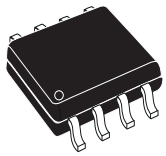
VNLD5090-E

OMNIFET III fully protected low-side driver for automotive applications

Datasheet - production data



SO-8

Features

Type	V_{clamp}	$R_{DS(on)}$	I_D
VNLD5090-E	41 V	90 mΩ	25 A

- AEC-Q100 qualified
- Drain current: 13 A
- ESD protection
- Overvoltage clamp
- Thermal shutdown
- Current and power limitation
- Very low standby current
- Very low electromagnetic susceptibility
- In compliance with the 2002/95/EC European directive

Description

The VNLD5090-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	VNLD5090-E	VNLD5090TR-E

Contents

List of tables

List of figures

1 Block diagrams and pins configurations

Figure 1. Block diagram

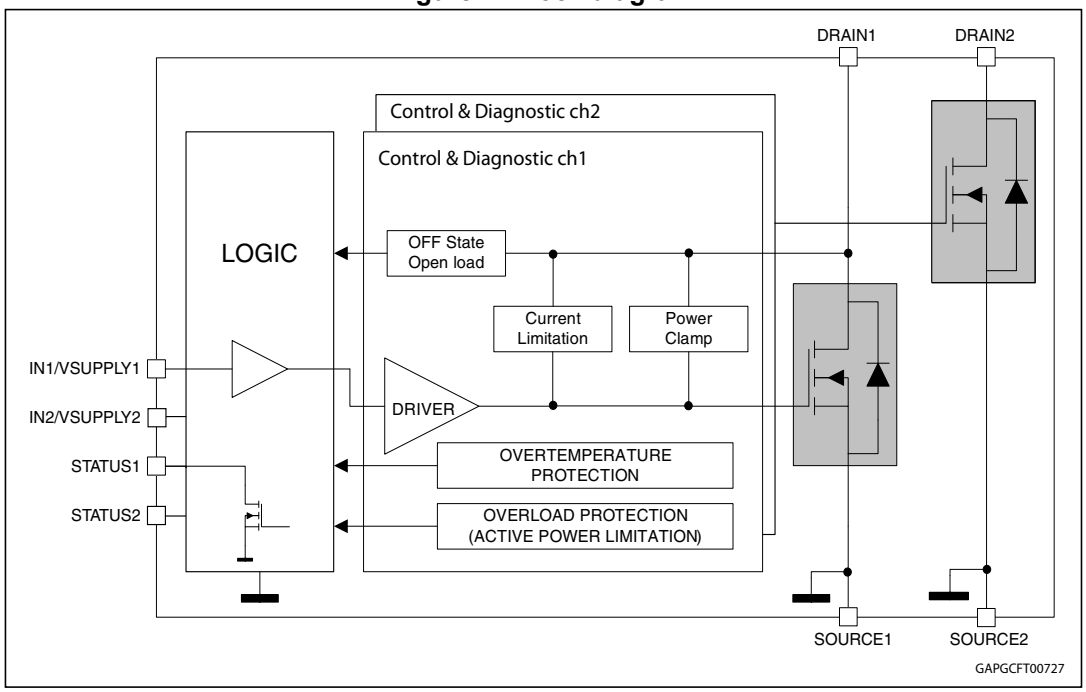


Table 2. Pin function

Name	Function
$IN_{1,2}$/$VSUPPLY_{1,2}$	Voltage controlled input pin with hysteresis, CMOS compatible. They controls output switch state
$DRAIN_{1,2}$	PowerMOS drain
$SOURCE_{1,2}$	PowerMOS source and ground reference for the control section
$STATUS_{1,2}$	Open drain digital diagnostic pin

