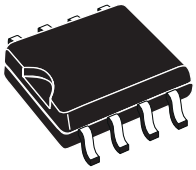
VN750SM

High-side driver

Features

Type	$R_{DS(on)}$	I_{OUT}	V_{CC}
VN750SM	55 mΩ	6 A	36 V

- CMOS compatible input
- On-state open load detection
- Off-state open load detection
- Shorted load protection
- Under-voltage and over-voltage shutdown
- Protection against loss of ground
- Very low stand-by current
- Reverse battery protected (see *Application schematic*)



SO-8

Obsolete Product(s) - Obsolete Product(s)

Description

The VN750SM is a monolithic device designed in STMicroelectronics VIPower M0-3 technology. The VN750SM 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 over-load. The device detects the open load condition in both the on 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.

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
SO-8	VN750SM	VN750SM13TR

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1 Block diagram and pin description

Figure 1. Block diagram

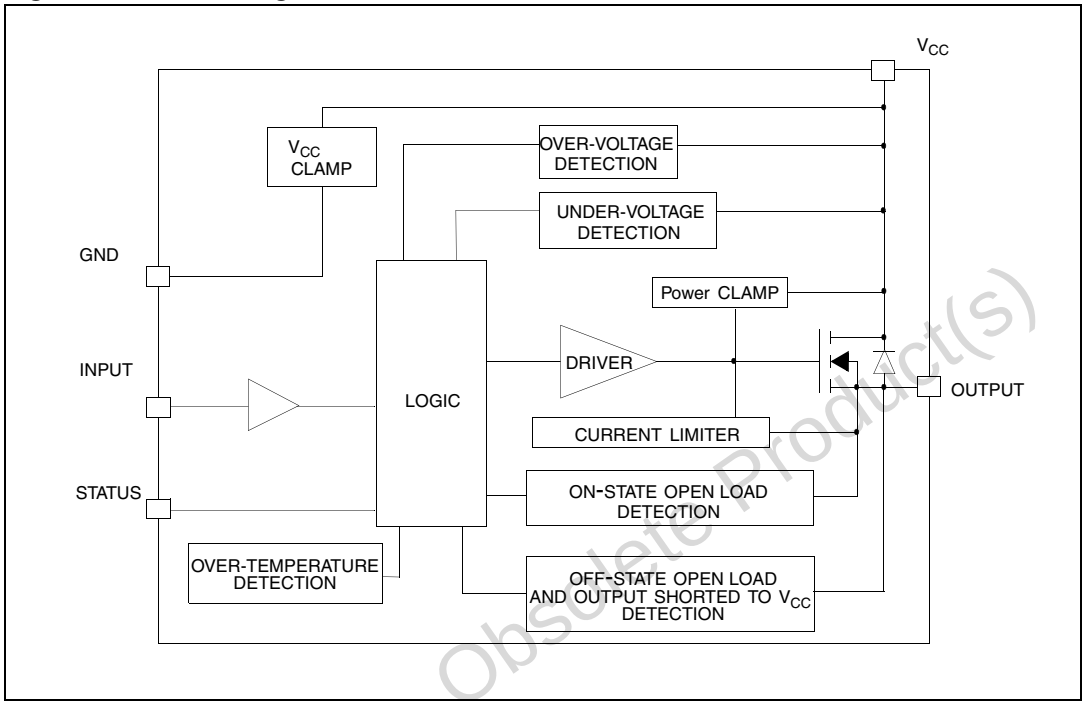


Figure 2. Configuration diagram (top view)

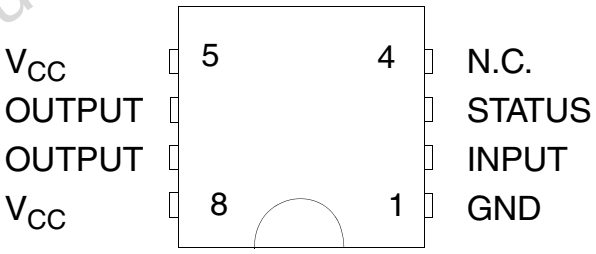


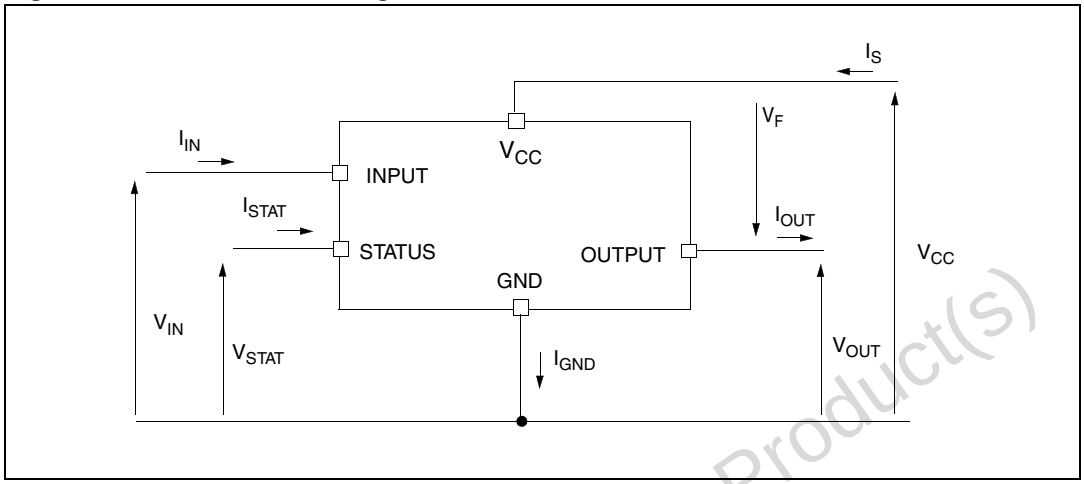
Table 2. Suggested connections for unused and not connected pins

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

Obsolete Product(s) - Obsolete Product(s)

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	- 6	A
I_{IN}	DC input current	+/- 10	mA
I_{STAT}	DC status current	+/- 10	mA
V_{ESD}	Electrostatic discharge (human body model: R =1.5KΩ; C =100pF) INPUT STATUS OUTPUT V_{CC}	 4000 4000 5000 5000	 V V V V
E_{MAX}	Maximum switching energy (L = 1.3mH; R_L= 0Ω; V_{bat} = 13.5V; T_{jstart} = 150ºC; I_L = 10A)	90	mJ

Obsolete Product(s) Obsolete Product(s)

Table 3. Absolute maximum ratings (continued)

Symbol	Parameter	Value	Unit
P_{tot}	Power dissipation T_C=25°C	4.2	W
T_j	Junction operating temperature	Internally limited	°C
T_{stg}	Storage temperature	- 55 to 150	°C

2.2 Thermal data

Table 4. Thermal data

Symbol	Parameter	Max. value		Unit
$R_{thj\text{-}lead}$	Thermal resistance junction-lead	30		°C/W
$R_{thj\text{-}amb}$	Thermal resistance junction-ambient	93(1)	82(2)	°C/W

1. When mounted on a standard single-sided FR-4 board with 0.5 cm^2 of Cu (at least 35µm thick) connected to all V_{CC} pins. Horizontal mounting and no artificial air flow.
2. When mounted on a standard single-sided FR-4 board with 2 cm^2 of Cu (at least 35µm thick). Horizontal mounting and no artificial air flow.

