



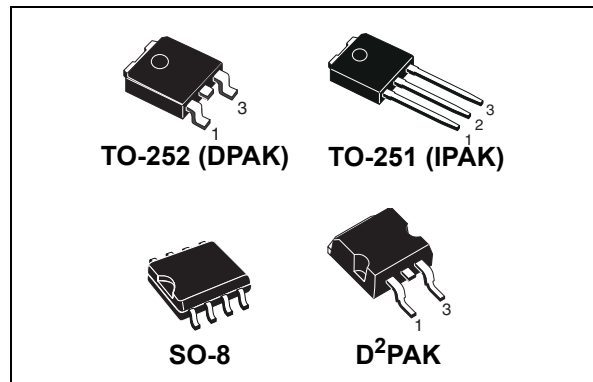
VNB14NV04, VND14NV04 VND14NV04-1, VNS14NV04

"OMNIFET II"
fully autoprotected Power MOSFET

Features

| TYPE | $R_{DS(on)}$ | I_{lim} | V_{clamp} |
|--|---------------|-----------|-------------|
| VNB14NV04 VND14NV04 VND14NV04-1 VNS14NV04 | 35 m Ω | 12 A | 40 V |

- 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



Description

The VNB14NV04, VND14NV04, VND14NV04-1 and VNS14NV04 are monolithic devices made using STMicroelectronics VIPower™ M0 technology, intended for replacement of standard power MOSFETS in DC to 50 KHz applications. Built-in thermal shutdown, linear current limitation and overvoltage clamp protect the chip in harsh environments.

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

Table 1. Device summary

| Package | Tube | Tube (lead free) | Tape and reel | Tape and reel (lead free) |
|--------------------|-------------|------------------|---------------|---------------------------|
| D ² PAK | VNB14NV04 | VNB14NV04-E | VNB14NV0413TR | VNB14NV04TR-E |
| TO-252 (DPAK) | VND14NV04 | VND14NV04-E | VND14NV0413TR | VND14NV04TR-E |
| TO-251 (IPAK) | VND14NV04-1 | VND14NV04-1-E | - | - |
| SO-8 | VNS14NV04 | - | - | - |

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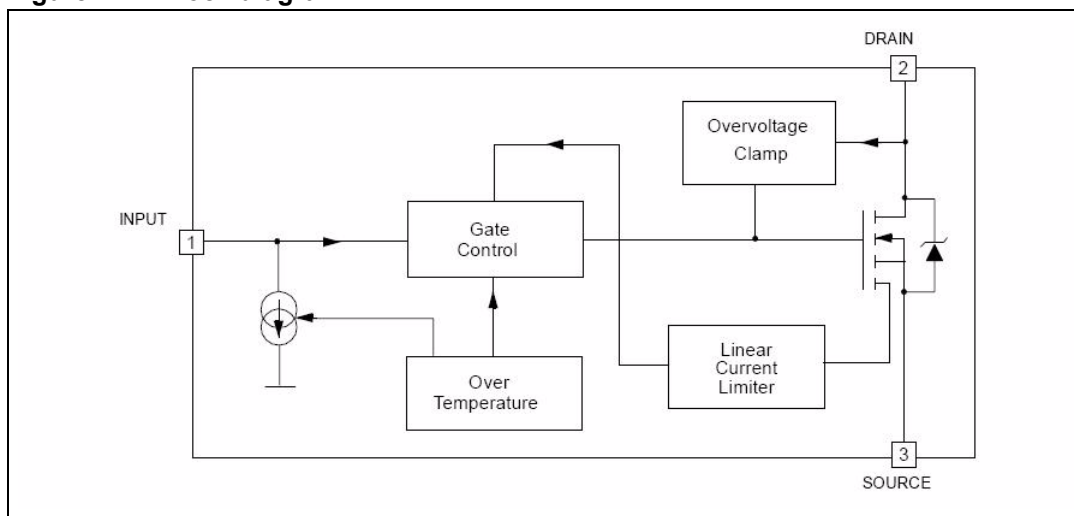
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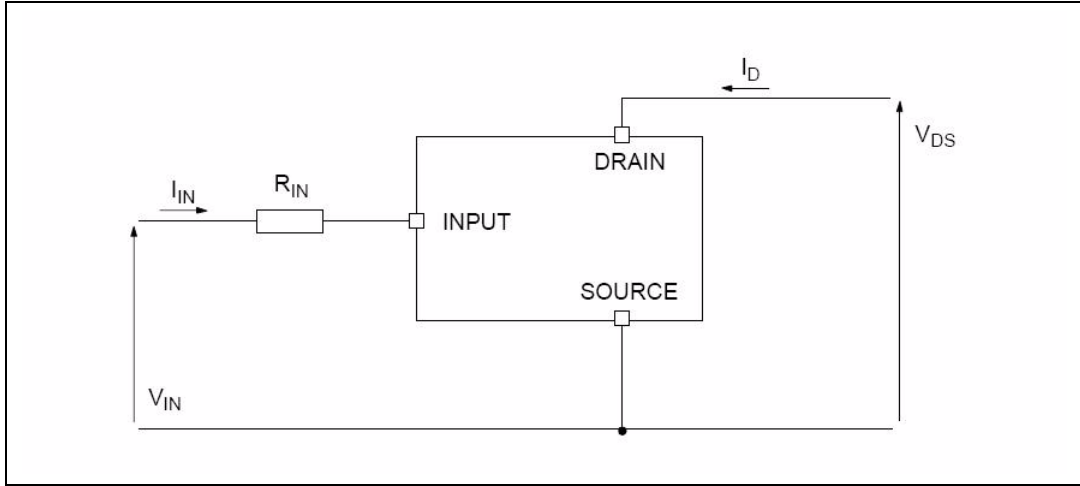
1 Block diagram

