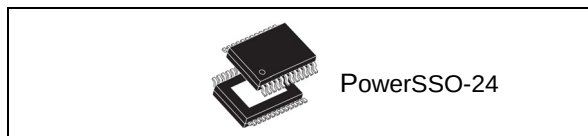


Quad high-side smart power solid-state relay

Datasheet - production data



- Fast demagnetization of inductive loads
- Conforms to IEC 61131-2
- ESD according to IEC 61000-4-2 up to +/- 25 kV

Features

Type	$V_{\text{demag}}^{(1)}$	$R_{\text{DS(on)}}^{(1)}$	$I_{\text{out}}^{(1)}$	V_{CC}
VNI4140K-32	$V_{\text{CC}}-41 \text{ V}$	0.08Ω	1 A	41 V

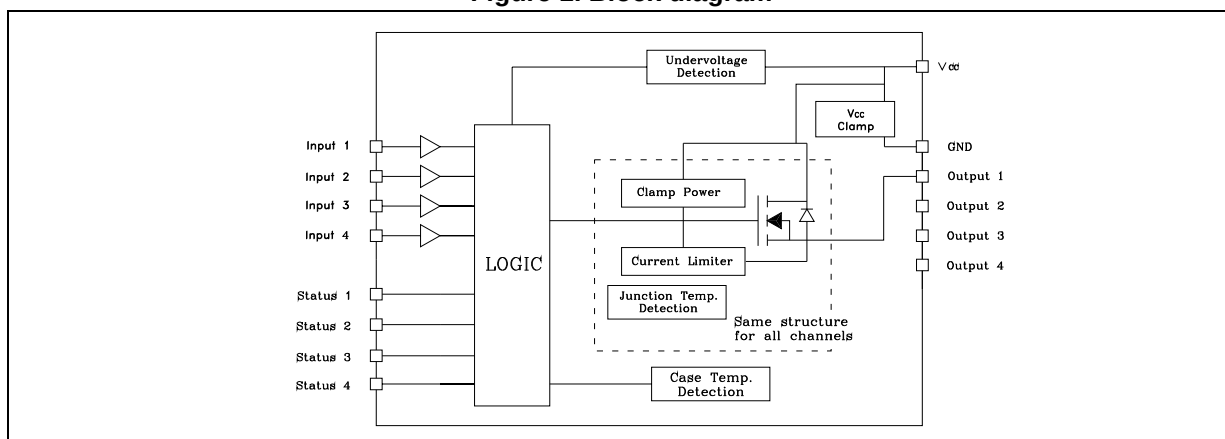
1. Per channel

- Output current: 1 A per channel
- Shorted load protections
- Junction overtemperature protection
- Case overtemperature protection for thermal independence of the channels
- Thermal case shutdown restart not simultaneous for the various channels
- Protection against loss of ground
- Current limitation
- Undervoltage shutdown
- Open drain diagnostic outputs
- 3.3 V CMOS/TTL compatible inputs

Description

The VNI4140K-32 is a monolithic device made using STMicroelectronics VIPower technology, intended to drive four independent resistive, capacitive or inductive loads with one side connected to ground. Active current limitation avoids the system power supply dropping in case of shorted load. Built-in thermal shutdown protects the chip from overtemperature and short-circuit. In overload conditions, the channel turns OFF and back ON automatically so to maintain junction temperature between T_{TSD} and T_{R} . If this condition causes case temperature to reach T_{CSD} , the overloaded channel is turned OFF and restarts only when case temperature has decreased down to T_{CR} . In case of more than one channel in overload, restart of the overloaded channels is not simultaneous, in order to avoid high peak current from the supply. Non-overloaded channels continue operating normally. The open drain diagnostic outputs indicate overtemperature conditions.

Figure 1. Block diagram



Contents

1	Pin connection	5
2	Maximum ratings	7
	2.1 Thermal data	7
3	Recommended	7
4	Electrical characteristics	8
5	Truth table	12
6	Thermal management	13
7	Switching waveforms	14
8	Pin functions	15
9	Package and PCB thermal data	17
	9.1 VNI4140K-32 thermal data	17
10	Reverse polarity protection	19
11	Demagnetization energy	20
12	Package mechanical data	21
13	Ordering information	26
14	Revision history	27

List of figures

Figure 1.	Block diagram	1
Figure 2.	Pin connection (top view)	5
Figure 3.	Switching parameter conventions	9
Figure 4.	Current and voltage conventions	11
Figure 5.	Thermal behavior	13
Figure 6.	Switching waveforms	14
Figure 7.	Input circuit	15
Figure 8.	Status circuit	15
Figure 9.	Charge pump switching frequency (typical) vs. temperature	16
Figure 10.	VNI4140K-32 PCB	17
Figure 11.	$R_{th(JA)}$ vs. PCB copper area in open box free air condition (one channel ON)	17
Figure 12.	VNI4140K-32 thermal impedance junction-ambient single pulse (one channel ON)	18
Figure 13.	Reverse polarity protection	19
Figure 14.	Maximum demagnetization vs. load current, typical values	20
Figure 15.	PowerSSO-24 package dimensions	22
Figure 16.	PowerSSO-24 tube shipment (no suffix)	22
Figure 17.	PowerSSO-24 reel shipment (suffix "TR")	23
Figure 18.	PowerSSO-24 tape drawings	24
Figure 19.	VNI4140K-32 suggested footprint.	25

List of tables

Table 1.	Pin description	5
Table 2.	Absolute maximum ratings	7
Table 3.	Thermal data.	7
Table 4.	Input switching limits.	7
Table 5.	Power section	8
Table 6.	Switching	8
Table 7.	Logical input	10
Table 8.	Protection and diagnostic	10
Table 9.	Truth table.	12
Table 10.	PowerSSO-24 mechanical data	21
Table 11.	PowerSSO-24 tube shipment	22
Table 12.	PowerSSO-24 reel dimensions.	23
Table 13.	PowerSSO-24 tape dimensions	24
Table 14.	Ordering information	26
Table 15.	Document revision history	27

1 Pin connection

Figure 2. Pin connection (top view)

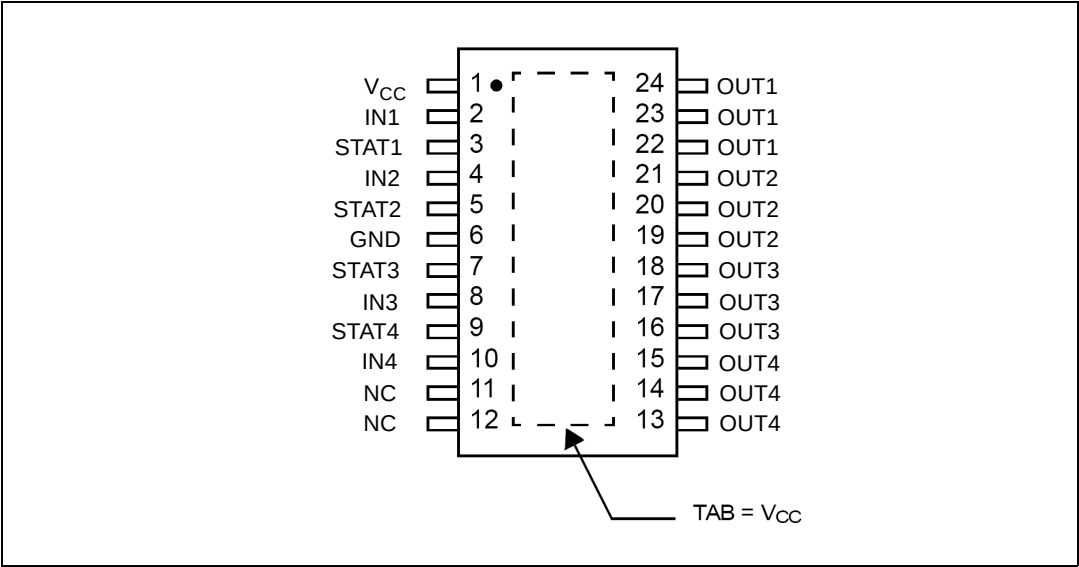


Table 1. Pin description

Pin	Name	Description
Tab	TAB	Exposed tab internally connected to V_{CC}
1	V_{CC}	Supply voltage
2	IN1	Channel 1 input 3.3 V CMOS/TTL compatible
3	STAT1	Channel 1 status in open drain configuration
4	IN2	Channel 2 input 3.3 V CMOS/TTL compatible
5	STA2	Channel 2 status in open drain configuration
6	GND	Device ground connection
7	STAT3	Channel 3 status in open drain configuration
8	IN3	Channel 3 input 3.3 V CMOS/TTL compatible
9	STAT4	Channel 4 status in open drain configuration
10	IN4	Channel 4 input 3.3 V CMOS/TTL compatible
11	NC	
12	NC	
13	OUT4	Channel 4 power stage output, internally protected
14	OUT4	Channel 4 power stage output, internally protected
15	OUT4	Channel 4 power stage output, internally protected
16	OUT3	Channel 3 power stage output, internally protected
17	OUT3	Channel 3 power stage output, internally protected