2.3 Electrical characteristics

Values specified in this section are for 8V < V_{CC} < 36V; -40°C < T_j < 150°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}	Under-voltage shutdown		3	4	5.5	V
$V_{USDhyst}$	Under-voltage shutdown hysteresis			0.5		V
V_{OV}	Over-voltage shutdown		36			V
R_{ON}	On-state resistance	I_{OUT} = 2A; T_j = 25°C; V_{CC} > 8V I_{OUT} = 2A; V_{CC} > 8V			55 110	mΩ mΩ
I_S	Supply current	Off-state; V_{CC} = 13V; V_{IN} = V_{OUT} = 0V Off-state; V_{CC} = 13V; V_{IN} = V_{OUT} = 0V; T_j = 25°C On-state; V_{CC} = 13V; V_{IN} = 5V; I_{OUT} = 0A		10 10 2	25 20 3.5	µA µA mA
$I_{L(off1)}$	Off-state output current	V_{IN} = V_{OUT} = 0V	0		50	µA
$I_{L(off2)}$	Off-state output current	V_{IN} = 0V; V_{OUT} = 3.5V	-75		0	µA

Obsolete Product(s) - Obsolete Product(s)

Table 5. Power (continued)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{L(off3)}$	Off-state output current	$V_{IN} = V_{OUT} = 0V$; $V_{CC} = 13V$; $T_j = 125°C$			5	µA
$I_{L(off4)}$	Off-state output current	$V_{IN} = V_{OUT} = 0V$; $V_{CC} = 13V$; $T_j = 25°C$			3	µA

Table 6. Switching (V_{CC}=13V)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$R_L = 6.5\Omega$ from V_{IN} rising edge to $V_{OUT} = 1.3V$		40		µs
$t_{d(off)}$	Turn-off delay time	$R_L = 6.5\Omega$ from V_{IN} falling edge to $V_{OUT} = 11.7V$		30		µs
$dV_{OUT}/dt_{(on)}$	Turn-on voltage slope	$R_L = 6.5\Omega$ from $V_{OUT} = 1.3V$ to V_{OUT}=10.4V	See *Figure 21.*			V/µs
$dV_{OUT}/dt_{(off)}$	Turn-off voltage slope	$R_L = 6.5\Omega$ from $V_{OUT} = 11.7V$ to V_{OUT}=1.3V	See *Figure 22.*			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	$V_{IN} = 1.25V$	1			µA
V_{IH}	Input high level		3.25			V
I_{IH}	High level input current	$V_{IN} = 3.25V$			10	µA
V_{hyst}	Input hysteresis voltage		0.5			V
V_{ICL}	Input clamp voltage	$I_{IN} = 1mA$ $I_{IN} = -1mA$	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	- $I_{OUT} = 1.4A$; $T_j = 150°C$			0.6	V

Table 9. Status pin

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{STAT}	Status low output voltage	$I_{STAT} = 1.6mA$			0.5	V
I_{LSTAT}	Status leakage current	Normal operation; $V_{STAT} = 5V$			10	µA
C_{STAT}	Status pin input capacitance	Normal operation; $V_{STAT} = 5V$			100	pF
V_{SCL}	Status clamp voltage	$I_{STAT} = 1mA$ I_{STAT}= - 1mA	6	6.8 - 0.7	8	V V

Obsolete Product(s) - Obsolete Product(s)

Table 10. Protections(1)

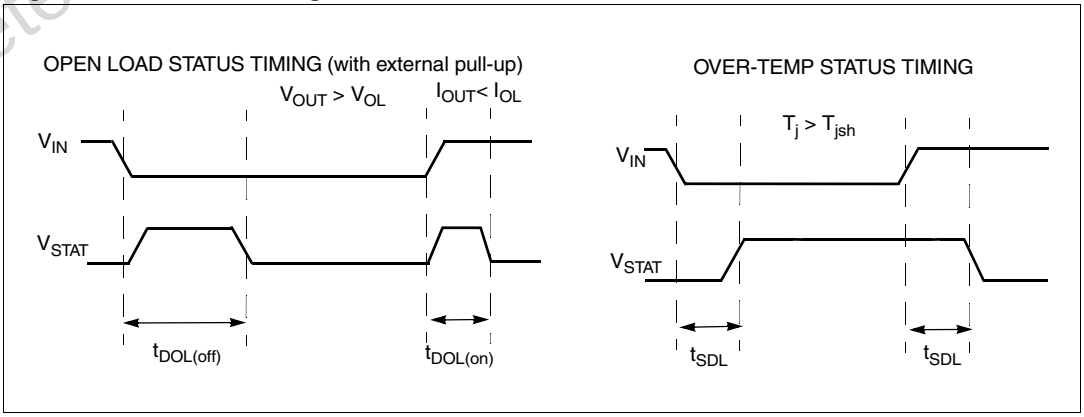
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
T_{TSD}	Shutdown temperature		150	175	200	°C
T_R	Reset temperature		135			°C
T_{hyst}	Thermal hysteresis		7	15		°C
t_{SDL}	Status delay in over-load condition	$T_j > T_{jsh}$			20	µs
I_{lim}	Current limitation	$9V < V_{CC} < 36V$ $5V < V_{CC} < 36V$	6	10	12 12	A A
V_{demag}	Turn-off output clamp voltage	I_{OUT} = 2 A; V_{IN} = 0V; L = 6mH	V_{CC} - 41	V_{CC} - 48	V_{CC} - 55	V

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 11. Open load detection

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{OL}	Open load on-state detection threshold	V_{IN} = 5V	0.6	0.9	1.2	A
$t_{DOL(on)}$	Open load on-state detection delay	I_{OUT} = 0A			200	µs
V_{OL}	Open load off-state voltage detection threshold	V_{IN} = 0V	1.5	2.5	3.5	V
$t_{DOL(off)}$	Open load detection delay at turn-off				1000	µs

Figure 4. Status timings



Obsolete Product(s) - Obsolete Product(s)

Figure 5. Switching time waveforms

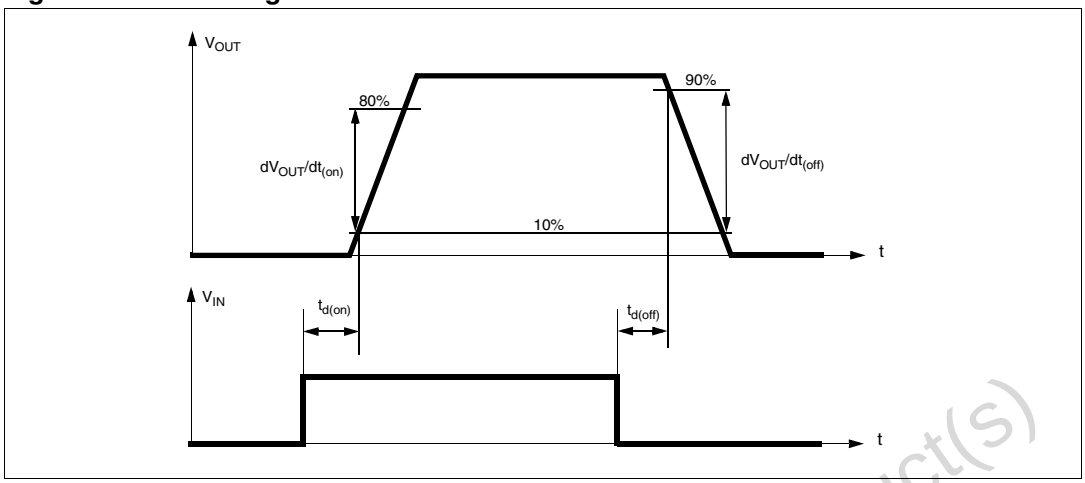


Table 12. Truth table

Conditions	Input	Output	Status
Normal operation	L H	L H	H H
Current limitation	L H H	L X X	H ($T_j < T_{TSD}$) H ($T_j > T_{TSD}$) L
Over-temperature	L H	L L	H L
Under-voltage	L H	L L	X X
Over-voltage	L H	L L	H H
Output voltage > V_{OL}	L H	H H	L H
Output current < I_{OL}	L H	L H	H L