Figure 1. Block diagram



2 Electrical specification

Figure 2. Current and voltage conventions



2.1 Absolute maximum rating

Table 2. Absolute maximum rating

| Symbol | Parameter | Value | | | | Unit |
|---------------------|---|--------------------|------|------|--------------------|------|
| | | SO-8 | DPAK | IPAK | D ² PAK | |
| V _{DS} | Drain-source voltage (V _{IN} =0 V) | Internally clamped | | | | V |
| V _{IN} | Input voltage | Internally clamped | | | | V |
| I _{IN} | Input current | +/-20 | | | | mA |
| R _{IN MIN} | Minimum input series impedance | 10 | | | | Ω |
| I _D | Drain current | Internally limited | | | | A |
| I _R | Reverse DC output current | -15 | | | | A |
| V _{ESD1} | Electrostatic discharge (R=1.5 KΩ, C=100 pF) | 4000 | | | | V |
| V _{ESD2} | Electrostatic discharge on output pin only (R=330 Ω, C=150 pF) | 16500 | | | | V |
| P _{tot} | Total dissipation at T _c =25 °C | 4.6 | 74 | 74 | 74 | W |
| E _{MAX} | Maximum switching energy (L=0.4 mH; R _L =0 Ω; V _{bat} =13.5 V; T _{jstart} =150 °C; I _L =18 A) | | 93 | | 93 | mJ |
| T _j | Operating junction temperature | Internally limited | | | | °C |
| T _c | Case operating temperature | Internally limited | | | | °C |
| T _{stg} | Storage temperature | -55 to 150 | | | | °C |

2.2 Thermal data

Table 3. Thermal data

| Symbol | Parameter | Value | | | | Unit |
|-----------------------|---|-------------------|-------------------|------|--------------------|------|
| | | SO-8 | DPAK | IPAK | D ² PAK | |
| R _{thj-case} | Thermal resistance junction-case max | | 1.7 | 1.7 | 1.7 | °C/W |
| R _{thj-lead} | Thermal resistance junction-lead max | 27 | | | | °C/W |
| R _{thj-amb} | Thermal resistance junction-ambient max | 90 ⁽¹⁾ | 65 ⁽¹⁾ | 102 | 52 ⁽¹⁾ | °C/W |

1. When mounted on a standard single-sided FR4 board with 0.5 cm² of Cu (at least 35 μm thick) connected to all DRAIN pins. Horizontal mounting and no artificial air flow.

2.3 Electrical characteristics

-40 < T_j < 150 °C unless otherwise specified.

Table 4. Electrical characteristics

| Symbol | Parameter | Test Conditions | Min | Typ | Max | Unit |
|---|---|--|-----------|-----|-----------|------|
| Off | | | | | | |
| V _{CLAMP} | Drain-source clamp voltage | V _{IN} =0 V; I _D =7 A | 40 | 45 | 55 | V |
| V _{CLTH} | Drain-source clamp threshold voltage | V _{IN} =0 V; I _D =2 mA | 36 | | | V |
| V _{INTH} | Input threshold voltage | V _{DS} =V _{IN} ; I _D =1 mA | 0.5 | | 2.5 | V |
| I _{ISS} | Supply current from input pin | V _{DS} =0 V; V _{IN} =5 V | | 100 | 150 | μA |
| V _{INCL} | Input-source clamp voltage | I _{IN} =1 mA I _{IN} =-1 mA | 6 -1.0 | 6.8 | 8 -0.3 | V |
| I _{DSS} | Zero input voltage drain current (V _{IN} =0 V) | V _{DS} =13 V; V _{IN} =0 V; T _j =25 °C V _{DS} =25 V; V _{IN} =0 V | | | 30 75 | μA |
| On | | | | | | |
| R _{DS(on)} | Static drain-source on resistance | V _{in} = 5 V I _D = 7 A T _j = 25 °C V _{in} = 5 V I _D = 7 A | | | 35 70 | mΩ |
| Dynamic (T_j=25°C, unless otherwise specified) | | | | | | |
| g _{fs} ⁽¹⁾ | Forward transconductance | V _{DD} = 13 V I _D = 7 A | | 18 | | S |
| C _{oss} | Output capacitance | V _{DS} = 13 V f = 1 MHz V _{IN} = 0 V | | 400 | | pF |
| Switching | | | | | | |
| t _{d(on)} | Turn-on delay time | V _{DD} = 15 V I _D = 7 A V _{gen} = 5 V R _{gen} = R _{IN MIN} = 10 Ω (see Figure 3) | | 80 | 250 | ns |
| t _r | Rise time | | | 350 | 1000 | ns |
| t _{d(off)} | Turn-off delay time | | | 450 | 1350 | ns |
| t _f | Fall time | | | 150 | 500 | ns |