Table 1. Pin description (continued)

Pin	Name	Description
18	OUT3	Channel 3 power stage output, internally protected
19	OUT2	Channel 2 power stage output, internally protected
20	OUT2	Channel 2 power stage output, internally protected
21	OUT2	Channel 2 power stage output, internally protected
22	OUT1	Channel 1 power stage output, internally protected
23	OUT1	Channel 1 power stage output, internally protected
24	OUT1	Channel 1 power stage output, internally protected

2 Maximum ratings

Table 2. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{CC}	Power supply voltage	41	V
$-V_{CC}$	Reverse supply voltage	-0.3	V
I_{GND}	DC ground reverse current	-250	mA
I_{OUT}	Output current (continuous)	Internally limited	A
I_R	Reverse output current (per channel)	-5	A
I_{IN}	Input current (per channel)	± 10	mA
V_{IN}	Input voltage	$+V_{CC}$	V
V_{STAT}	Status pin voltage	$+V_{CC}$	V
I_{STAT}	Status pin current	± 10	mA
V_{ESD}	Electrostatic discharge (R = 1.5 k Ω ; C = 100 pF)	2000	V
E_{AS}	$I_{OUT} = 500$ mA $T_{AMB} = 125$ °C	5	J
P_{TOT}	Power dissipation at $T_c = 25$ °C	Internally limited	W
T_J	Junction operating temperature	Internally limited	°C
T_{STG}	Storage temperature	-55 to 150	°C

2.1 Thermal data

Table 3. Thermal data

Symbol	Parameter	Value	Unit
$R_{th(JC)}$	Thermal resistance junction-case ⁽¹⁾	Max. 2	°C/W
$R_{th(JA)}$	Thermal resistance junction-ambient	Max. see Figure 11	°C/W

1. Per channel.

3 Recommended

Table 4. Input switching limits

Symbol	Parameter	Value	Unit
$f_{Vin\ MAX}$	Maximum input switching frequency	10	kHz

4 Electrical characteristics

$10.5\text{ V} < V_{CC} < 36\text{ V}$; $-40\text{ }^{\circ}\text{C} < T_J < 125\text{ }^{\circ}\text{C}$; unless otherwise specified.

Table 5. Power section

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{CC}	Supply voltage		10.5		36	V
$R_{DS(on)}$	ON state resistance	$I_{OUT} = 0.7\text{ A}$ at $T_J = 25\text{ }^{\circ}\text{C}$ $I_{OUT} = 0.7\text{ A}$			0.080 0.140	Ω Ω
V_{clamp}		$I_S = 20\text{ mA}$	41	45	52	V
I_S	Supply current	All channels in OFF state, ON state with $V_{IN} = 5\text{ V}$		250 2.4	4	μA mA
$V_{OUT(OFF)}$	OFF state output voltage	$V_{IN} = 0\text{ V}$ and $I_{OUT} = 0\text{ A}$			1	V
$I_{OUT(OFF)}$	OFF state output current	$V_{IN} = V_{OUT} = 0\text{ V}$	0		5	μA
I_{LGND}	Output current in ground disconnection	$V_{CC} = V_{IN} = \text{GND} = 24\text{ V}$; $T_J = 125\text{ }^{\circ}\text{C}$			500	μA
F_{CP}	Charge pump frequency	Channel in ON state ⁽¹⁾		1450		kHz

1. To cover EN55022 class A and class B normative.

$V_{CC} = 24\text{ V}$; $-40\text{ }^{\circ}\text{C} < T_J < 125\text{ }^{\circ}\text{C}$, $R_L = 48\text{ }\Omega$, input rise time $< 0.1\text{ }\mu\text{s}$

Table 6. Switching

Symbol	Parameter	Min.	Typ.	Max.	Unit
$t_{d(ON)}$	Turn ON delay	-	6	-	μs
t_r	Rise time	-	5	-	μs
$t_{d(OFF)}$	Turn OFF	-	12	-	μs
t_f	Fall time	-	5	-	μs
$dV/dt_{(ON)}$	Turn ON voltage slope	-	4	-	V/ μs
$dV/dt_{(OFF)}$	Turn OFF voltage slope	-	4	-	V/ μs