Obsolete Product(s) - Obsolete Product(s)

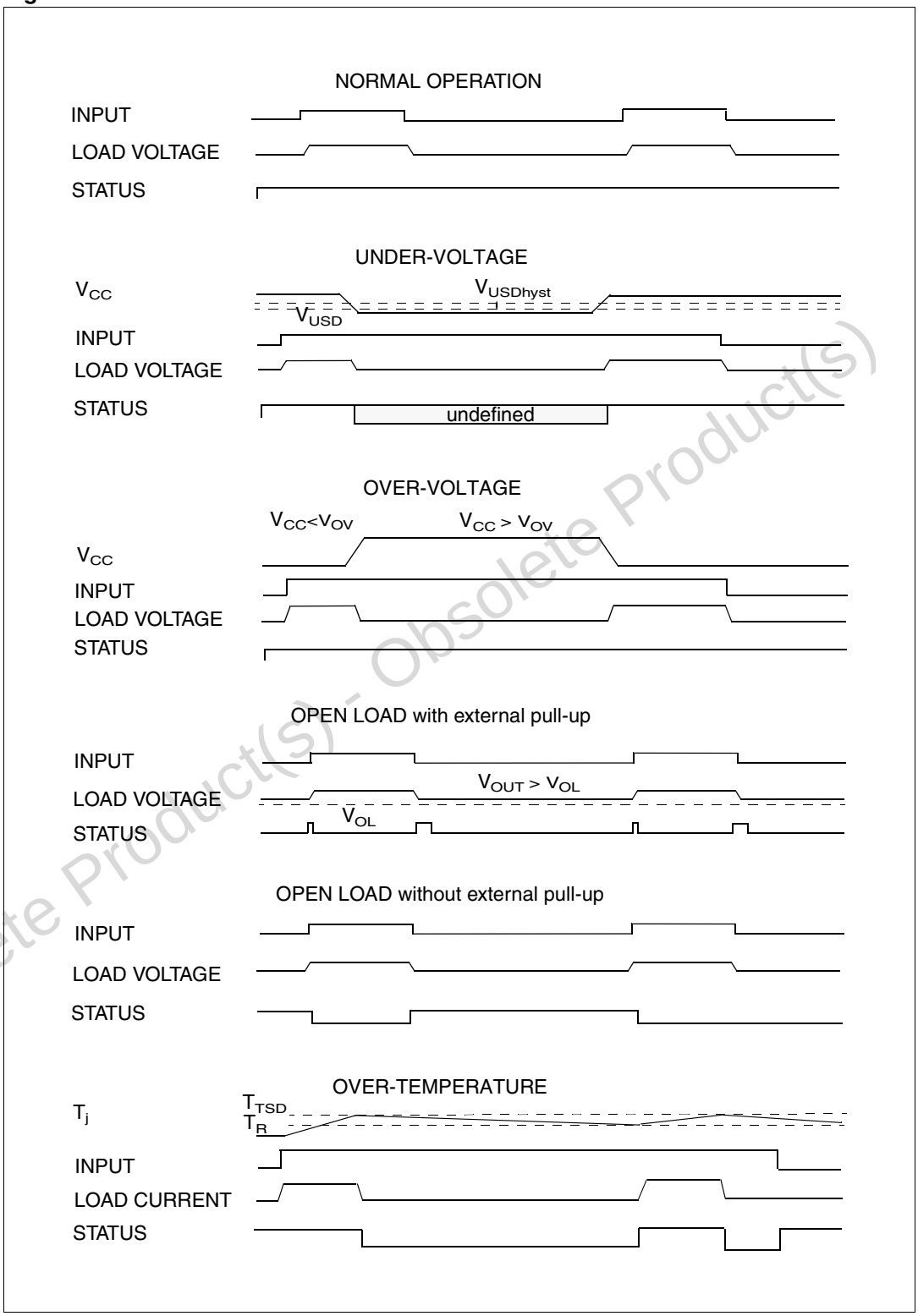
Table 13. Electrical transient requirements

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

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.

Obsolete Product(s) - Obsolete Product(s)

Figure 6. Waveforms



Obsolete Product(s) - Obsolete Product(s)

