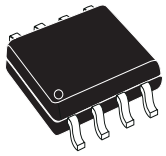
VNL5300S5-E

OMNIFET III
fully protected low-side driver

Datasheet - production data



SO-8

Features

Type	V_{clamp}	$R_{DS(on)}$	I_D
VNL5300S5-E	41 V	300 mΩ	2 A

- Drain current: 2 A
- ESD protection
- Overvoltage clamp
- Thermal shutdown
- Current and power limitation
- Very low standby current
- Very low electromagnetic susceptibility
- Compliant with European directive 2002/95/EC
- Open drain status output

Description

The VNL5300S5-E is a monolithic device made using STMicroelectronics® VIPower® technology, intended for driving resistive or inductive loads with one side connected to the battery.

Built-in thermal shutdown protects the chip from overtemperature and short-circuit. Output current limitation protects the device in an overload condition. In case of long duration overload, the device limits the dissipated power to a safe level up to thermal shutdown intervention. Thermal shutdown, with automatic restart, allows the device to recover normal operation as soon as a fault condition disappears. Fast demagnetization of inductive loads is achieved at turn-off.

Table 1. Devices summary

Package	Order codes	
	Tube	Tape and reel
SO-8	VNL5300S5-E	VNL5300S5TR-E

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1 Block diagrams and pins configurations

Figure 1. Block diagram

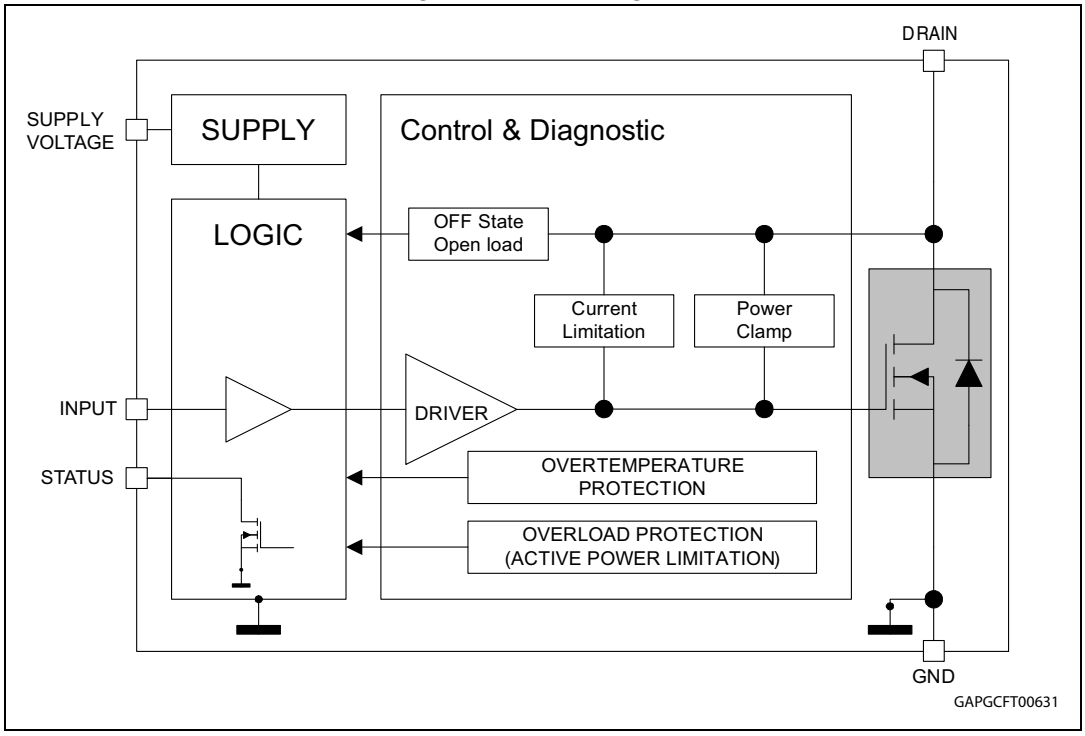


Table 2. Pin function

Name	Function
INPUT	Voltage controlled input pin with hysteresis, CMOS compatible. It Controls output switch state
DRAIN	PowerMOS drain
SOURCE	PowerMOS source and ground reference for the control section
SUPPLY VOLTAGE	Supply voltage connected to the signal part (5 V)
STATUS	Open drain digital diagnostic pin