Figure 3. Switching parameter conventions

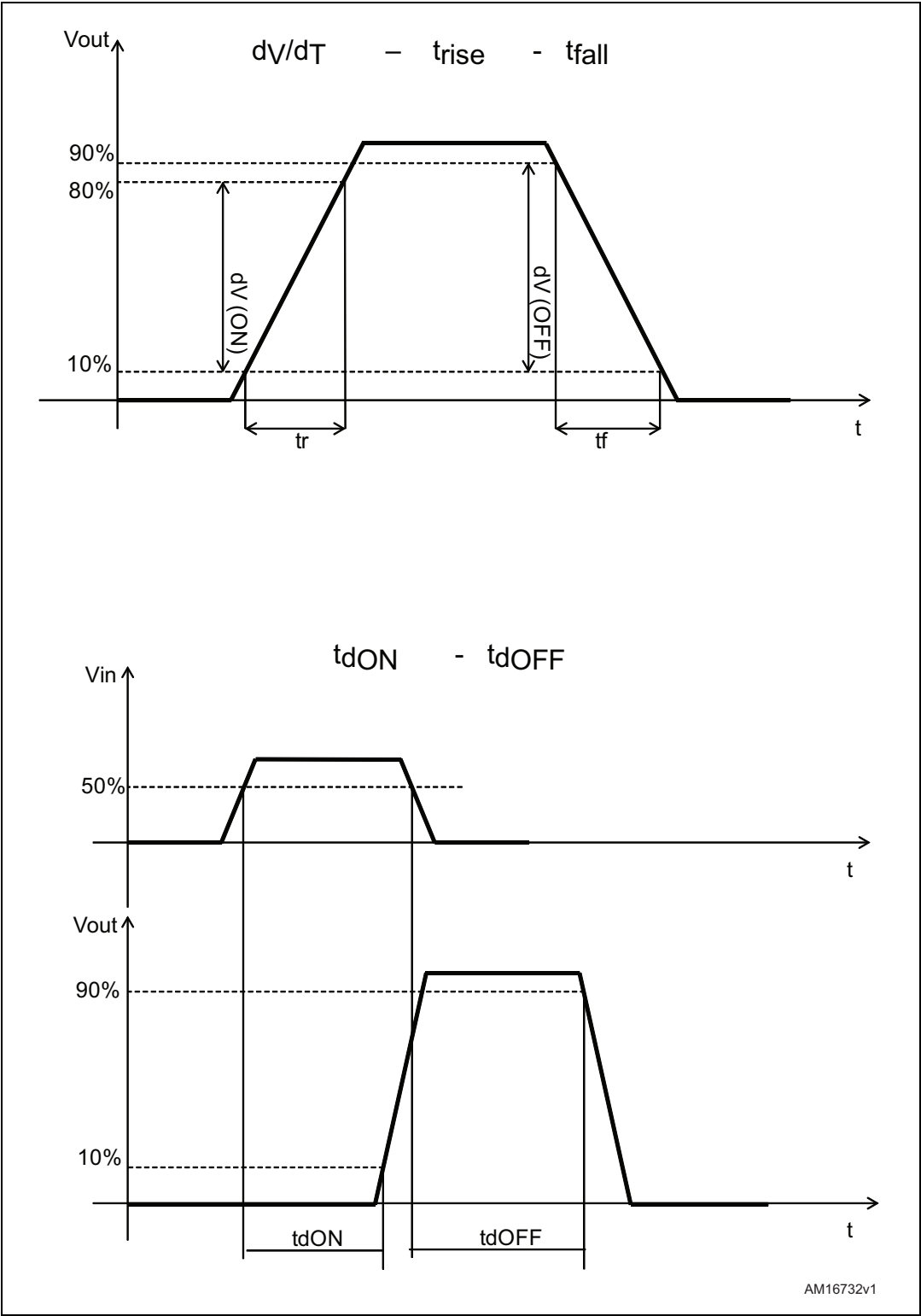


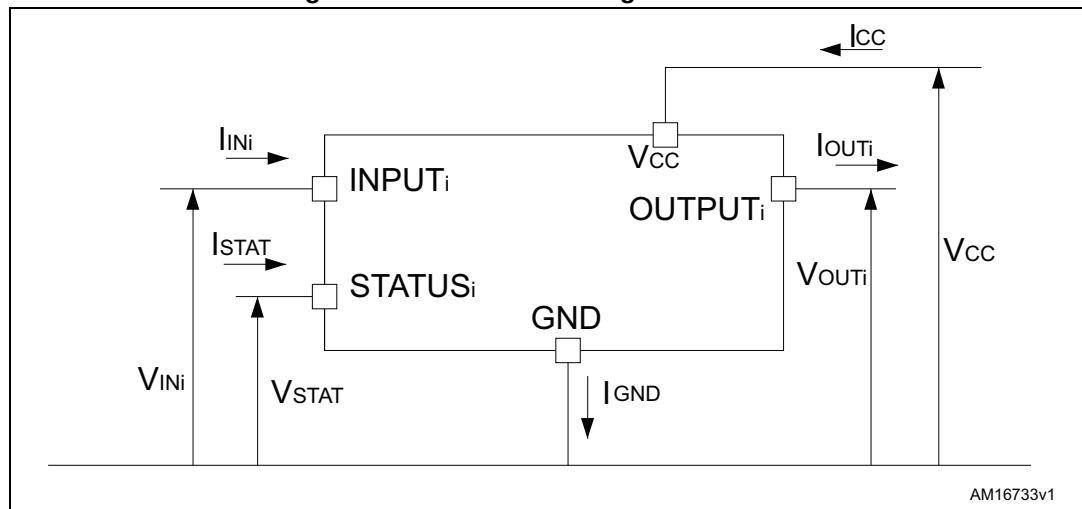
Table 7. Logical input

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{IL}	Input low level voltage				0.8	V
V_{IH}	Input high level voltage		2.20			V
$V_{I(HYST)}$	Input hysteresis voltage			0.15		V
I_{IN}	Input current	$V_{IN} = 15\text{ V}$			10	μA
		$V_{IN} = 36\text{ V}$			210	

Table 8. Protection and diagnostic

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{STAT}	Status voltage output low	$I_{STAT} = 1.6\text{ mA}$			0.6	V
V_{USD}	Undervoltage protection		7		10.5	V
V_{USDHYS}	Undervoltage hysteresis		0.4	0.5		V
I_{LIM}	DC short-circuit current	$V_{CC} = 24\text{ V}$; $R_{LOAD} < 10\text{ m}\Omega$	1.1		2.6	A
I_{PEAK}	Maximum DC output current	Dynamic load		1.6		A
I_{LSTAT}	Status leakage current	$V_{CC} = V_{STAT} = 36\text{ V}$		30		μA
T_{TSD}	Junction shutdown temperature		150	170	190	$^{\circ}\text{C}$
T_R	Junction reset temperature		135			$^{\circ}\text{C}$
T_{HIST}	Junction thermal hysteresis		7	15		$^{\circ}\text{C}$
T_{CSD}	Case shutdown temperature		125	130	135	$^{\circ}\text{C}$
T_{CR}	Case reset temperature		110			$^{\circ}\text{C}$
T_{CHYST}	Case thermal hysteresis		7	15		$^{\circ}\text{C}$
V_{demag}	Output voltage at turn-OFF	$I_{OUT} = 0.5\text{ A}$; $L_{LOAD} \geq 1\text{ mH}$	$V_{CC}-41$	$V_{CC}-45$	$V_{CC}-52$	V

Figure 4. Current and voltage conventions



5 Truth table

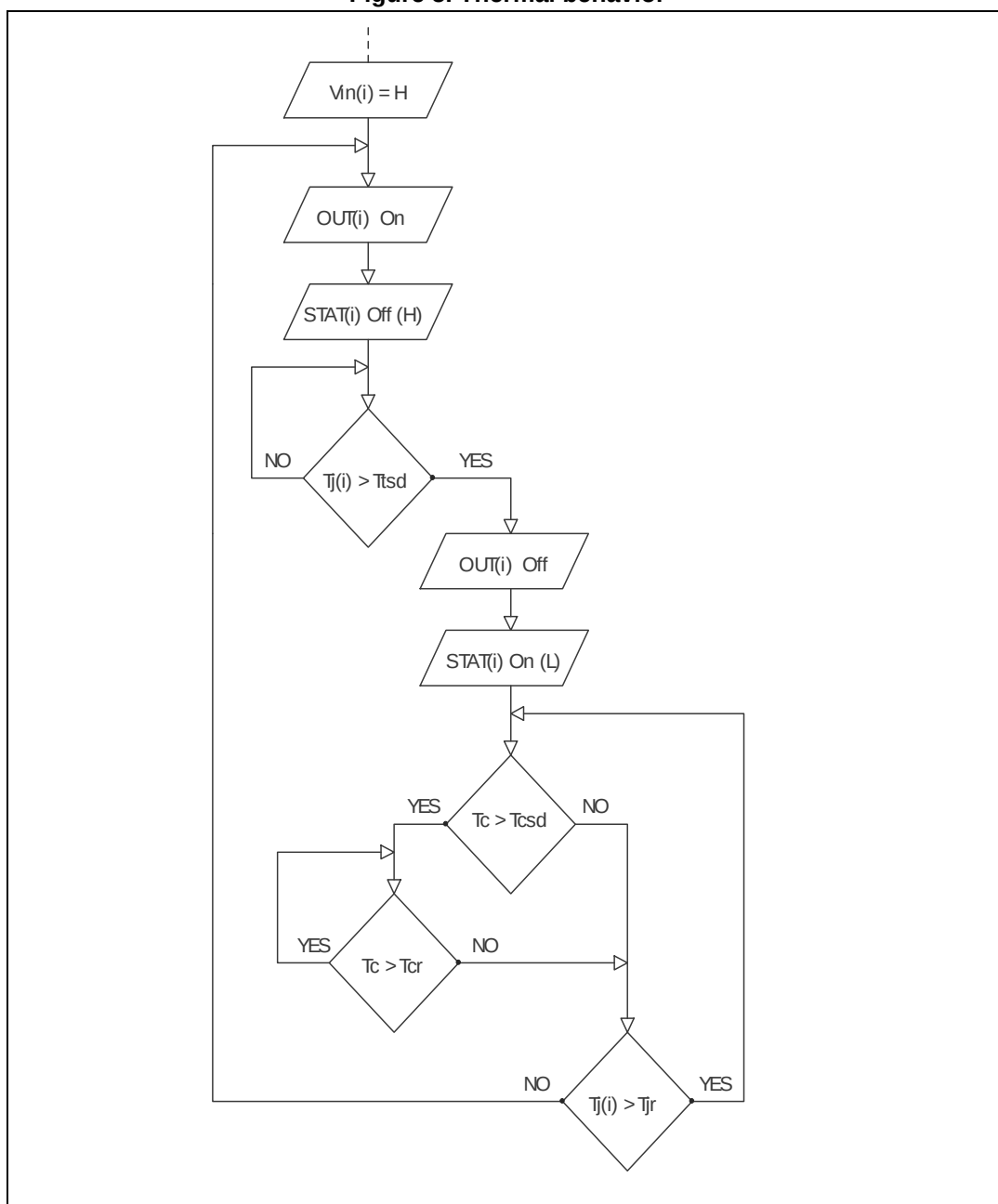
Table 9. Truth table

Conditions	INPUTn	OUTPUTn	STATUSn
Normal operation	L	L	H
	H	H	H
Overtemperature	L	L	H
	H	L	L
Undervoltage	L	L	X
	H	L	X
Shorted load (current limitation before thermal shutdown)	L	L	H
	H	X	H