2.4 Electrical characteristics curves

Figure 7. Off-state output current

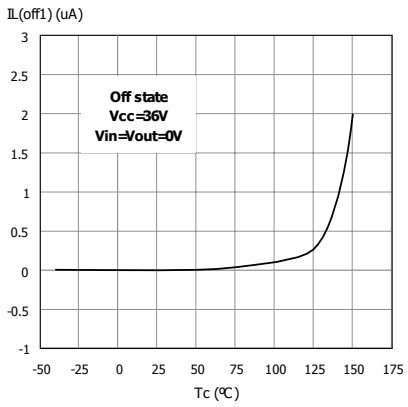


Figure 8. High level input current

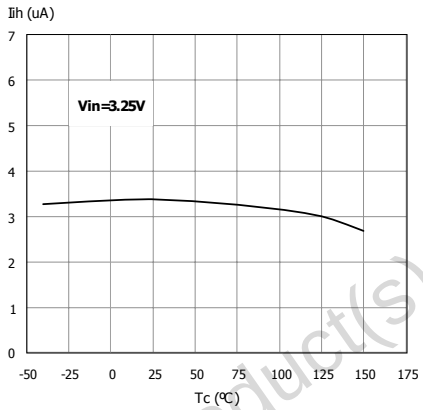


Figure 9. Input clamp voltage

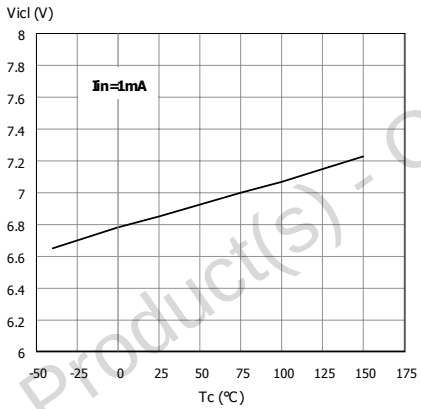


Figure 10. Status leakage current

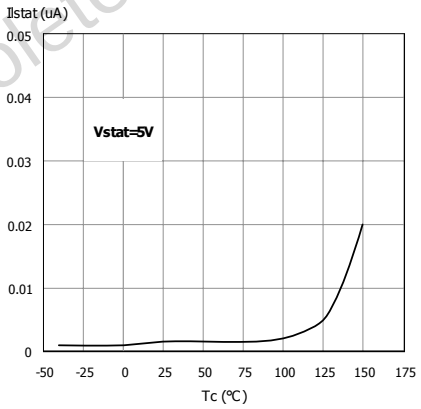


Figure 11. Status low output voltage

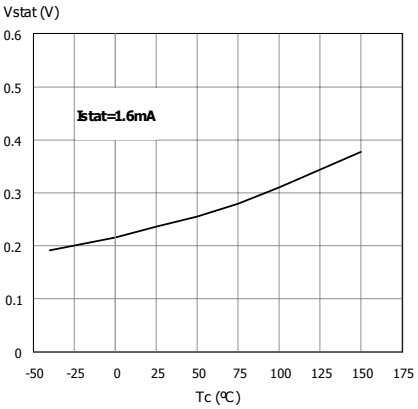
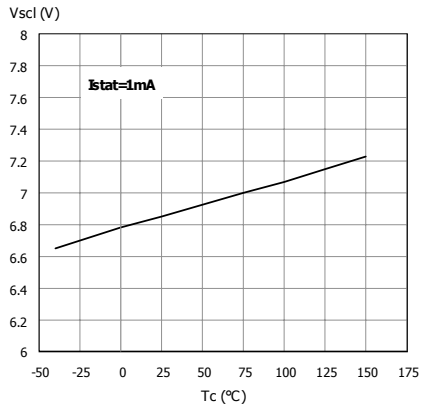


Figure 12. Status clamp voltage



Obsolete Product(s) - Obsolete Product(s)

Figure 13. On-state resistance Vs T_{case}

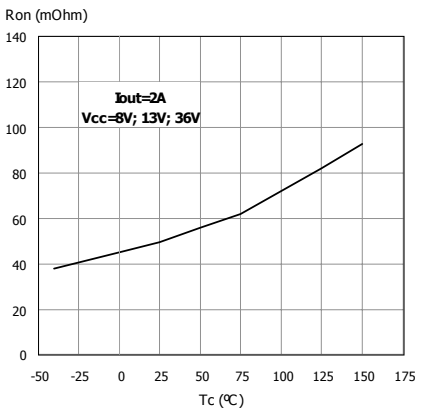


Figure 14. On-state resistance Vs V_{CC}

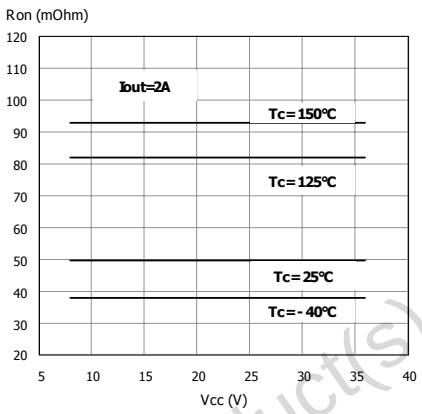


Figure 15. Open load on-state detection threshold

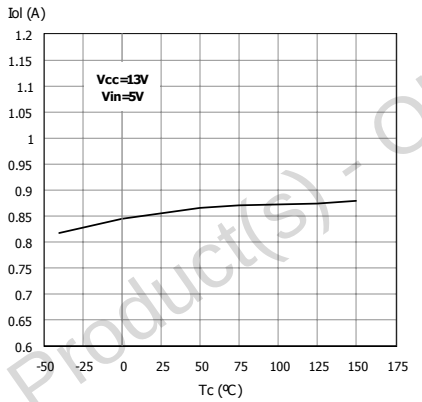


Figure 16. Input high level

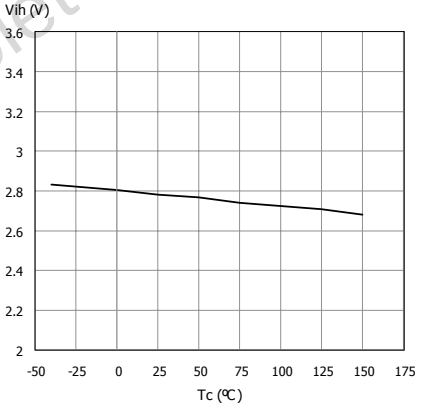


Figure 17. Input low level

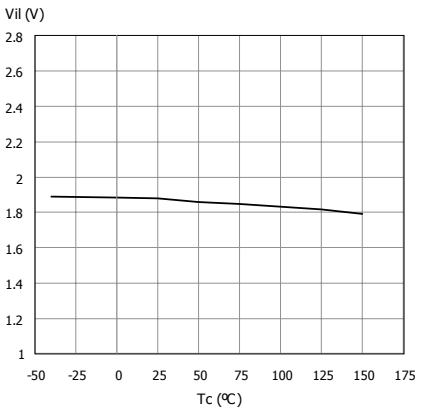
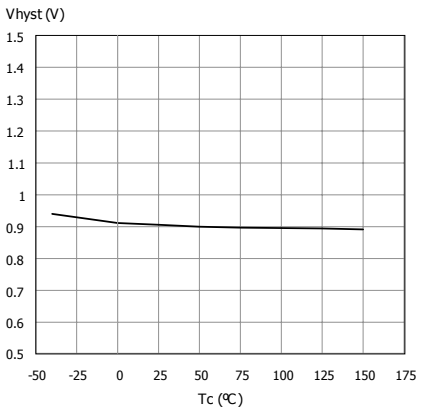


Figure 18. Input hysteresis voltage



Obsolete Product(s) - Obsolete Product(s)