Figure 2. Current and voltage conventions

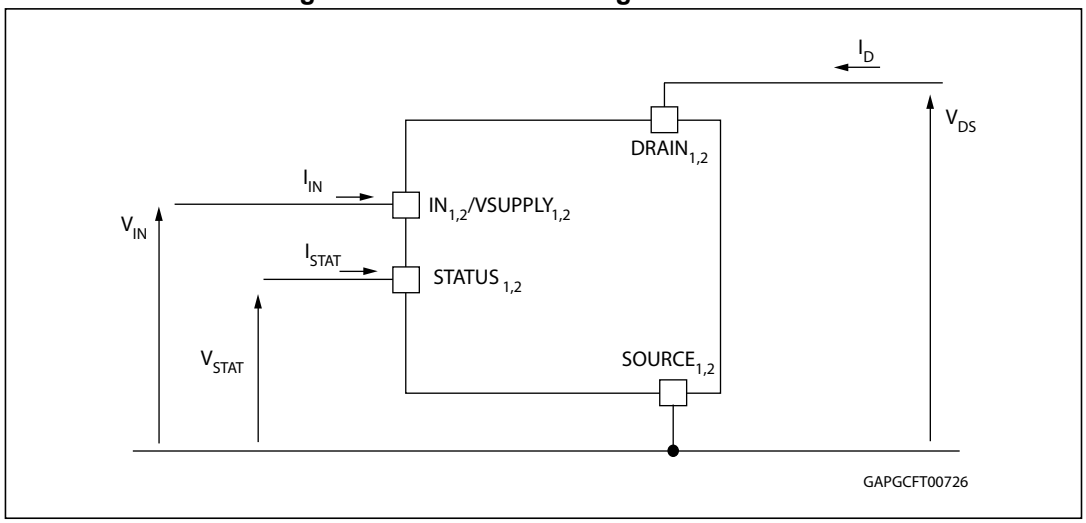


Figure 3. Configuration diagrams (top view)

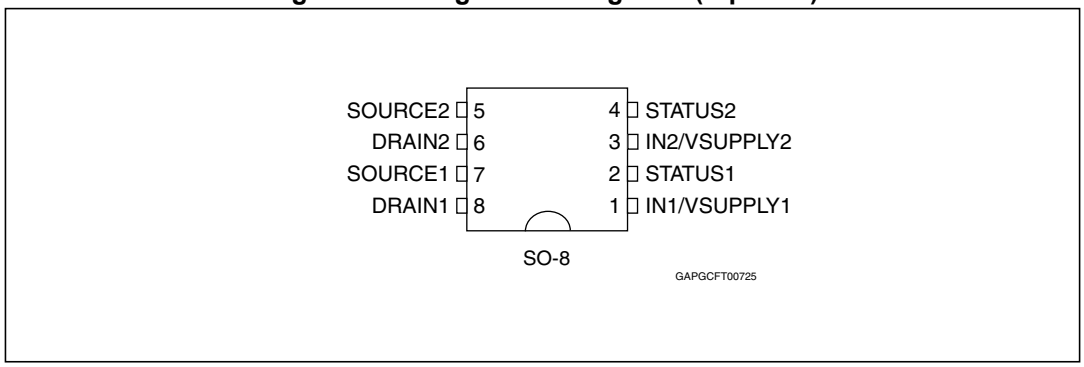


Table 3. Suggested connections for unused and n.c. pins

Connection / pin	$STATUS_{1,2}$	N.C.	$INPUT_{1,2}$
Floating	X(1)	X	X
To ground	Not allowed	X	Through 10 kΩ resistor

1. X: do not care.

2 Electical specifications

2.1 Absolute maximum ratings

Stressing the device above the rating listed in the *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
		SO-8	
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	12.5	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 = 1.1 mH; T_j = 150 °C; R_L = 0; I_{OUT} = I_{limL})	50	mJ

2.2 Thermal data

Table 5. Thermal data

Symbol	Parameter	Maximum value	Unit
		SO-8	
$R_{thj\text{-}amb}$	Thermal resistance junction-ambient	108	°C/W

2.3 Electrical characteristics

Values specified in this section are for $V_{INx/SUPPLYx}$ = 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
R_{ON}	ON-state resistance	I_D = 1.6 A; T_j = 25°C, $V_{INx/SUPPLYx}$ = 5 V			90	mΩ
		I_D = 1.6 A; T_j = 150°C, $V_{INx/SUPPLYx}$ = 5 V			180	
		I_D = 1.6 A; T_j = 150°C, $V_{INx/SUPPLYx}$ = 4.5 V			190	
V_{CLAMP}	Drain-source clamp voltage	V_{IN} = 5 V; I_D = 1.6 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 = 1.6 A; V_{IN} = 0 V	—	0.8	—	V

Table 8. Input section

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{ISS}	Supply current from input pin	ON-state: $V_{INx/SUPPLYx}$ = 5 V; V_{DS} = 0 V		30	65	µA
		OFF-state; T_j = 25°C; V_{IN} = V_{DRAIN} = 0 V;		10	25	
V_{ICL}	Input clamp voltage	I_S = 1 mA	5.5		7	V
		I_S = -1 mA		-0.7		
V_{INTH}	Input threshold voltage	V_{DS} = V_{IN}; I_D = 1 mA	1		3.5	V