6 Thermal management

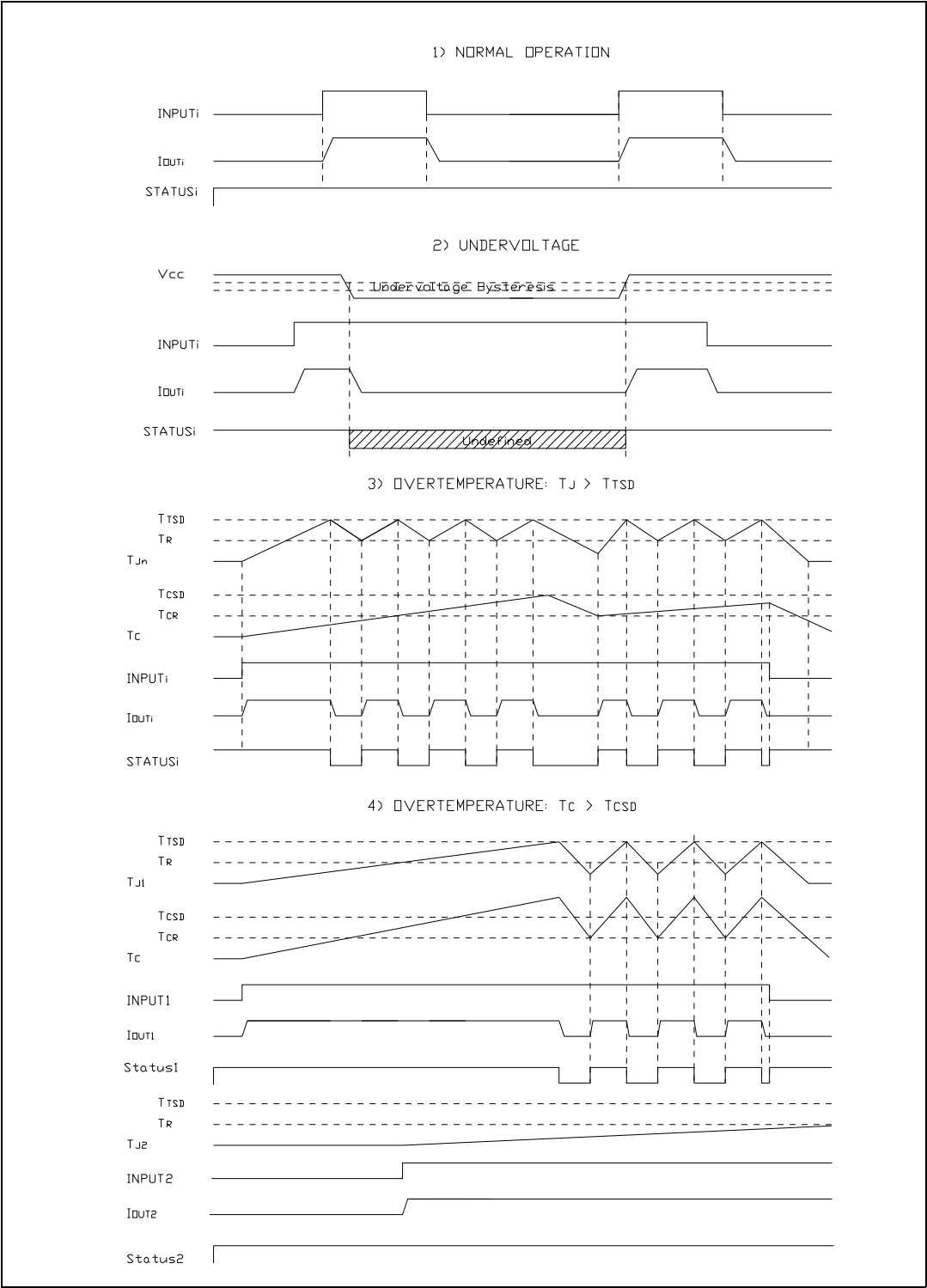
The power dissipation in the IC is the main factor that sets the safe operating condition of the device in the application. Therefore, it must be considered very carefully. Furthermore, the available space on the PCB should be chosen considering the power dissipation. Heat sinking can be achieved using copper on the PCB with proper area and thickness. Two different protections have been implemented to guarantee safety of the device if it overheats due to an overloaded condition or high environment temperature. The following flowchart explains in detail this protection functionality.