Table 4. Electrical characteristics (continued)

| Symbol | Parameter | Test Conditions | Min | Typ | Max | Unit |
|---------------------------|-------------------------------|---|-----|------|------|------------------------|
| $t_{d(on)}$ | Turn-on delay time | $V_{DD} = 15\text{ V}$ $I_d = 7\text{ A}$ $V_{gen} = 5\text{ V}$ $R_{gen} = 2.2\text{ K}\Omega$ (see Figure 3) | | 1.5 | 4.5 | μs |
| t_r | Rise time | | | 9.7 | 30.0 | μs |
| $t_{d(off)}$ | Turn-off delay time | | | | 25.0 | μs |
| t_f | Fall time | | | 10.2 | 30.0 | μs |
| $(di/dt)_{on}$ | Turn-on current slope | $V_{DD} = 15\text{ V}$ $I_D = 7\text{ A}$ $V_{gen} = 5\text{ V}$ $R_{gen} = R_{IN\text{ MIN}} = 10\ \Omega$ | | 16 | | $\text{A}/\mu\text{s}$ |
| Q_i | Total input charge | $V_{DD} = 12\text{ V}$ $I_D = 7\text{ A}$ $V_{in} = 5\text{ V}$; $I_{gen} = 2.13\text{ mA}$ (see Figure 7) | | 36.8 | | nC |
| Source drain diode | | | | | | |
| $V_{SD}^{(1)}$ | Forward on voltage | $I_{SD} = 7\text{ A}$ $V_{in} = 0\text{ V}$ | | 0.8 | | V |
| t_{rr} | Reverse recovery time | $I_{SD} = 7\text{ A}$; $di/dt = 40\text{ A}/\mu\text{s}$ $V_{DD} = 30\text{ V}$ $L = 200\ \mu\text{H}$ (see test circuit, Figure 4) | | 300 | | ns |
| Q_{rr} | Reverse recovery charge | | | 0.8 | | μC |
| I_{RRM} | Reverse recovery current | | | 5 | | A |
| Protection | | | | | | |
| I_{lim} | Drain current limit | $V_{IN} = 5\text{ V}$; $V_{DS} = 13\text{ V}$ | 12 | 18 | 24 | A |
| t_{dlim} | Step response current limit | $V_{IN} = 5\text{ V}$; $V_{DS} = 13\text{ V}$ | | 45 | | μs |
| T_{jsh} | Over temperature shutdown | | 150 | 175 | 200 | $^{\circ}\text{C}$ |
| T_{jrs} | Over temperature 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 $T_j = 25\text{ }^{\circ}\text{C}$; $V_{DD} = 24\text{ V}$ $V_{IN} = 5\text{ V}$; $R_{gen} = R_{IN\text{ MIN}} = 10\ \Omega$; $L = 24\text{ mH}$ (see Figure 5 and Figure 6) | 400 | | | mJ |

1. Pulsed: Pulse duration = 300 μs , duty cycle 1.5 %

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 μ A) flows into the input pin in order to supply the internal circuitry.

The device integrates:

- 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.
- 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 over temperature threshold T_{jsh} .
- Over temperature 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. Over temperature 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.
- Status feedback: in the case of an over temperature 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 0 V. 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_{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.

