



# VNS1NV04DP-E

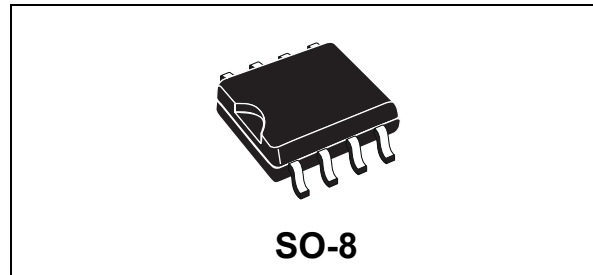
## OMNIFET II fully autoprotected Power MOSFET

### Features

|   |              |               |
|---|--------------|---------------|
| Max On-state resistance <sup>(1)</sup>    | $R_{DS(on)}$ | 250m $\Omega$ |
| Current limitation (typ) <sup>(1)</sup>   | $I_{LIMH}$   | 1.7A          |
| Drain-Source clamp voltage <sup>(1)</sup> | $V_{CLAMP}$  | 40V           |

1. Per each device.

- 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
- In compliance with the 2002/95/EC european directive



### Description

The VNS1NV04DP-E is a device formed by two monolithic OMNIFET II chips housed in a standard SO-8 package. The OMNIFET II are designed in STMicroelectronics VIPower™ M0-3 technology: they are intended for replacement of standard Power MOSFETs from DC up to 50KHz applications. Built in thermal shutdown, linear current limitation and overvoltage clamp protects the chip in harsh environments.

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

**Table 1. Device summary**

| Package | Order codes  |                |
|---------|--------------|----------------|
|         | Tube         | Tape and reel  |
| SO-8    | VNS1NV04DP-E | VNS1NV04DPTR-E |

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# 1 Block diagram and pin description

Figure 1. Block diagram

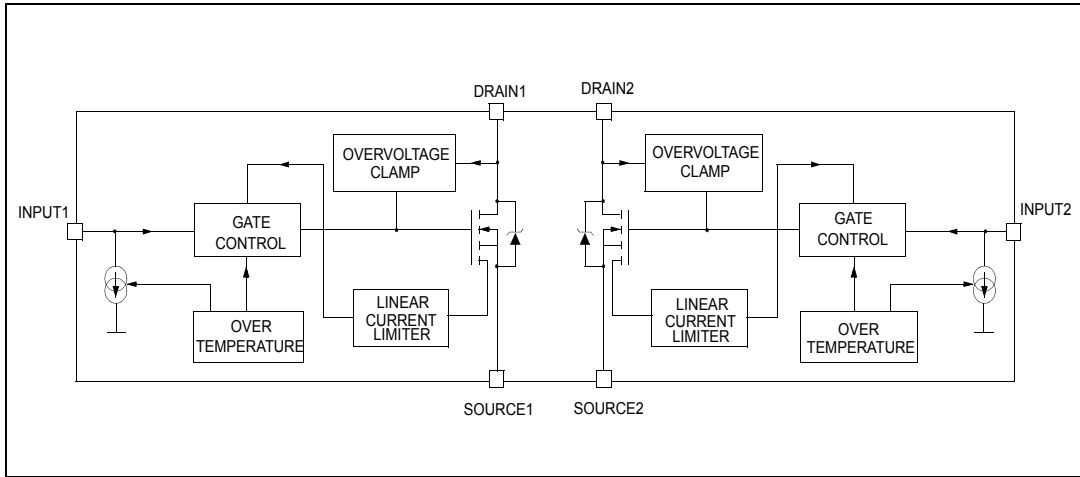
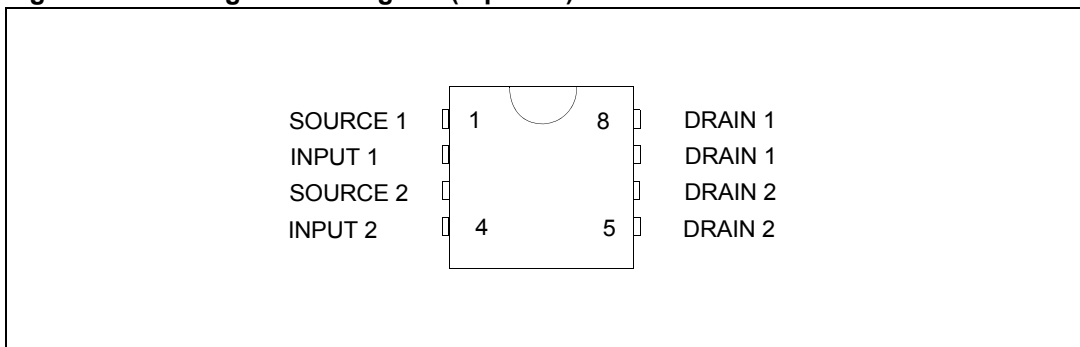
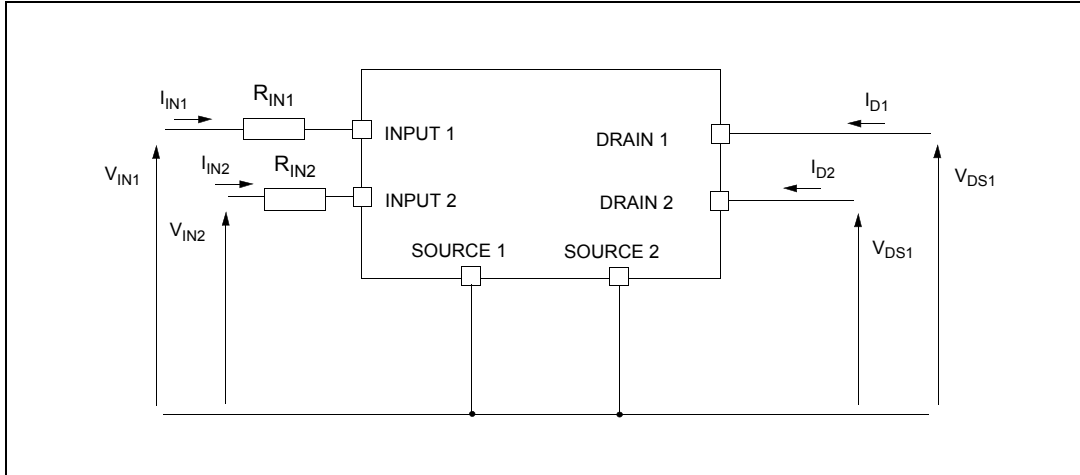


Figure 2. Configuration diagram (top view)



## 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 2. 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   | 330                | $\Omega$         |
| $I_{Dn}$       | Drain current  | Internally limited | A                |
| $I_{Rn}$       | Reverse DC output current  | -3                 | 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 3. 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            | See <a href="#">Figure 31</a> | °C/W |

## 2.3 Electrical characteristics

**Table 4. Off<sup>(1)</sup>**

| Symbol      | Parameter  | Test conditions  | Min.      | Typ. | Max.      | Unit     |
|-------------|--|--|-----------|------|-----------|----------|
| $V_{CLAMP}$ | Drain-source clamp voltage                                 | $V_{IN} = 0\text{ V}; I_D = 0.5\text{ A}$  | 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                                 | $I_{IN} = 1\text{ mA}$<br>$I_{IN} = -1\text{ mA}$  | 6<br>-1.0 | 6.8  | 8<br>-0.3 | V<br>V   |
| $I_{DSS}$   | Zero input voltage drain current ( $V_{IN} = 0\text{ V}$ ) | $V_{DS} = 13\text{ V}; V_{IN} = 0\text{ V}; T_j = 25\text{ °C}$<br>$V_{DS} = 25\text{ V}; V_{IN} = 0\text{ V}$ |           |      | 30<br>75  | μA<br>μA |

1.  $-40\text{ °C} < T_j < 150\text{ °C}$ , unless otherwise specified.

**Table 5. On<sup>(1)</sup>**

| Symbol       | Parameter                         | Test conditions  | Min. | Typ. | Max.       | Unit     |
|--------------|-----------------------------------|--|------|------|------------|----------|
| $R_{DS(on)}$ | Static drain-source on resistance | $V_{IN} = 5\text{ V}; I_D = 0.5\text{ A}; T_j = 25\text{ °C}$<br>$V_{IN} = 5\text{ V}; I_D = 0.5\text{ A}$ |      |      | 250<br>500 | mΩ<br>mΩ |

1.  $-40\text{ °C} < T_j < 150\text{ °C}$ , unless otherwise specified.