Figure 5. Thermal behavior



7 Switching waveforms

Figure 6. Switching waveforms



8 Pin functions

Figure 7. Input circuit

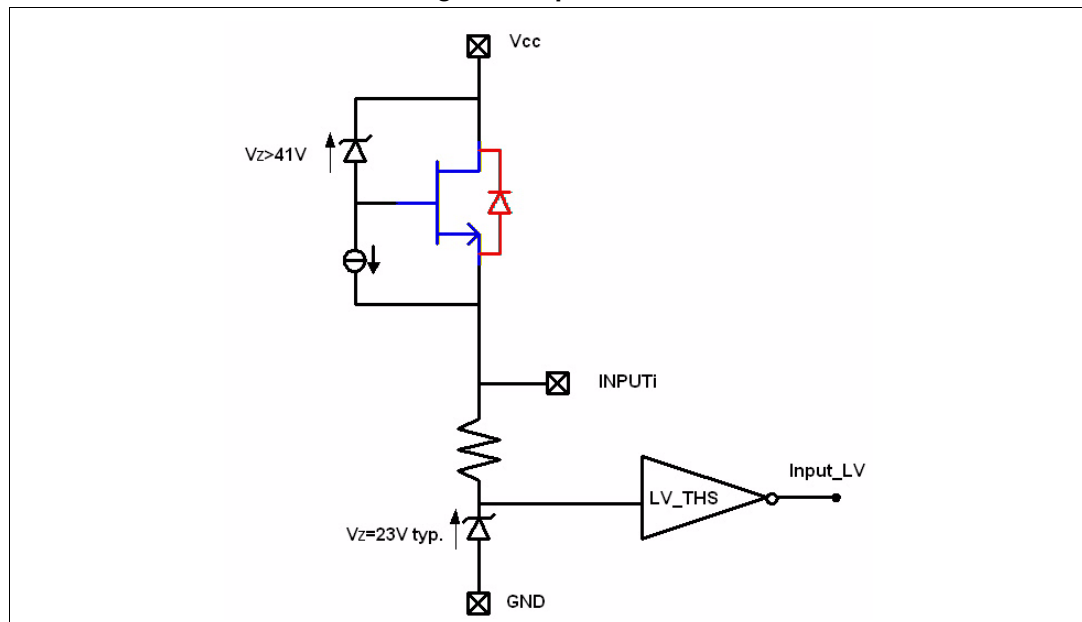


Figure 8. Status circuit

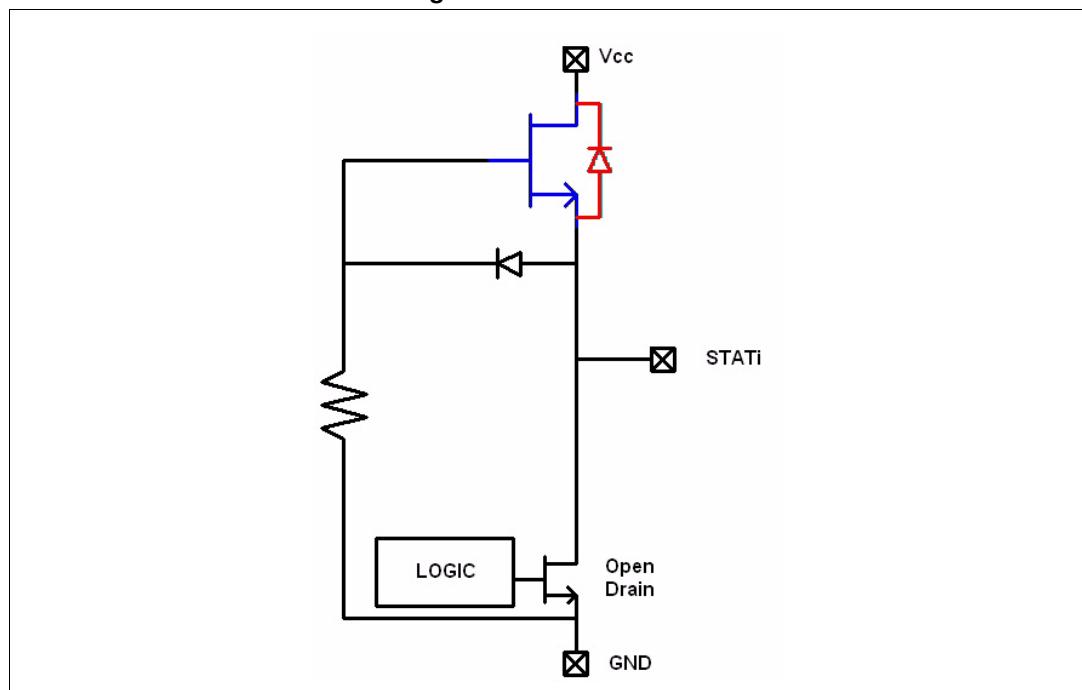
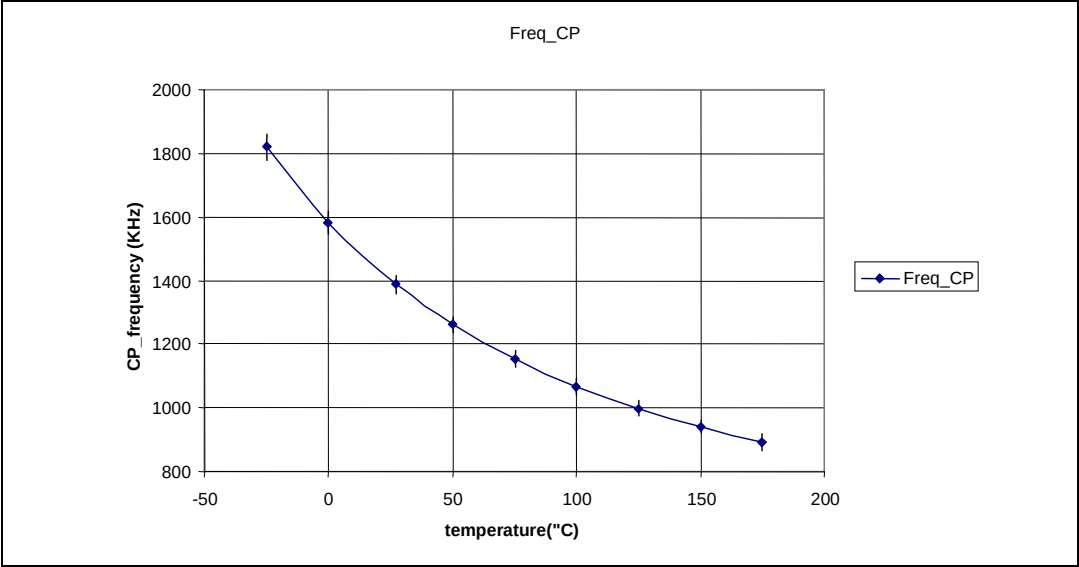


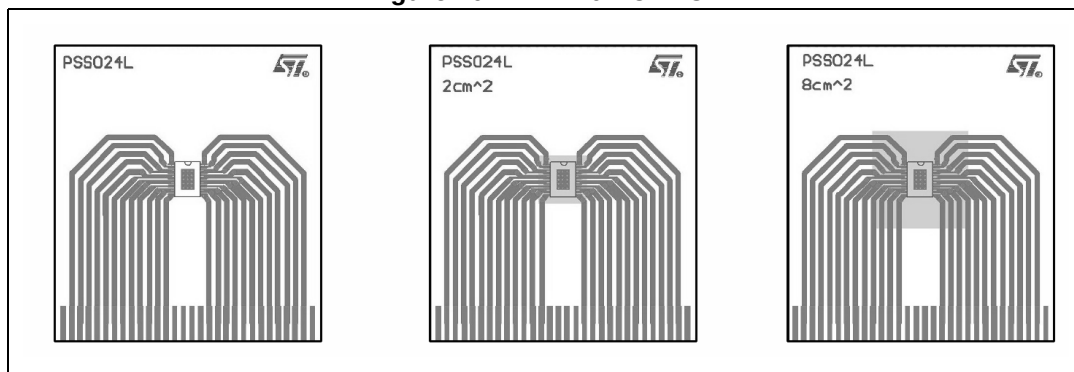
Figure 9. Charge pump switching frequency (typical) vs. temperature



9 Package and PCB thermal data

9.1 VNI4140K-32 thermal data

Figure 10. VNI4140K-32 PCB



Note:

Layout condition of R_{th} and Z_{th} measurements (PCB: double layer, thermal vias, FR4 area = 77 mm x 86 mm, PCB thickness=1.6 mm, Cu thickness = 70 mm (front and back side), copper areas: from minimum pad layout to 8 cm²).

Figure 11. $R_{th(JA)}$ vs. PCB copper area in open box free air condition (one channel ON)

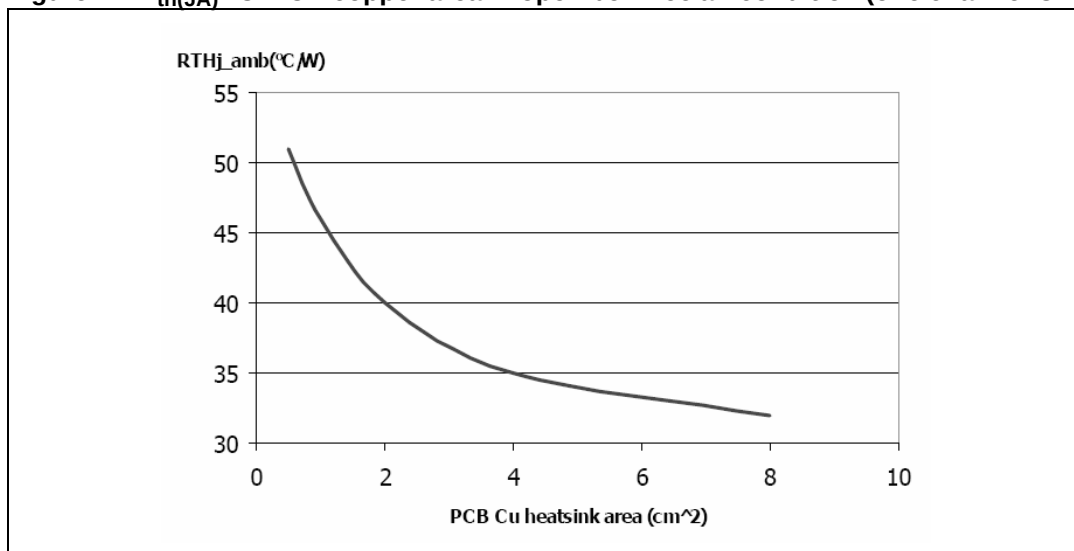
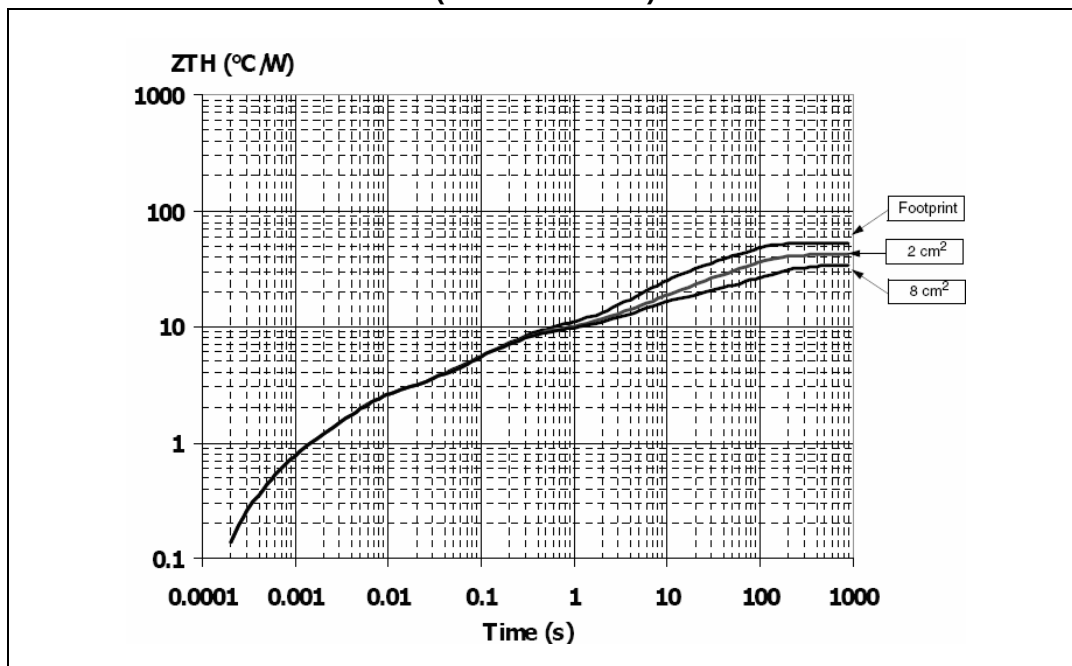


