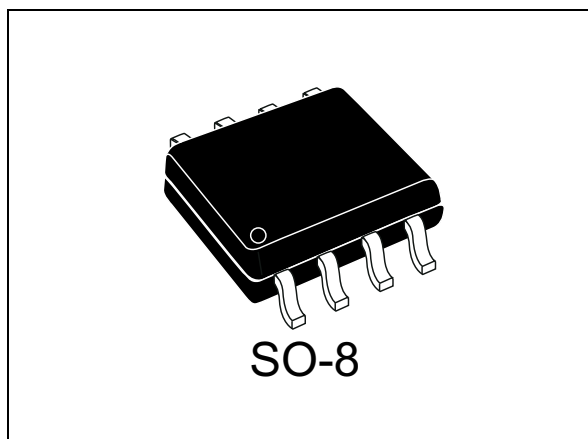


## Automotive OMNIFET II fully autoprotected Power MOSFET

Datasheet - production data



- Linear current limitation
- Thermal shutdown
- Short-circuit protection
- Integrated clamp
- Low current drawn from input pin
- Diagnostic feedback through input pin
- ESD protection
- Direct access to the gate of the Power MOSFET (analog driving)
- Compatible with standard Power MOSFET

### Features

Max on-state resistance (per ch.)	$R_{ON}$	120 m $\Omega$
Current limitation (typ)	$I_{LIMH}$	3.5 A
Drain-source clamp voltage	$V_{CLAMP}$	40 V

- AEC-Q100 qualified
- ECOPACK: lead free and RoHS compliant



### Description

The VNS3NV04DP-E device is made up of two monolithic chips (OMNIFET II) housed in a standard SO-8 package. The OMNIFET II is designed using STMicroelectronics VIPower M0-3 technology and is intended for replacement of standard Power MOSFETs in up to 50 kHz DC applications.

Built-in thermal shutdown, linear current limitation and overvoltage clamp protect the chip in harsh environments.

Fault feedback can be detected by monitoring voltage at the input pin.

Table 1. Device summary

Package	Order codes	
	Tray	Tape and reel
SO-8	VNS3NV04DP-E	VNS3NV04DPTR-E

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# 1 Block diagram and pin description

Figure 1. Block diagram

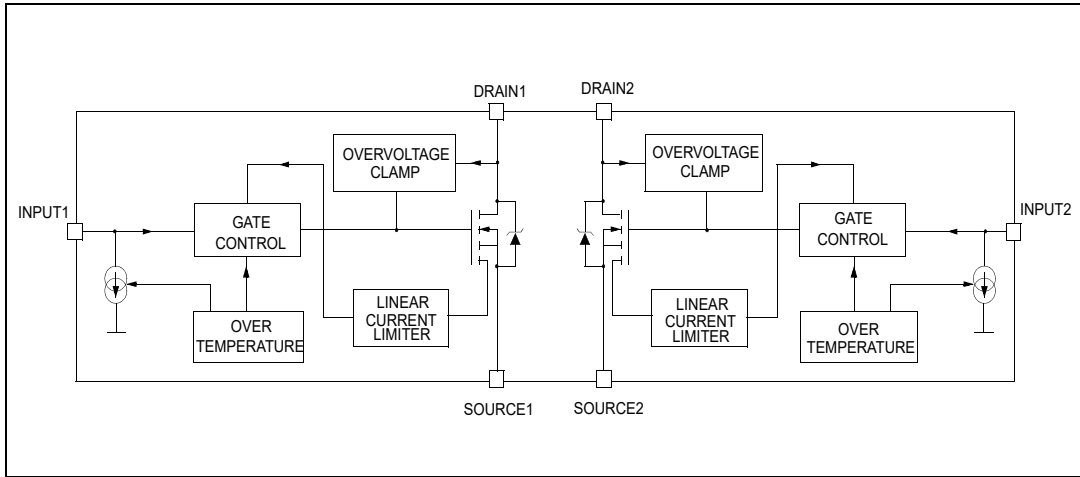
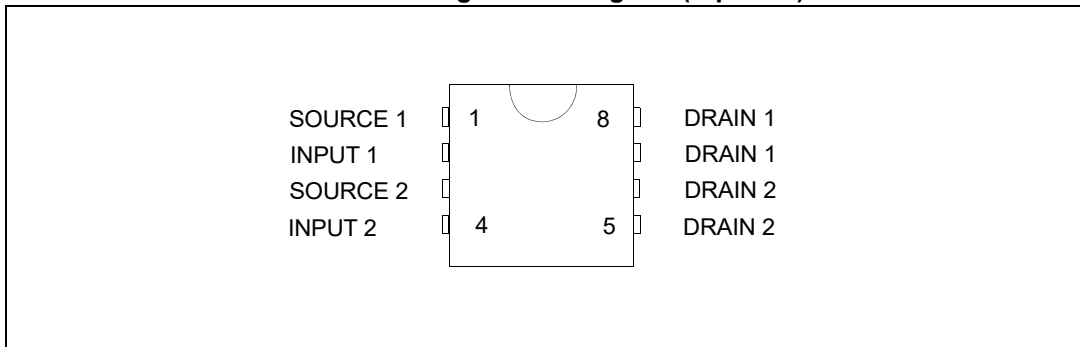
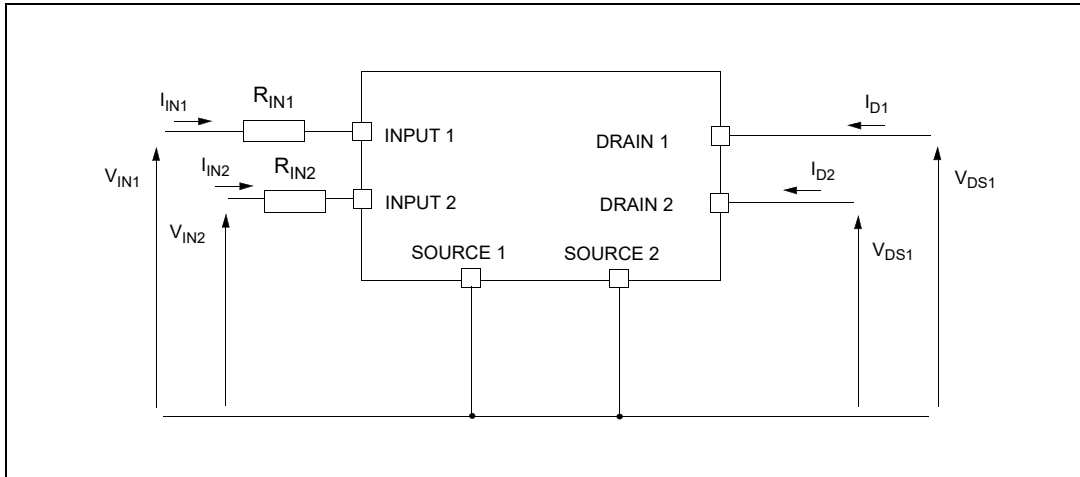


Table 2. Configuration diagram (top view)



## 2 Electrical specifications

Table 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 4. Absolute maximum ratings