Figure 2. Current and voltage conventions

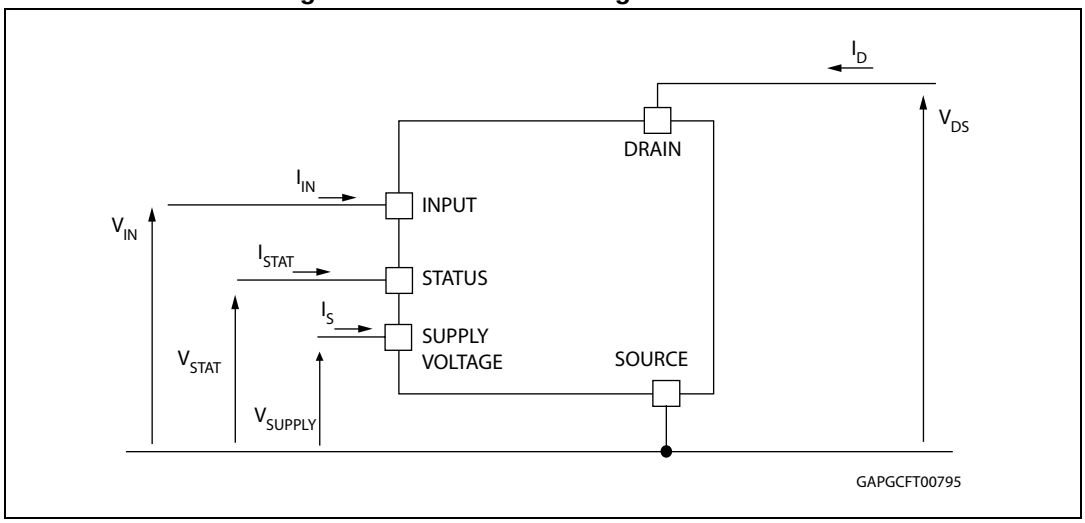
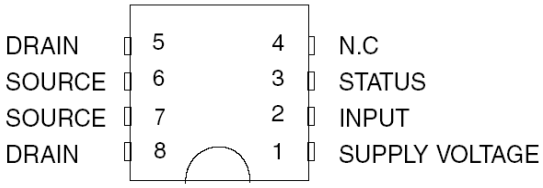


Figure 3. Configuration diagrams (top view)



SO-8

Table 3. Suggested connections for unused and N.C. pins

Connection / pin	STATUS	N.C.	INPUT
Floating	X(1)	X	X
To ground	Not allowed	X	Through 10 kΩ resistor

1. X: do not care.

2 Electrical specifications

2.1 Absolute maximum ratings

Stressing the device above the rating listed in *Table 4* 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.

Table 4. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{DS}	Drain-source voltage (V_{IN} = 0 V)	Internally clamped	V
I_D	DC drain current	Internally limited	A
$-I_D$	Reverse DC drain current	6	A
I_S	DC supply current	-1 to 10	mA
I_{IN}	DC input current	-1 to 10	mA
I_{STAT}	DC status current	-1 to 10	mA
V_{ESD1}	Electrostatic discharge (R = 1.5 kΩ; C = 100 pF) – DRAIN – SUPPLY, INPUT, STATUS	 5000 4000	V
V_{ESD2}	Electrostatic discharge on output pin only (R = 330 Ω, C = 150 pF)	2000	V
T_j	Junction operating temperature	-40 to 150	°C
T_{stg}	Storage temperature	-55 to 150	°C
E_{AS}	Single pulse avalanche energy (L = 19 mH, T_j = 150 °C, R_L = 0, I_{OUT} = I_{limL})	26	mJ

2.2 Thermal data

Table 5. Thermal data

Symbol	Parameter	Maximum value	Unit
$R_{thj\text{-}amb}$	Thermal resistance junction-ambient	115	°C/W

2.3 Electrical characteristics

Values specified in this section are for V_{supply} = V_{IN} = 4.5 V to 5.5 V, -40°C < T_j < 150°C; unless otherwise stated.

Table 6. PowerMOS section

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{supply}	Operating supply voltage	-	3.5	5	5.5	V
R_{ON}	ON-state resistance	I_D = 0.8 A; T_j = 25 °C, V_{supply} = V_{IN} = 4.5 V		300		mΩ
		I_D = 0.8 A; T_j = 150°C, V_{supply} = V_{IN} = 4.5 V			600	
V_{CLAMP}	Drain-source clamp voltage	V_{IN} = 0 V; I_D = 0.8 A	41	46	52	V
V_{CLTH}	Drain-source clamp threshold voltage	V_{IN} = 0 V; I_D = 2 mA	36			V
I_{DSS}	OFF-state output current	V_{IN} = 0 V; V_{DS} = 13 V; T_j = 25°C	0		3	µA
		V_{IN} = 0 V; V_{DS} = 13 V; T_j = 125°C	0		5	

Table 7. Source drain diode

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{SD}	Forward on voltage	I_D = 0.8 A; V_{IN} = 0 V	—	0.8	—	V

Table 8. Status pin

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{STAT}	Status low output voltage	I_{STAT} = 1 mA			0.5	V
I_{LSTAT}	Status leakage current	Normal operation, V_{STAT} = 5 V			10	µA
C_{STAT}	Status pin input capacitance	Normal operation, V_{STAT} = 5 V			100	pF
V_{STCL}	Status clamp voltage	I_{STAT} = 1 mA	5.5		7	V
		I_{STAT} = -1 mA		-0.7		

Table 9. Logic input

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{IL}	Low-level input voltage				0.9	V
I_{IL}	Low-level input current	V_{IN} = 0.9 V	1			µA
V_{IH}	High-level input voltage		2.1			V
I_{IH}	High-level input current	V_{IN} = 2.1 V			10	µA
$V_{I(hyst)}$	Input hysteresis voltage		0.13			V