Table 9. 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

Table 9. Status pin (continued)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{STCL}	Status clamp voltage	I_{STAT} = 1 mA	5.5		7	V
		I_{STAT} = -1 mA		-0.7		

Table 10. Switching characteristics(1)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(ON)}$	Turn-on delay time	R_L = 8.2 Ω; V_{CC} = 13 V(2)	—	8	—	µs
$t_{d(OFF)}$	Turn-off delay time	R_L = 8.2 Ω; V_{CC} = 13 V(2)	—	3.4	—	µs
t_r	Rise time	R_L = 8.2 Ω; V_{CC} = 13 V(2)	—	10	—	µs
t_f	Fall time	R_L = 8.2 Ω; V_{CC} = 13 V(2)	—	2.7	—	µs
W_{ON}	Switching energy losses at turn-on	R_L = 8.2 Ω; V_{CC} = 13 V(2)	—	57	—	µJ
W_{OFF}	Switching energy losses at turn-off	R_L = 8.2 Ω; V_{CC} = 13 V(2)	—	14	—	µJ
Qg	Total gate change	$V_{INx/SUPPLYx}$ = 5 V		2		nC

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

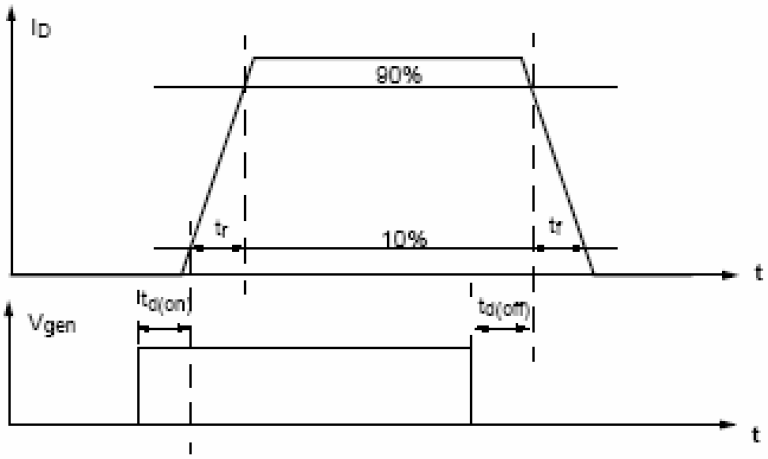
Table 11. Protection and diagnostics

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{limH}	DC short-circuit current	V_{DS} = 13 V; $V_{INx/SUPPLYx}$ = 5 V	13	18	25	A
I_{limL}	Short-circuit current during thermal cycling	V_{DS} = 13 V; $T_R < T_j < T_{TSD}$; $V_{INx/SUPPLYx}$ = 5 V		8		A
t_{dlimL}	Step response current limit	V_{DS} = 13 V; V_{input} = 5 V		44		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 12. Truth table