Figure 3. Switching time test circuit for resistive load

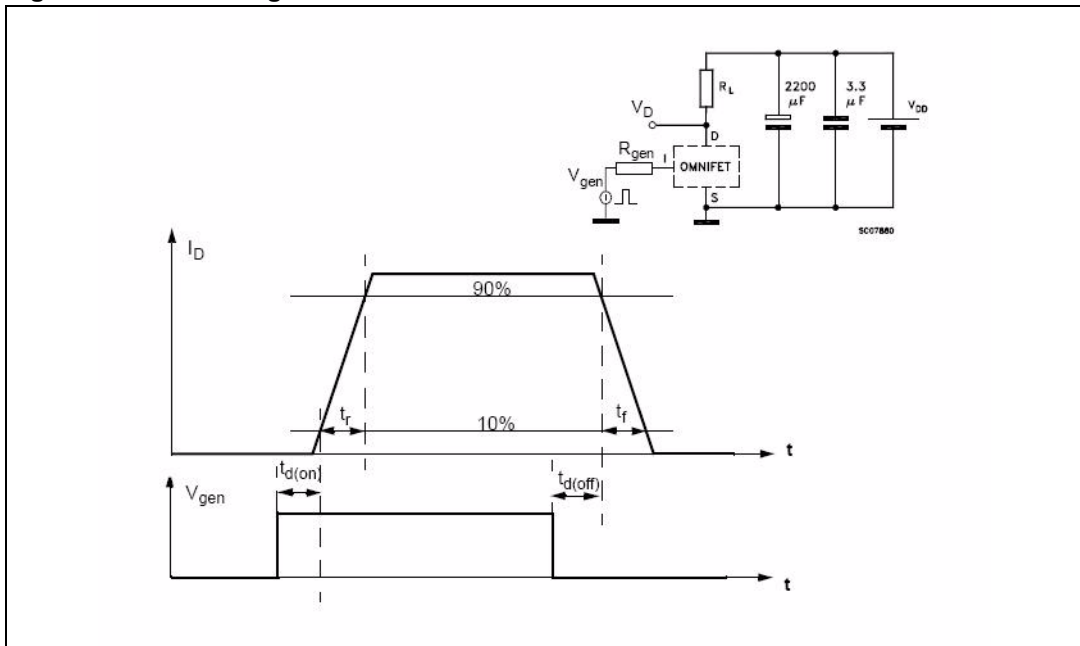


Figure 4. Test circuit for diode recovery times

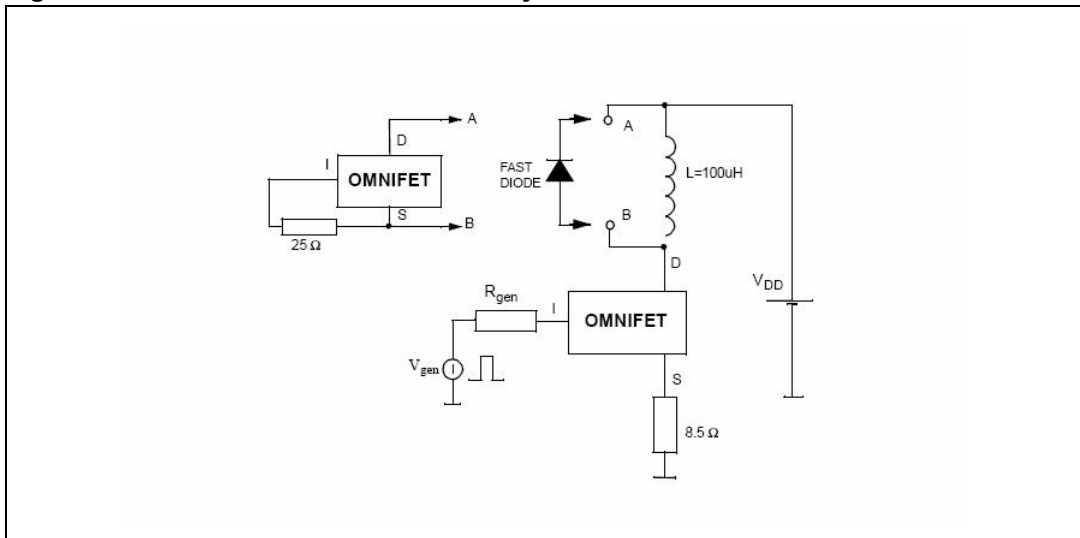


Figure 5. Unclamped inductive load test circuits

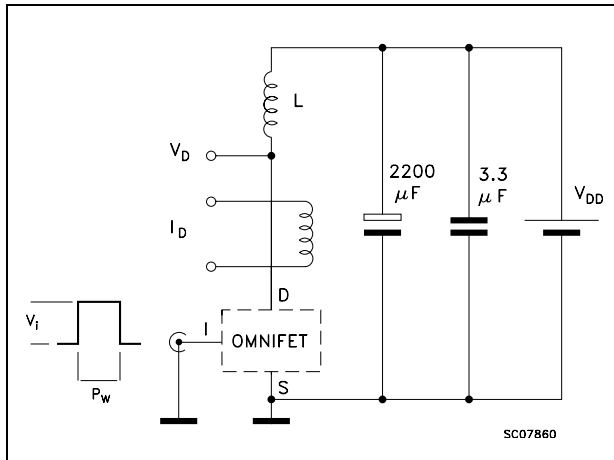


Figure 6. Unclamped inductive waveforms

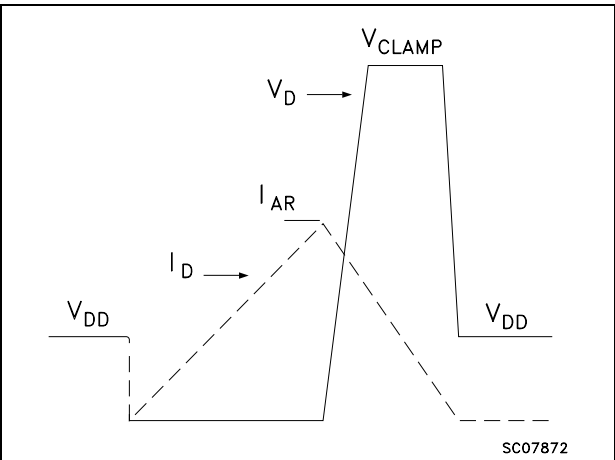


Figure 7. Input charge test circuit

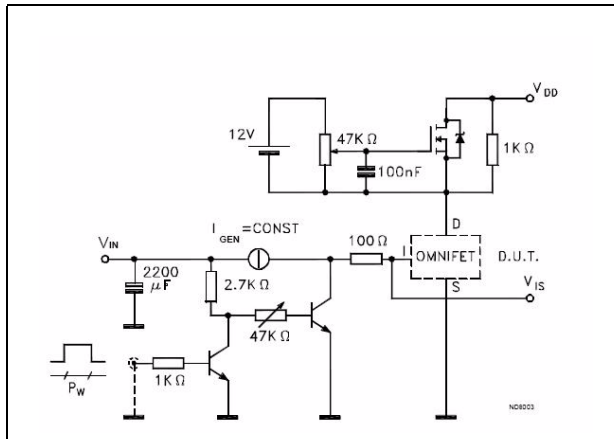


