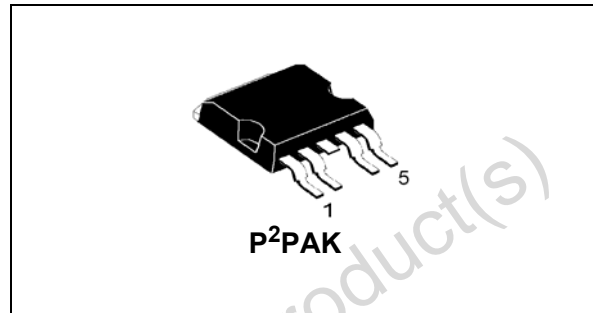


## Single-channel high-side solid state relay

### Features

Type	R <sub>DS(on)</sub>	I <sub>OUT</sub>	V <sub>CC</sub>
VN920-B5H	18 mΩ	30 A	36 V

- CMOS compatible input
- Proportional load current sense
- Shorted load protection
- Under voltage and overvoltage shutdown
- Overvoltage clamp
- Thermal shutdown
- Current limitation
- Protection against loss of ground and loss of V<sub>CC</sub>
- Very low standby power dissipation
- Reverse battery protected (see [Figure 19: Application schematic](#))



### Description

The VN920-B5H is a monolithic device made by using STMicroelectronics VIPower™ M0-3 technology, intended for driving any kind of load with one side connected to ground. Active V<sub>CC</sub> pin voltage clamp protects the device against low energy spikes (see ISO7637 transient compatibility able).

Active current limitation combined with thermal shutdown and automatic restart protect the device against overload. The device integrates an analog current sense output which delivers a current proportional to the load current. Device automatically turns off in case of ground pin disconnection.

**Table 1. Device summary**

Package	Order codes	
	Tube	Tape and reel
P <sup>2</sup> PAK	VN920-B5H	VN920-B5H13TR

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# 1 Block diagram and pin description

Figure 1. Block diagram

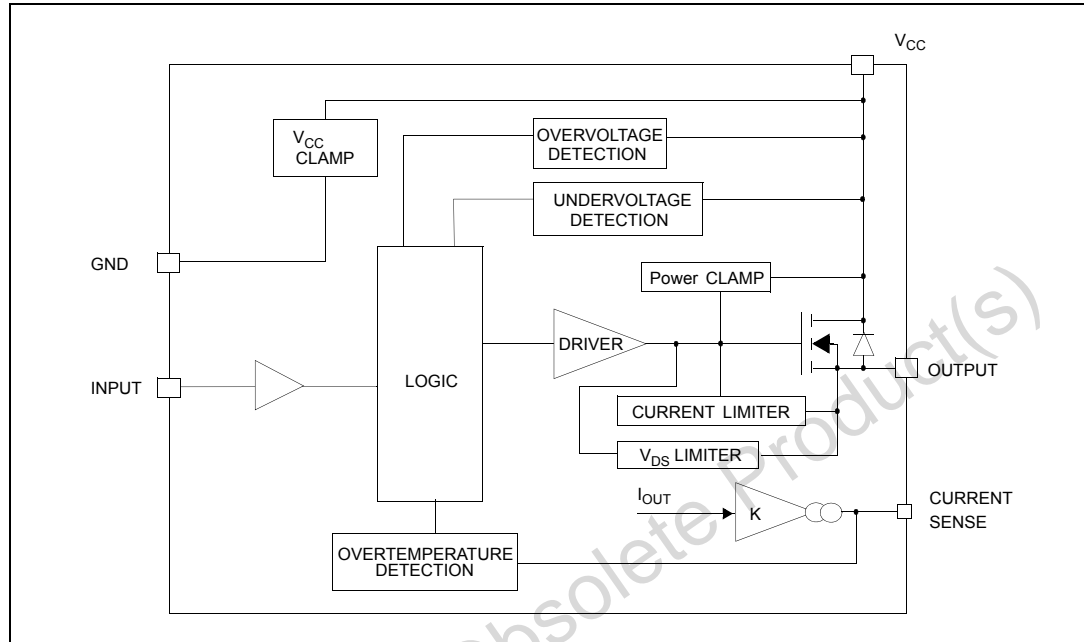


Figure 2. Configuration diagram (top view)

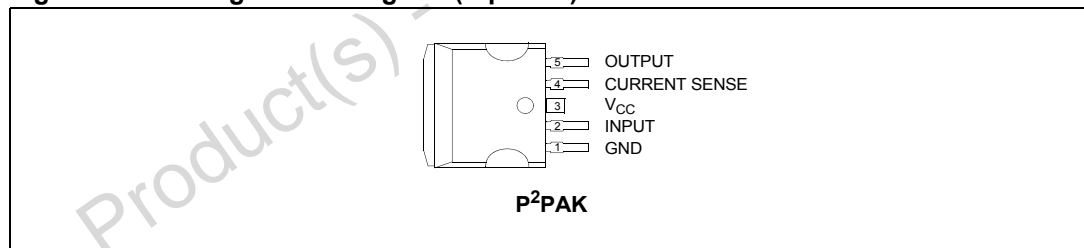
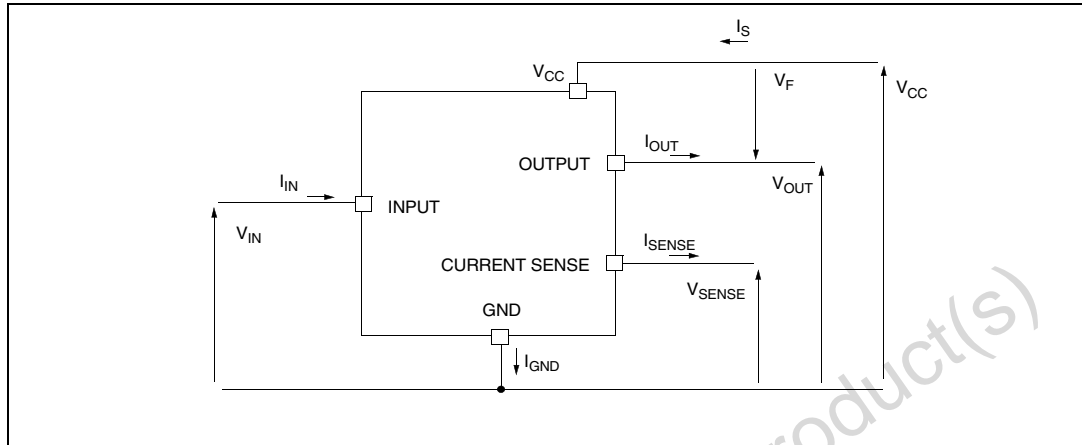


Table 2. Suggested connections for unused and not connected pins

Connection / pin	Current Sense	N.C.	Output	Input
Floating		X	X	X
To ground	Through 1 KΩ resistor	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 “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
$V_{CC}$	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 + 15	V V
$V_{ESD}$	Electrostatic discharge (human body model: $R = 1.5K\Omega$ ; $C = 100pF$ )		
	– Input	4000	V
	– Current sense	2000	V
	– Output	5000	V
	– $V_{CC}$	5000	V

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

Symbol	Parameter	Value	Unit
$E_{MAX}$	Maximum switching energy ( $L = 0.25\text{mH}$ ; $R_L = 0\Omega$ ; $V_{bat} = 13.5\text{V}$ ; $T_{jstart} = 150^\circ\text{C}$ ; $I_L = 45\text{A}$ )	364	mJ
$P_{tot}$	Power dissipation $T_C \leq 25^\circ\text{C}$	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
$R_{thj-case}$	Thermal resistance junction-case (max)	1.3	$^\circ\text{C/W}$
$R_{thj-amb}$	Thermal resistance junction-ambient (max)	51.3 <sup>(1)</sup>	$^\circ\text{C/W}$
		61.3 <sup>(2)</sup>	$^\circ\text{C/W}$

1. When mounted on a standard single-sided FR-4 board with  $0.5\text{cm}^2$  of Cu (at least  $35\mu\text{m}$  thick).
2. When mounted on a standard single-sided FR-4 board with  $6\text{cm}^2$  of Cu (at least  $35\mu\text{m}$  thick).