Symbol	Parameter	Value	Unit
$V_{DSn}$	Drain-Source Voltage ( $V_{INn} = 0\text{ V}$ )	Internally clamped	V
$V_{INn}$	Input voltage	Internally clamped	V
$I_{INn}$	Input current	+/- 20	mA
$R_{IN\ MINn}$	Minimum input series impedance	220	$\Omega$
$I_{Dn}$	Drain current	Internally limited	A
$I_{Rn}$	Reverse DC output current	-5.5	A
$V_{ESD1}$	Electrostatic discharge ( $R = 1.5\text{ K}\Omega$ , $C = 100\text{ pF}$ )	4000	V
$V_{ESD2}$	Electrostatic discharge on output pins only ( $R = 330\ \Omega$ , $C = 150\text{ pF}$ )	16500	V
$P_{tot}$	Total dissipation at $T_c = 25\text{ }^\circ\text{C}$	4	W
$T_j$	Operating junction temperature	Internally limited	$^\circ\text{C}$
$T_c$	Case operating temperature	Internally limited	$^\circ\text{C}$
$T_{stg}$	Storage temperature	-55 to 150	$^\circ\text{C}$

## 2.2 Thermal data

**Table 5. Thermal data**

Symbol	Parameter	Max value	Unit
$R_{thj-lead}$	Thermal resistance junction-lead (per channel)	30	°C/W
$R_{thj-amb}$	Thermal resistance junction-ambient	80 <sup>(1)</sup>	°C/W

1. When mounted on a standard single-sided FR4 board with 50mm<sup>2</sup> of Cu (at least 35 μm thick) connected to all DRAIN pins of the relative channel

## 2.3 Electrical characteristics

Values specified in this section are for  $-40\text{ °C} < T_j < 150\text{ °C}$ , unless otherwise stated.

**Table 6. Off**

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
$V_{CLAMP}$	Drain-source clamp voltage	$V_{IN} = 0\text{ V}; I_D = 1.5\text{ A}$	40	45	55	V
$V_{CLTH}$	Drain-source clamp threshold voltage	$V_{IN} = 0\text{ V}; I_D = 2\text{ mA}$	36			V
$V_{INTH}$	Input threshold voltage	$V_{DS} = V_{IN}; I_D = 1\text{ mA}$	0.5		2.5	V
$I_{ISS}$	Supply current from input pin	$V_{DS} = 0\text{ V}; V_{IN} = 5\text{ V}$		100	150	μA
$V_{INCL}$	Input-source clamp voltage	$I_{IN} = 1\text{ mA}$	6	6.8	8	V
		$I_{IN} = -1\text{ mA}$	-1		-0.3	V
$I_{DSS}$	Zero input voltage drain current ( $V_{IN} = 0\text{ V}$ )	$V_{DS} = 13\text{ V}; V_{IN} = 0\text{ V}; T_j = 25\text{ °C}$			30	μA
		$V_{DS} = 25\text{ V}; V_{IN} = 0\text{ V}$			75	μA

**Table 7. On**

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
$R_{DS(on)}$	Static drain-source on resistance	$V_{IN} = 5\text{ V}; I_D = 1.5\text{ A}; T_j = 25\text{ °C}$	—	—	120	mΩ
		$V_{IN} = 5\text{ V}; I_D = 1.5\text{ A}$	—	—	240	mΩ

$T_j = 25\text{ °C}$ , unless otherwise specified

**Table 8. Dynamic**

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
$g_{fs}^{(1)}$	Forward transconductance	$V_{DD} = 13\text{ V}; I_D = 1.5\text{ A}$	—	5.0	—	S
$C_{OSS}$	Output capacitance	$V_{DS} = 13\text{ V}; f = 1\text{ MHz}; V_{IN} = 0\text{ V}$	—	150	—	pF

**Table 9. Switching**

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 15\text{ V}; I_D = 1.5\text{ A};$ $V_{gen} = 5\text{ V}; R_{gen} = R_{IN}$ $R_{IN\text{ MIN}} = 220\ \Omega$ (see <a href="#">Figure 2</a> )		90	300	ns
$t_r$	Rise time			250	750	ns
$t_{d(off)}$	Turn-off delay time			450	1350	ns
$t_f$	Fall time			250	750	ns
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 15\text{ V}; I_D = 1.5\text{ A};$ $V_{gen} = 5\text{ V}; R_{gen} = 2.2\text{ K}\Omega$ (see <a href="#">Figure 2</a> )		0.45	1.35	$\mu\text{s}$
$t_r$	Rise time			2.5	7.5	$\mu\text{s}$
$t_{d(off)}$	Turn-off delay time			3.3	10.0	$\mu\text{s}$
$t_f$	Fall time			2.0	6.0	$\mu\text{s}$
$(di/dt)_{on}$	Turn-on current slope	$V_{DD} = 15\text{ V}; I_D = 1.5\text{ A};$ $V_{gen} = 5\text{ V};$ $R_{gen} = R_{IN\text{ MIN}} = 220\ \Omega$		4.7		A/ $\mu\text{s}$
$Q_i$	Total input charge	$V_{DD} = 12\text{ V}; I_D = 1.5\text{ A}; V_{IN} = 5\text{ V};$ $I_{gen} = 2.13\text{ mA}$ (see <a href="#">Figure 5</a> )		8.5		nC

**Table 10. Source drain diode**

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
$V_{SD}^{(1)}$	Forward on voltage	$I_{SD} = 1.5\text{ A}; V_{IN} = 0\text{ V}$		0.8		V
$t_{rr}$	Reverse recovery time	$I_{SD} = 1.5\text{ A}; di/dt = 12\text{ A}/\mu\text{s};$ $V_{DD} = 30\text{ V}; L = 200\ \mu\text{H}$ (see <a href="#">Figure 3</a> )		107		ns
$Q_{rr}$	Reverse recovery charge			37		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current			0.7		A

1. Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%

-40 °C <  $T_j$  < 150 °C, unless otherwise specified

**Table 11. Protections**

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
$I_{lim}$	Drain current limit	$V_{IN} = 5\text{ V}; V_{DS} = 13\text{ V}$	3.5	5	7	A
$t_{dlim}$	Step response current limit	$V_{IN} = 5\text{ V}; V_{DS} = 13\text{ V}$		10		$\mu\text{s}$
$T_{jsh}$	Overtemperature shutdown		150	175	200	°C



Table 11. Protections (continued)

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
$T_{jrs}$	Overtemperature reset		135			°C
$I_{gf}$	Fault sink current	$V_{IN} = 5\text{ V}; V_{DS} = 13\text{ V}; T_J = T_{Jsh}$	10	15	20	mA
$E_{as}$	Single pulse avalanche energy	Starting $T_J = 25\text{ °C}; V_{DD} = 24\text{ V}; V_{IN} = 5\text{ V}; R_{gen} = R_{IN\ MIN} = 220\ \Omega; L = 24\text{ mH}$ (see <a href="#">Figure 4</a> and <a href="#">Figure 6</a> )	100			mJ