Table 9. Logic input (continued)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{ICL}	Input clamp voltage	I_{IN} = 1 mA	5.5		7	V
		I_{IN} = -1 mA		-0.7		

Table 10. Openload detection

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{OL}	Openload OFF-state voltage detection threshold	V_{IN} = 0 V	0.6	1.2	1.7	V
$t_{d(oloff)}$	Delay between INPUT falling edge and STATUS falling edge in openload condition	I_{OUT} = 0 A	45	425	1100	µs

Table 11. Supply section

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_S	Supply current	OFF-state; T_j = 25°C; V_{IN} = V_{DRAIN} = 0 V;		10	25	µA
		ON-state; V_{IN} = 5 V; V_{DS} = 0 V		25	65	
V_{SCL}	Supply clamp voltage	I_{SCL} = 1 mA	5.5		7	V
		I_{SCL} = -1 mA		-0.7		

Table 12. Switching characteristics(1)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(ON)}$	Turn-on delay time	R_L = 16 Ω; V_{CC} = 13 V(2)	—	8	—	µs
$t_{d(OFF)}$	Turn-off delay time	R_L = 16 Ω; V_{CC} = 13 V(2)	—	12	—	µs
t_r	Rise time	R_L = 16 Ω; V_{CC} = 13 V(2)	—	11	—	µs
t_f	Fall time	R_L = 16 Ω; V_{CC} = 13 V(2)	—	7	—	µs
W_{ON}	Switching energy losses at turn-on	R_L = 16 Ω; V_{CC} = 13 V(2)	—	0.026	—	mJ
W_{OFF}	Switching energy losses at turn-off	R_L = 16 Ω; V_{CC} = 13 V(2)	—	0.016	—	mJ
Q_g	Total gate charge	V_{SUPPLY} = V_{IN} = 5 V	—	0.6	—	nC

1. See *Figure 5: Application schematic*
2. See *Figure 4: Switching characteristics*

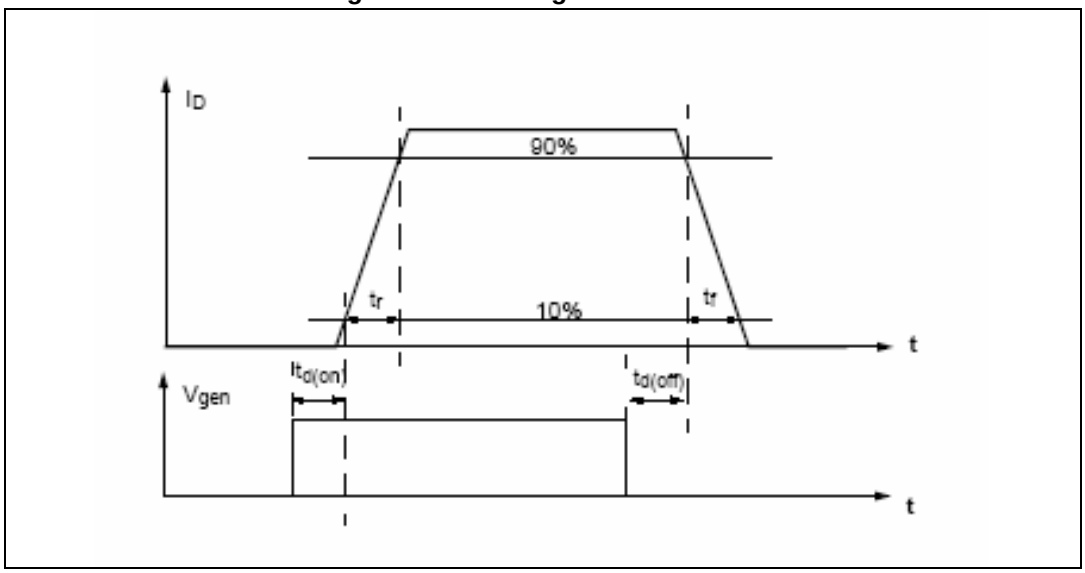
Table 13. Protection and diagnostics

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{limH}	DC short-circuit current	V_{DS} = 13 V; V_{supply} = V_{IN} = 5 V	2	2.8	3.8	A
I_{limL}	Short-circuit current during thermal cycling	V_{DS} = 13 V; $T_R < T_j < T_{TSD;}$ V_{supply} = V_{IN} = 5 V		1.4		A
t_{dlimL}	Step response current limit	V_{DS} = 13 V; V_{input} = 5 V		7		µs
T_{TSD}	Shutdown temperature		150	175	200	°C
T_R	Reset temperature		T_{RS} + 1	T_{RS} + 5		°C
T_{RS}	Thermal reset of STATUS		135			°C
T_{HYST}	Thermal hysteresis (T_{TSD} - T_R)			7		°C