## 2.3 Electrical characteristics

Values specified in this section are for  $8\text{V} < V_{CC} < 36\text{V}$ ;  $-40^\circ\text{C} < T_j < 150^\circ\text{C}$ , 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
$V_{OV}$	Overvoltage shutdown		36			V
$R_{ON}$	On-state resistance	$I_{OUT} = 10\text{A}$ ; $T_j = 25^\circ\text{C}$ ;			18	m $\Omega$
		$I_{OUT} = 10\text{A}$ ;			32	m $\Omega$
		$I_{OUT} = 3\text{A}$ ; $V_{CC} = 6\text{V}$			55	m $\Omega$
$V_{CLAMP}$	Clamp voltage	$I_{CC} = 20\text{mA}^{(1)}$	41	48	55	V

**Table 5. Power (continued)**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_S$	Supply current	Off-state; $V_{CC} = 13V$ ; $V_{IN} = V_{OUT} = 0V$		10	25	$\mu A$
		Off-state; $V_{CC} = 13V$ ; $V_{IN} = V_{OUT} = 0V$ ; $T_j = 25^\circ C$		10	20	$\mu A$
		On-state; $V_{CC} = 13V$ ; $V_{IN} = 5V$ ; $I_{OUT} = 0A$ ; $R_{SENSE} = 3.9 k\Omega$				5
$I_{L(off1)}$	Off-state output current	$V_{IN} = V_{OUT} = 0V$	0		50	$\mu A$
$I_{L(off2)}$	Off-state output current	$V_{IN} = 0$ ; $V_{OUT} = 3.5V$	-75		0	$\mu A$
$I_{L(off3)}$	Off-state output current	$V_{IN} = V_{OUT} = 0V$ ; $V_{CC} = 13V$ ; $T_j = 125^\circ C$			5	$\mu A$
$I_{L(off4)}$	Off-state output current	$V_{IN} = V_{OUT} = 0V$ ; $V_{CC} = 13V$ ; $T_j = 25^\circ C$			3	$\mu A$

1.  $V_{clamp}$  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 5</a> )	-	50	-	$\mu s$
$t_{d(off)}$	Turn-off delay time	$R_L = 1.3\Omega$ (see <a href="#">Figure 5</a> )	-	50	-	$\mu s$
$dV_{OUT}/dt_{(on)}$	Turn-on voltage slope	$R_L = 1.3\Omega$ (see <a href="#">Figure 5</a> )	-	See <a href="#">Figure 15</a>	-	V/ $\mu s$
$dV_{OUT}/dt_{(off)}$	Turn-off voltage slope	$R_L = 1.3\Omega$ (see <a href="#">Figure 5</a> )	-	See <a href="#">Figure 16</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	$I_{IN} = 1mA$	6	6.8	8	V
		$I_{IN} = -1mA$		-0.7		V



Table 8. Current sense (9 V ≤ V<sub>CC</sub> ≤ 16 V)<sup>(1)</sup>

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
K <sub>1</sub>	I <sub>OUT</sub> /I <sub>SENSE</sub>	I <sub>OUT</sub> = 1A; V <sub>SENSE</sub> = 0.5V; T <sub>j</sub> = -40 °C to 150 °C	3300	4400	6000	
dK <sub>1</sub> /K <sub>1</sub>	Current sense ratio drift	I <sub>OUT</sub> = 1A; V <sub>SENSE</sub> = 0.5V; T <sub>j</sub> = -40 °C to 150 °C	-10		+10	%
K <sub>2</sub>	I <sub>OUT</sub> /I <sub>SENSE</sub>	I <sub>OUT</sub> = 10A; V <sub>SENSE</sub> = 4V; T <sub>j</sub> = -40°C T <sub>j</sub> = 25°C to 150°C	4200 4400	4900 4900	6700 6700	
dK <sub>2</sub> /K <sub>2</sub>	Current sense ratio drift	I <sub>OUT</sub> = 10A; V <sub>SENSE</sub> = 4V; T <sub>j</sub> = -40°C to 150°C	-8		+8	%
K <sub>3</sub>	I <sub>OUT</sub> /I <sub>SENSE</sub>	I <sub>OUT</sub> = 30A; V <sub>SENSE</sub> = 4V; T <sub>j</sub> = -40°C T <sub>j</sub> = 25°C to 150°C	4200 4400	4900 4900	6700 6700	
dK <sub>3</sub> /K <sub>3</sub>	Current sense ratio drift	I <sub>OUT</sub> = 30A; V <sub>SENSE</sub> = 4V; T <sub>j</sub> = -40°C to 150°C	-6		+6	%
I <sub>SENSE0</sub>	Analog sense leakage current	V <sub>CC</sub> = 6V to 16V; I <sub>OUT</sub> = 0A; V <sub>SENSE</sub> = 0V; T <sub>j</sub> = -40°C to 150°C	0		10	μA
V <sub>SENSE</sub>	Max analog sense output voltage	V <sub>CC</sub> = 5.5V; I <sub>OUT</sub> = 5A; R <sub>SENSE</sub> = 10kΩ V <sub>CC</sub> > 8V, I <sub>OUT</sub> = 10A; R <sub>SENSE</sub> = 10kΩ	2 4			V V
V <sub>SENSEH</sub>	Sense voltage in overtemperature condition	V <sub>CC</sub> = 13V; R <sub>SENSE</sub> = 3.9kΩ		5.5		V
R <sub>VSENSEH</sub>	Analog sense output impedance in overtemperature condition	V <sub>CC</sub> = 13V; T <sub>j</sub> > T <sub>TSD</sub> ; output open		400		Ω
t <sub>DSENSE</sub>	Current sense delay response	To 90% I <sub>SENSE</sub> <sup>(2)</sup>			500	μs

1. See [Figure 4](#).

2. Current sense signal delay after positive input slope.

**Table 9. Protections<sup>(1)</sup>**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
T <sub>TSD</sub>	Shutdown temperature		150	175	200	°C
T <sub>R</sub>	Reset temperature		135			°C
T <sub>hyst</sub>	Thermal hysteresis		7	15		°C
I <sub>lim</sub>	DC short circuit current	V <sub>CC</sub> = 13V 5V < V <sub>CC</sub> < 36V	30	45	75 75	A A
V <sub>demag</sub>	Turn-off output clamp voltage	I <sub>OUT</sub> = 2A; V <sub>IN</sub> = 0V; L = 6mH	V <sub>CC</sub> - 41	V <sub>CC</sub> - 48	V <sub>CC</sub> - 55	V
V <sub>ON</sub>	Output voltage drop limitation	I <sub>OUT</sub> = 1 A; T <sub>J</sub> = -40°C to 150°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 10. V<sub>CC</sub> output diode**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V <sub>F</sub>	Forward on voltage	- I <sub>OUT</sub> = 5A; T <sub>J</sub> = 150°C	-	-	0.6	V