Figure 2. Switching time test circuit for resistive load

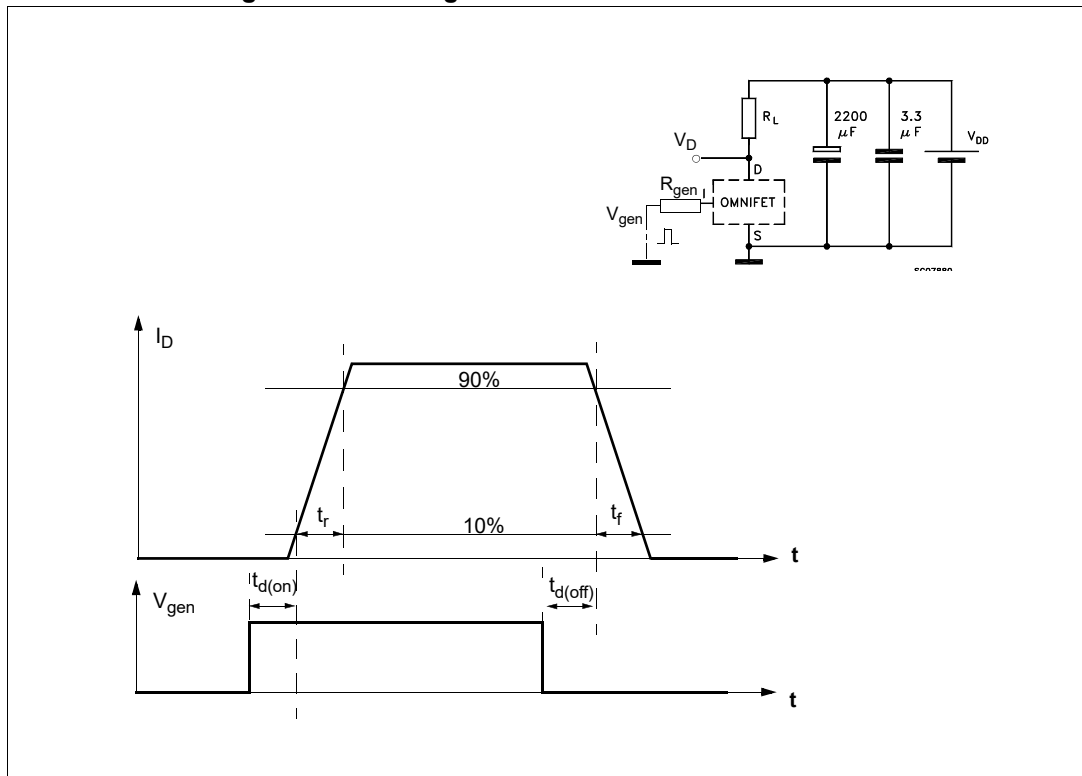


Figure 3. Test circuit for diode recovery times

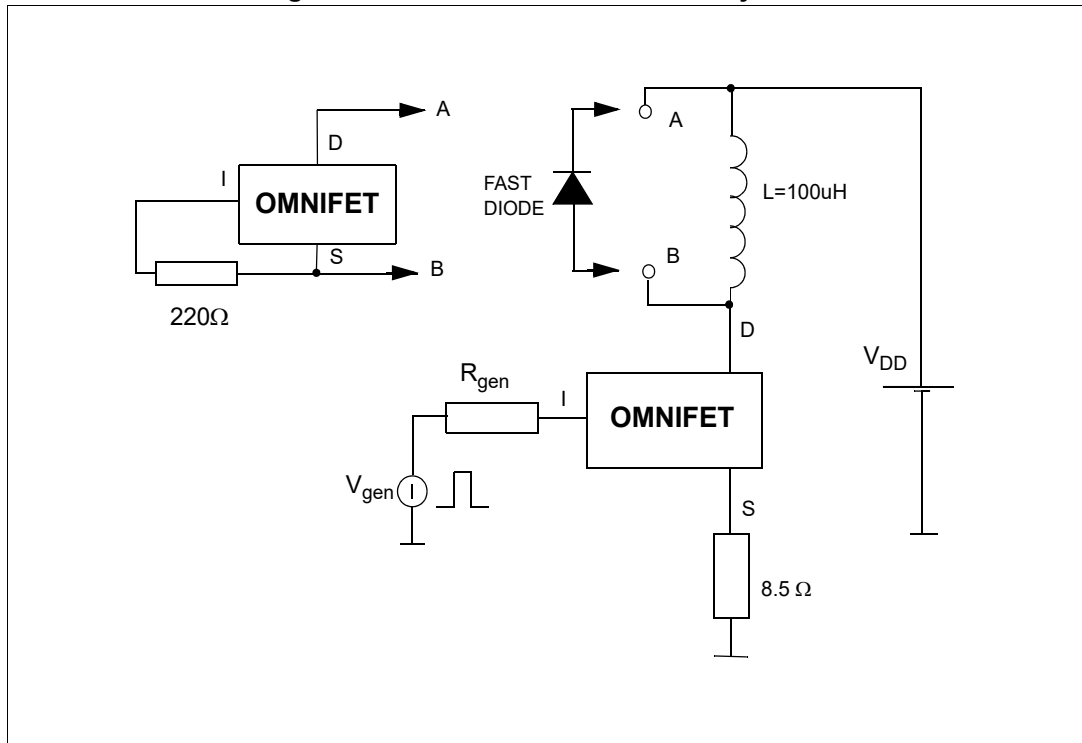


Figure 4. Unclamped inductive load test circuits

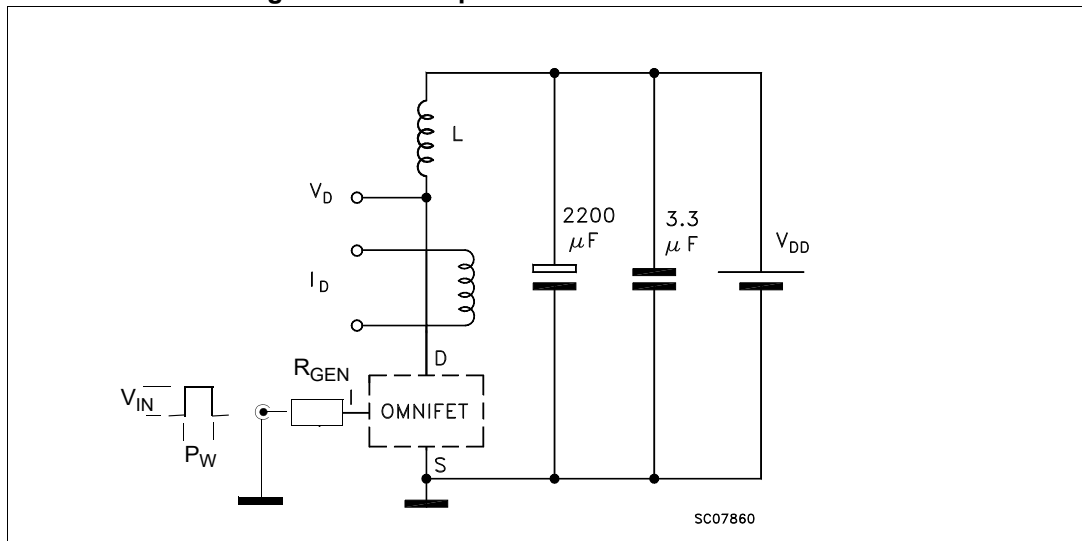


Figure 5. Input charge test circuit