Table 14. Truth table

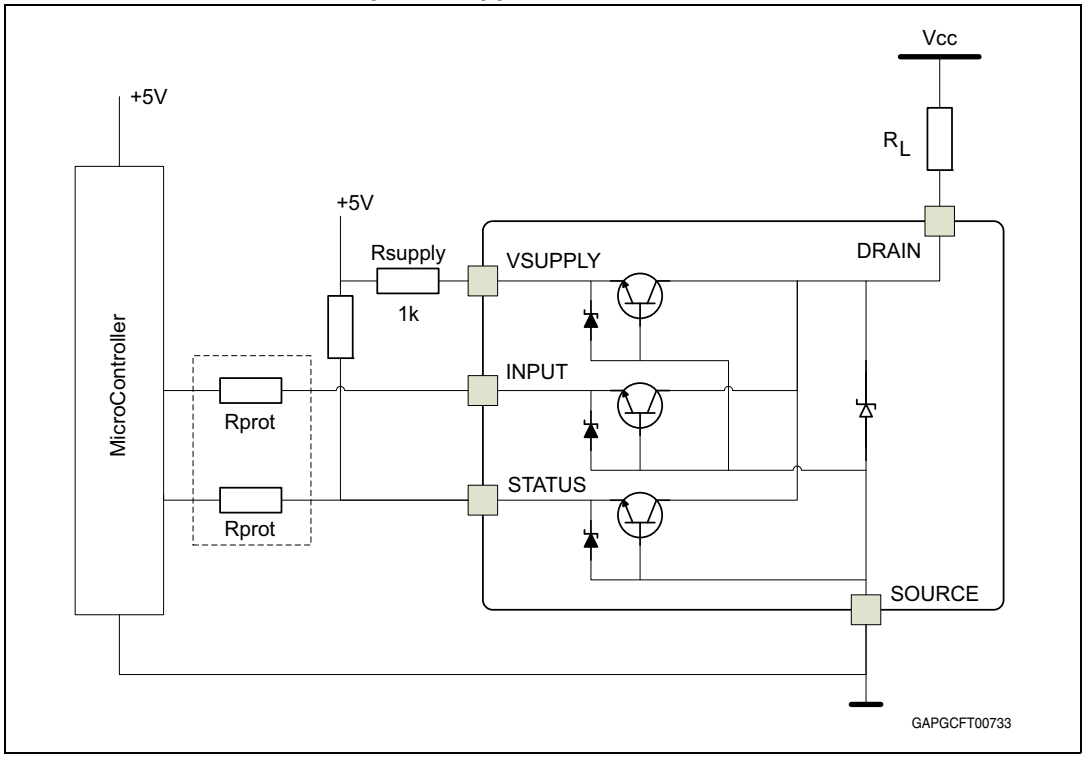
Conditions	INPUT	DRAIN	STATUS
Normal operation	L H	H L	H H
Current limitation	L H	H X	H H
Overtemperature	L H	H H	H L
Undervoltage	L H	H H	X X
Output voltage < V_{OL}	L H	L L	L H

Figure 4. Switching characteristics



3 Application information

Figure 5. Application schematic



3.1 MCU I/O protection

ST suggests to insert a resistor (R_{prot}) in line to prevent the microcontroller I/O pins from latching up[(a)]. The value of these resistors is a compromise between the leakage current of microcontroller and the current required by the LSD I/Os (input levels compatibility) with the latch-up limit of microcontroller I/Os:

Equation 1

$$\frac{0.7}{I_{latchup}} \leq R_{prot} \leq \frac{(V_{OH\mu C} - V_{IH})}{I_{IH\ max}}$$