Figure 19. Over-voltage shutdown

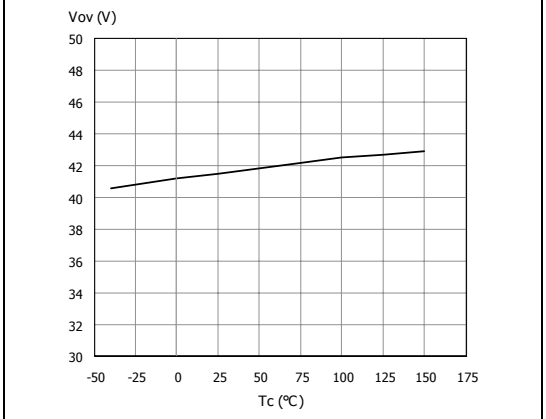


Figure 20. Open load off-state voltage detection threshold

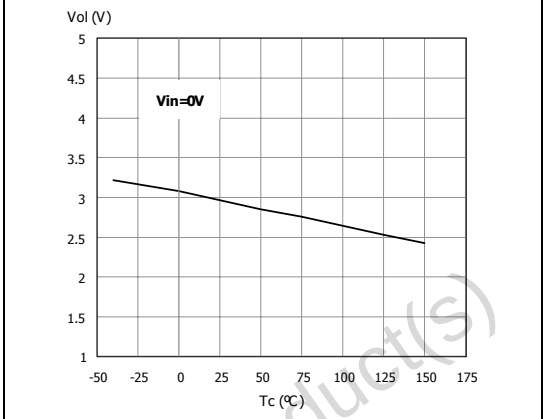


Figure 21. Turn-on voltage slope

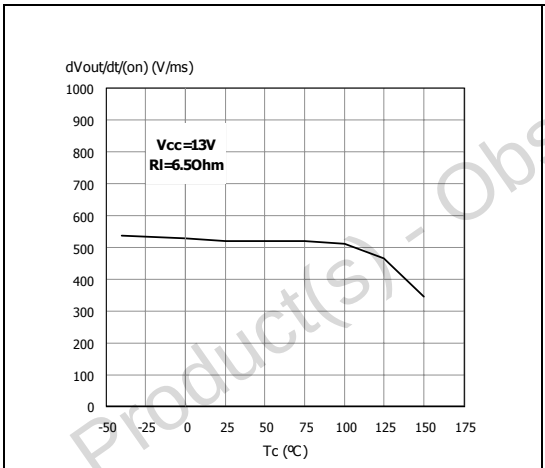


Figure 22. Turn-off voltage slope

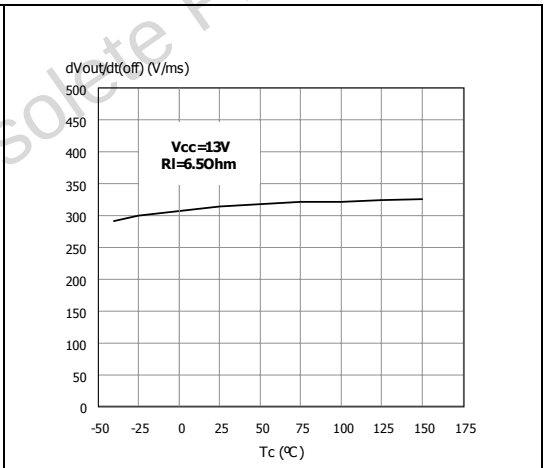
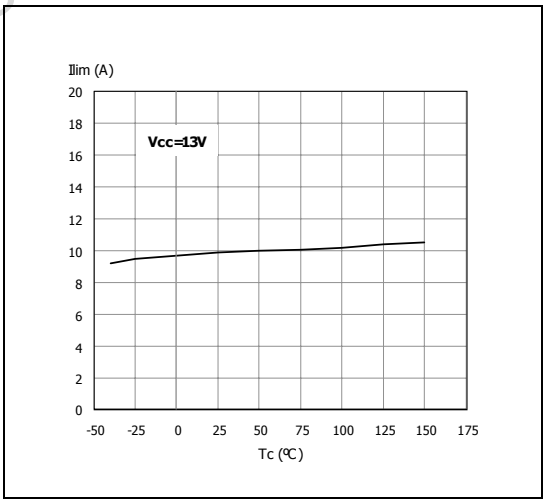


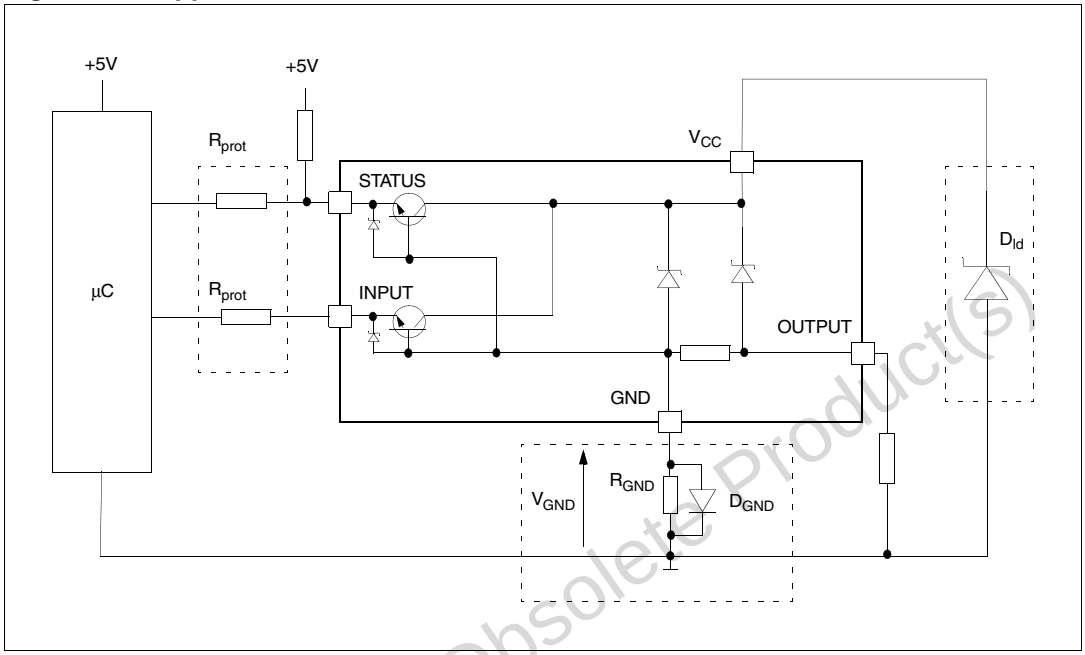
Figure 23. I_{lim} Vs T_{case}



Obsolete Product(s) - Obsolete Product(s)

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. $R_{GND} \leq 600mV / (I_{S(on)max})$.
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} will produce a shift ($I_{S(on)max} * R_{GND}$) in the input thresholds and the status output values. This shift will vary 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).

Obsolete Product(s) - Obsolete Product(s)

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

A resistor (R_{GND} = 1kΩ) 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 will produce a shift (≈ 600mV) in the input threshold and in the status output values if the microprocessor ground is not common to the device ground. This shift will 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 the ISO 7637-2: 2004(E) 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 will be pulled negative. ST suggests to insert a resistor (R_{prot}) in line to prevent the µC I/Os pins to latch-up.

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

5kΩ $\leq R_{prot} \leq$ 65kΩ

Recommended values: R_{prot} =10kΩ.

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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 +5V line used to supply the microprocessor.

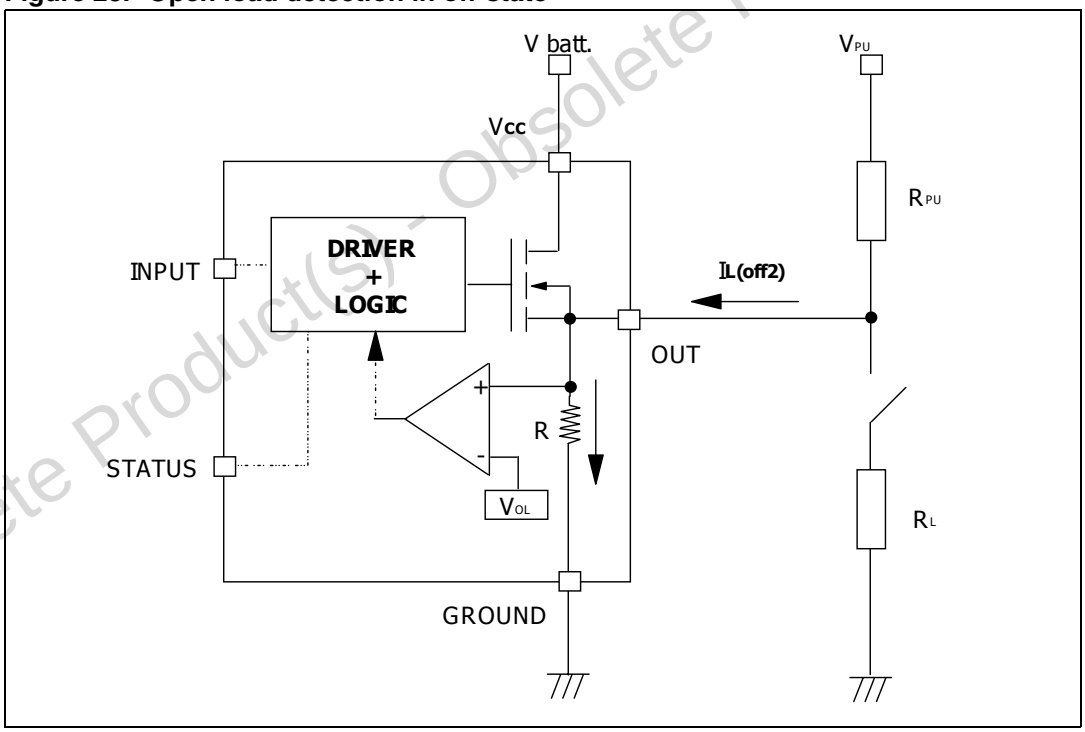
The external resistor has to be selected according to the following requirements:

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 the electrical characteristics section.