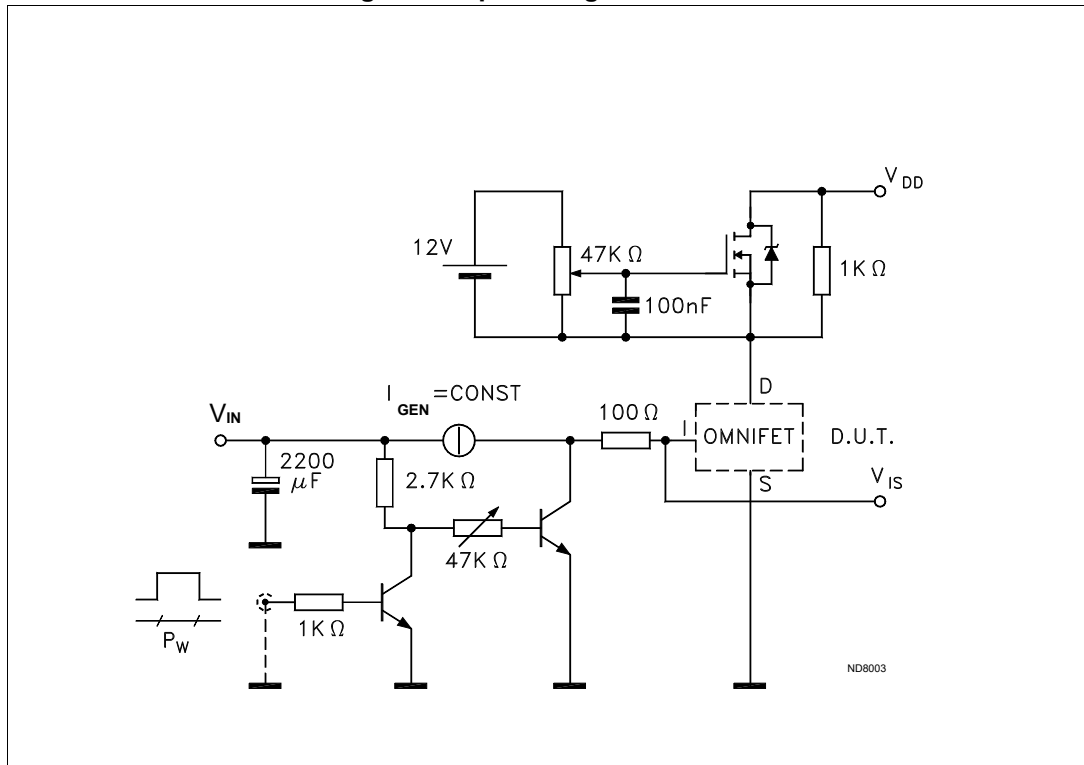
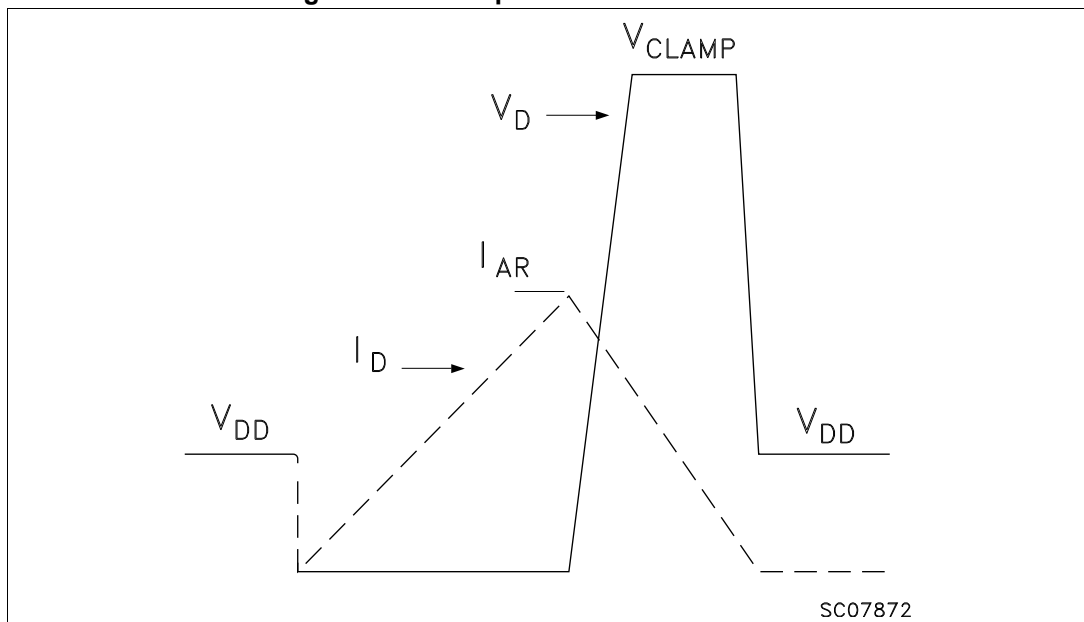
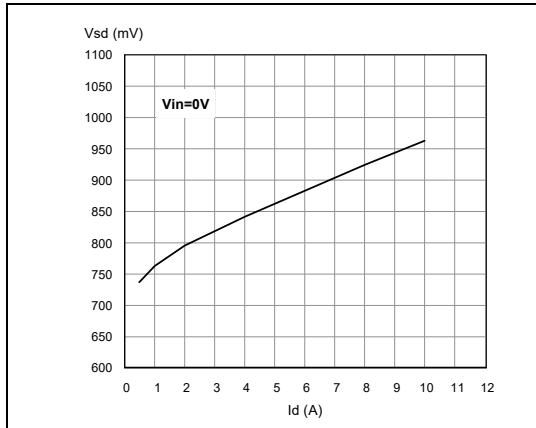


Figure 6. Unclamped inductive waveforms

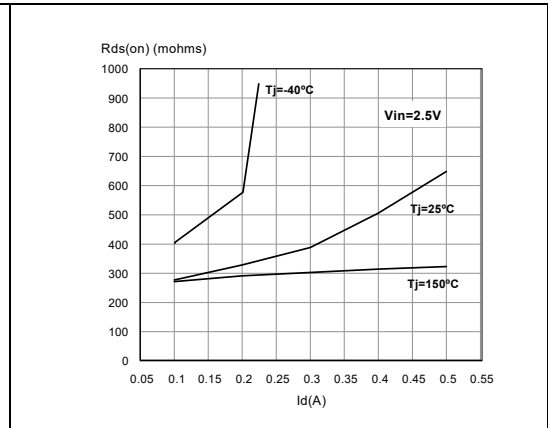


## 2.4 Electrical characteristics curves

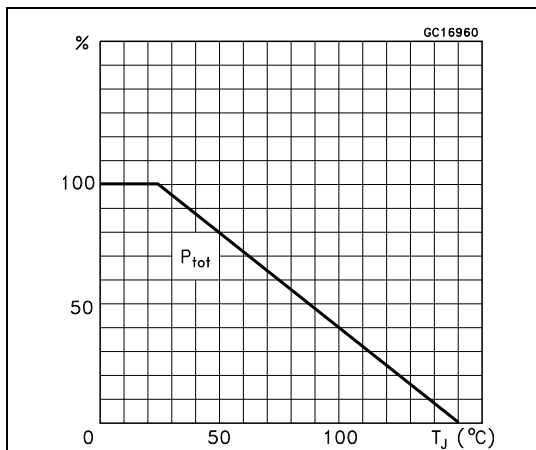
**Figure 7. Source-drain diode forward characteristics**