**Table 6. Dynamic<sup>(1)</sup>**

| Symbol         | Parameter                | Test conditions   | Min. | Typ. | Max. | Unit |
|----------------|--------------------------|---|------|------|------|------|
| $g_{fs}^{(1)}$ | Forward transconductance | $V_{DD} = 13\text{ V}; I_D = 0.5\text{ A}$                    |      | 2    |      | S    |
| $C_{OSS}$      | Output capacitance       | $V_{DS} = 13\text{ V}; f = 1\text{ MHz}; V_{IN} = 0\text{ V}$ |      | 90   |      | pF   |

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

**Table 7. Switching<sup>(1)</sup>**

| Symbol         | Parameter             | Test conditions   | Min. | Typ. | Max. | Unit             |
|----------------|-----------------------|---|------|------|------|------------------|
| $t_{d(on)}$    | Turn-on delay time    | $V_{DD} = 15\text{ V}; I_D = 0.5\text{ A};$<br>$V_{gen} = 5\text{ V}; R_{gen} = R_{IN\ MIN} = 330\ \Omega$<br>(see <a href="#">Figure 4</a> ) |      | 70   | 200  | ns               |
| $t_r$          | Rise time             |   |      | 170  | 500  | ns               |
| $t_{d(off)}$   | Turn-off delay time   |   |      | 350  | 1000 | ns               |
| $t_f$          | Fall time             |   |      | 200  | 600  | ns               |
| $t_{d(on)}$    | Turn-on delay time    | $V_{DD} = 15\text{ V}; I_D = 0.5\text{ A}$<br>$V_{gen} = 5\text{ V}; R_{gen} = 2.2\text{ K}\Omega$<br>(see <a href="#">Figure 4</a> )         |      | 0.25 | 1    | $\mu\text{s}$    |
| $t_r$          | Rise time             |   |      | 1.3  | 4    | $\mu\text{s}$    |
| $t_{d(off)}$   | Turn-off delay time   |   |      | 1.8  | 5.5  | $\mu\text{s}$    |
| $t_f$          | Fall time             |   |      | 1.2  | 4    | $\mu\text{s}$    |
| $(dI/dt)_{on}$ | Turn-on current slope | $V_{DD} = 15\text{ V}; I_D = 1.5\text{ A}$<br>$V_{gen} = 5\text{ V}; R_{gen} = R_{IN\ MIN} = 330\ \Omega$                                     |      | 5    |      | A/ $\mu\text{s}$ |
| $Q_i$          | Total input charge    | $V_{DD} = 12\text{ V}; I_D = 0.5\text{ A}; V_{IN} = 5\text{ V}$<br>$I_{gen} = 2.13\text{ mA}$ (see <a href="#">Figure 7</a> )                 |      | 5    |      | nC               |

1.  $T_j = 25\text{ }^\circ\text{C}$ , unless otherwise specified.

**Table 8. Source Drain diode<sup>(1)</sup>**

| Symbol         | Parameter                | Test conditions  | Min. | Typ. | Max. | Unit |
|----------------|--------------------------|--|------|------|------|------|
| $V_{SD}^{(2)}$ | Forward on voltage       | $I_{SD} = 0.5\text{ A}; V_{IN} = 0\text{ V}$   | -    | 0.8  | -    | V    |
| $t_{rr}$       | Reverse recovery time    | $I_{SD} = 0.5\text{ A}; dI/dt = 6\text{ A}/\mu\text{s}$<br>$V_{DD} = 30\text{ V}; L = 200\ \mu\text{H}$<br>(see <a href="#">Figure 5</a> ) | -    | 205  | -    | ns   |
| $Q_{rr}$       | Reverse recovery charge  |  | -    | 100  | -    | nC   |
| $I_{RRM}$      | Reverse recovery current |  | -    | 0.75 | -    | A    |

1.  $T_j = 25\text{ }^\circ\text{C}$ , unless otherwise specified.

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

**Table 9. Protections<sup>(1)</sup>**

| Symbol     | Parameter                     | Test conditions   | Min. | Typ. | Max. | Unit             |
|------------|-------------------------------|---|------|------|------|------------------|
| $I_{lim}$  | Drain current limit           | $V_{IN} = 5\text{ V}; V_{DS} = 13\text{ V}$   | 1.7  |      | 3.5  | A                |
| $t_{dlim}$ | Step response current limit   | $V_{IN} = 5\text{ V}; V_{DS} = 13\text{ V}$   |      | 2    |      | $\mu\text{s}$    |
| $T_{jsh}$  | Overtemperature shutdown      |   | 150  | 175  | 200  | $^\circ\text{C}$ |
| $T_{jrs}$  | Overtemperature reset         |   | 135  |      |      | $^\circ\text{C}$ |
| $I_{gf}$   | 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 $T_j = 25\text{ }^\circ\text{C}$ ; $V_{DD} = 24\text{ V}$<br>$V_{IN} = 5\text{ V}; R_{gen} = R_{IN\ MIN} = 330\ \Omega;$<br>$L = 50\text{ mH}$<br>(see <a href="#">Figure 6</a> and <a href="#">Figure 8</a> ) | 55   |      |      | mJ               |

1.  $-40\text{ }^\circ\text{C} < T_j < 150\text{ }^\circ\text{C}$ , unless otherwise specified.