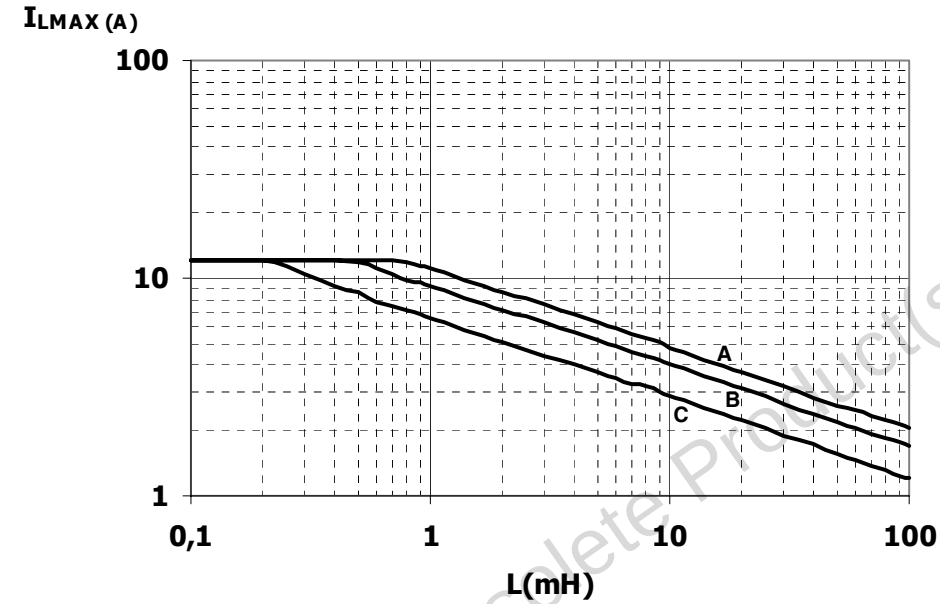
Figure 25. Open load detection in off-state



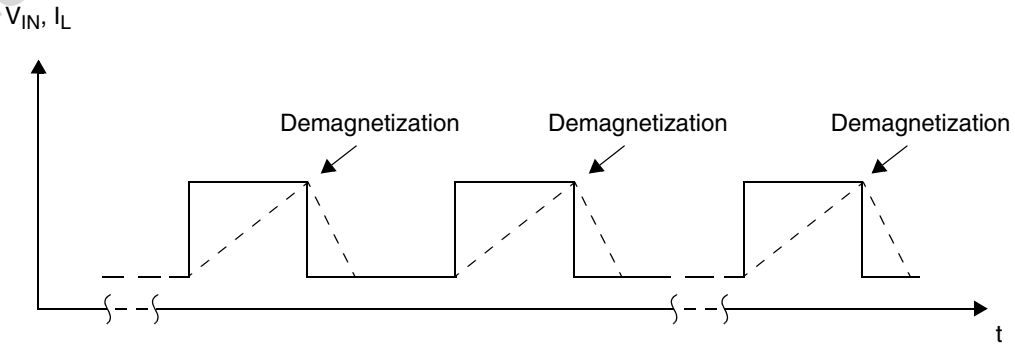
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3.5 Maximum demagnetization energy (V_{CC} = 13.5V)

Figure 26. Maximum turn-off current versus inductance



A: T_{jstart} = 150°C single pulse
B: T_{jstart} = 100°C repetitive pulse
C: T_{jstart} = 125°C repetitive pulse



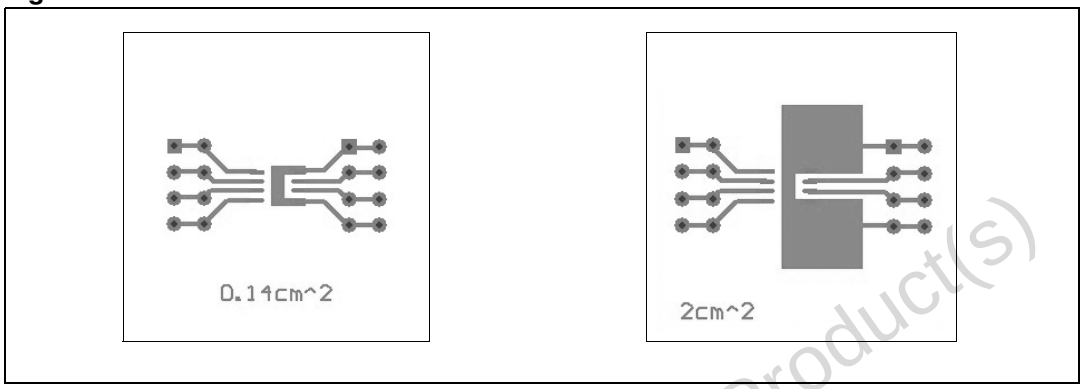
Note: Values are generated with R_L =0 Ω In case of repetitive pulses, T_{jstart} (at beginning of each demagnetization) of every pulse must not exceed the temperature specified above for curves A and B.

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4 Package and PCB thermal data