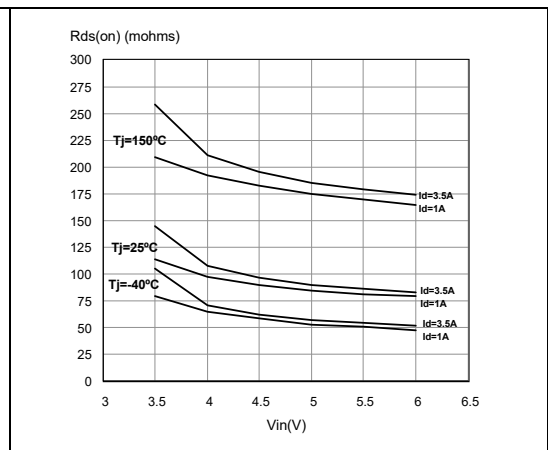
**Figure 8. Static drain-source on resistance**



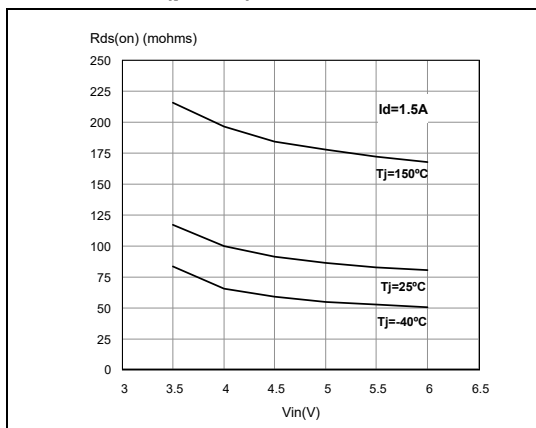
**Figure 9. Derating curve**



**Figure 10. Static drain-source on resistance vs input voltage (part 1)**



**Figure 11. Static drain-source on resistance vs input voltage (part 2)**



**Figure 12. Transconductance**

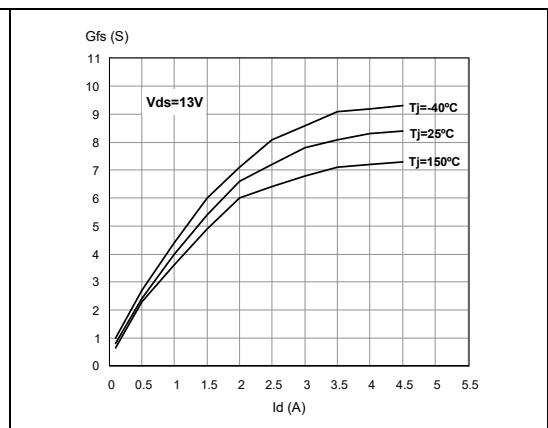


Figure 13. Static drain-source on resistance vs Id

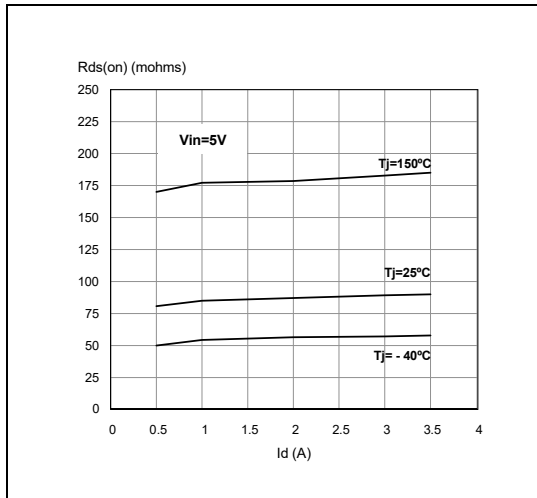


Figure 14. Transfer characteristics

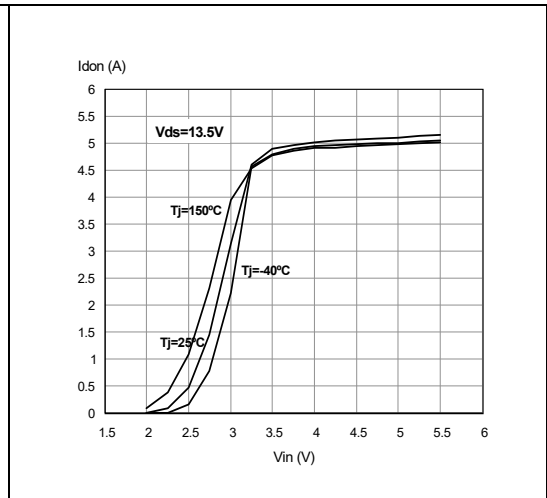


Figure 15. Turn-on current slope (part 1) Figure 16. Turn-on current slope (part 2)