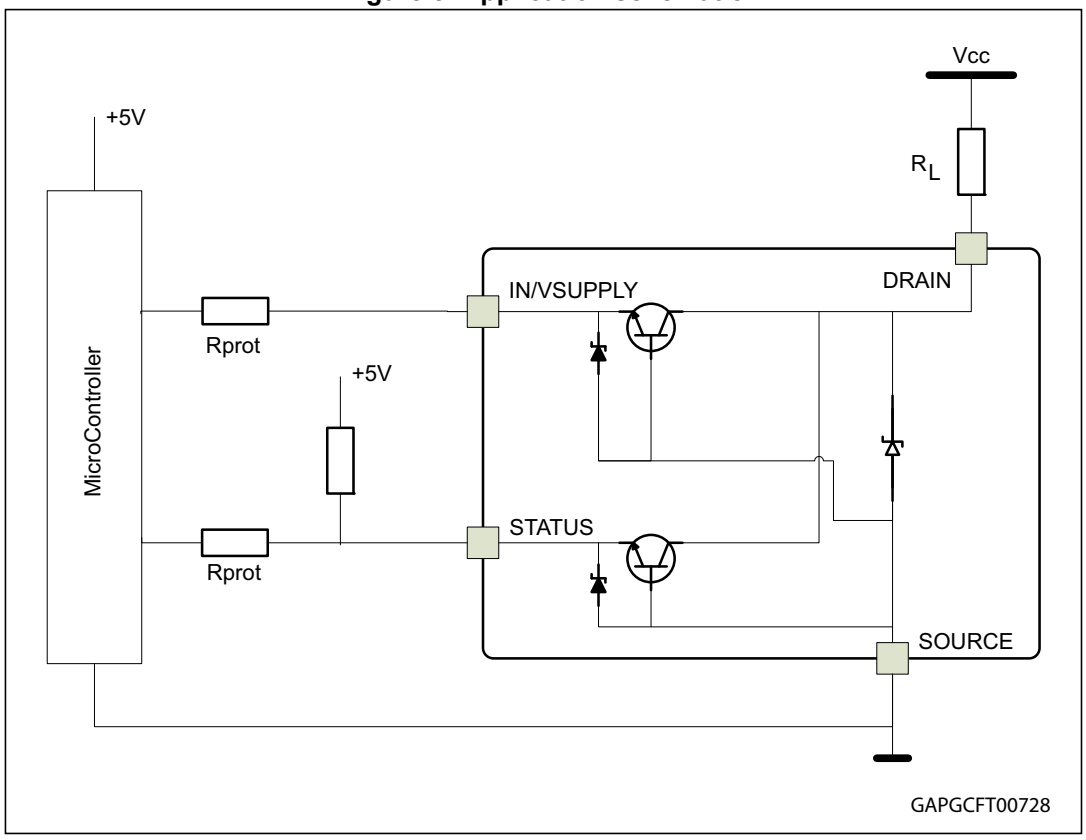
Conditions	INPUT	DRAIN	STATUS
Normal operation	L H	H L	H H
Current limitation	L H	H X	H H
Overtemperature	L H	H H	H L
Undervoltage	L H	H H	X X

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:

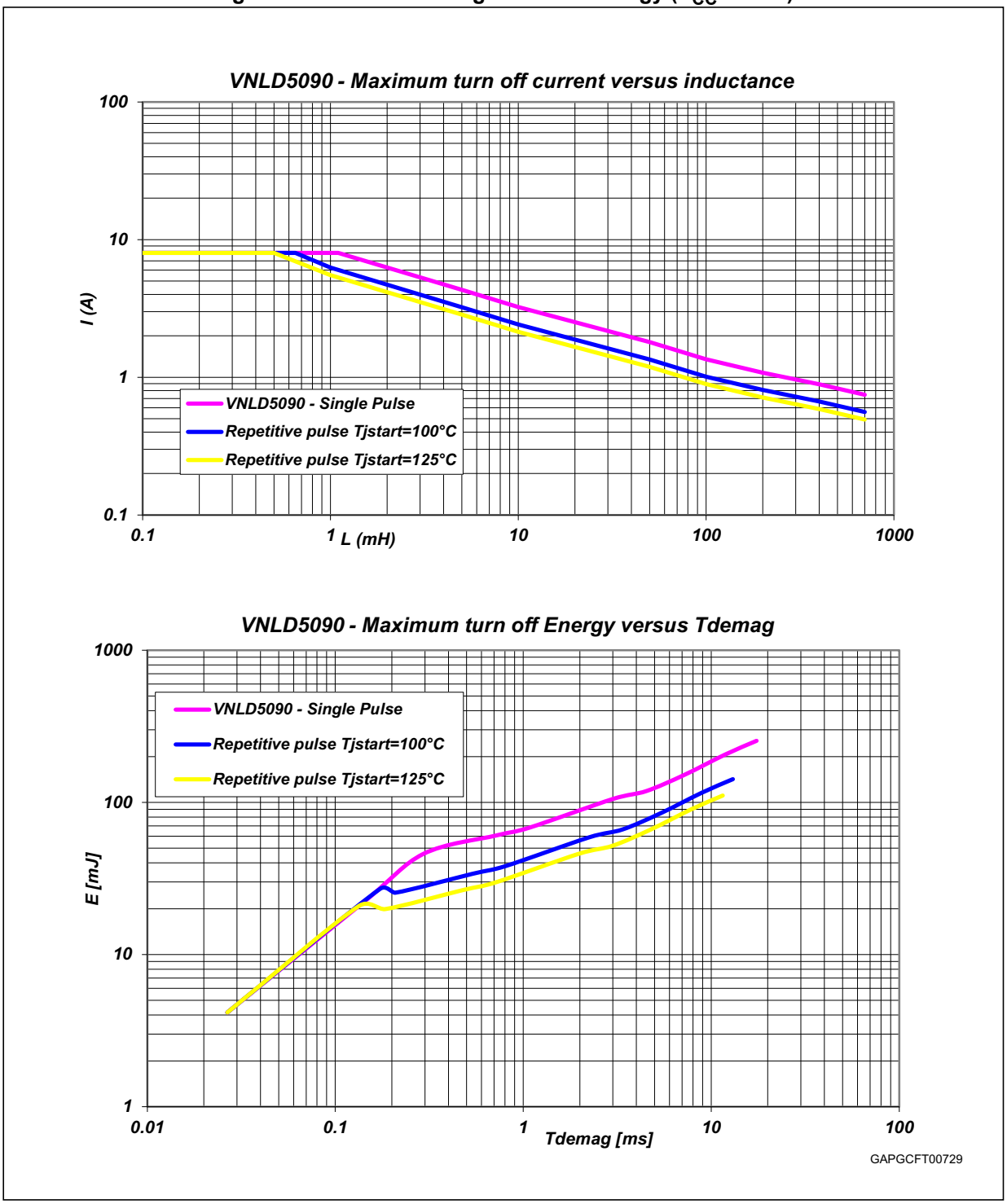
- $I_{latchup} \geq 20$ mA
- $V_{OH\mu C} \geq 4.5$ V
- $35\ \Omega \leq R_{prot} \leq 100\ K\Omega$