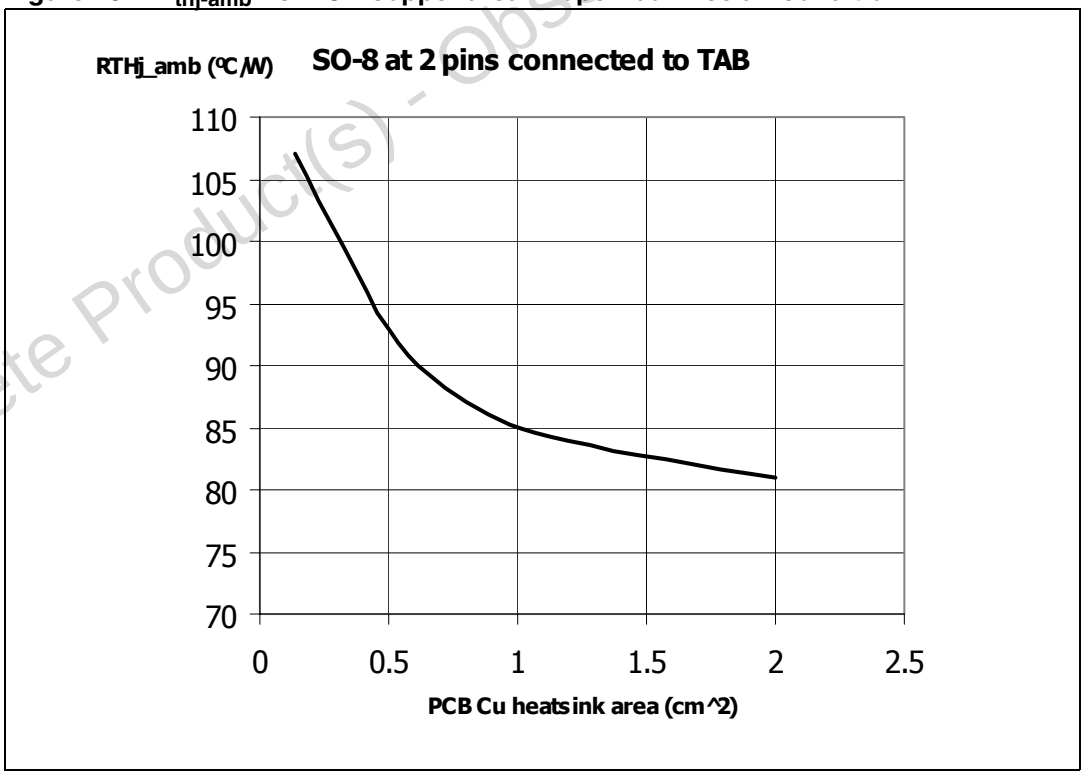
4.1 SO-8 thermal data

Figure 27. PC board



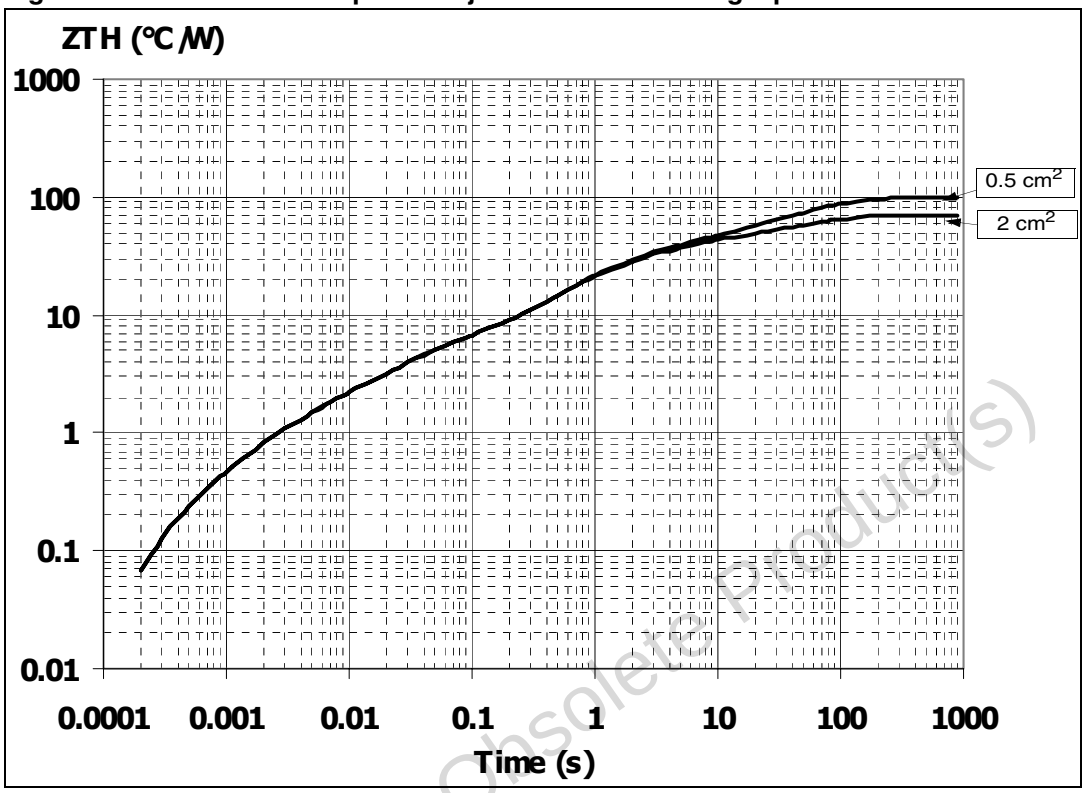
Note: Layout condition of R_{th} and Z_{th} measurements (PCB FR4 area = 58mm x 58 mm,PCB thickness = 2 mm, Cu thickness=35µm , Copper areas: 0.14 cm^2, 2 cm^2).

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



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Figure 29. SO-8 thermal impedance junction ambient single pulse

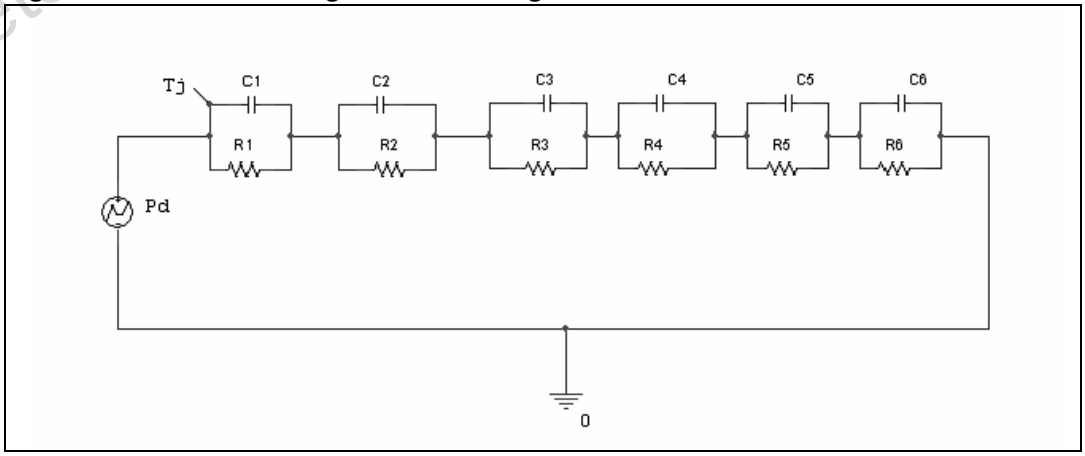


Equation 1: pulse calculation formula

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

where $\delta = t_P/T$

Figure 30. Thermal fitting model of a single channel



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Table 14. Thermal parameter

Area/island (cm^2)	0.5	2
R1 (°C/W)	0.05	
R2 (°C/W)	0.8	
R3 (°C/W)	3.5	
R4 (°C/W)	21	
R5 (°C/W)	16	
R6 (°C/W)	58	28
C1 (W·s/°C)	0.006	
C2 (W·s/°C)	0.0026	
C3 (W·s/°C)	0.0075	
C4 (W·s/°C)	0.045	
C5 (W·s/°C)	0.35	
C6 (W·s/°C)	1.05	2