Figure 4. Switching time test circuit for resistive load

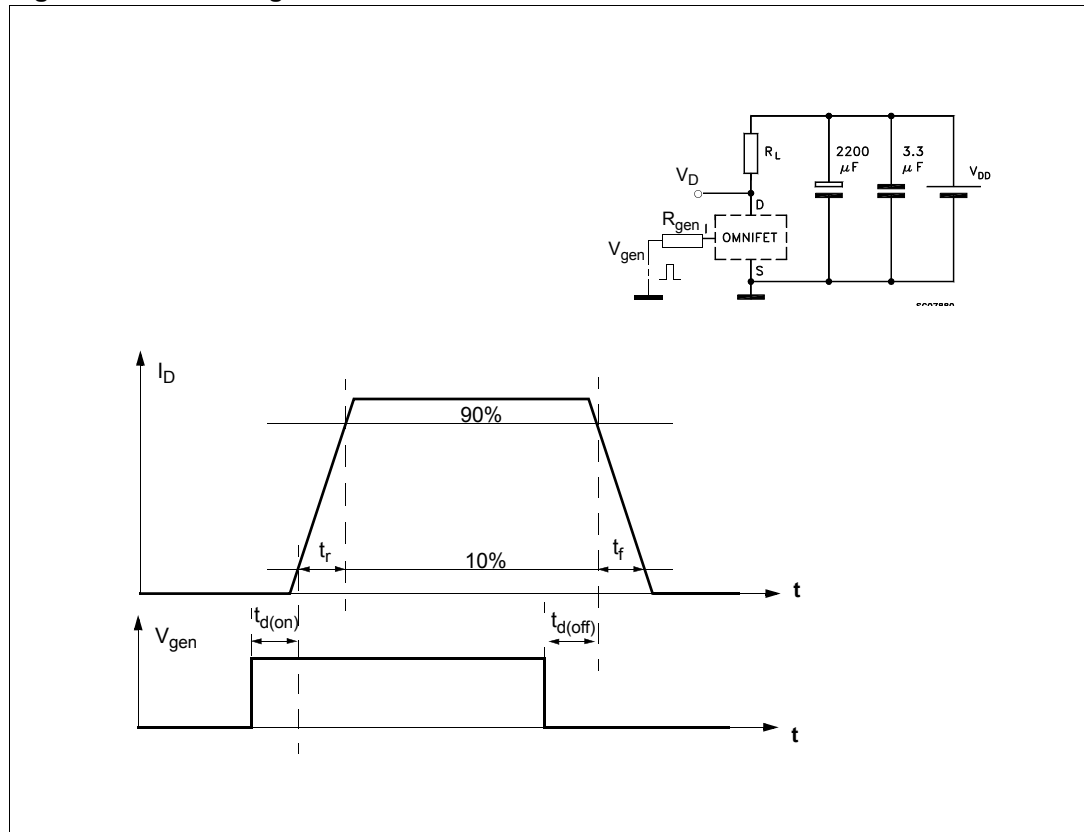


Figure 5. Test circuit for diode recovery times

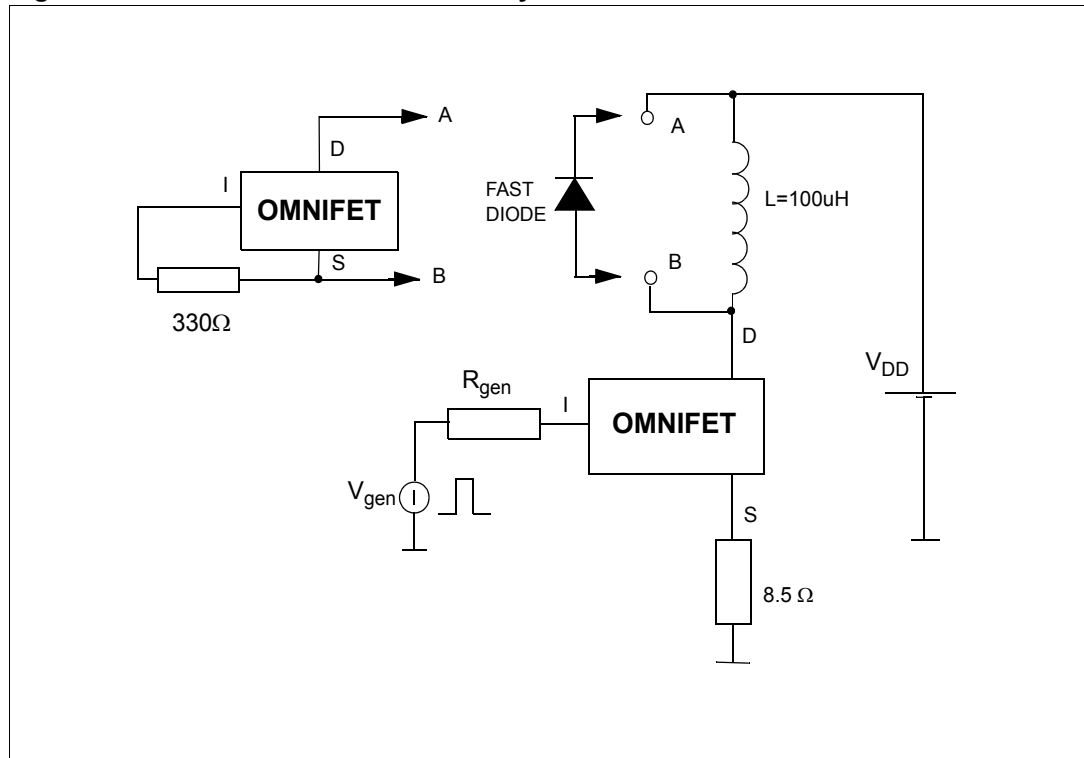


Figure 6. Unclamped inductive load test circuits

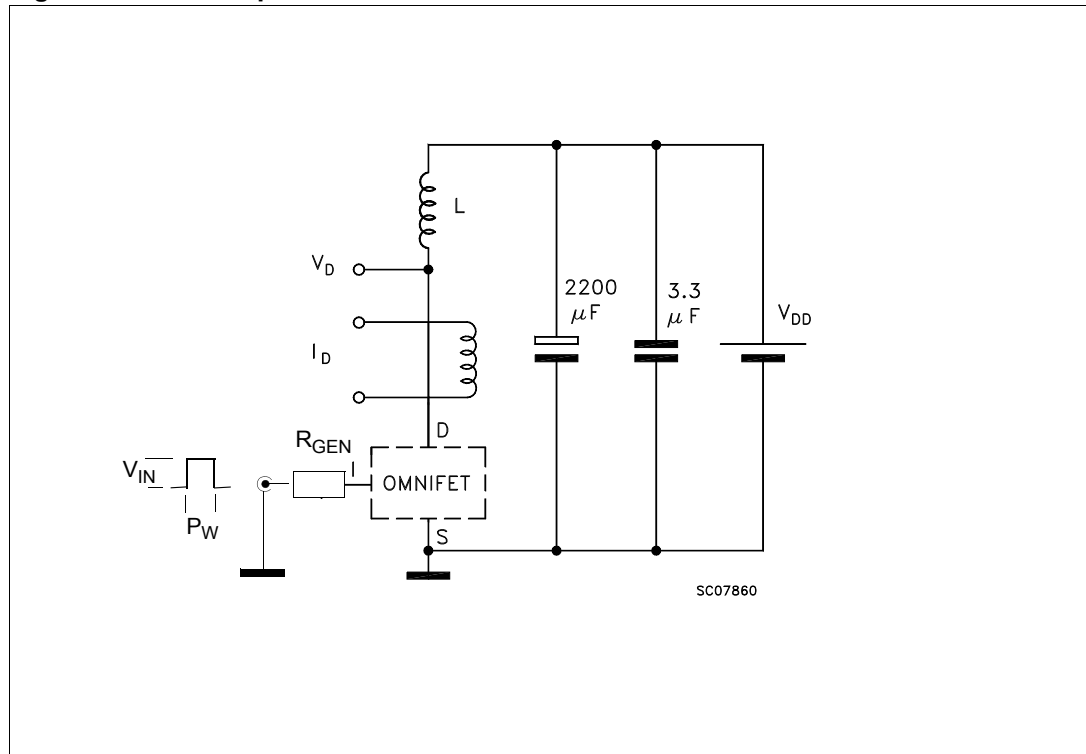


Figure 7. Input charge test circuit

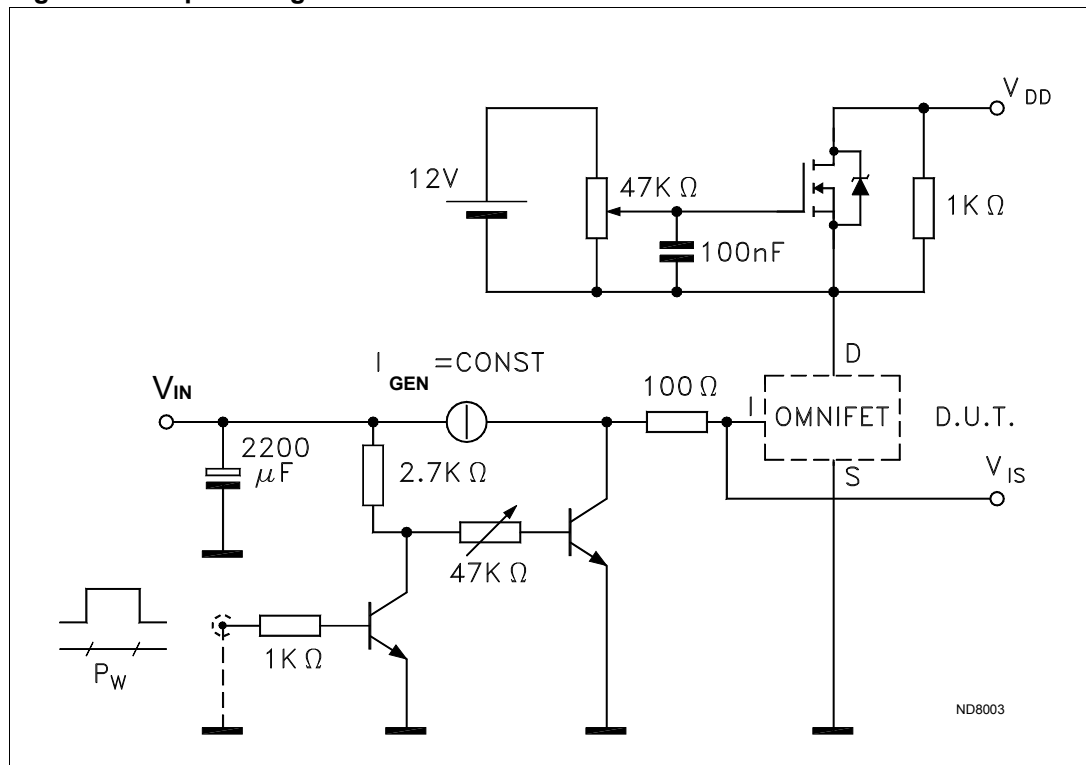
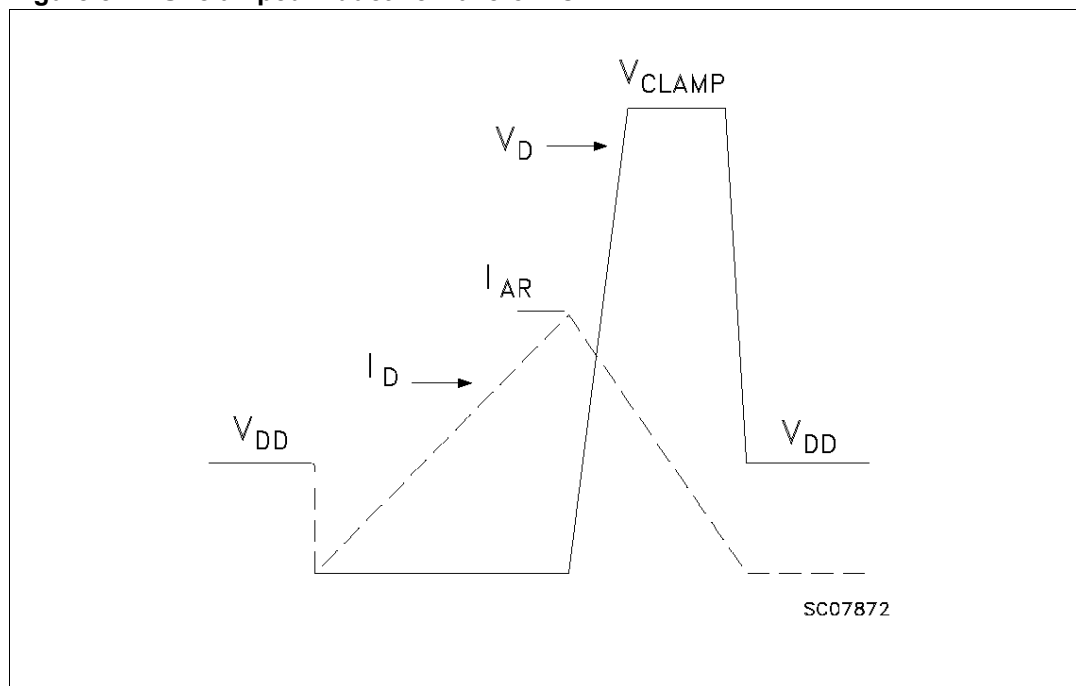
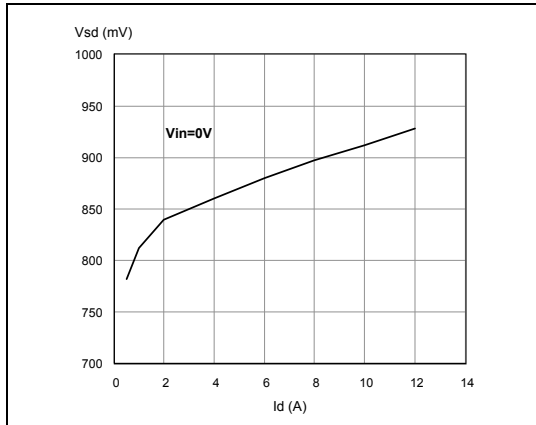


Figure 8. Unclamped inductive waveforms