Figure 12. VNI4140K-32 thermal impedance junction-ambient single pulse
(one channel ON)



10 Reverse polarity protection

Reverse polarity protection can be implemented on board using two different solutions:

1. Placing a resistor (R_{GND}) between IC GND pin and load GND
2. Placing a diode between IC GND pin and load GND

If option 1 is selected, the minimum resistance value has to be selected according to the following equation:

Equation 1

$$R_{GND} \geq V_{CC} / I_{GND}$$

where I_{GND} is the DC reverse ground pin current and can be found in [Section 2: Maximum ratings](#) of this datasheet.

Power dissipated by R_{GND} (when $V_{CC} < 0$: during reverse polarity situations) is:

Equation 2

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

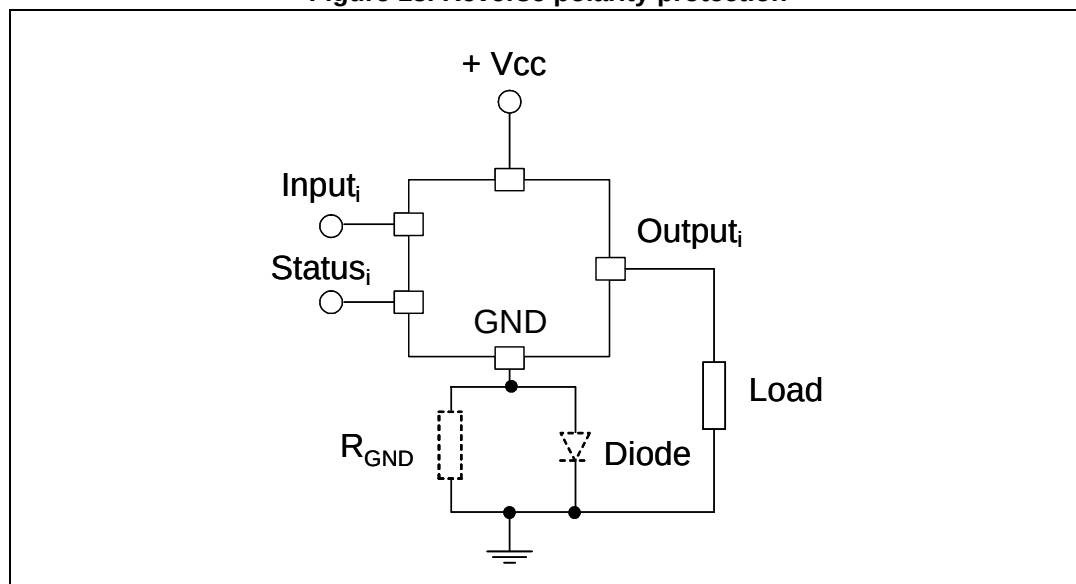
If option 2 is selected, the diode has to be chosen by taking into account $V_{RRM} > |V_{CC}|$ and its power dissipation capability:

Equation 3

$$P_D \geq I_S \cdot V_F$$

Note: In normal conditions (no reverse polarity), due to the diode, there is a voltage drop between GND of the device and GND of the system.

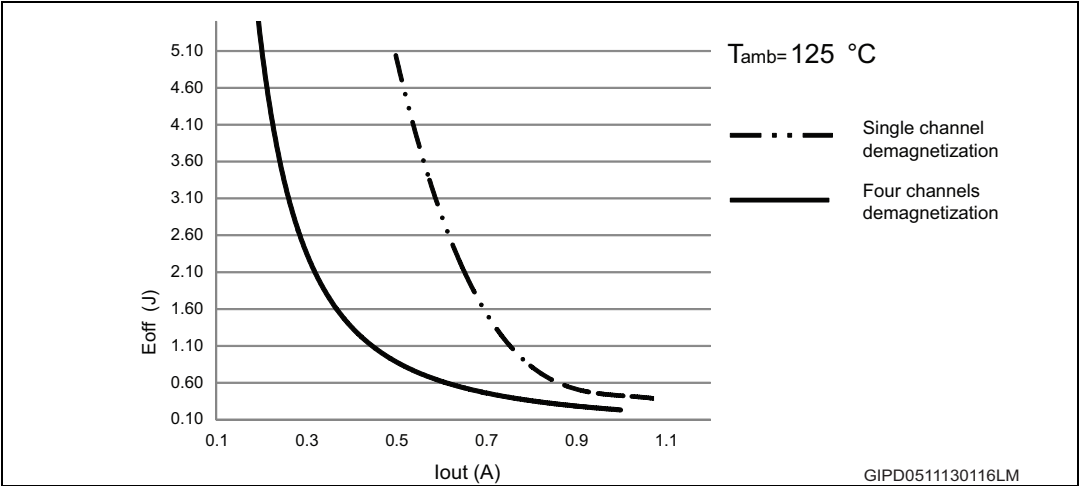
Figure 13. Reverse polarity protection



This schematic can be used with any type of load.

11 Demagnetization energy

Figure 14. Maximum demagnetization energy vs. load current, typical values



12 Package mechanical data

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. ECOPACK® is an ST trademark.