Figure 8. Source-drain diode forward characteristics

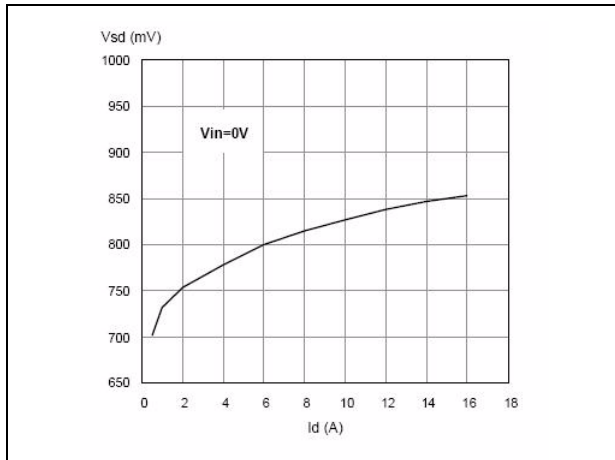


Figure 9. Static drain source on resistance

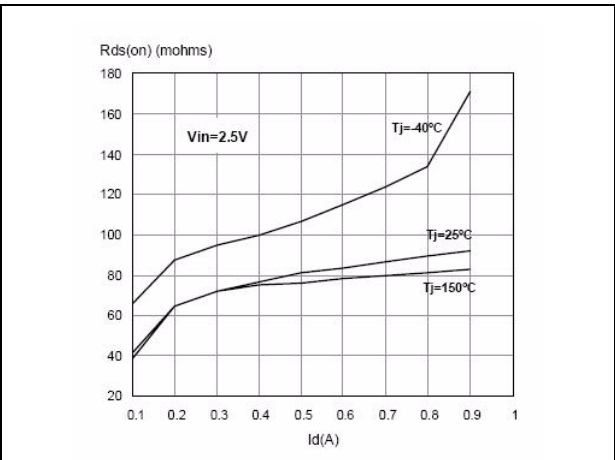


Figure 10. Derating curve

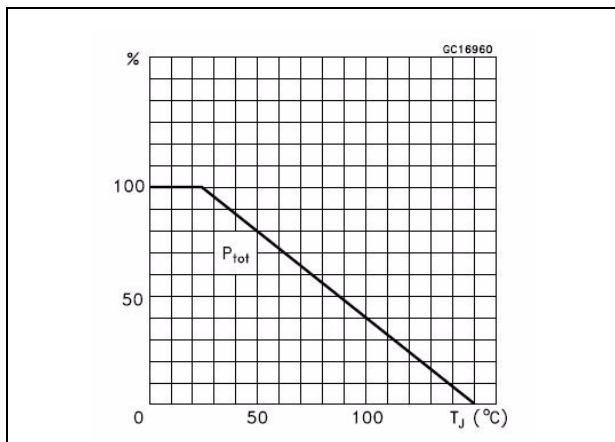


Figure 11. Static drain-source on resistance vs. input voltage (part 1/2)

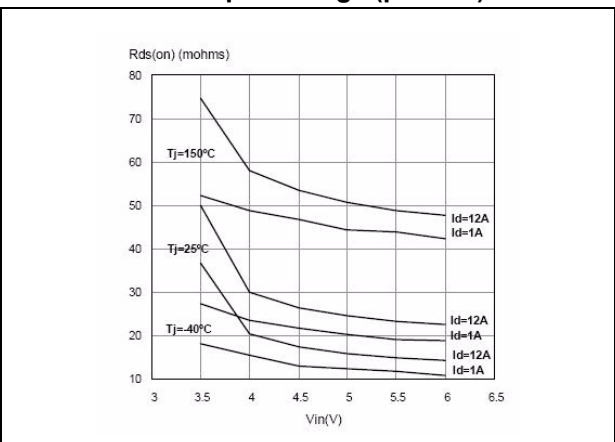


Figure 12. Static drain-source on resistance vs. input voltage (part 2/2)