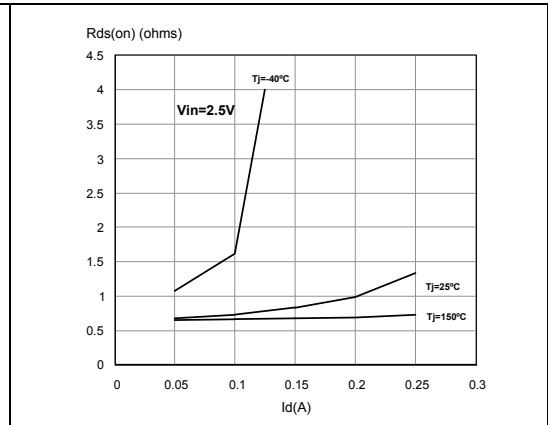


## 2.4 Electrical characteristics curves

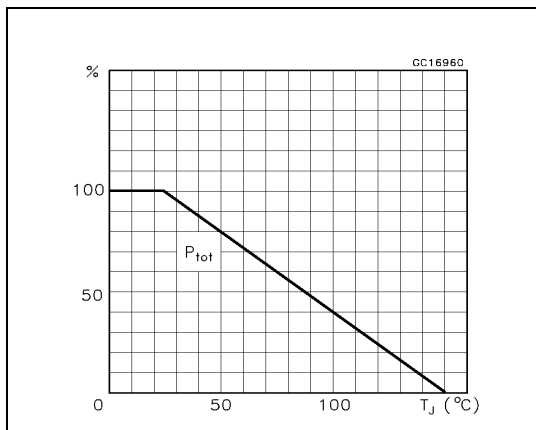
**Figure 9. Source-drain diode forward characteristics**



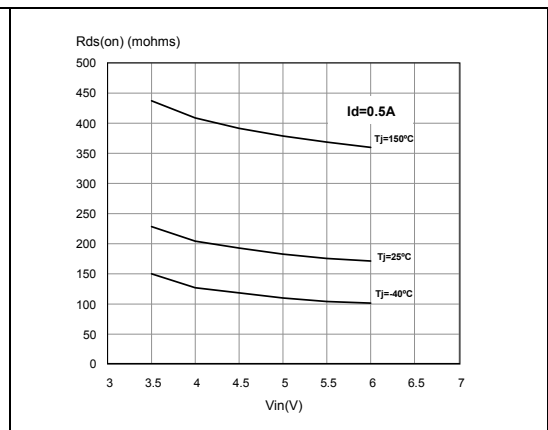
**Figure 10. Static drain-source on resistance**



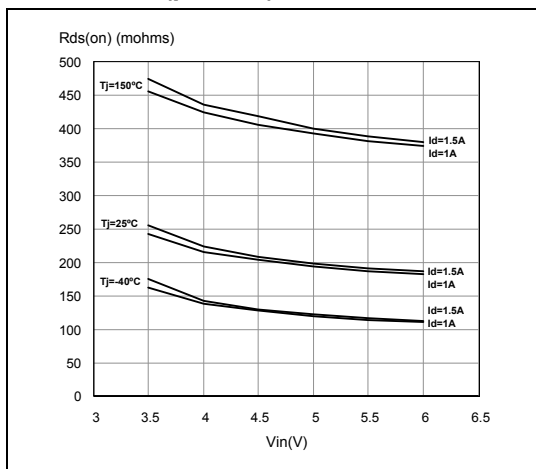
**Figure 11. Derating curve**



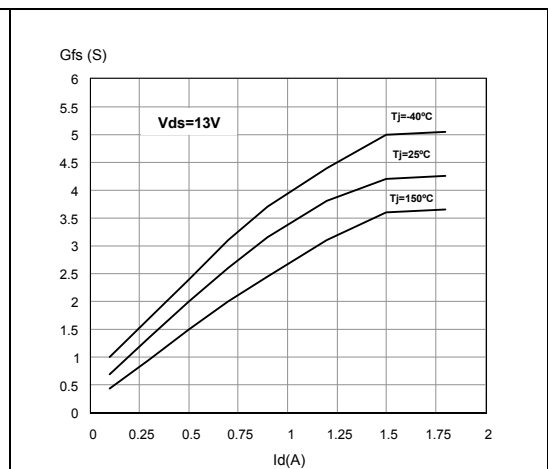
**Figure 12. Static drain-source on resistance vs input voltage (part 1/2)**



