUALIFIED ARE DEEMED SUITABLE FOR USE IN AEROSPACE BY THE CORRESPONDING GOVERNMENTAL AGENCY.**

Resale of ST products with provisions different from the statements and/or technical features set forth in this document shall immediately void any warranty granted by ST for the ST product or service described herein and shall not create or extend in any manner whatsoever, any liability of ST.

ST and the ST logo are trademarks or registered trademarks of ST in various countries.

Information in this document supersedes and replaces all information previously supplied.

The ST logo is a registered trademark of STMicroelectronics. All other names are the property of their respective owners.

© 2013 STMicroelectronics - All rights reserved

STMicroelectronics group of companies

Australia - Belgium - Brazil - Canada - China - Czech Republic - Finland - France - Germany - Hong Kong - India - Israel - Italy - Japan - Malaysia - Malta - Morocco - Philippines - Singapore - Spain - Sweden - Switzerland - United Kingdom - United States of America

[www.st.com](http://www.st.com)