**Figure 4. I<sub>OUT</sub>/I<sub>SENSE</sub> versus I<sub>OUT</sub>**

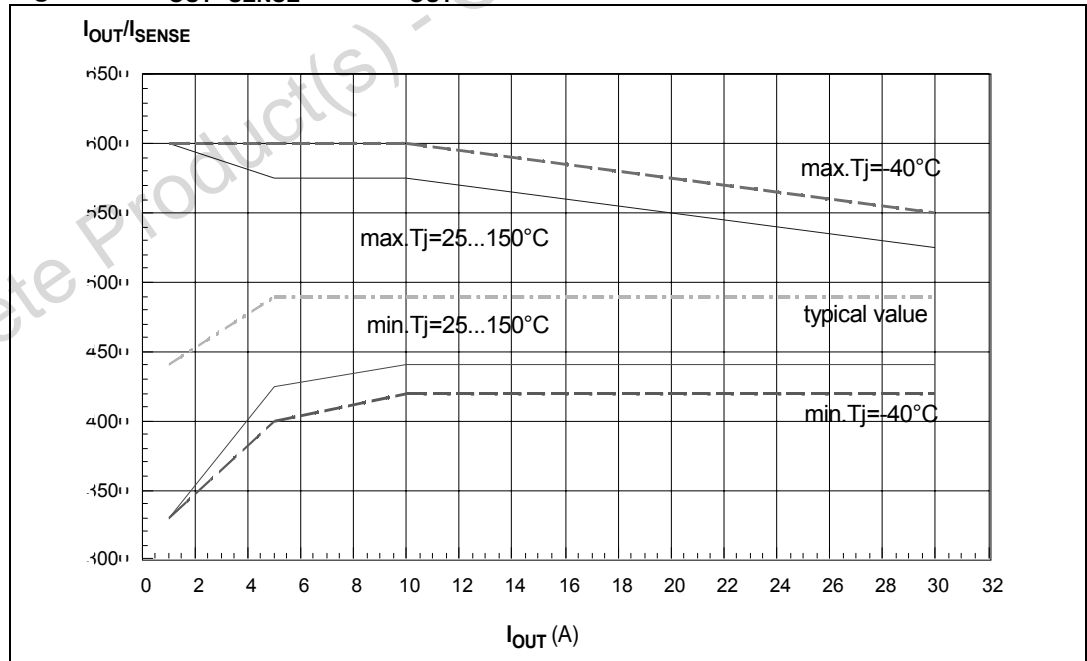


Figure 5. Switching characteristics (resistive load  $R_L = 1.3 \Omega$ )

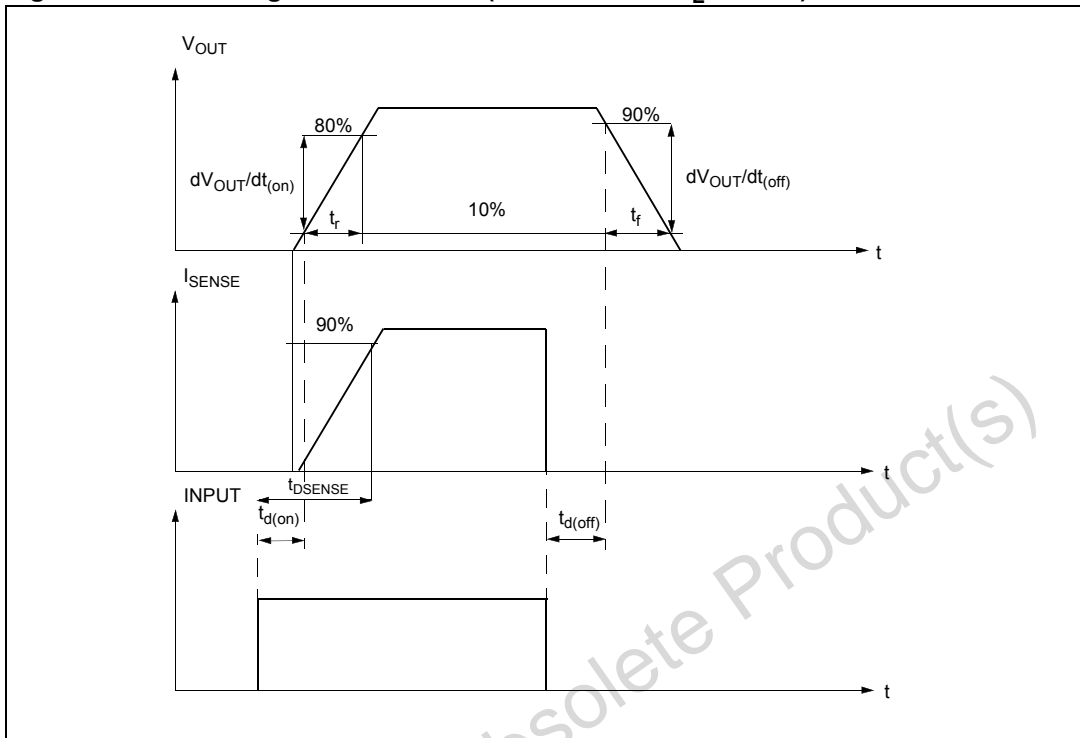


Table 11. Truth table

Conditions	Input	Output	Sense
Normal operation	L	L	0
	H	H	Nominal
Overtemperature	L	L	0
	H	L	$V_{SENSEH}$
Undervoltage	L	L	0
	H	L	0
Overvoltage	L	L	0
	H	L	0
Short circuit to GND	L	L	0
	H	L	$(T_j < T_{TSD}) 0$ $(T_j > T_{TSD}) V_{SENSEH}$
Short circuit to $V_{CC}$	L	H	0
	H	H	< Nominal
Negative output voltage clamp	L	L	0

**Table 12. Electrical transient requirements (part 1/3)**

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

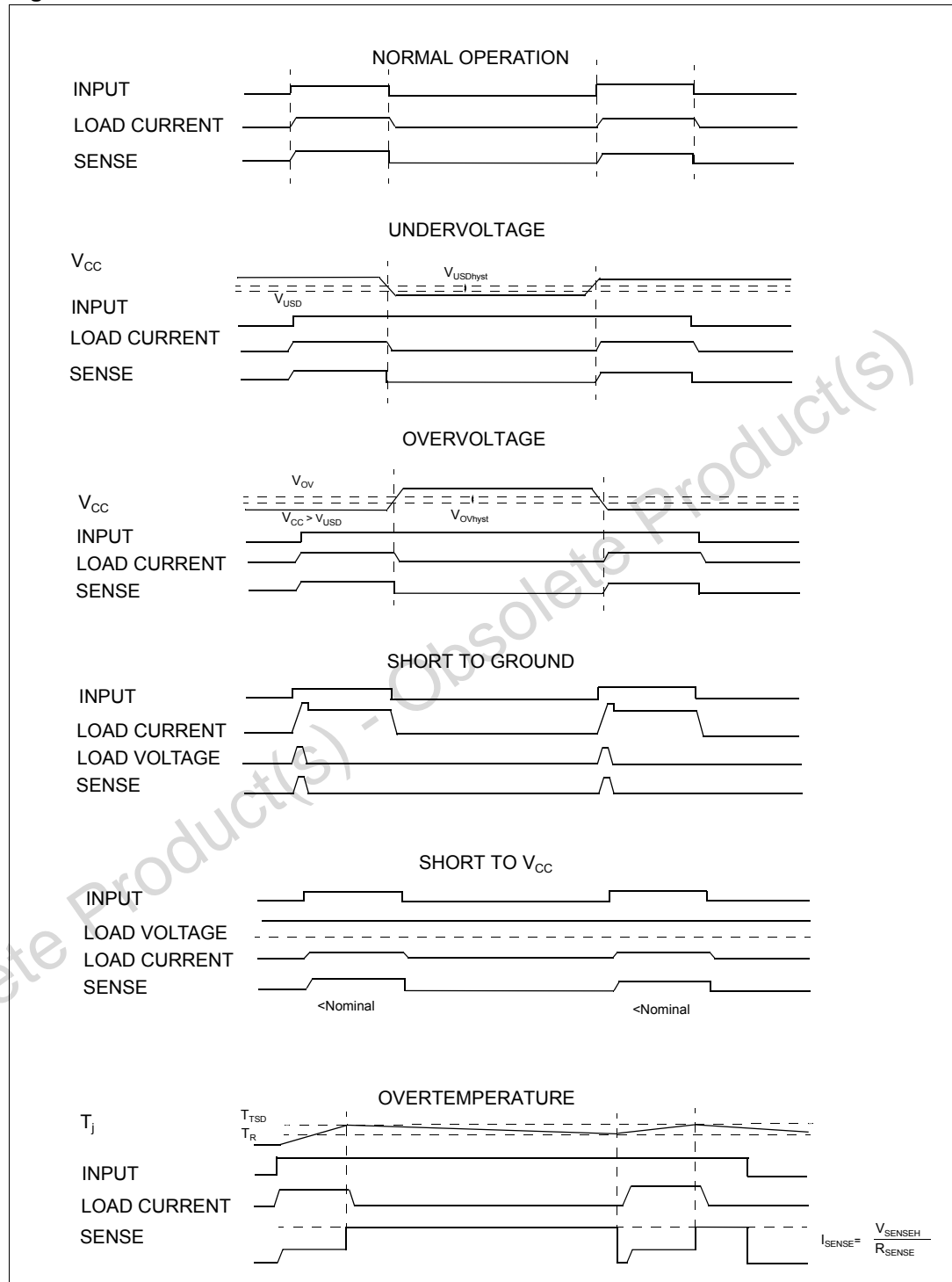
**Table 13. Electrical transient requirements (part 2/3)**