Table 10. PowerSSO-24 mechanical data

Symbol	mm		
	Min.	Typ.	Max.
A	2.15		2.47
A2	2.15		2.40
a1	0		0.075
b	0.33		0.51
c	0.23		0.32
D	10.10		10.50
E	7.4		7.6
e		0.8	
e3		8.8	
G			0.1
G1			0.06
H	10.1		10.5
h			0.4
L	0.55		0.85
N			10deg
X	4.1		4.7
Y	6.5		7.1

Figure 15. PowerSSO-24 package dimensions

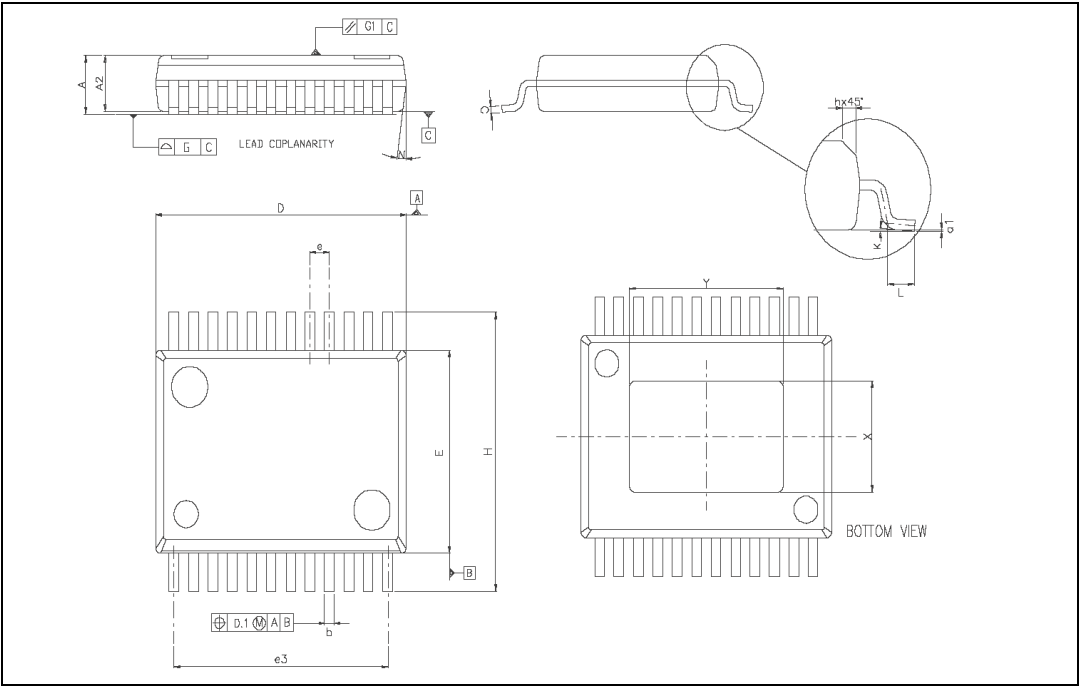


Figure 16. PowerSSO-24 tube shipment (no suffix)

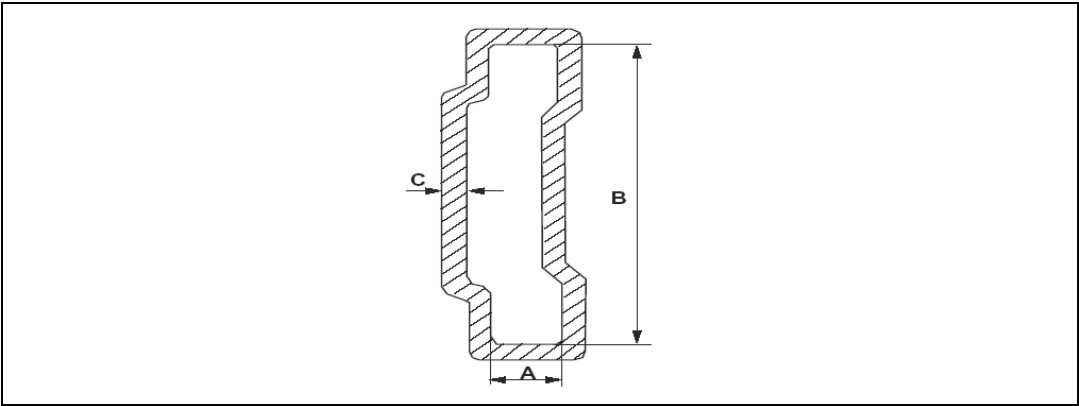


Table 11. PowerSSO-24 tube shipment

Base quantity	49
Bulk quantity	1225
Tube length (± 0.5)	532
A	3.5
B	13.8
C (± 0.1)	0.6

Note: All dimensions are in mm.

Figure 17. PowerSSO-24 reel shipment (suffix "TR")

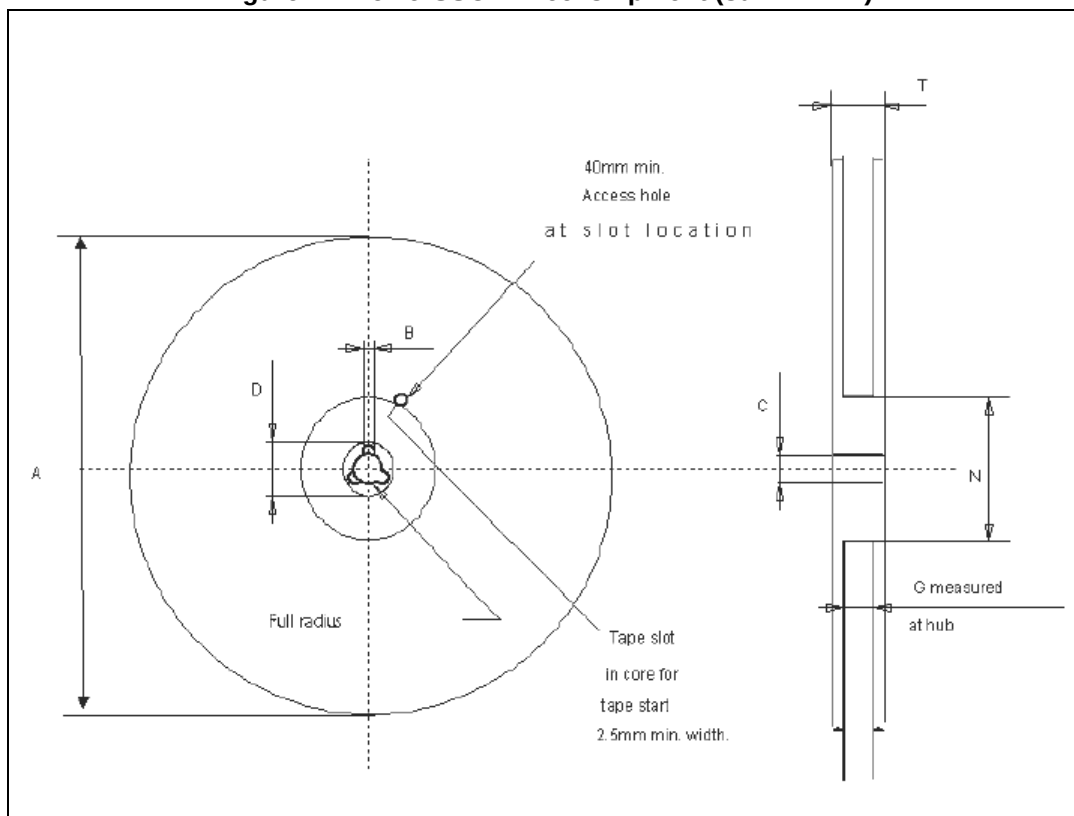


Table 12. PowerSSO-24 reel dimensions

Base quantity	1000
Bulk quantity	1000
A (max.)	330
B (min.)	1.5
C (± 0.2)	13
F	20.2
G (2 ± 0)	24.4
N (min.)	100
T (max.)	30.4