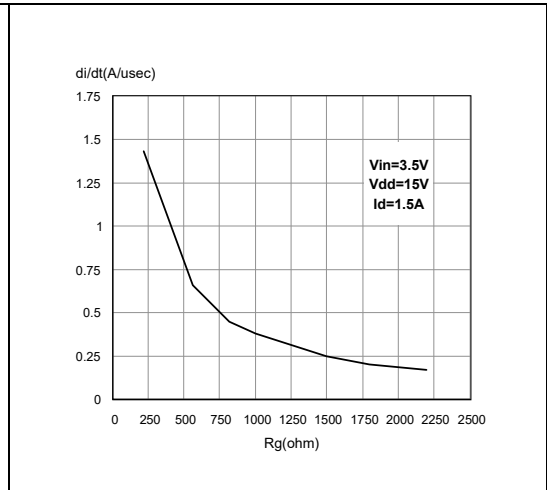
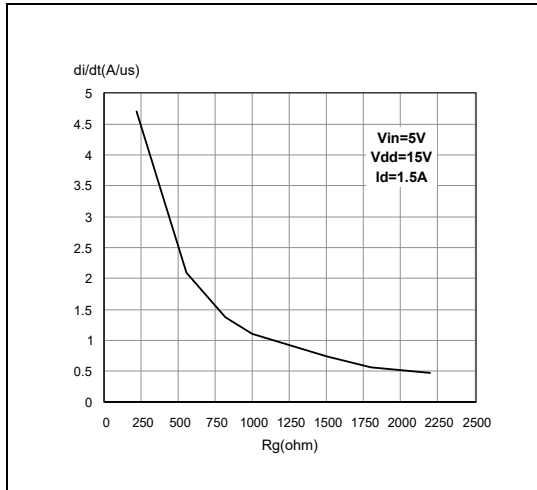
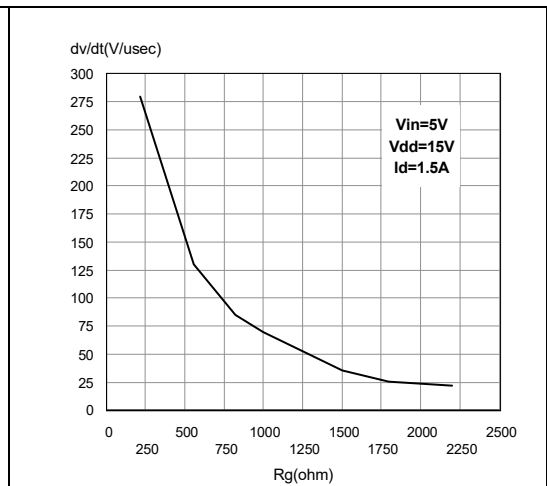
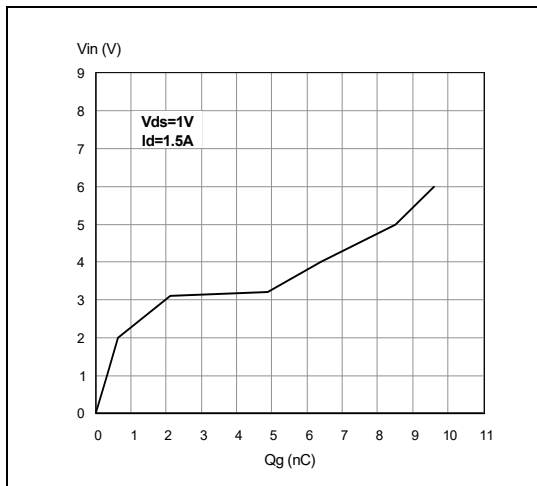
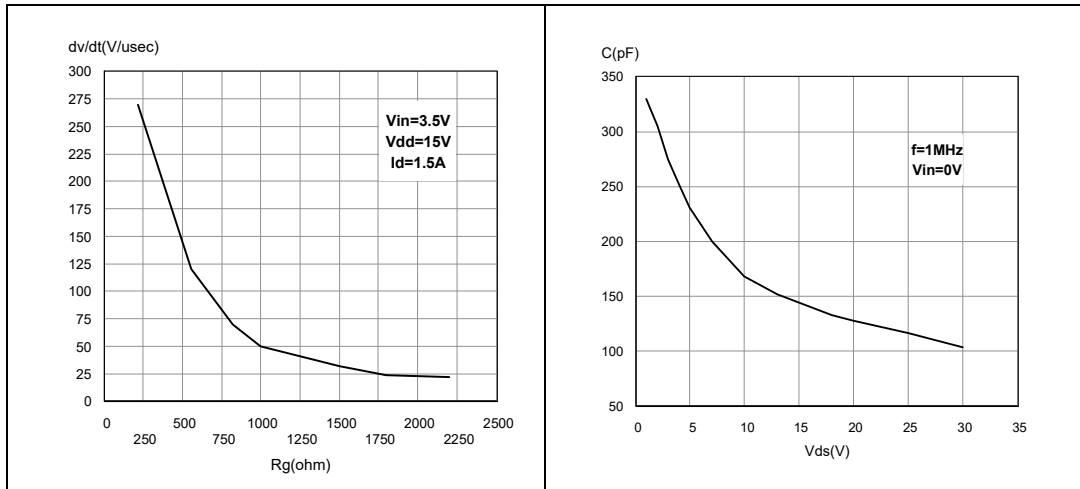


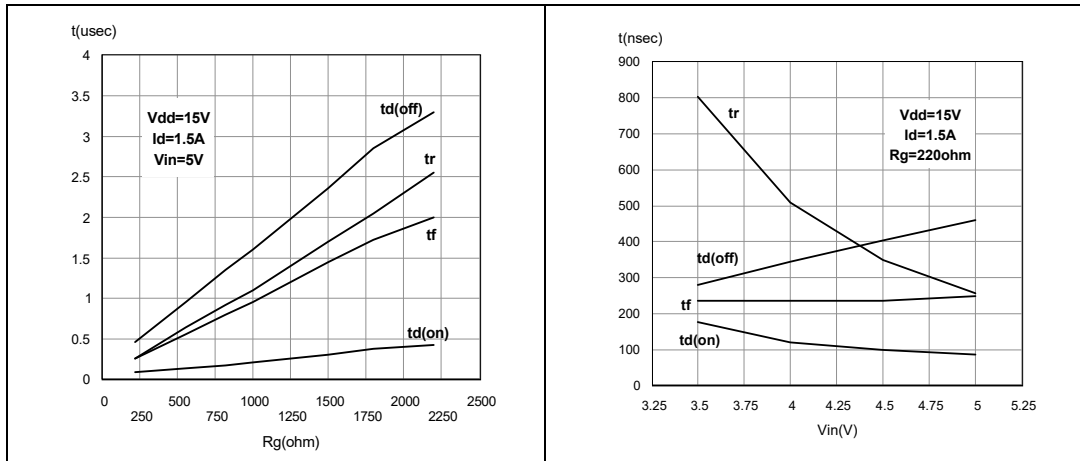
Figure 17. Input voltage vs input charge Figure 18. Turn-off drain source voltage slope (part 1)



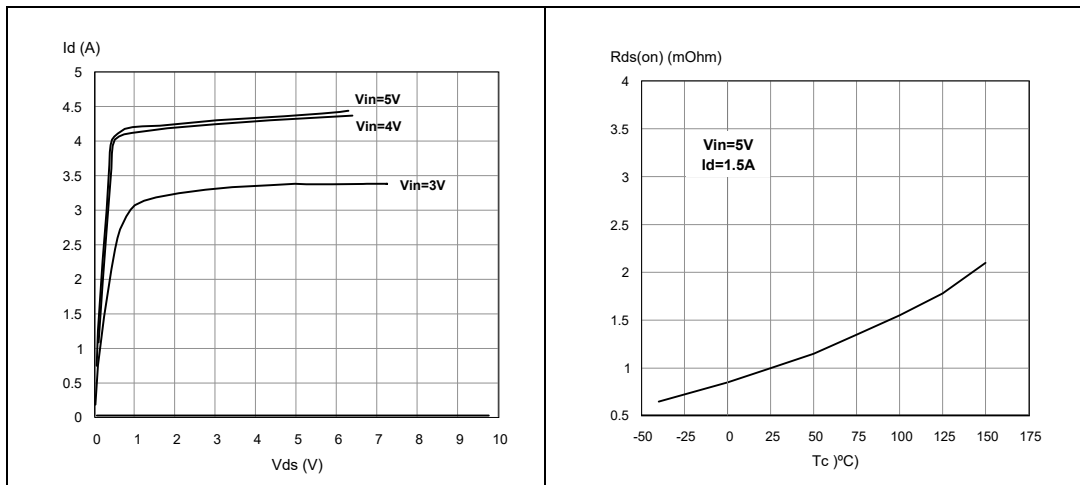
**Figure 19. Turn-off drain-source voltage slope (part 2)** **Figure 20. Capacitance variations**