ISO T/R 7637/1 Test pulse	Test level 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 14. Electrical transient requirements (part 3/3)**

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 6. Waveforms



## 2.4 Electrical characteristics curves

Figure 7. Off-state output current

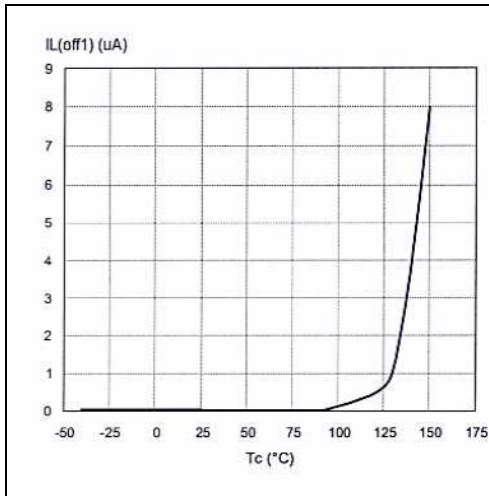


Figure 8. High-level input current

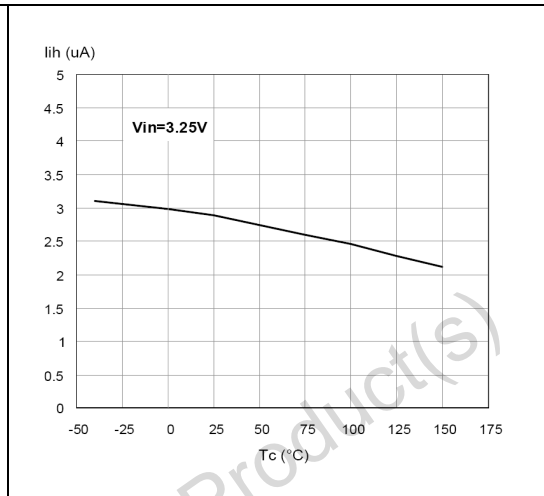


Figure 9. Input clamp voltage

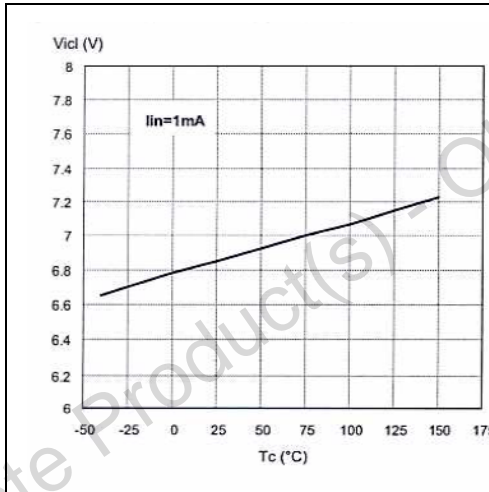


Figure 10. Input high-level voltage

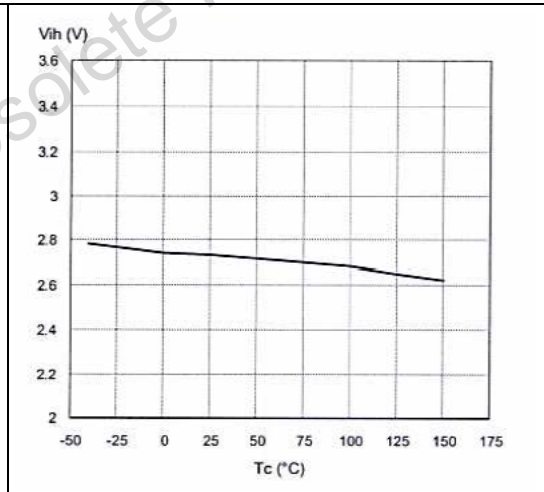


Figure 11. Input low-level voltage

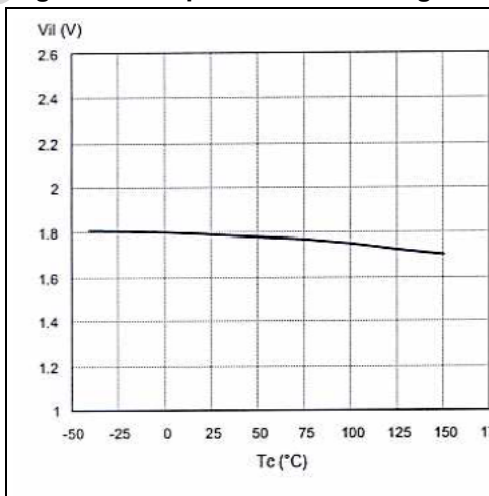


Figure 12. Input hysteresis voltage

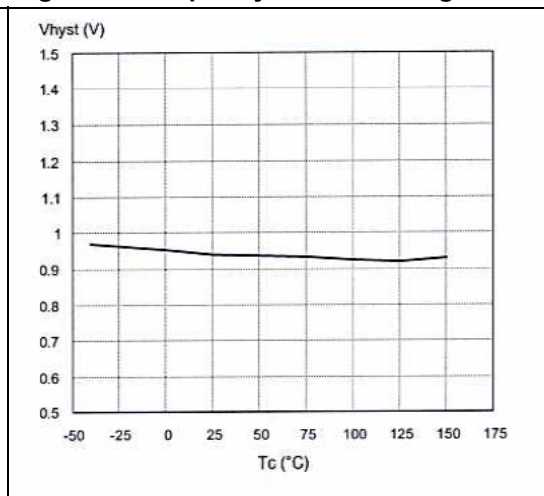


Figure 13. Overvoltage shutdown

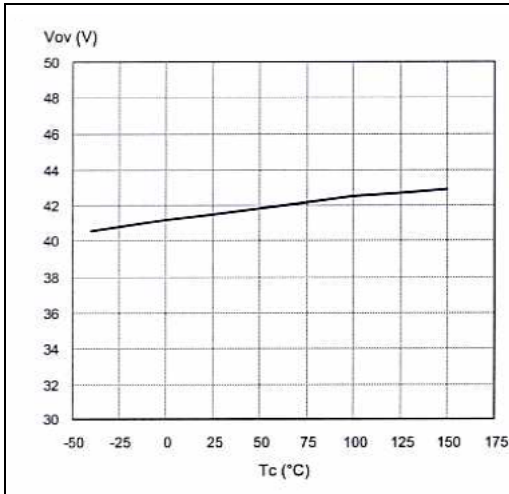


Figure 14. I<sub>LIM</sub> vs T<sub>case</sub>

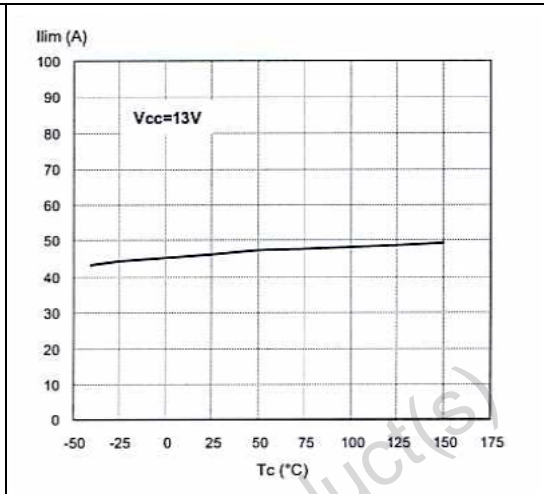


Figure 15. Turn-on voltage slope

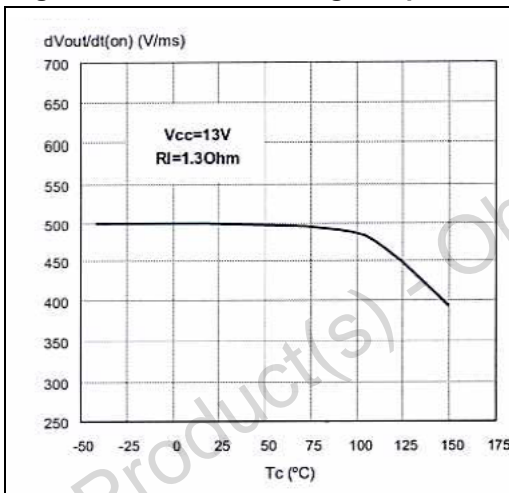