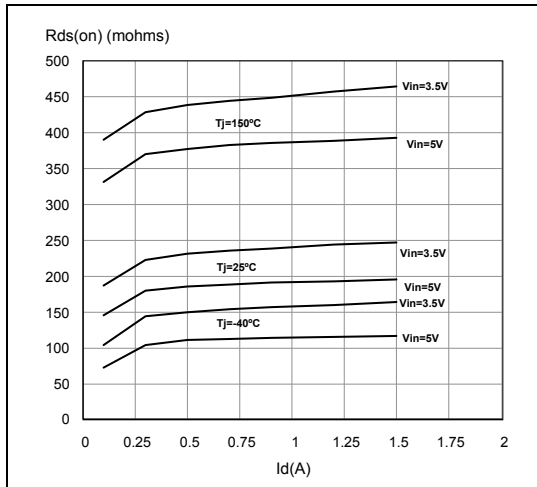
**Figure 13. Static drain-source on resistance vs input voltage (part 2/2)**



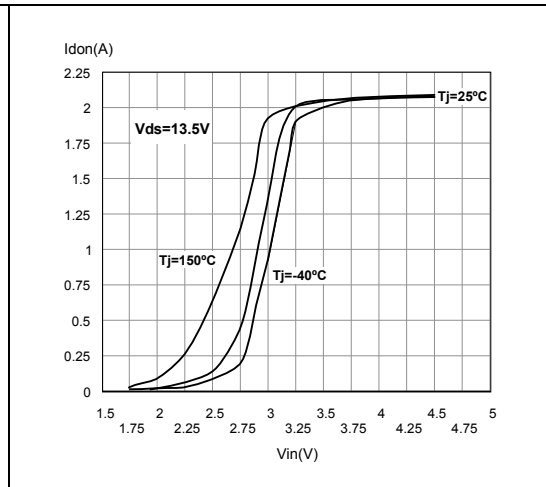
**Figure 14. Transconductance**



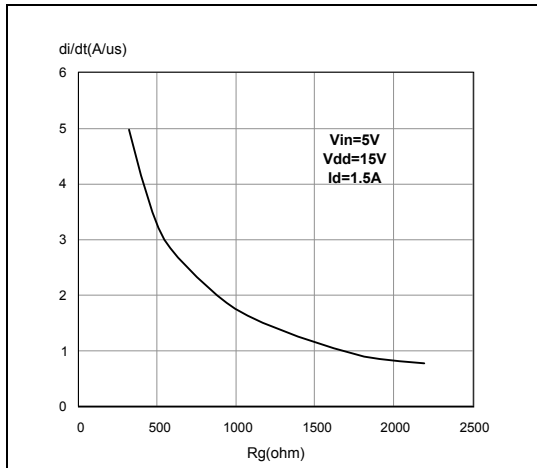
**Figure 15. Static drain-source on resistance vs id**



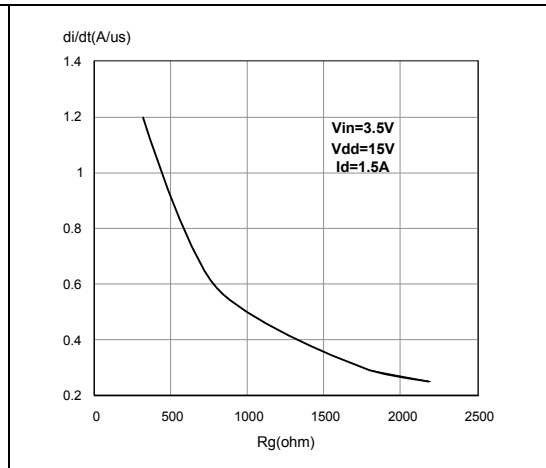
**Figure 16. Transfer characteristics**



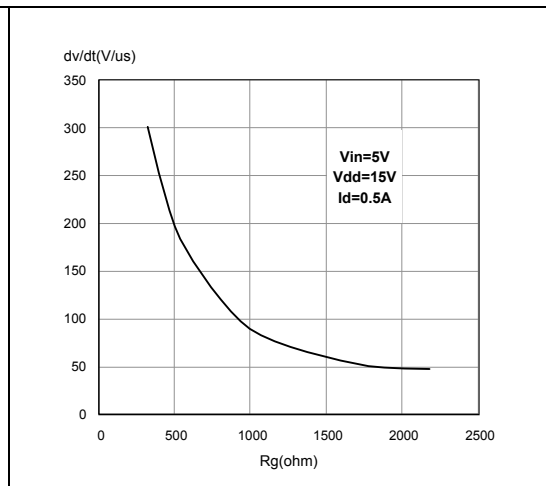
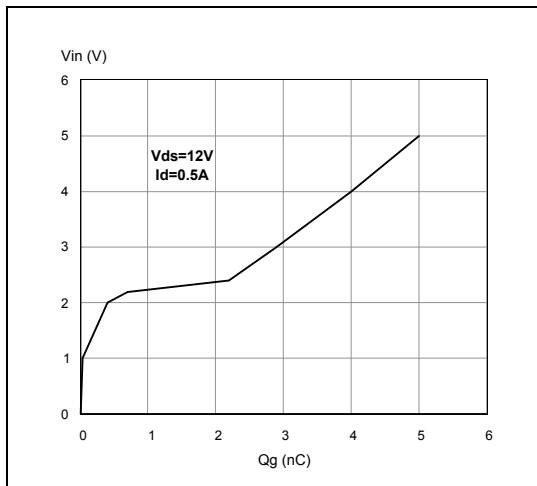
**Figure 17. Turn-on current slope (part 1/2)**



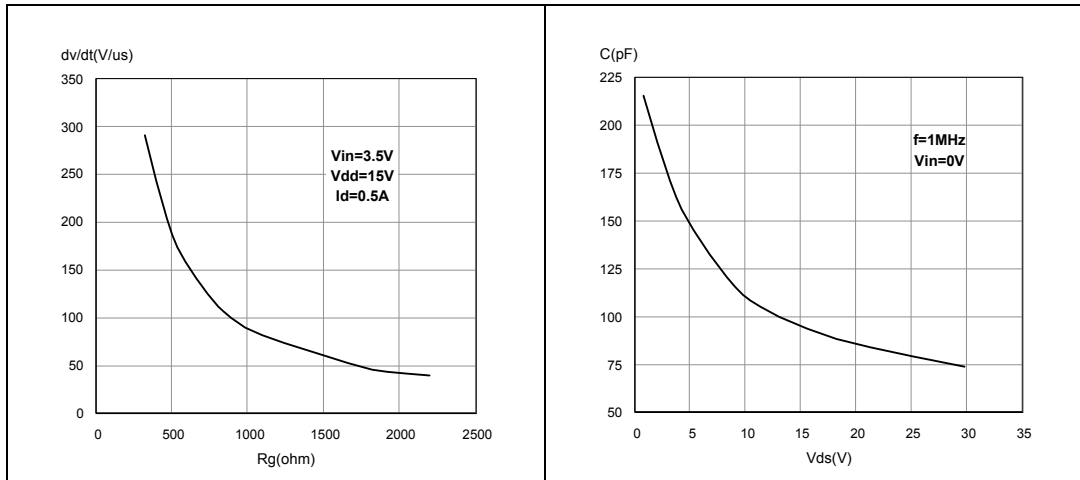
**Figure 18. Turn-on current slope (part 2/2)**



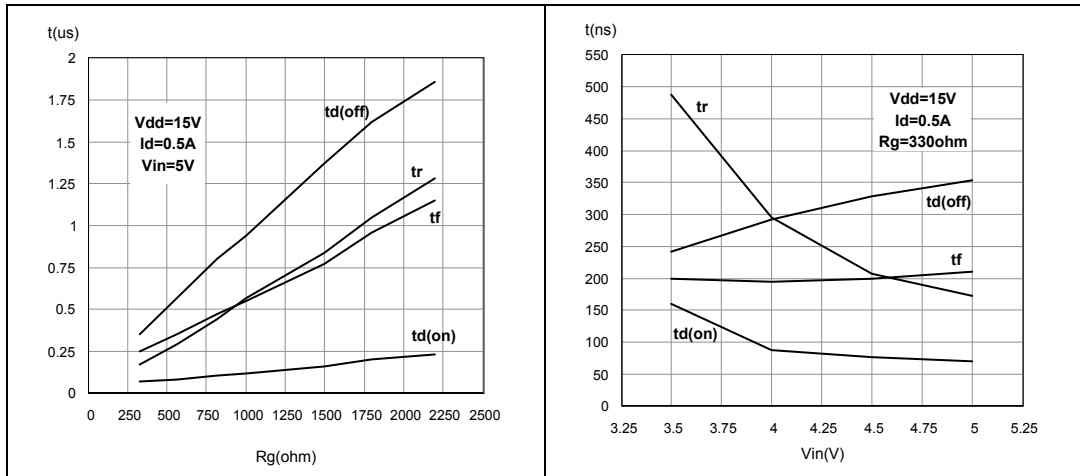
**Figure 19. Input voltage vs input charge** **Figure 20. Turn-off drain source voltage slope (part 1/2)**