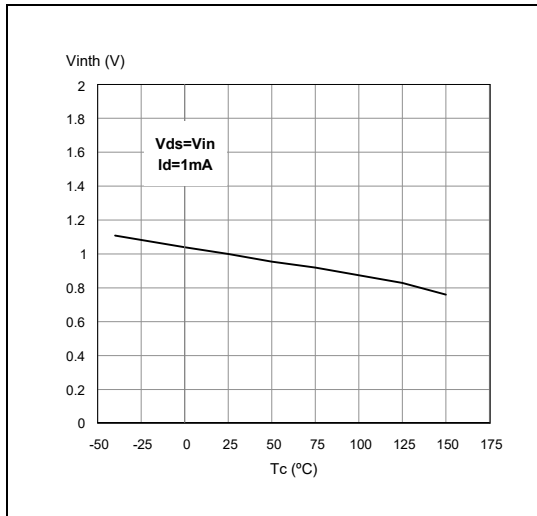
**Figure 21. Switching time resistive load (part 1)** **Figure 22. Switching time resistive load (part 1)**



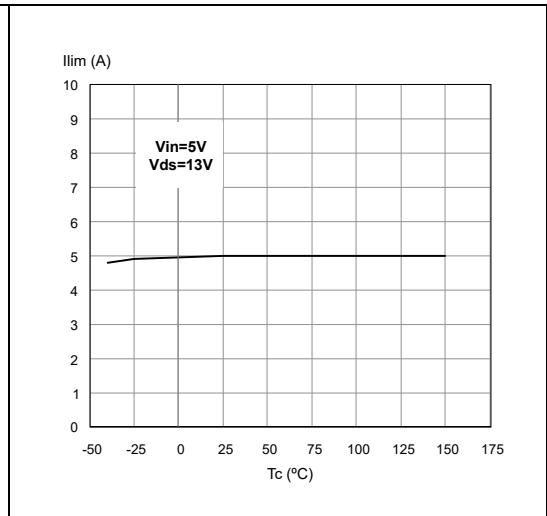
**Figure 23. Output characteristics** **Figure 24. Normalized on resistance vs temperature**



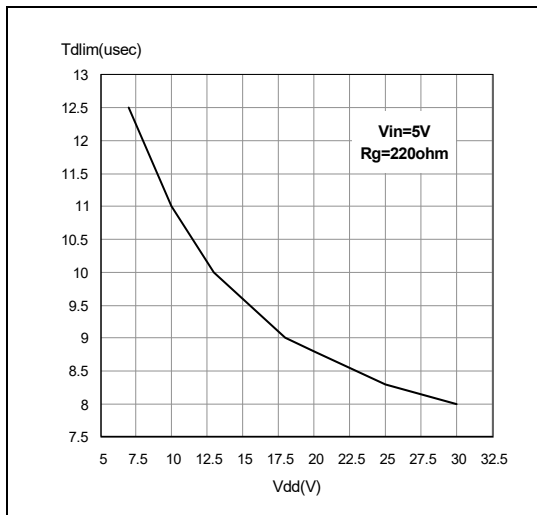
**Figure 25. Normalized input threshold voltage vs temperature**



**Figure 26. Normalized current limit vs junction temperature**



**Figure 27. Step response current limit**



## 3 Protection features

During normal operation, the INPUT pin is electrically connected to the gate of the internal power MOSFET through a low impedance path.

The device then behaves like a standard power MOSFET and can be used as a switch from DC up to 50 KHz. The only difference from the user's standpoint is that a small DC current  $I_{ISS}$  (typ. 100  $\mu$ A) flows into the INPUT pin in order to supply the internal circuitry.

The following sections describe the device features.

### 3.1 Overvoltage clamp protection

Internally set at 45 V, along with the rugged avalanche characteristics of the Power MOSFET stage give this device unrivalled ruggedness and energy handling capability. This feature is mainly important when driving inductive loads.

### 3.2 Linear current limiter circuit

Limits the drain current  $I_D$  to  $I_{lim}$  whatever the INPUT pin voltages. When the current limiter is active, the device operates in the linear region, so power dissipation may exceed the capability of the heatsink. Both case and junction temperatures increase, and if this phase lasts long enough, junction temperature may reach the overtemperature threshold  $T_{jsh}$ .

### 3.3 Overtemperature and short circuit protection

These are based on sensing the chip temperature and are not dependent on the input voltage. The location of the sensing element on the chip in the power stage area ensures fast, accurate detection of the junction temperature. Overtemperature cutout occurs in the range 150 to 190 °C, a typical value being 170 °C. The device is automatically restarted when the chip temperature falls of about 15 °C below shutdown temperature.

### 3.4 Status feedback

In the case of an overtemperature fault condition ( $T_j > T_{jsh}$ ), the device tries to sink a diagnostic current  $I_{gf}$  through the INPUT pin in order to indicate fault condition. If driven from a low impedance source, this current may be used in order to warn the control circuit of a device shutdown. If the drive impedance is high enough so that the INPUT pin driver is not able to supply the current  $I_{gf}$ , the INPUT pin falls to 0 V. This however not affects the device operation: no requirement is put on the current capability of the INPUT pin driver except to be able to supply the normal operation drive current  $I_{ISS}$ .

Additional features of this device are ESD protection according to the Human Body model and the ability to be driven from a TTL Logic circuit.