Figure 16. Turn-off voltage slope

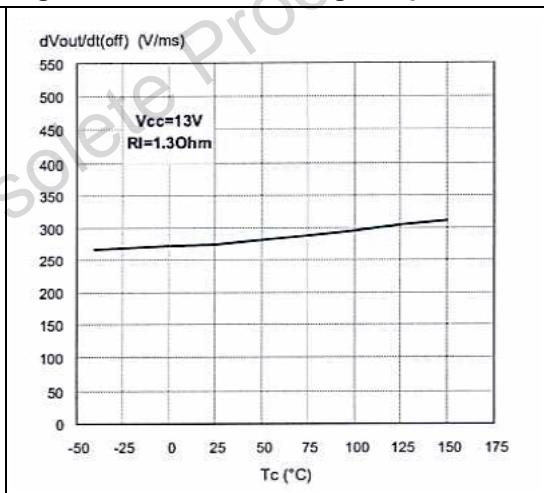


Figure 17. On-state resistance vs T<sub>CASE</sub>

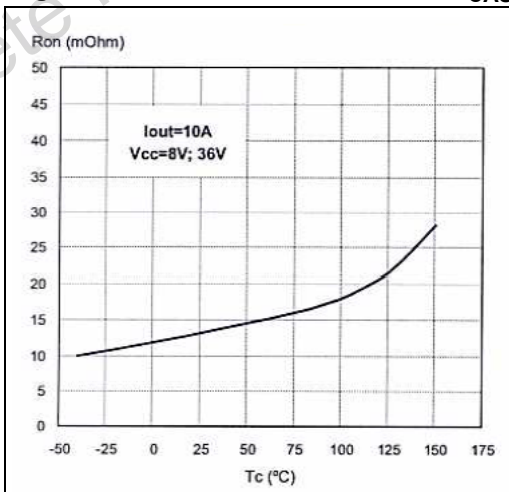
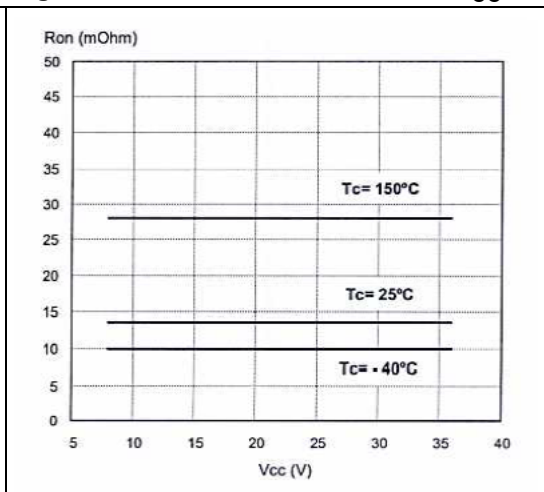
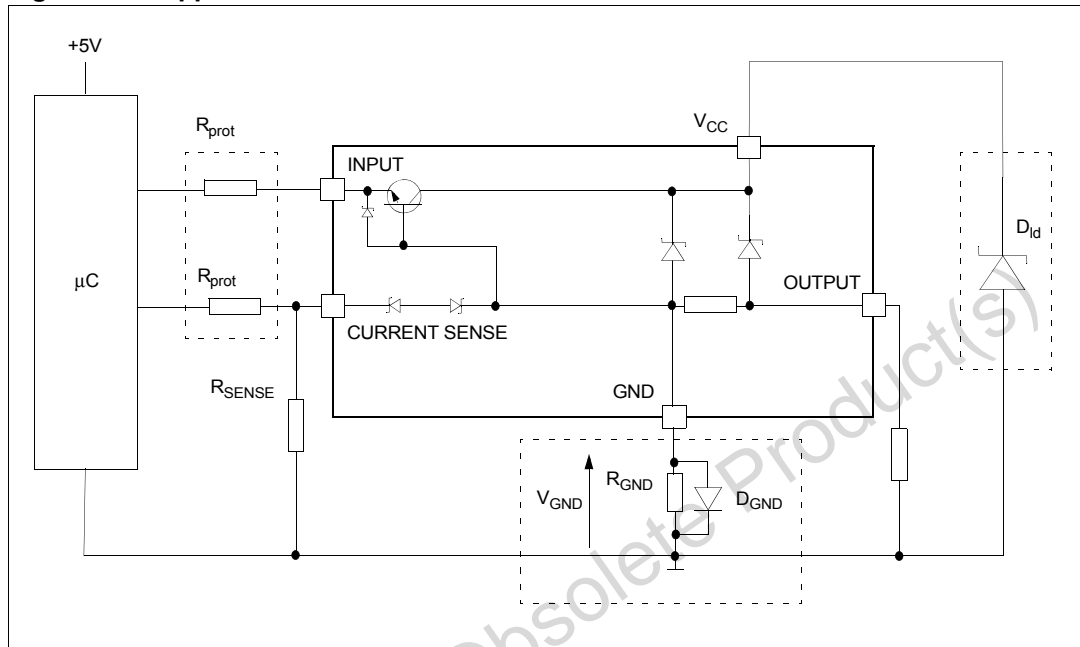


Figure 18. On-state resistance vs V<sub>CC</sub>



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

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

Power Dissipation in  $R_{GND}$  (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 below).



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

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

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

Series resistor in INPUT lines is also required to prevent that, during battery voltage transient, the current exceeds the absolute maximum rating.

Safest configuration for unused INPUT pin is to leave it unconnected, while unused SENSE pin has to be connected to ground pin.