Figure 18. PowerSSO-24 tape drawings

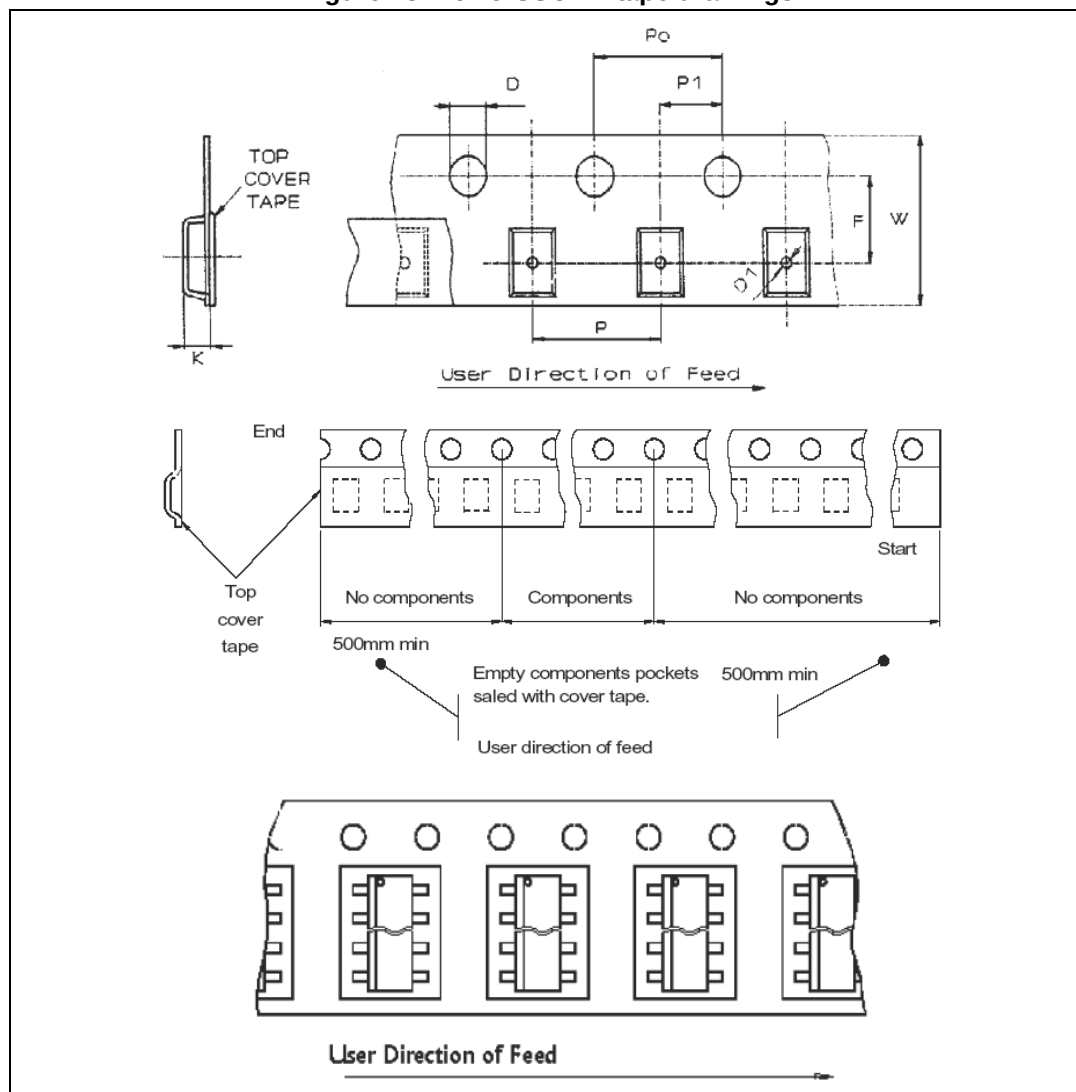
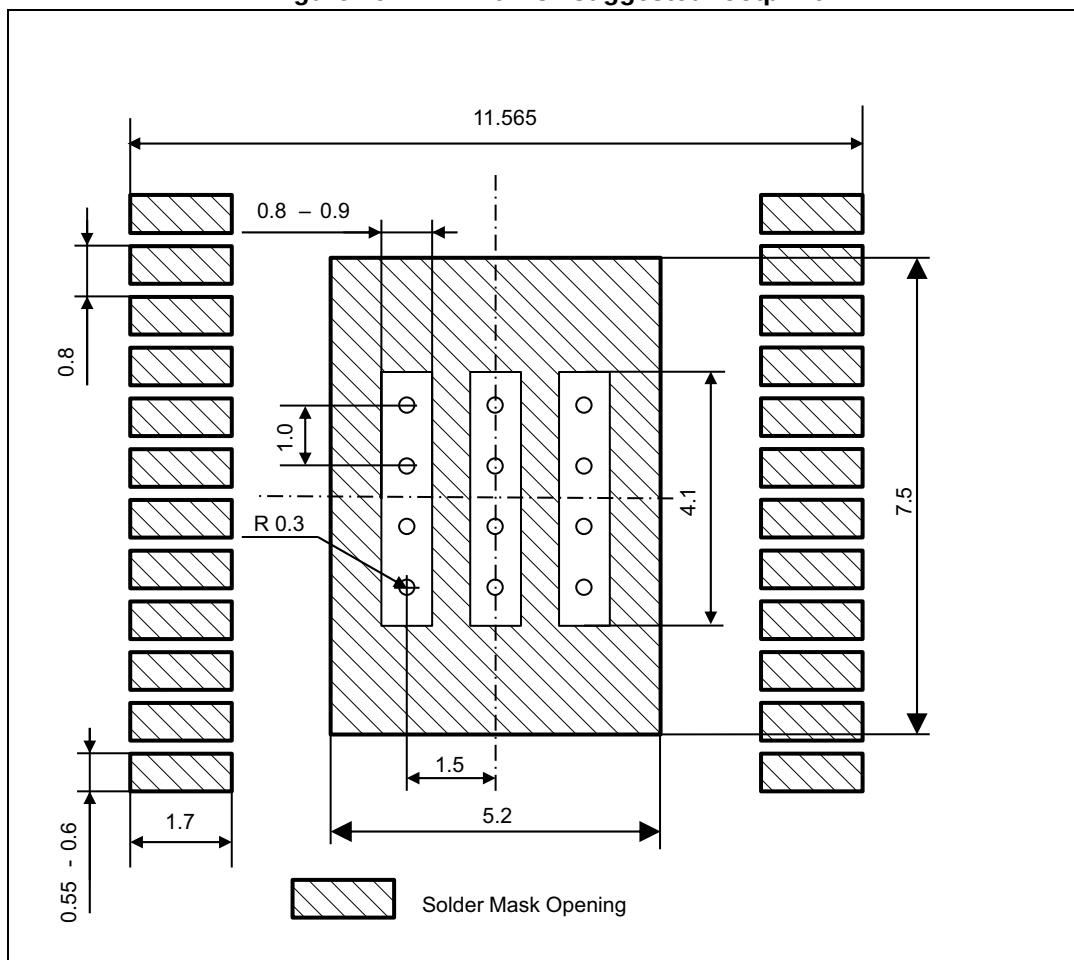


Table 13. PowerSSO-24 tape dimensions

Tape width	W	24
Tape hole spacing	$P_0 (\pm 0.1)$	4
Component spacing	P	12
Hole diameter	$D (\pm 0.05)$	1.55
Hole diameter	D1 (min.)	1.5
Hole position	$F (\pm 0.1)$	11.5
Compartment depth	K (max.)	2.85
Hole spacing	$P_1 (\pm 0.1)$	2

Note: According to the Electronic Industries Association (EIA) standard 481 rev. A, Feb 1986.

Figure 19. VNI4140K-32 suggested footprint



Note: STMicroelectronics is not responsible for any PCB related issues. The footprint shown in the above figure is a suggestion which might not be in line to the customer PCB supplier design rules.

All dimensions are in mm.

13 Ordering information

Table 14. Ordering information

Order codes	Package	Packaging
VNI4140K-32	PowerSSO-24	Tube
VNI4140KTR-32	PowerSSO-24	Tape and reel

14 Revision history

Table 15. Document revision history

Date	Revision	Changes
12-Dec-2011	1	Initial release.
06-Feb-2012	2	Updated I_{lim} minimum value in Table 8: Protection and diagnostic . Inserted new feature: ESD according to IEC 61000-4-2 up to +/-25 KV, in cover page.
07-Mar-2012	3	Suggested footprint inserted. In Table 5 , parameter I_{LGND} has been added.
25-Mar-2013	4	Updated I_{LIM} minimum value in Table 8 . Minor text changes.
06-Nov-2013	5	Updated E_{AS} value in Table 2: Absolute maximum ratings . Added Figure 14 .
11-Dec-2013	6	Updated Section 10 .

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

Mouser Electronics

Authorized Distributor

Click to View Pricing, Inventory, Delivery & Lifecycle Information:

[STMicroelectronics:](#)

[VNI4140K-32](#) [VNI4140KTR-32](#)