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

Then, the recommended value is R_{prot} = 1 KΩ

Figure 6 shows the turn-off current drawn during the demagnetization.

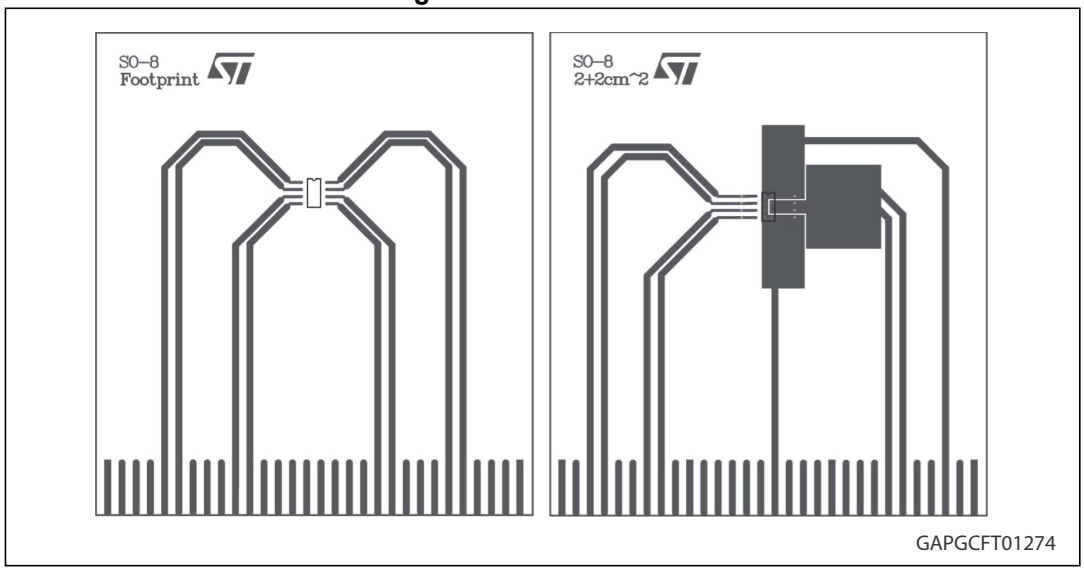
Figure 6. Maximum demagnetization energy (V_{CC} = 16 V)