## 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 T/R 7637/1 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 is 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:

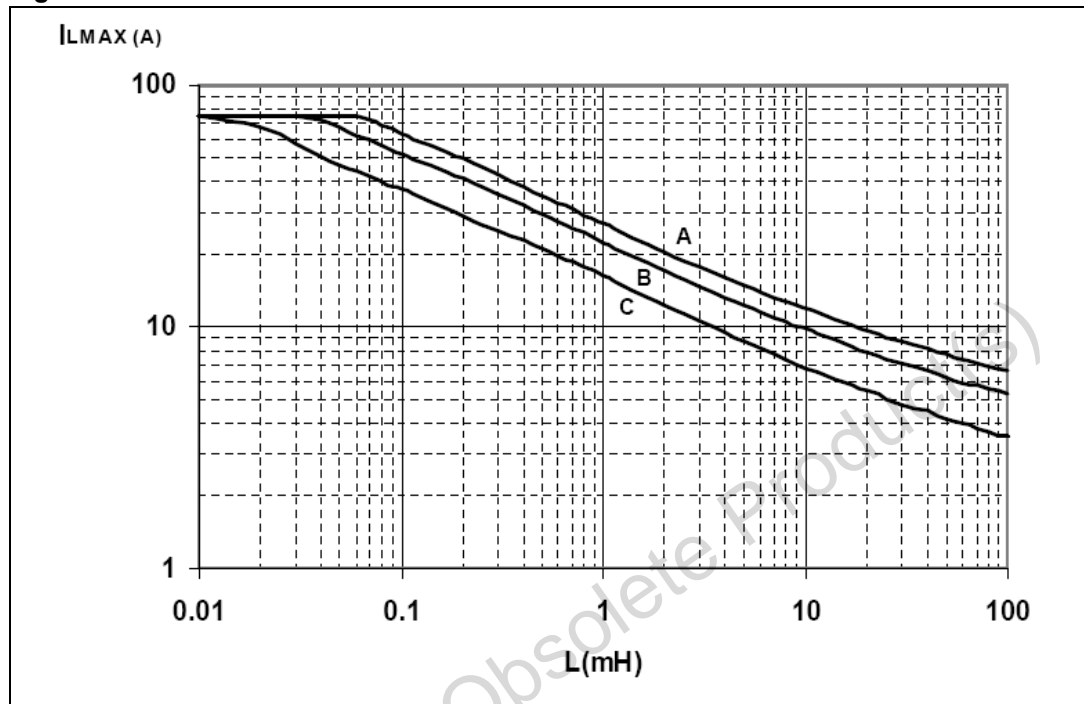
For  $V_{CCpeak} = -100V$  and  $I_{latchup} \geq 20mA$ ;  $V_{OH\mu C} \geq 4.5V$

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

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

### 3.4 Maximum demagnetization energy

Figure 20. Maximum turn-off current versus load inductance



Legend:

A = Single Pulse at  $T_{Jstart}=150\text{ }^{\circ}\text{C}$

B = Repetitive pulse at  $T_{Jstart}=100\text{ }^{\circ}\text{C}$

C = Repetitive Pulse at  $T_{Jstart}=125\text{ }^{\circ}\text{C}$

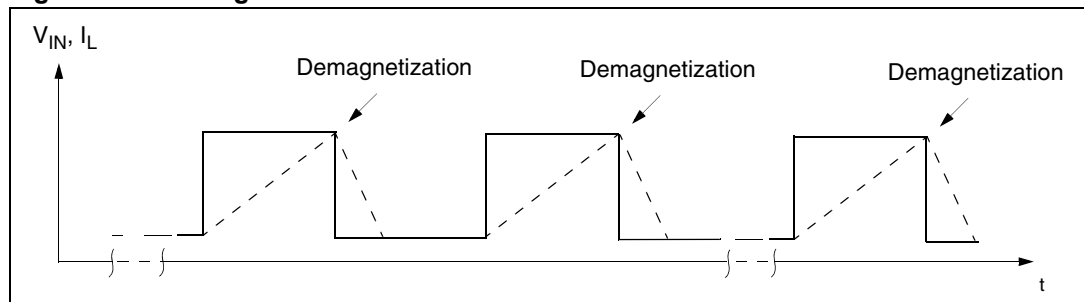
Conditions:

$V_{CC}=13.5\text{ V}$

Values are generated with  $R_L=0\text{ }\Omega$

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.

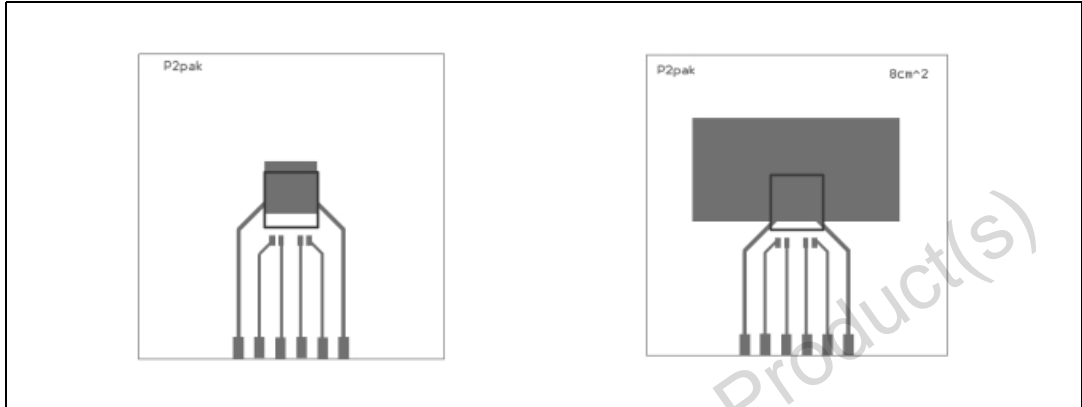
Figure 21. Demagnetization



## 4 Package and PCB thermal data

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

Figure 22. 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 23.  $R_{thj-amb}$  vs PCB copper area in open box free air condition