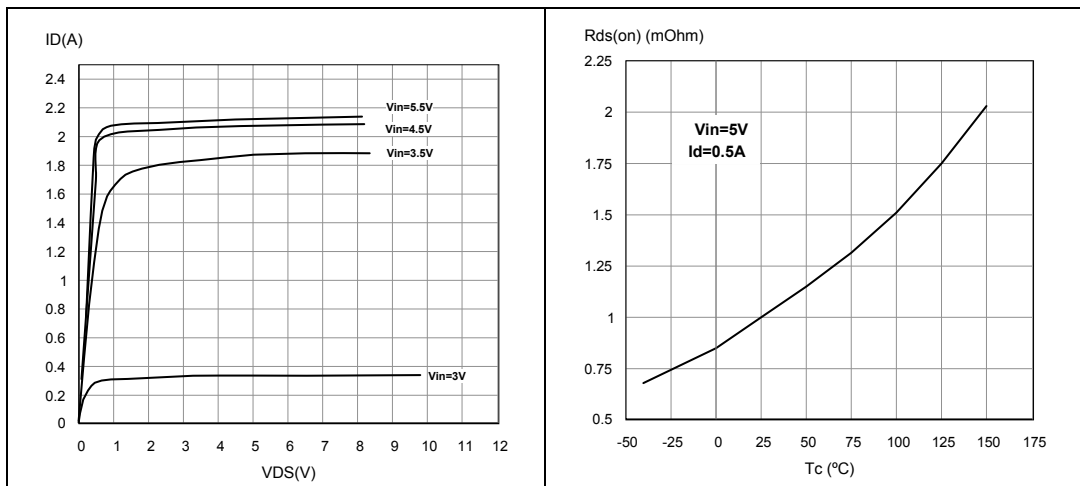
**Figure 21. Turn-off drain-source voltage slope (part 2/2)** **Figure 22. Capacitance variations**



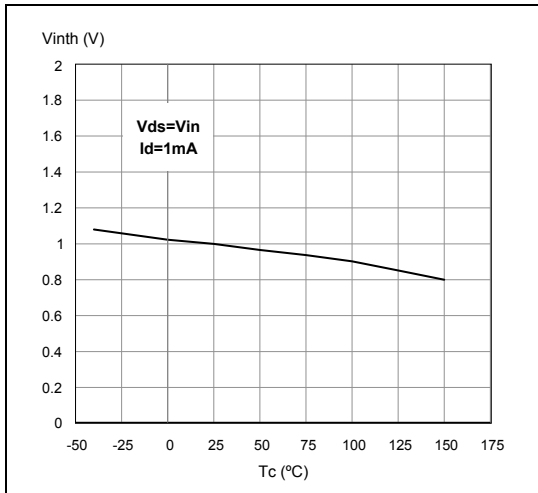
**Figure 23. Switching time resistive load (part 1/2)** **Figure 24. Switching time resistive load (part 2/2)**



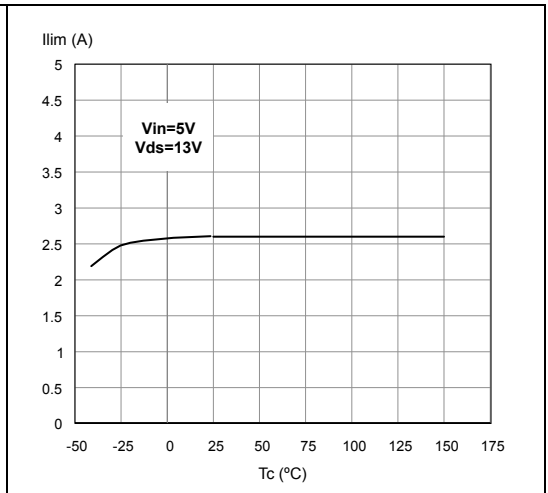
**Figure 25. Output characteristics** **Figure 26. Normalized on resistance vs temperature**



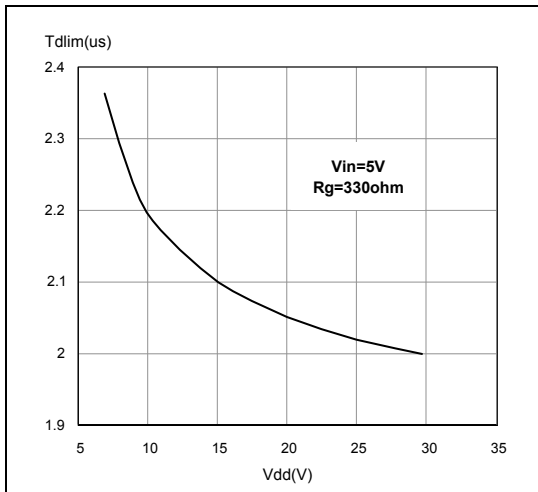
**Figure 27. Normalized input threshold voltage vs temperature**



**Figure 28. Normalized current limit vs junction temperature**



**Figure 29. 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  $I_{SS}$  (typ. 100  $\mu$ A) flows into the INPUT pin in order to supply the internal circuitry.

The device integrates:

### 3.1 Overvoltage clamp protection

Internally set at 45V, 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 voltage. 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 will fall to 0V. This will not however affect 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  $I_{SS}$ .

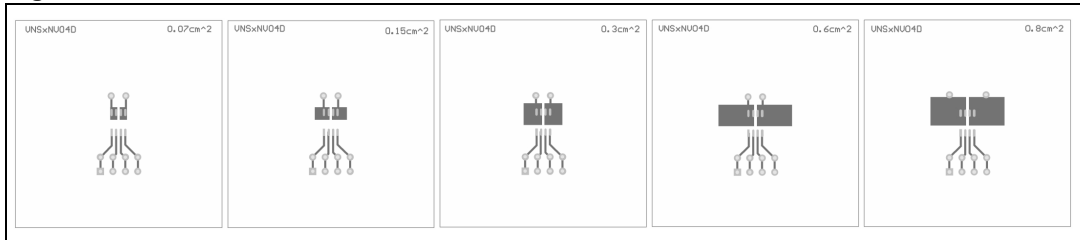
Additional features of this device are ESD protection according to the Human Body model and the ability to be driven from a TTL Logic circuit.



## 4 Package and PCB thermal data

### 4.1 SO-8 thermal data

Figure 30. SO-8 PC board



Note: Layout condition of  $R_{th}$  and  $Z_{th}$  measurements (PCB FR4 area = 58 mm x 58 mm, PCB thickness = 2 mm, Cu thickness = 35  $\mu$ m, Copper areas: from minimum pad lay-out to 0.8 cm<sup>2</sup>).