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

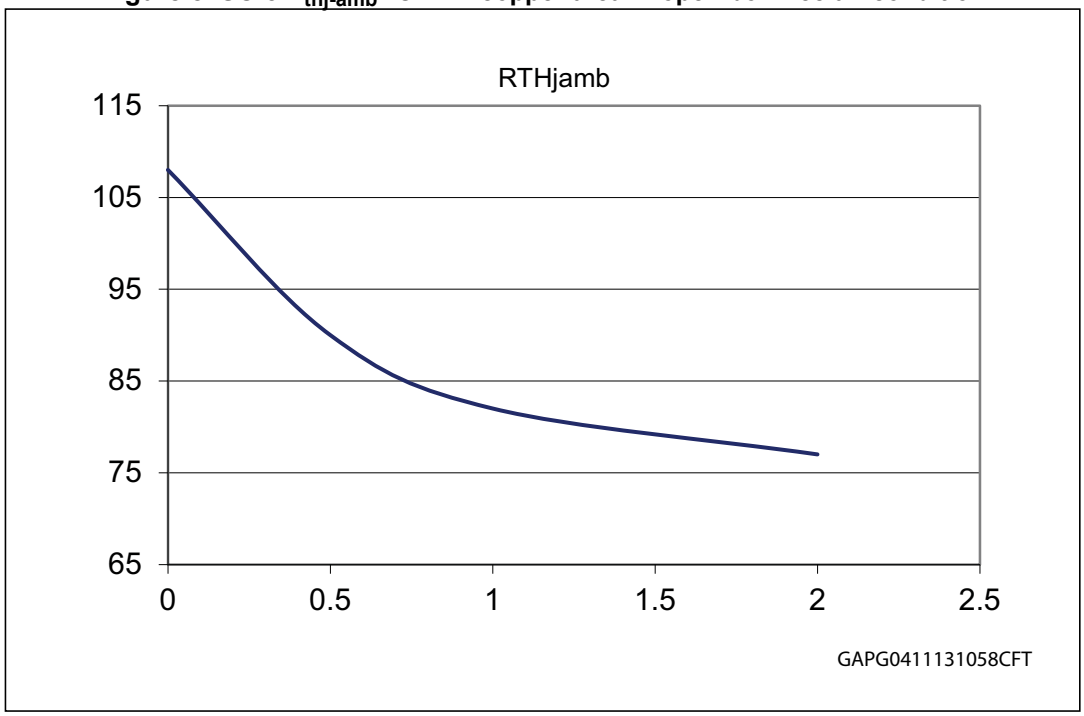
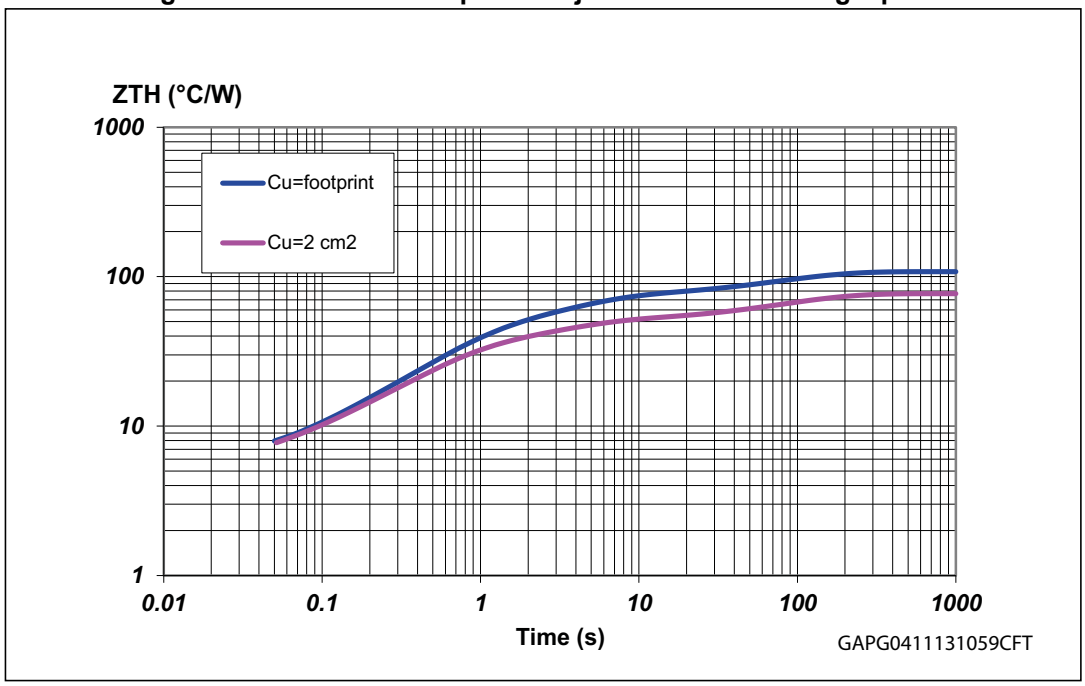