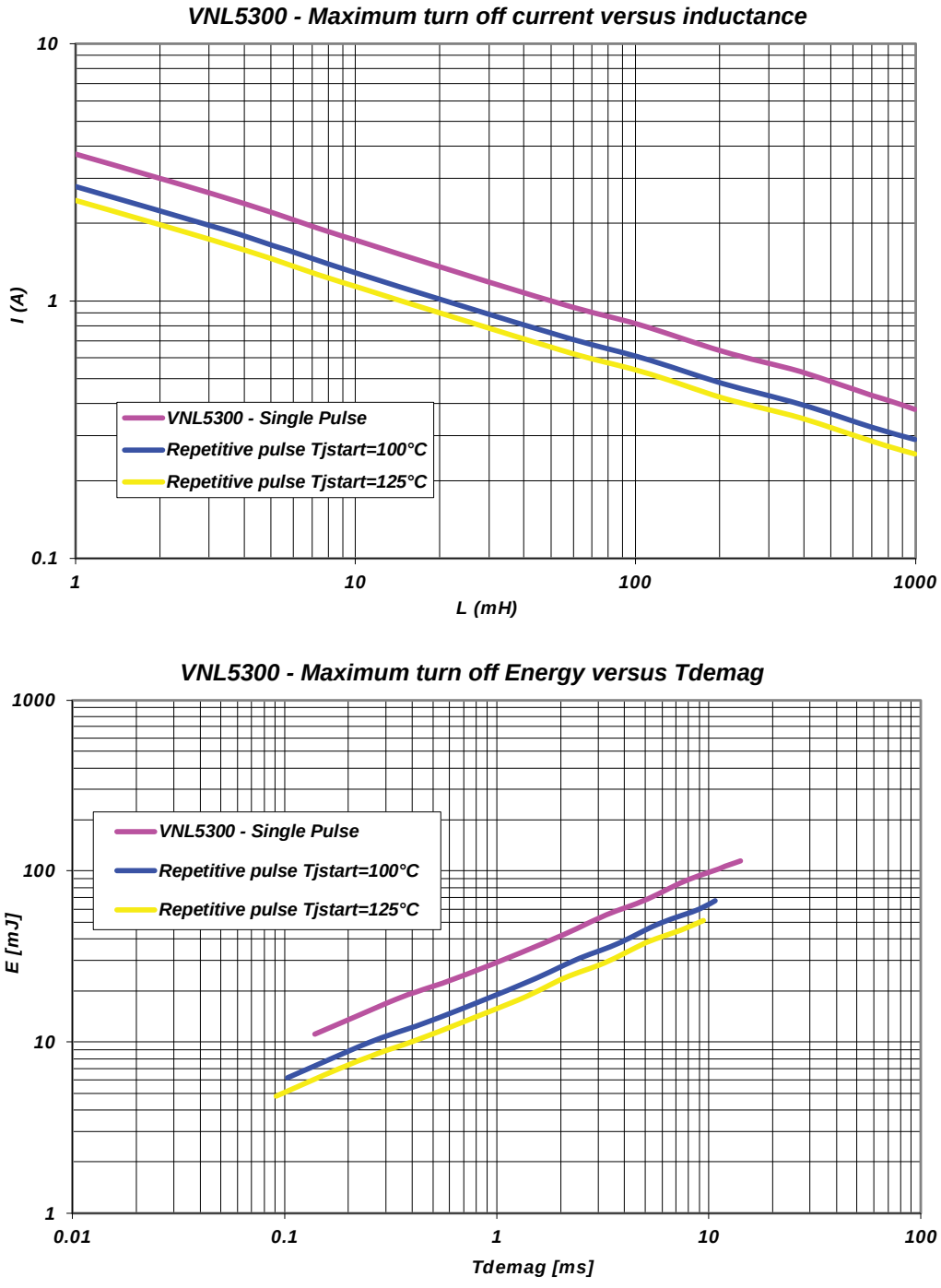
Let:

- $I_{latchup} \geq 20$ mA
- $V_{OH\mu C} \geq 4.5$ V
- $35\ \Omega \leq R_{prot} \leq 100\ K\Omega$

Then, the recommended value is $R_{prot} = 1\ K\Omega$

a. In case of negative transient on the drain pin.

Figure 6. Maximum demagnetization energy

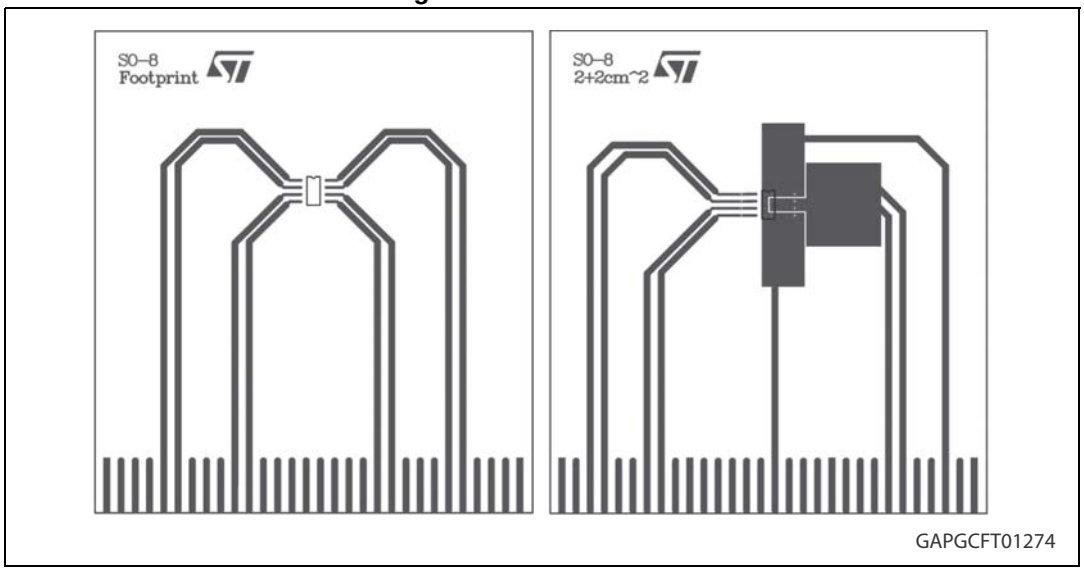


1. Values are generated with R_L = 0Ω.
In case of repetitive pulses, T_{jstart} (at the beginning of each demagnetization) of every pulse must not exceed the temperature specified above for curves A and B.

4 Package and PC board thermal data

4.1 SO-8 thermal data

Figure 7. SO-8 PC board



Note: Layout condition of R_{th} and Z_{th} measurements (Board finish thickness 1.6 mm +/- 10%; Board double layer; Board dimension 78 mm x 86 mm; Board Material FR4; Cu thickness 0.070 mm (front and back side); Thermal vias separation 1.2 mm; Thermal via diameter 0.3 mm +/- 0.08 mm; Cu thickness on vias 0.025 mm).