Figure 31.  $R_{thj-amb}$  vs PCB copper area in open box free air condition

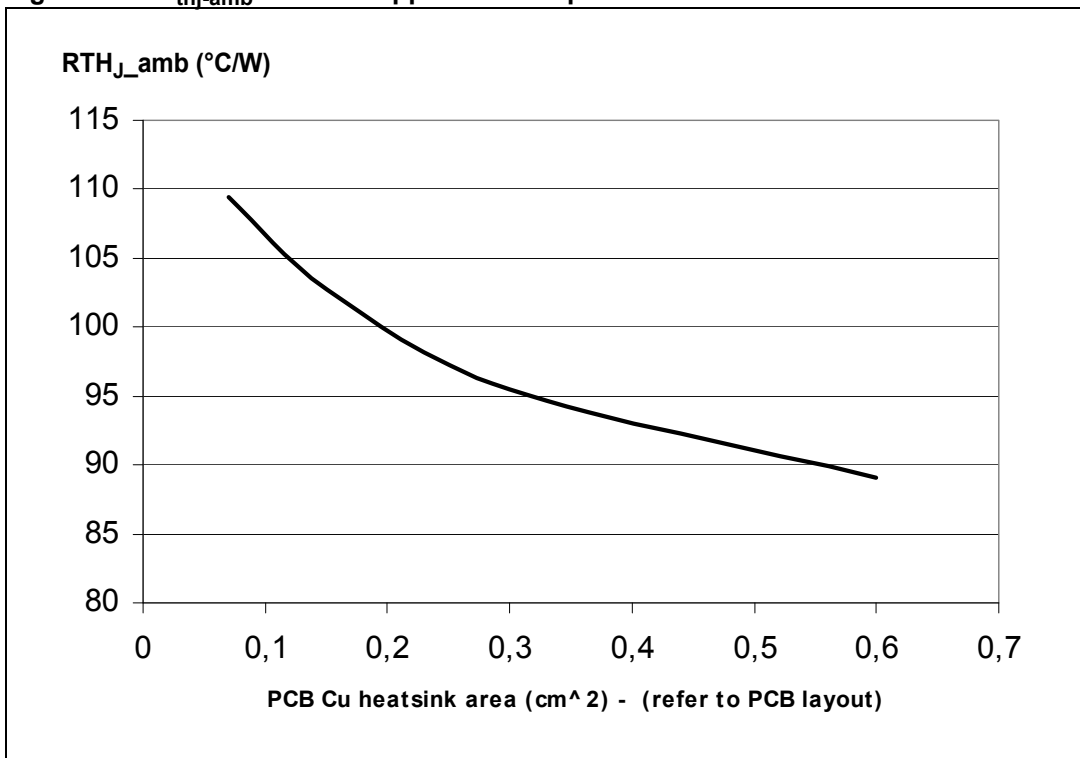
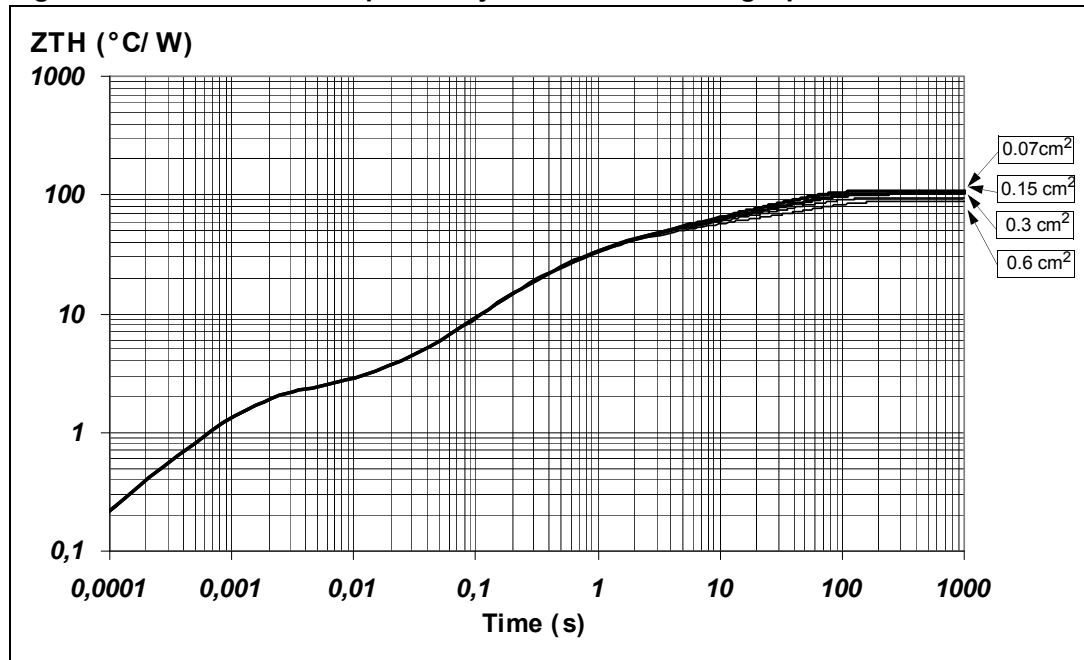


Figure 32. SO-8 thermal impedance junction ambient single pulse



Equation 1: pulse calculation formula

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

where  $\delta = t_p/T$

Figure 33. Thermal fitting model of a double channel HSD in SO-8

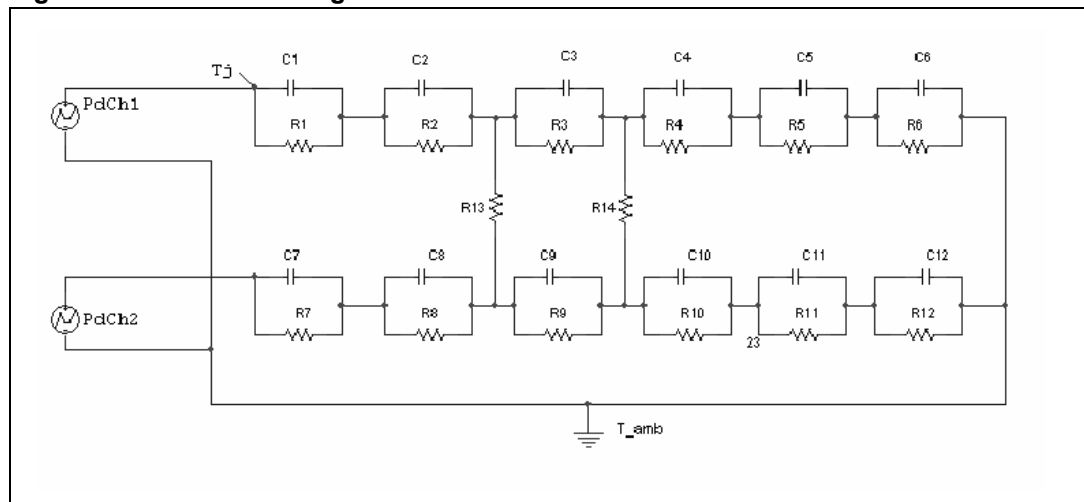


Table 10. Thermal parameters

| Area/island (cm <sup>2</sup> ) | 0.07   | 0.15 | 0.3  | 0.6  |
|--------------------------------|--------|------|------|------|
| R1 = R7 (°C/W)                 | 0.02   |      |      |      |
| R2 = R8 (°C/W)                 | 2      |      |      |      |
| R3 = R9 (°C/W)                 | 11     |      |      |      |
| R4 = R10 (°C/W)                | 30     |      |      |      |
| R5 = R11 (°C/W)                | 25     |      |      |      |
| R6 = R12 (°C/W)                | 100    | 87.5 | 74.2 | 62.6 |
| R13 = R14 (°C/W)               | 250    |      |      |      |
| C1 = C2 = C7 = C8 (W.s/°C)     | 0.0005 |      |      |      |
| C3 = C9 (W.s/°C)               | 0.02   |      |      |      |
| C4 = C10 (W.s/°C)              | 0.035  |      |      |      |
| C5 = C11 (W.s/°C)              | 0.2    |      |      |      |
| C6 = C12 (W.s/°C)              | 0.4    | 0.51 | 0.65 | 0.95 |

## 5 Package and packing information

### 5.1 ECOPACK<sup>®</sup> packages

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK<sup>®</sup> packages, depending on their level of environmental compliance. ECOPACK<sup>®</sup> specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com).