Figure 9. SO-8 thermal impedance junction ambient single pulse

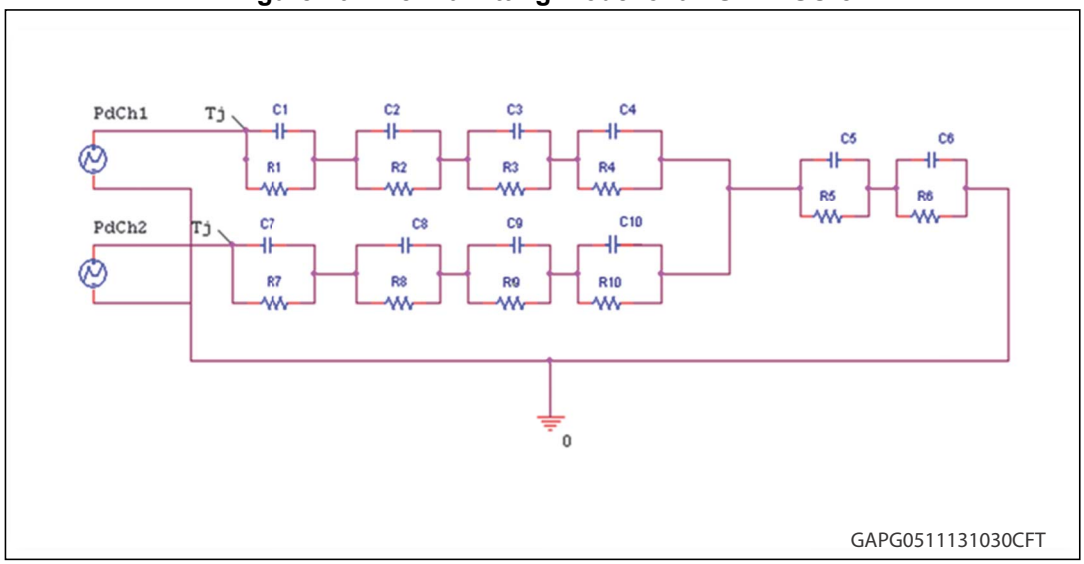


Equation 2: pulse calculation formula

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

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 13. SO-8 thermal parameters

Area/island (cm^2)	Footprint	2
R1 = R7 (°C/W)	0.8	0.8
R2 = R8 (°C/W)	2.7	2.7
R3 = R9 (°C/W)	1.5	1.5
R4 = R10 (°C/W)	32	25
R5 (°C/W)	36	20
R6 (°C/W)	35	27
C1 = C7 (W.s/°C)	0.00005	0.00005
C2 = C8 (W.s/°C)	0.001	0.001
C3 = C9 (W.s/°C)	0.01	0.01
C4 = C10 (W.s/°C)	0.02	0.02
C5 (W.s/°C)	0.1	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