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

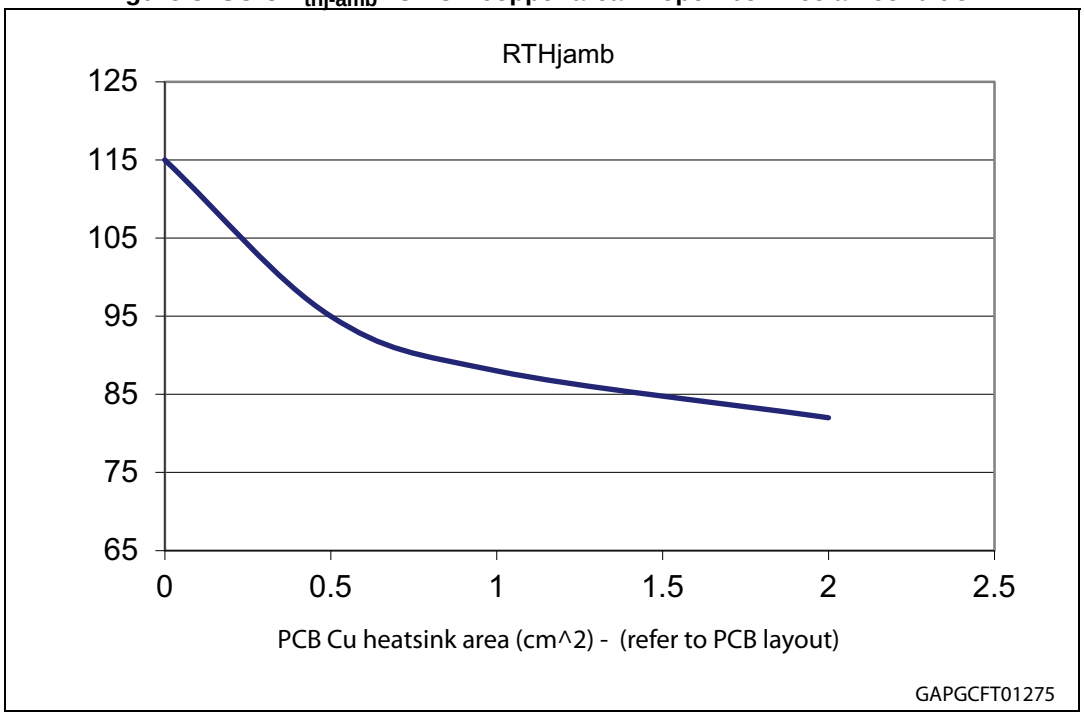
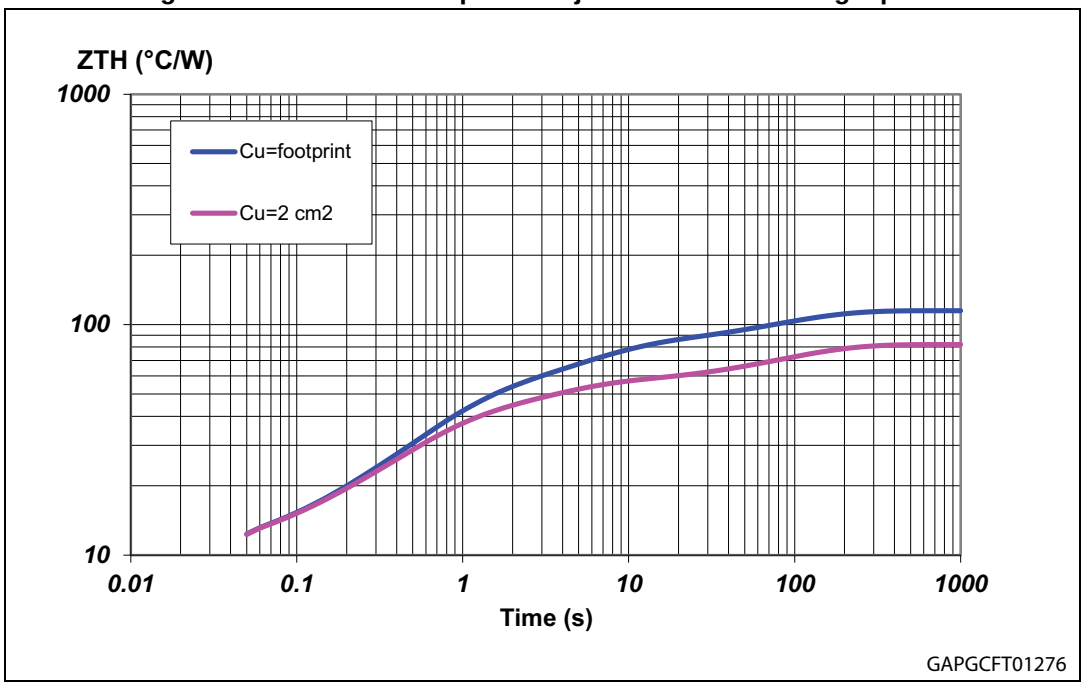