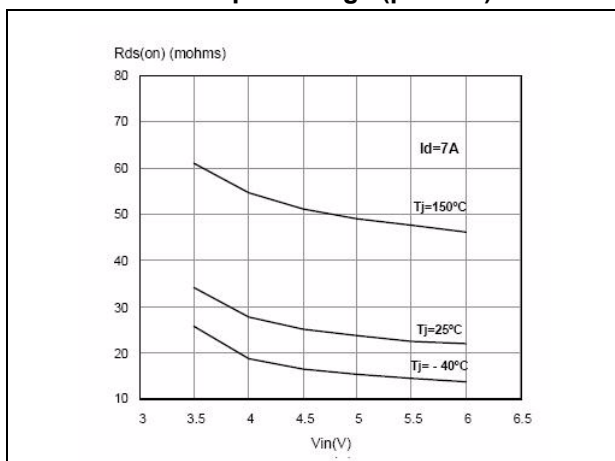


Figure 13. Transconductance

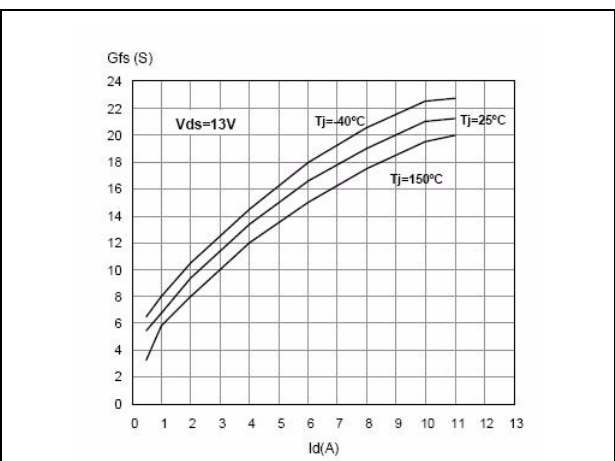


Figure 14. Static drain-source on resistance vs. id

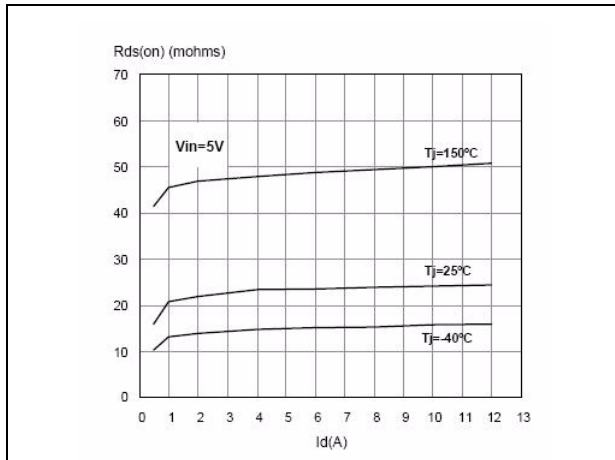


Figure 15. Transfer characteristics

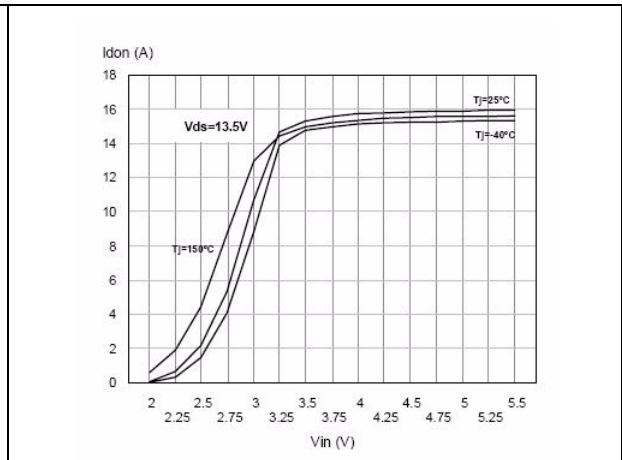


Figure 16. Turn-on current slope (part 1/2)

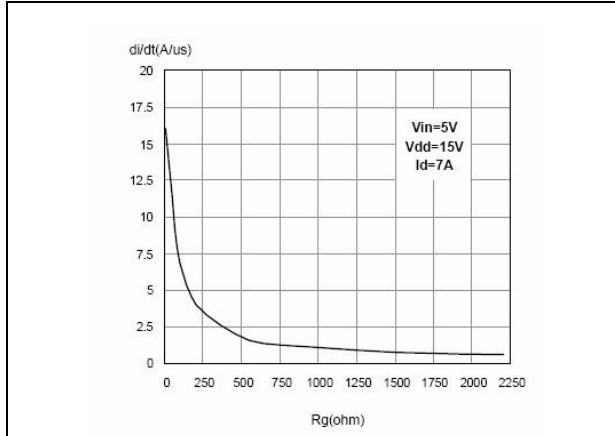


Figure 17. Turn-on current slope (part 2/2)