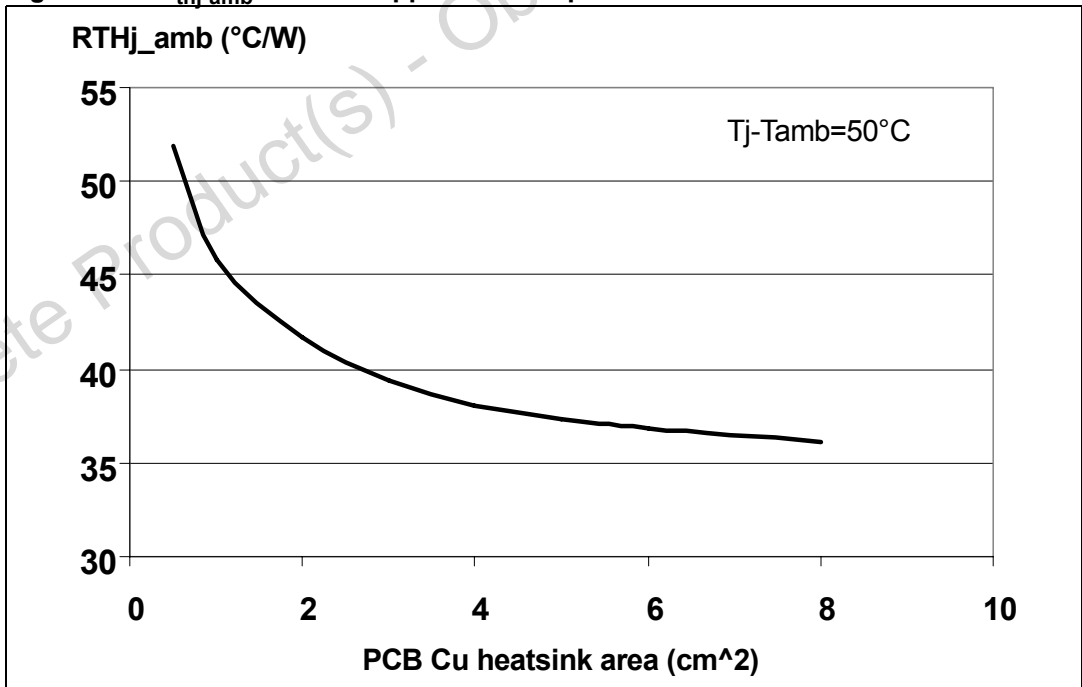
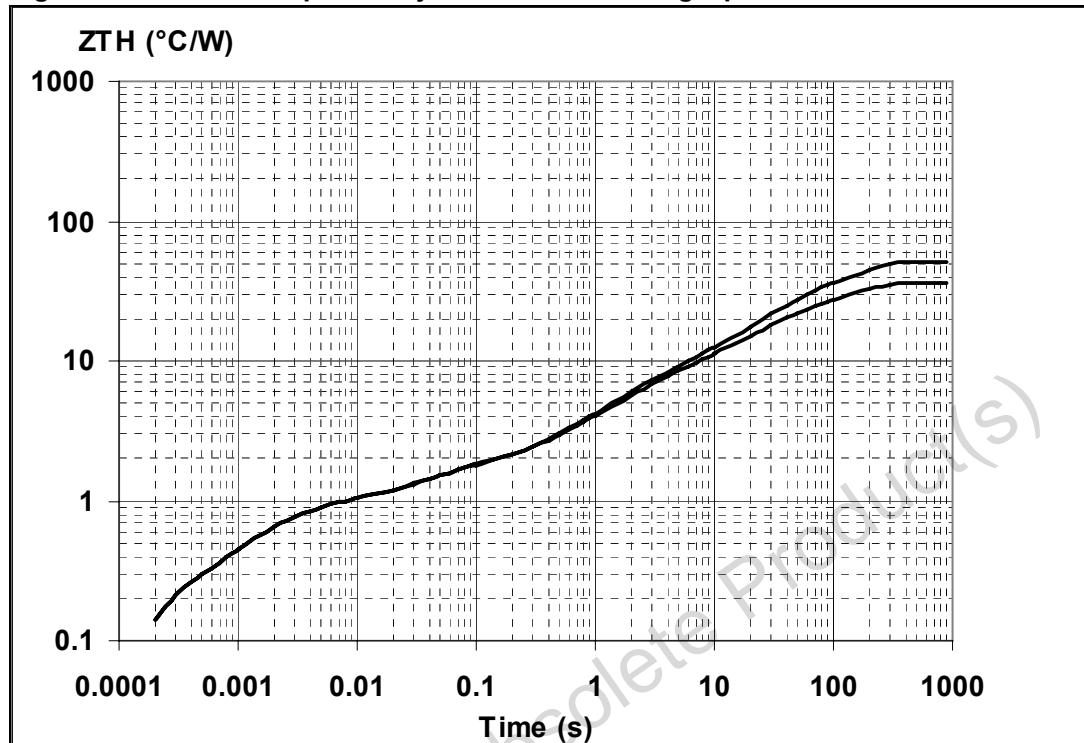


Figure 24. Thermal impedance junction ambient single pulse



Equation 1: pulse calculation formula

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

where  $\delta = t_p / T$

Figure 25. Thermal fitting model of a quad channel HSD in P<sup>2</sup>PAK

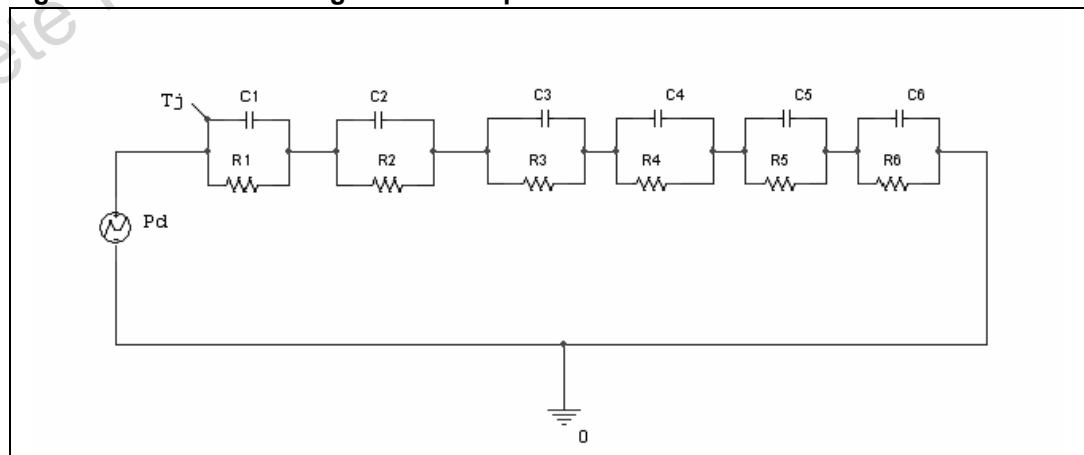


Table 15. Thermal parameter

Area/island (cm <sup>2</sup> )	0.5	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)	0.00015	-
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<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.