## 4 Package and packing information

### 4.1 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](http://www.st.com). ECOPACK is an ST trademark.

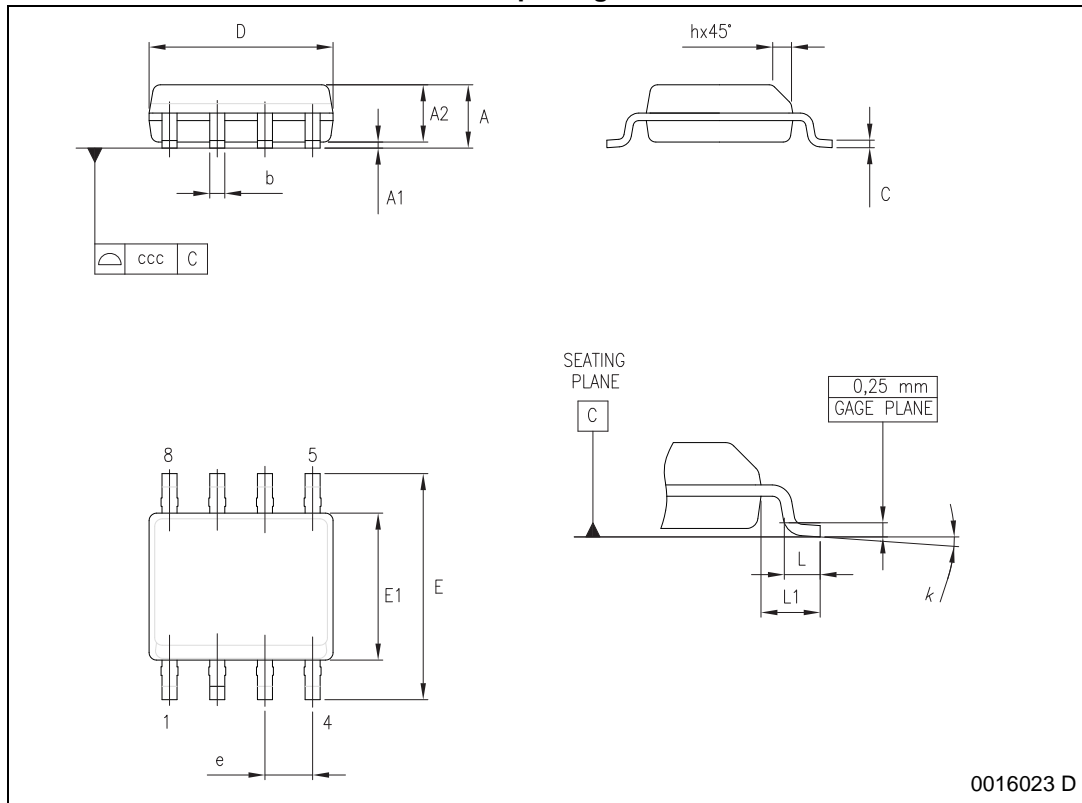
### 4.2 SO-8 mechanical data

Table 12. SO-8 mechanical data

Dim.	mm		
	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 <sup>(1)</sup>	4.80	4.90	5.00
E	5.80	6.00	6.20
E1 <sup>(2)</sup>	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. Dimension "D" does not include mold Flash, protrusions or gate burrs. Mold flash, protrusions 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.

Table 13. SO-8 package dimension



0016023 D

### 4.3 SO-8 packing information

Figure 28. SO-8 tube shipment (no suffix)

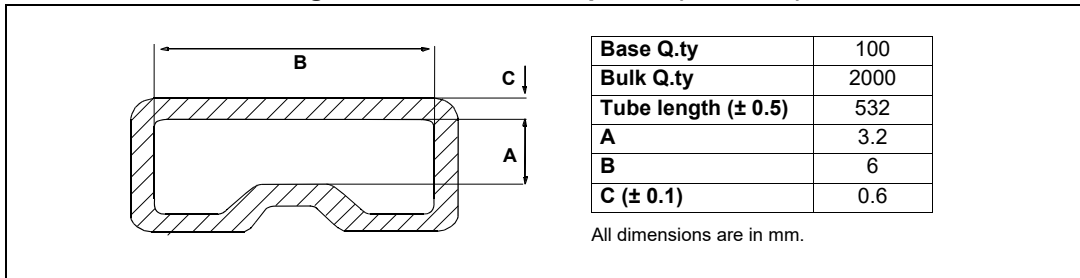
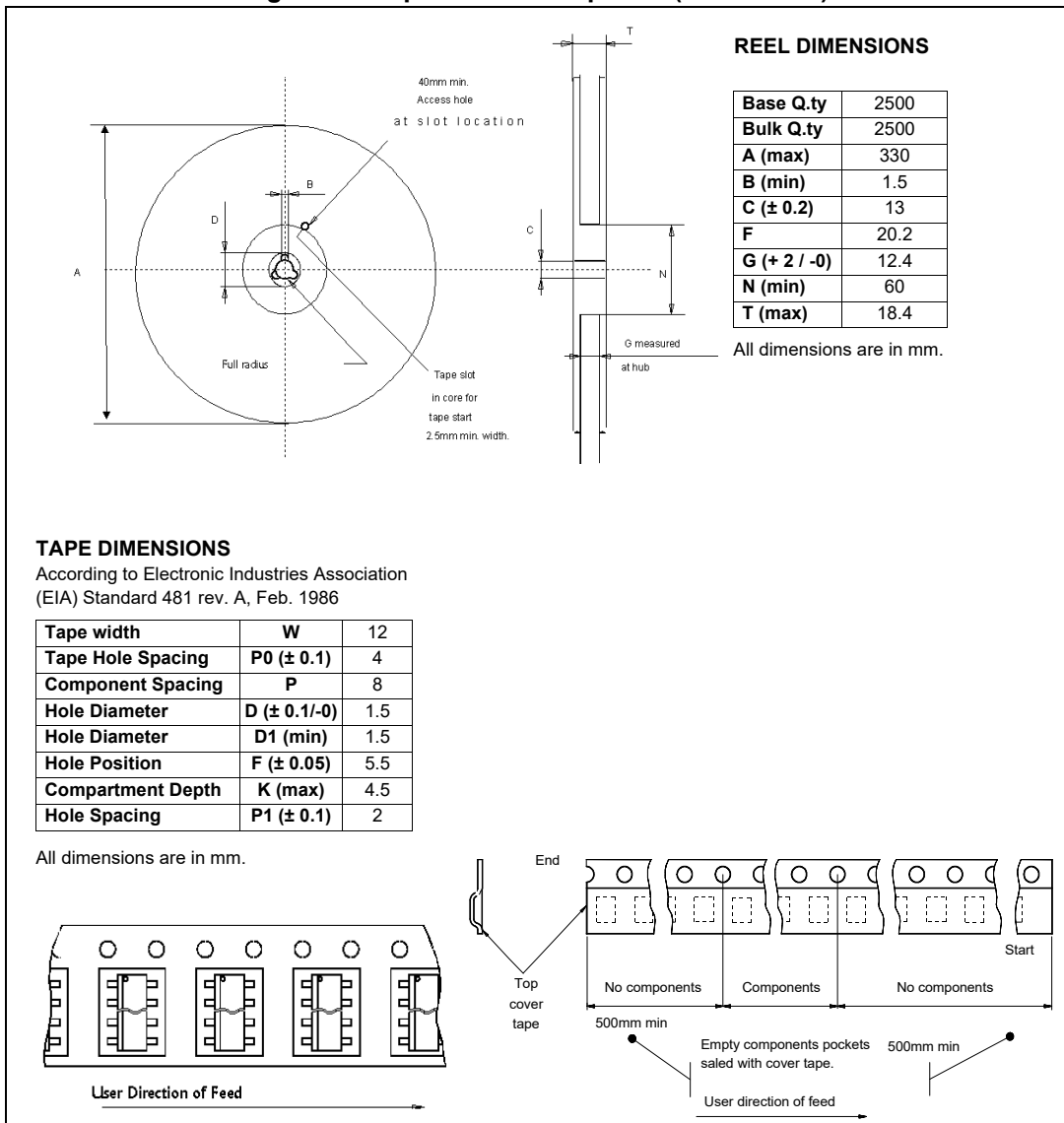


Figure 29. Tape and reel shipment (suffix "TR")



## 5 Revision history

**Table 14. Document revision history**

Date	Revision	Changes
09-Mar-2011	1	Initial release.
18-Sep-2013	2	Updated Disclaimer
04-Jul-2023	3	Updated <a href="#">Table 4: Absolute maximum ratings</a> .

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