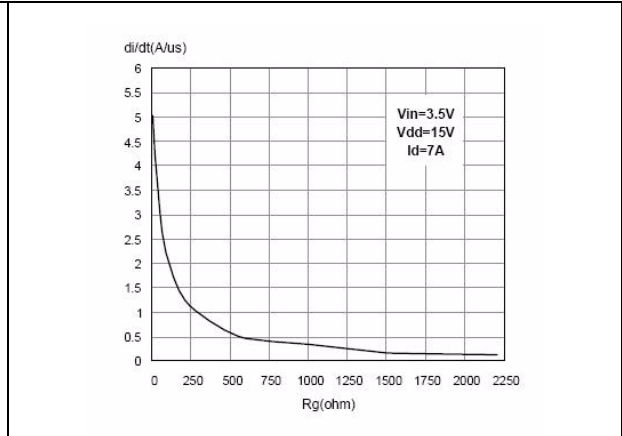


Figure 18. Input voltage vs. input charge

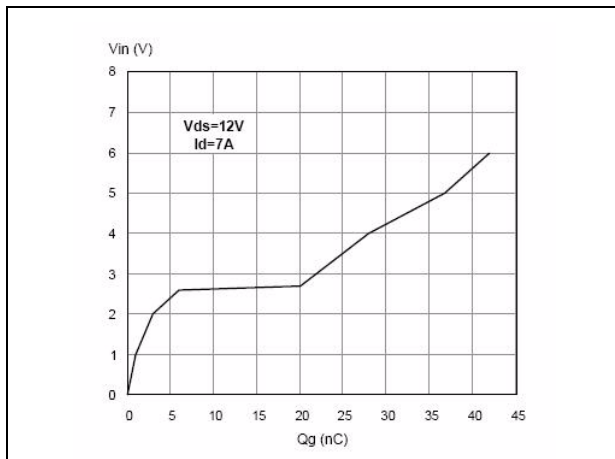


Figure 19. Turn-off drain source voltage slope (part 1/2)

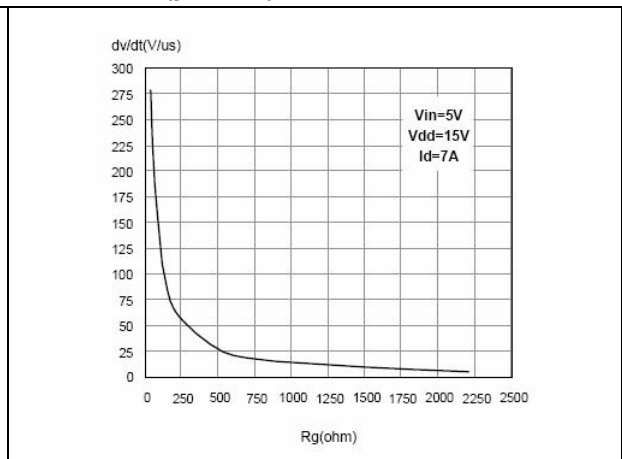


Figure 20. Turn-off drain source voltage slope Figure 21. Capacitance variations (part 2/2)

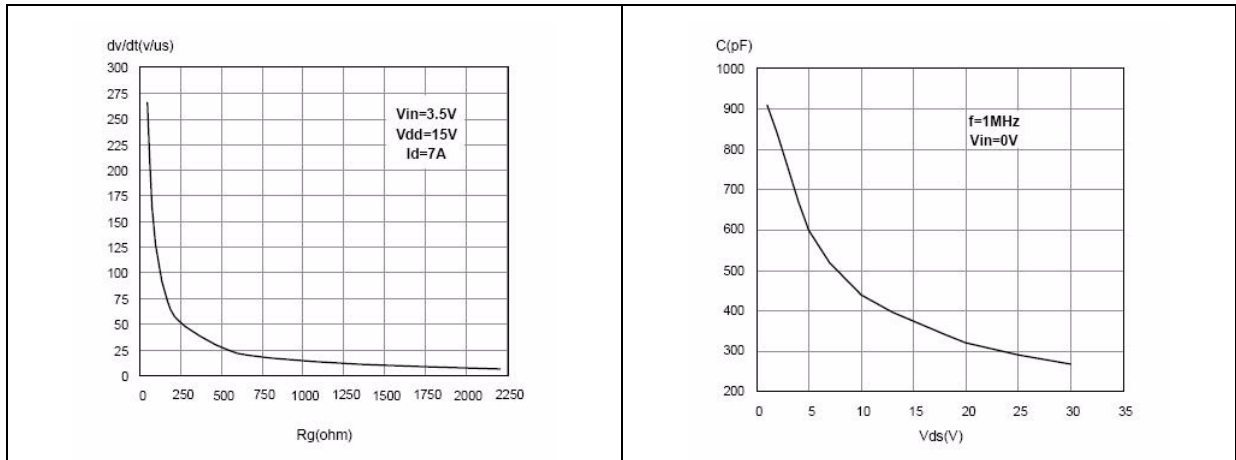


Figure 22. Switching time resistive load (part 1/2) Figure 23. Switching time resistive load (part 2/2)