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

Figure 26. P<sup>2</sup>PAK package dimensions

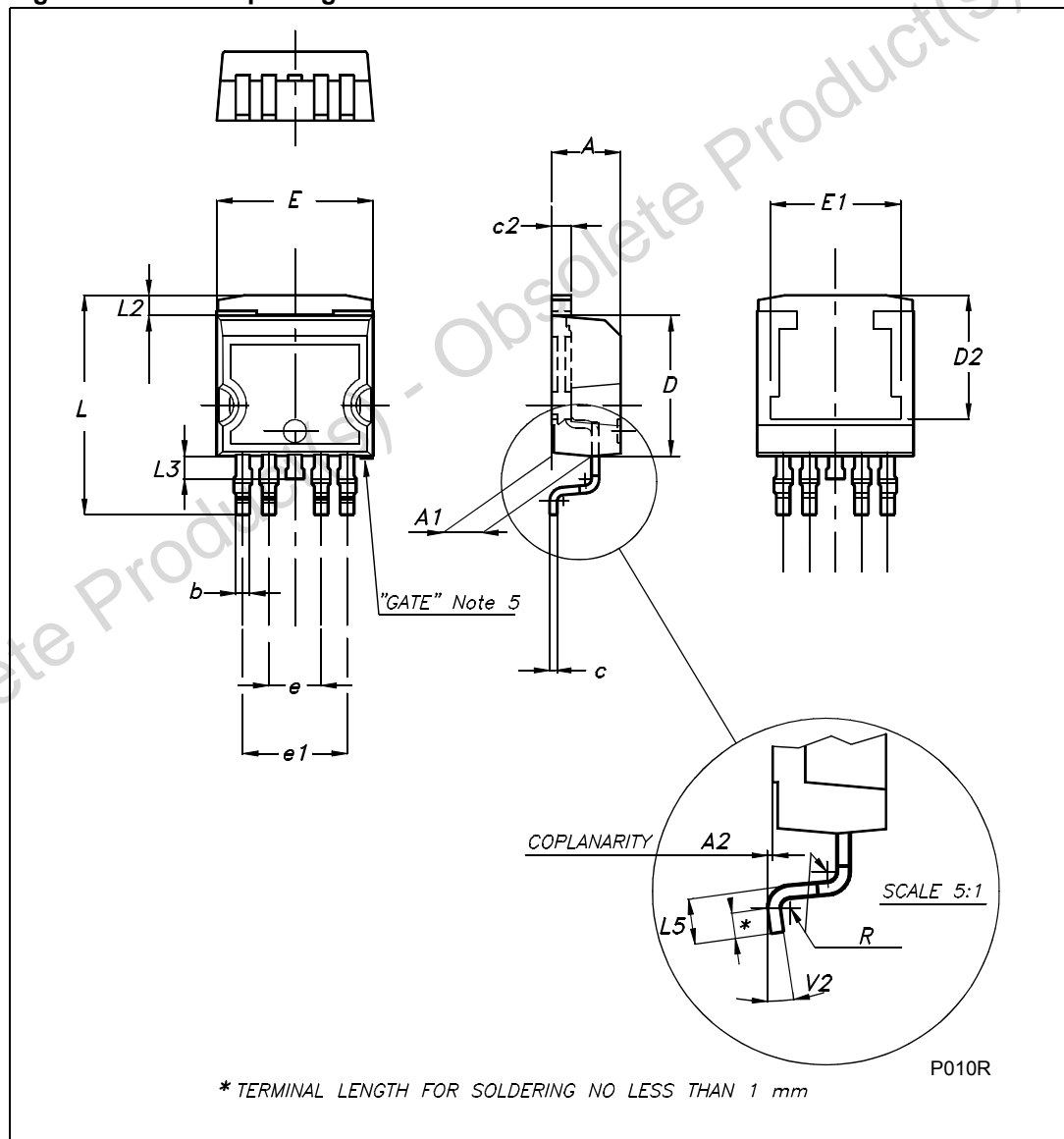


Table 16. P<sup>2</sup>PAK mechanical data

Symbol	millimeters		
	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	
Package weight	0°		8°

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

Figure 27. P<sup>2</sup>PAK tube shipment (no suffix)

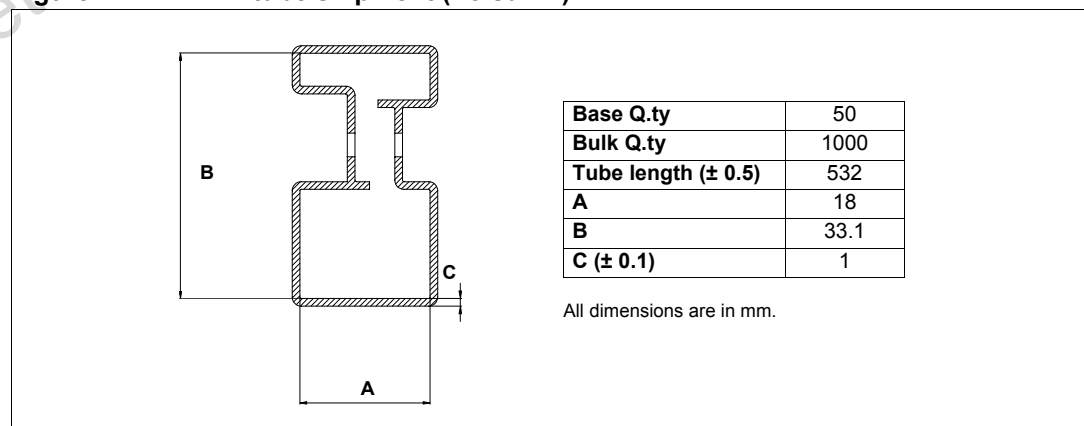
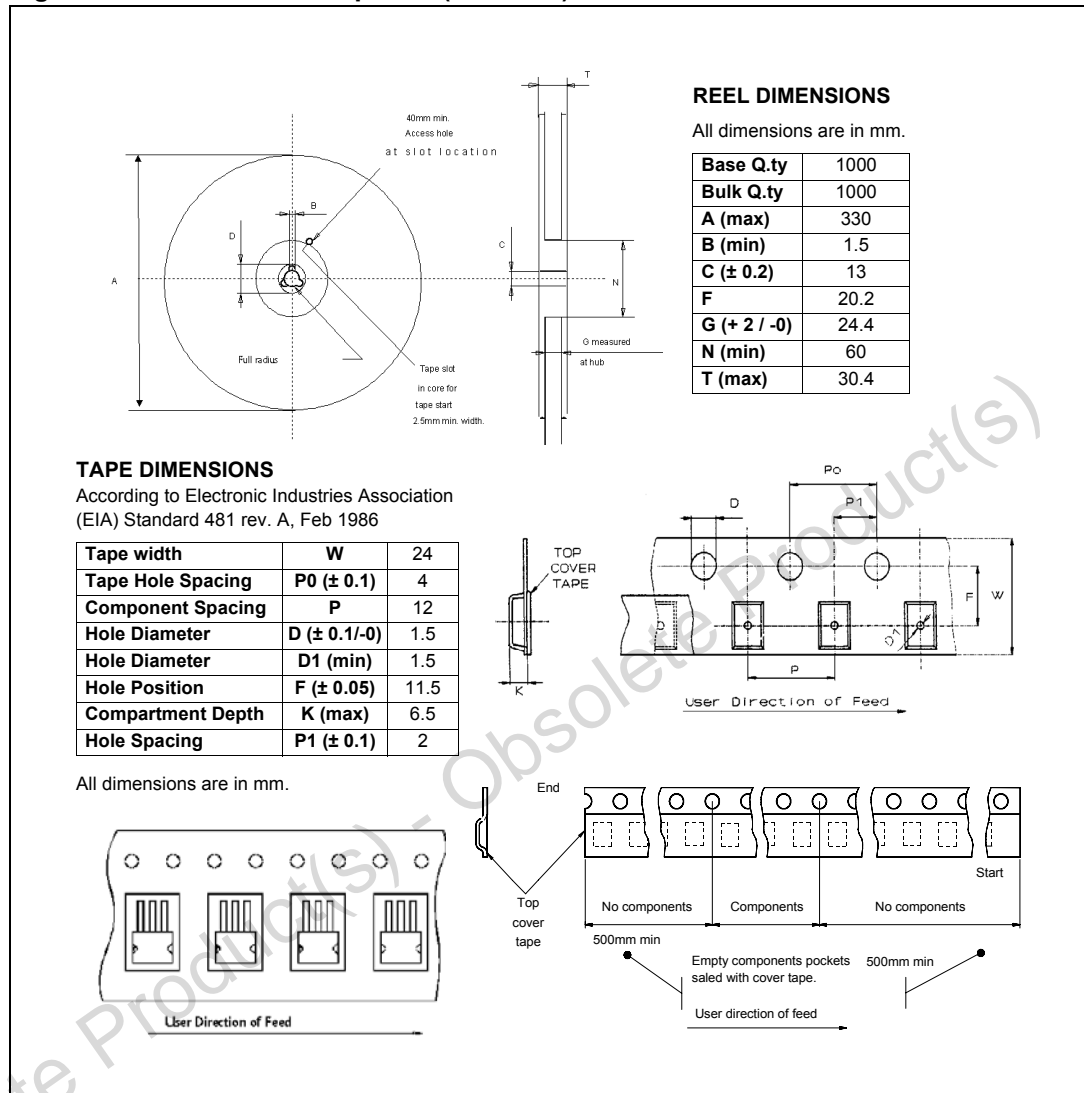


Figure 28. P<sup>2</sup>PAK tube shipment (no suffix)





## 6 Revision history

Table 17. Document revision history

Date	Revision	Changes
01-Dec-2005	1	Initial release.
22-Oct-2009	2	Updated <a href="#">Table 8: Current sense (9 V ≤ VCC ≤ 16 V)</a>
25-Sep-2013	3	Updated Disclaimer.

Obsolete Product(s) - Obsolete Product(s)

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