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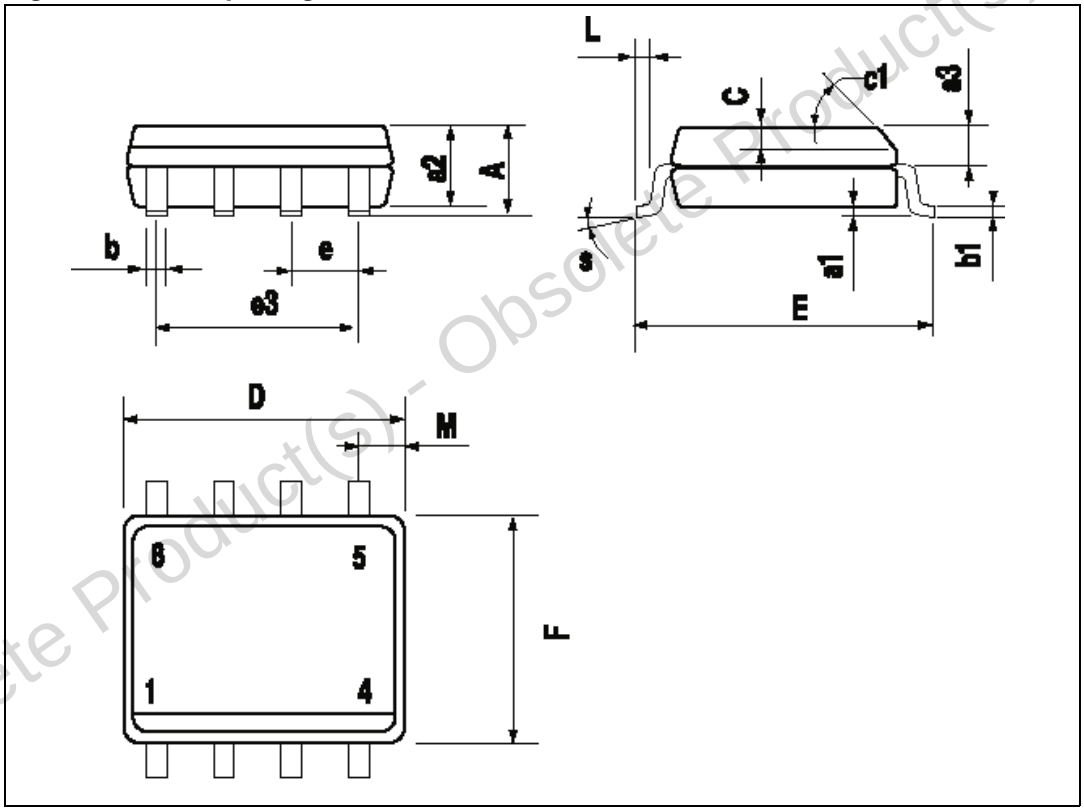
5 Package and packing information

5.1 ECOPACK® packages

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.

5.2 SO-8 package information

Figure 31. SO-8 package dimensions



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Table 15. SO-8 mechanical data

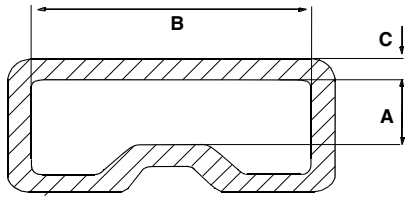
Dim.	mm		
	Min.	Typ.	Max.
A			1.75
a1	0.1		0.25
a2			1.65
a3	0.65		0.85
b	0.35		0.48
b1	0.19		0.25
C	0.25		0.5
c1	45 (typ.)		
D	4.8		5
E	5.8		6.2
e		1.27	
e3		3.81	
F	3.8		4
L	0.4		1.27
M			0.6
S	8 (max.)		
L1	0.8		1.2

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5.3 SO-8 packing information

The devices can be packed in tube or tape and reel shipments (see the *Device summary on page 1*).

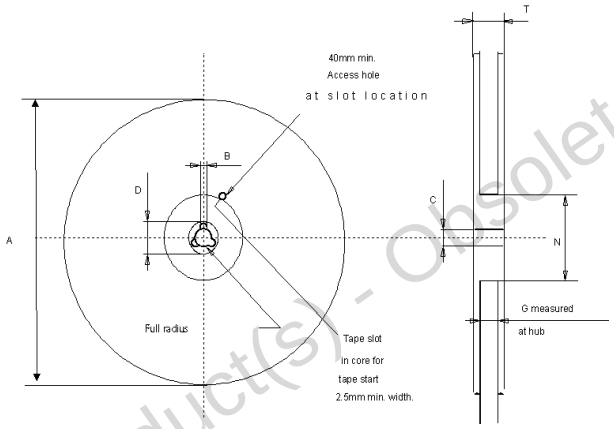
Figure 32. SO-8 tube shipment (no suffix)



Base Q.ty	100
Bulk Q.ty	2000
Tube length (± 0.5)	532
A	3.2
B	6
C (± 0.1)	0.6

All dimensions are in mm.

Figure 33. SO-8 tape and reel shipment (suffix "TR")



Reel dimensions

Base Q.ty	2500
Bulk Q.ty	2500
A (max)	330
B (min)	1.5
C (± 0.2)	13
F	20.2
G (+ 2 / -0)	12.4
N (min)	60
T (max)	18.4

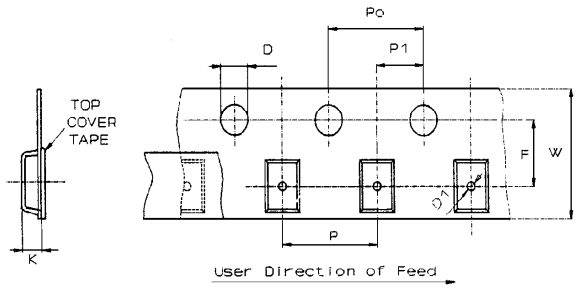
All dimensions are in mm.

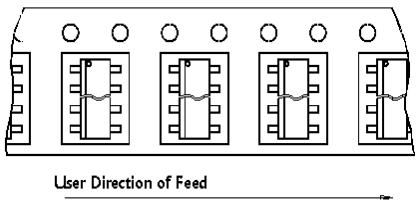
Tape dimensions

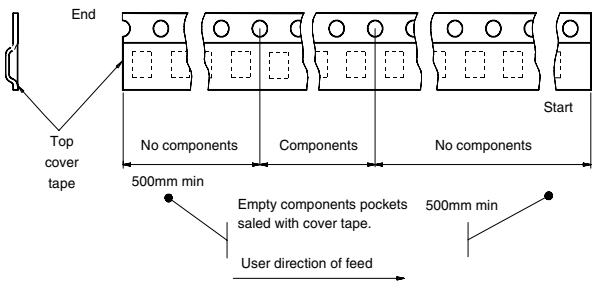
According to Electronic Industries Association (EIA) Standard 481 rev. A, Feb. 1986

Tape width	**W**	12
Tape Hole Spacing	**P0 (± 0.1)**	4
Component Spacing	**P**	8
Hole Diameter	**D (+0.1/-0)**	1.5
Hole Diameter	**D1 (min)**	1.5
Hole Position	**F (± 0.05)**	5.5
Compartment Depth	**K (max)**	4.5
Hole Spacing	**P1 (± 0.1)**	2

All dimensions are in mm.







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6 Revision history

Table 16. Document revision history

Date	Revision	Changes
09-Sep-2004	1	Initial release.
03-May-2006	2	Minor changes. Current and voltage convention update (page 2). Configuration diagram (top view) and suggested connections for unused and n.c. pins insertion (page 2). 2 cm2 Cu condition insertion in thermal data table (page 3). V_{CC} - output diode section update (page 4). Revision history table insertion (page18). Disclaimers update (page 19).
16-Dec-2008	3	Document reformatted and restructured. Added content, list of figures and tables. Added *ECOPACK® packages* information.
24-Sep-2013	4	Updated Disclaimer.

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