Figure 9. SO-8 thermal impedance junction ambient single pulse

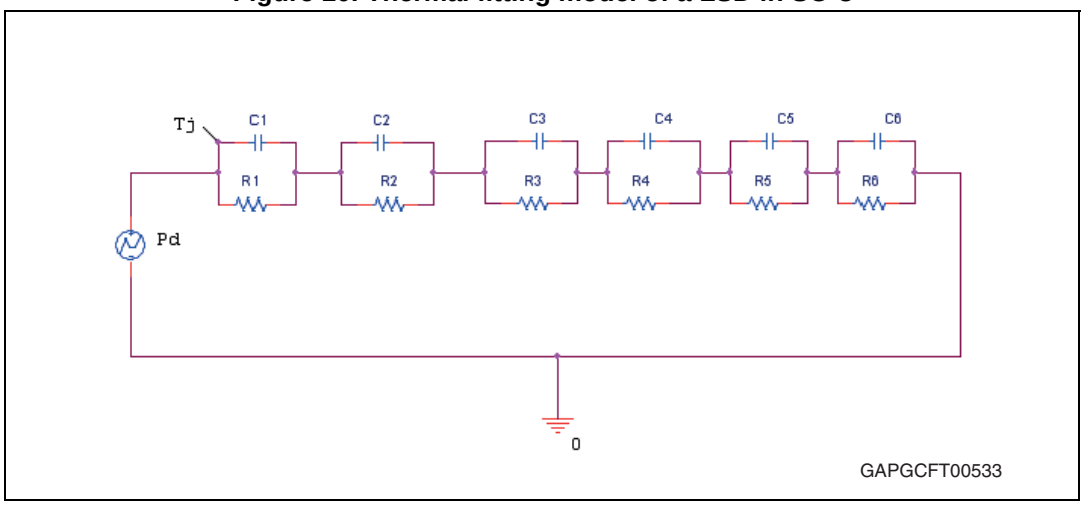


Equation 2: pulse calculation formula

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

where $\delta = t_P/T$

Figure 10. Thermal fitting model of a LSD in SO-8



Note: The fitting model is a semplified thermal tool and is valid for transient evolutions where the embedded protections (power limitation or thermal cycling during thermal shutdown) are not triggered.

Table 15. SO-8 thermal parameters

Area/island (cm^2)	Footprint	2
R1 (°C/W)	2.8	2.8
R2 (°C/W)	3.7	3.7
R3 (°C/W)	3.5	3.5
R4 (°C/W)	34	25
R5 (°C/W)	36	20
R6 (°C/W)	35	27
C1 (W.s/°C)	0.00002	0.00002
C2 (W.s/°C)	0.001	0.001
C3 (W.s/°C)	0.005	0.005
C4 (W.s/°C)	0.02	0.02
C5 (W.s/°C)	0.15	0.15
C6 (W.s/°C)	2.5	3.5

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. ECOPACK® is an ST trademark.