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### 5.2 SO-8 package information

Figure 34. SO-8 package dimensions

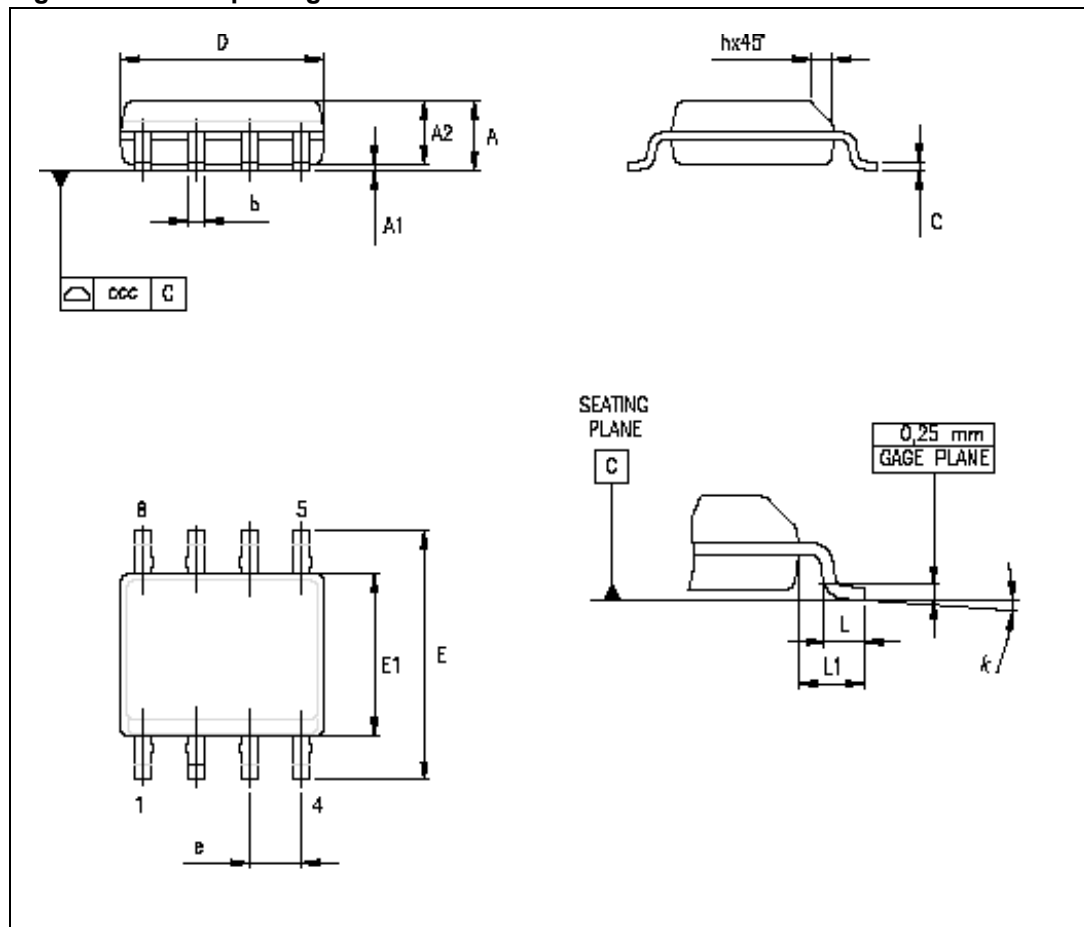


Table 11. SO-8 mechanical data

| 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 <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. Dimensions 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.

### 5.3 SO-8 packing information

Figure 35. SO-8 tube shipment (no suffix)

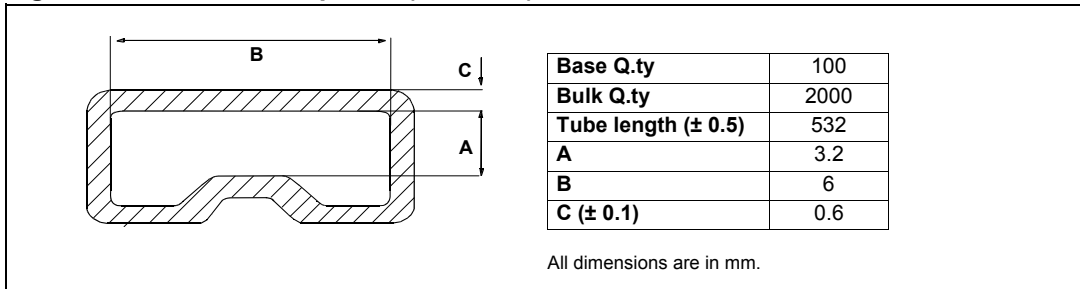
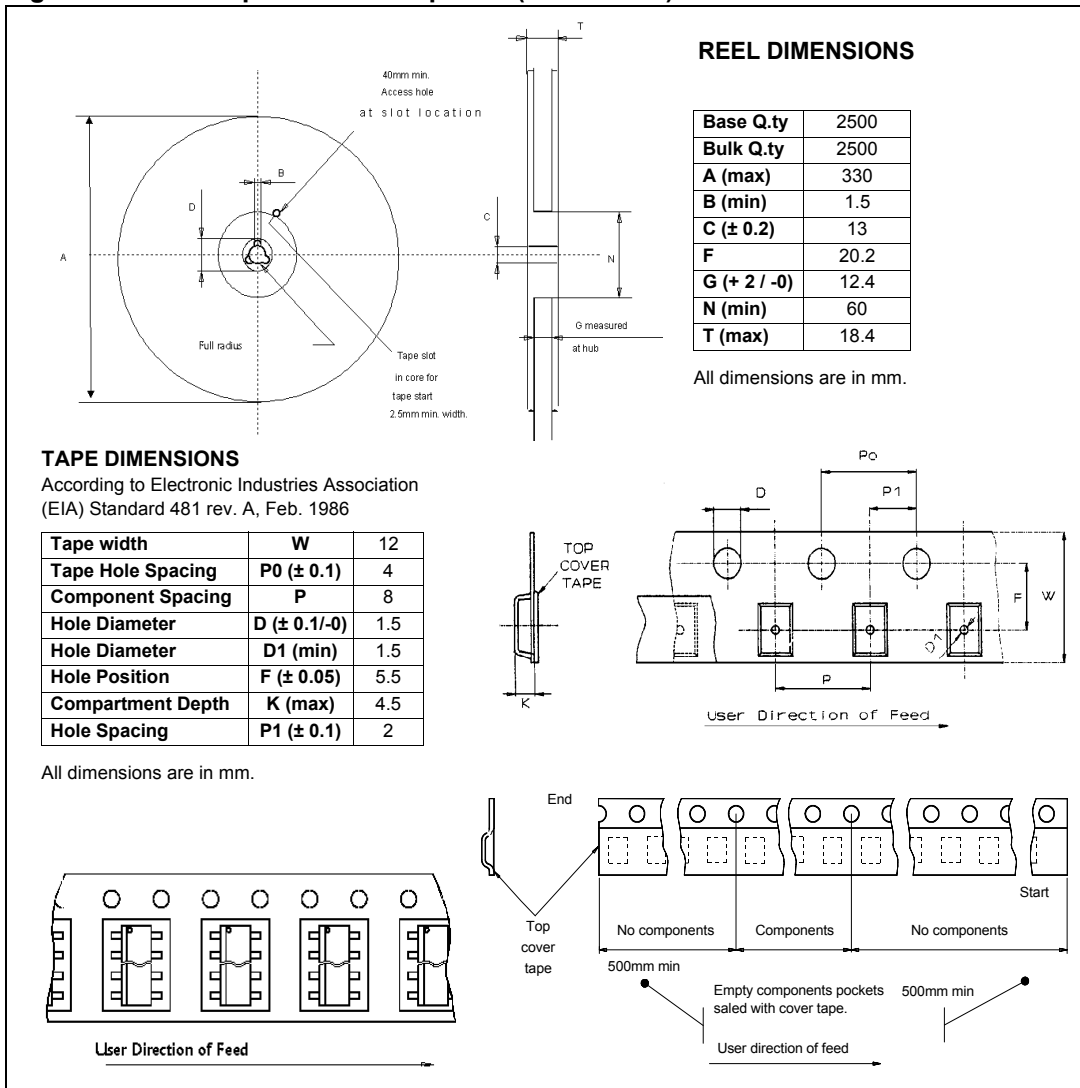


Figure 36. SO-8 tape and reel shipment (suffix "TR")



## 6 Revision history

**Table 12. Document revision history**

| Date        | Revision | Changes   |
|-------------|----------|---|
| 09-Jun-2008 | 1        | Initial release.  |
| 02-Apr-2010 | 2        | Changed template.<br>Updated <a href="#">Table 17: Turn-on current slope (part 1/2)</a> . |
| 20-Sep-2013 | 3        | Updated Disclaimer.   |

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