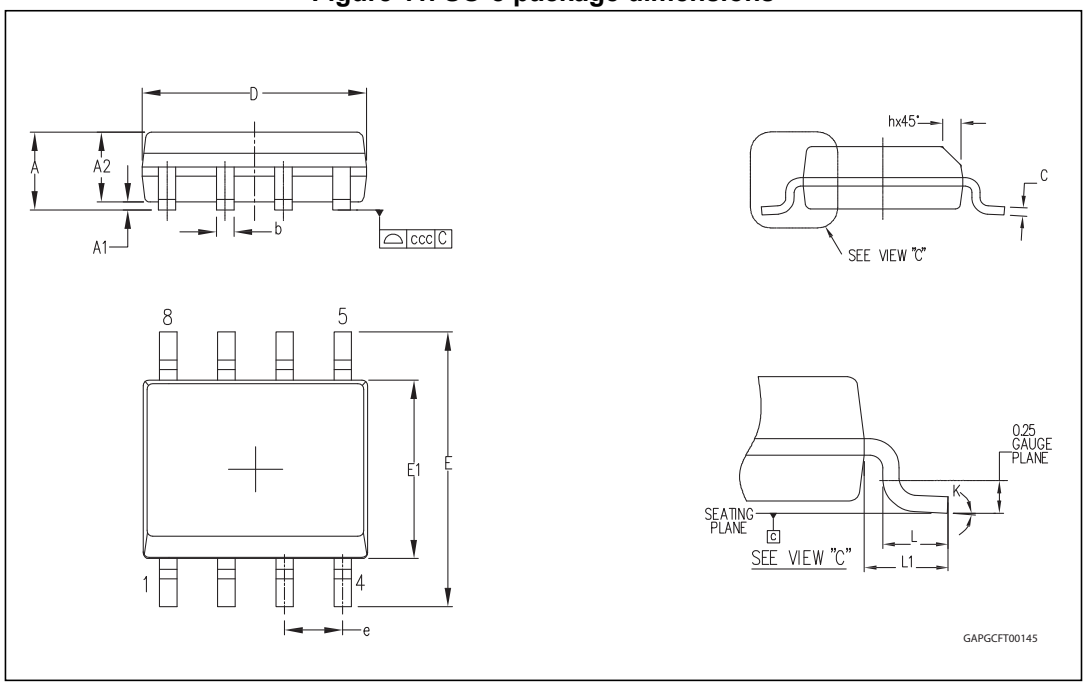


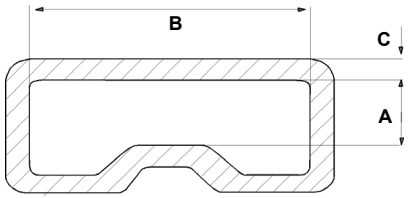
Table 14. SO-8 mechanical data

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

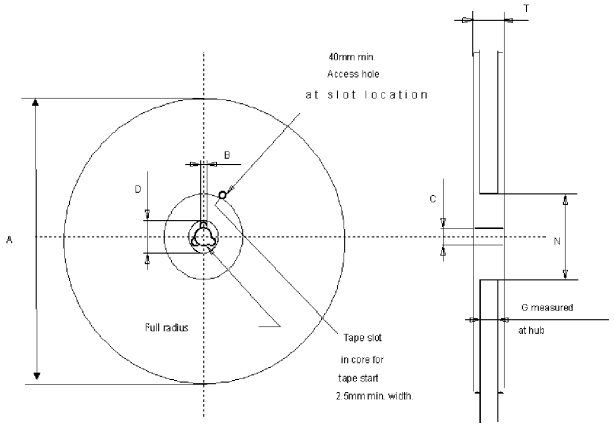
Figure 12. SO-8 tube shipment (no suffix)



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

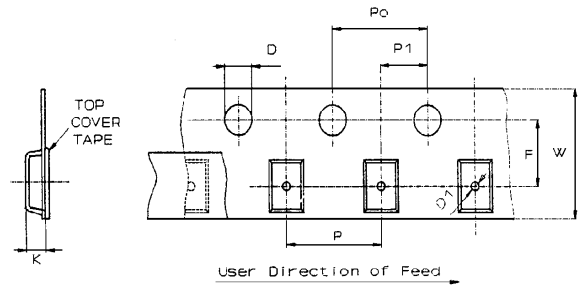
All dimensions are in mm.

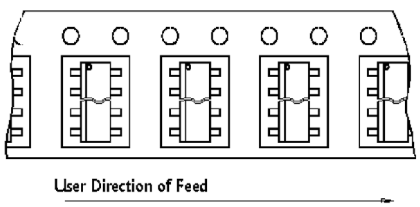
Tape dimensions

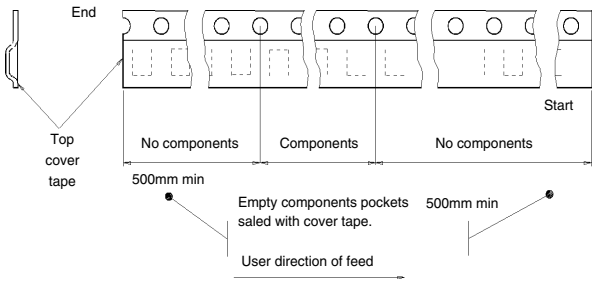
According to Electronic Industries Association (EIA) Standard 481 rev. A, Feb. 1986

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 15. Document revision history

Date	Revision	Changes
16-May-2012	1	Initial release.
21-Jun-2012	2	Updated *Figure 3: Configuration diagrams (top view)*
13-Nov-2013	3	Updated *Features* list *Table 4: Absolute maximum ratings*: – $-I_D$, E_{AS}: updated values Updated *Table 5: Thermal data* *Table 6: PowerMOS section*: – V_{CLAMP}: updated parameter *Table 8: Input section*: – I_{ISS}: updated maximum value *Table 10: Switching characteristics*: – W_{ON}, W_{OFF}: updated unit values Updated *Figure 5: Application schematic* Updated *Section 3.1: MCU I/O protection* Added *Chapter 4: Package and PC board thermal data*
26-Feb-2015	4	*Table 12: Truth table*: removed “Output voltage < V_{OL}” condition
26-Oct-2017	5	Added in cover page “automotive” word in the title and the icon of the car. Updated *Features on page 1*.