5.2 SO-8 mechanical data

Figure 11. SO-8 package dimensions

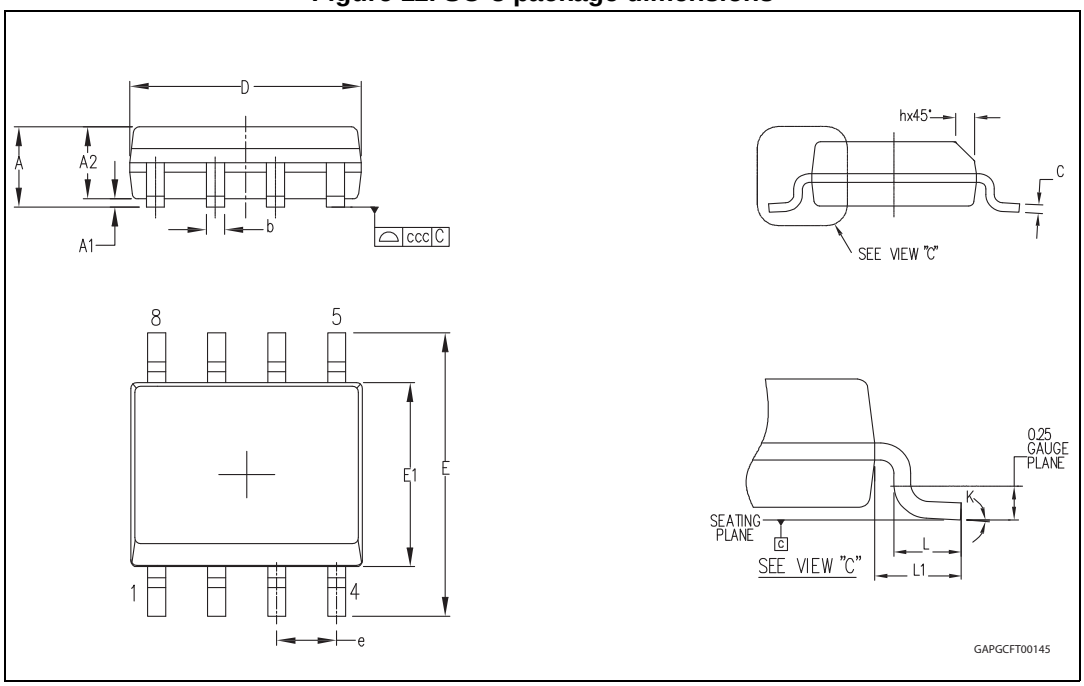


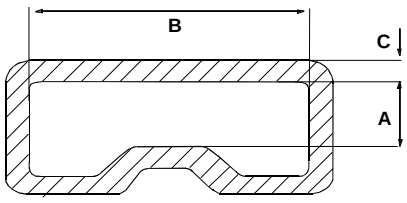
Table 16. SO-8 mechanical data

Symbol	Millimeters		
	Min.	Typ.	Max.
A			1.75
A1	0.10		0.25
A2	1.25		
b	0.28		0.48
c	0.17		0.23
D(1)	4.80	4.90	5.00
E	5.80	6.00	6.20
E1(2)	3.80	3.90	4.00
e		1.27	
h	0.25		0.50
L	0.40		1.27
L1		1.04	
k	0°		8°
ccc			0.10

1. Dimensions D does not include mold flash, protrusions or gate burrs. Mold flash, potrusions or gate burrs shall not exceed 0.15 mm in total (both side).
2. Dimension “E1” does not include interlead flash or protrusions. Interlead flash or protrusions shall not exceed 0.25 mm per side.

5.3 SO-8 packing information

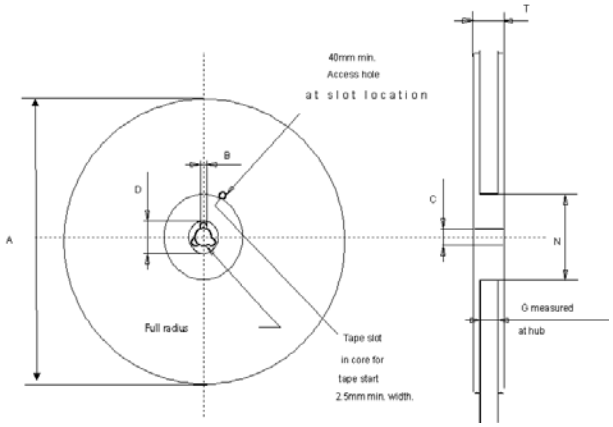
Figure 12. SO-8 tube shipment (no suffix)



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 13. 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

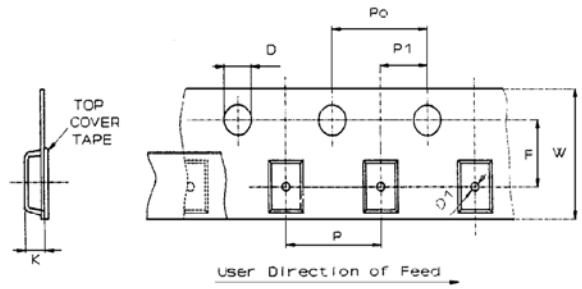
All dimensions are in mm.

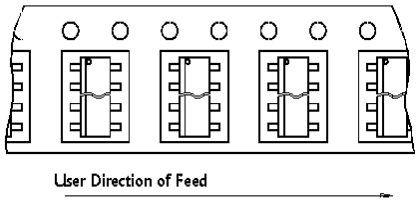
Tape dimensions

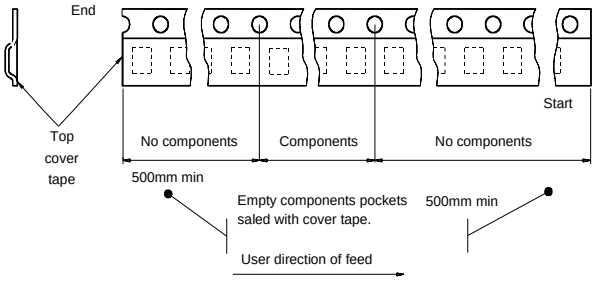
According to Electronic Industries Association (EIA) Standard 481 rev. A, Feb. 1986

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.







6 Revision history

Table 17. Document revision history

Date	Revision	Changes
02-Jul-2012	1	Initial release.
23-May-2013	2	*Table 5: Thermal data*: – $R_{thj\text{-}amb}$: updated value *Table 6: PowerMOS section*: – R_{ON}: updated value *Table 11: Supply section*: – I_S: updated value *Table 12: Switching characteristics*: – $t_{d(ON)}$, $t_{d(OFF)}$, t_r, W_{ON}, W_{OFF}: updated values *Table 13: Protection and diagnostics*: – t_{dlimL}: updated value Updated *Figure 5: Application schematic* Updated *Section 3.1: MCU I/O protection* Updated *Chapter 4: Package and PC board thermal data*
18-Jul-2013	3	*Table 4: Absolute maximum ratings*: – $-I_D$: updated value – E_{AS}: updated parameter value *Table 12: Switching characteristics*: – $t_{d(ON)}$, t_r, W_{ON}, W_{OFF}: updated typical values Added *Figure 6: Maximum demagnetization energy*
18-Sep-2013	4	Updated disclaimer.
13-Dec-2013	5	*Table 6: PowerMOS section*: – R_{ON}: updated test conditions

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