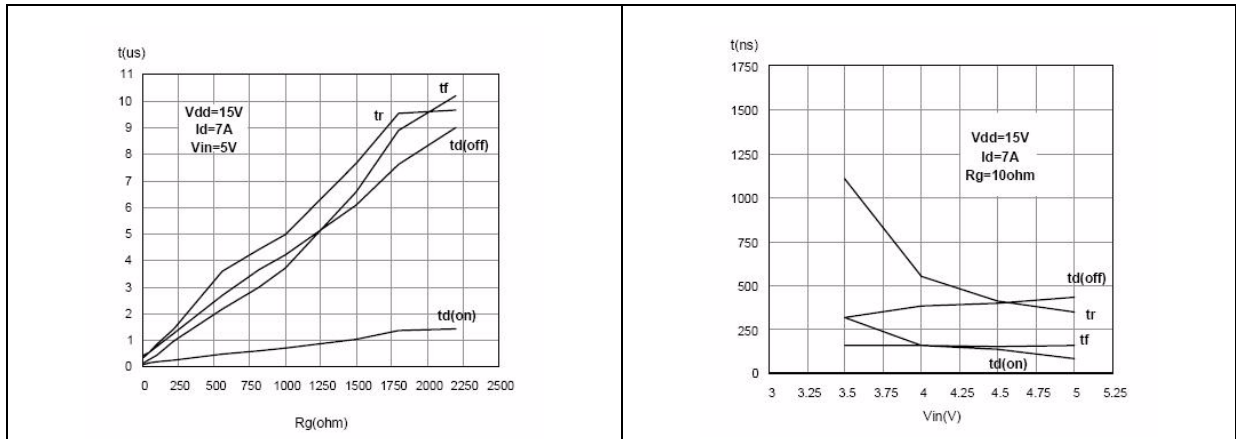


Figure 24. Output characteristics Figure 25. Normalized on resistance vs. temperature

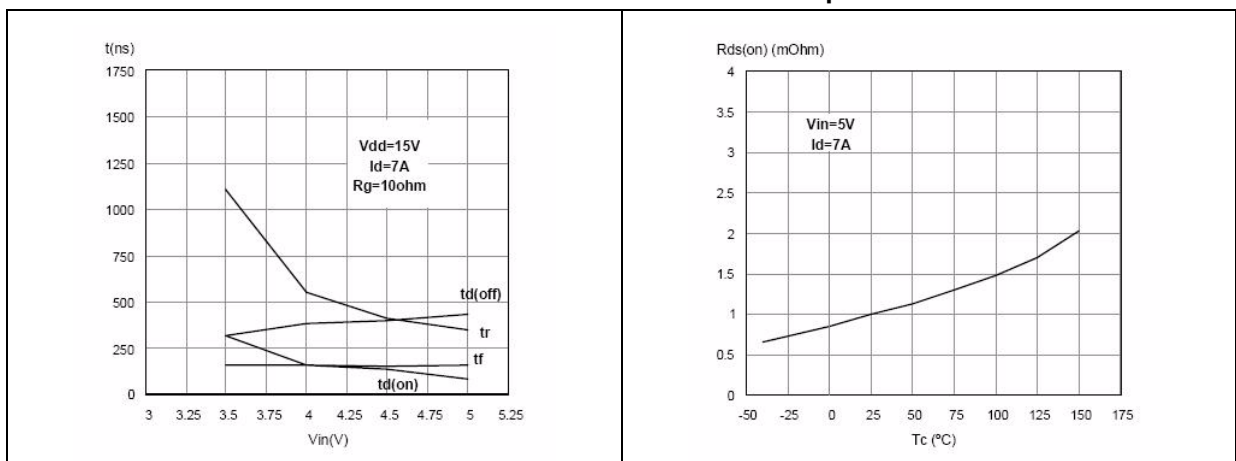


Figure 26. Normalized input threshold voltage vs. temperature **Figure 27. Current limit vs. junction temperatures**

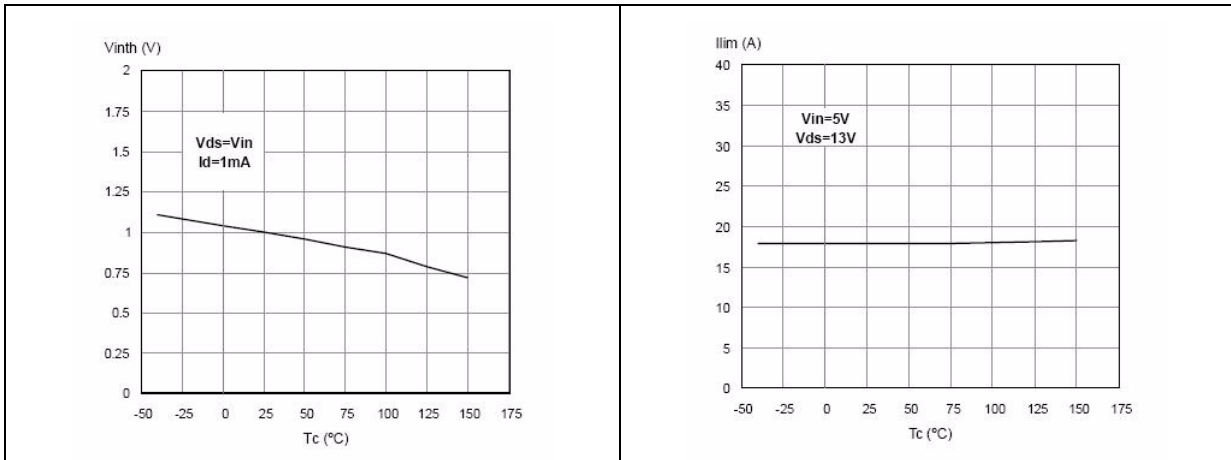


Figure 28. Step response current limit

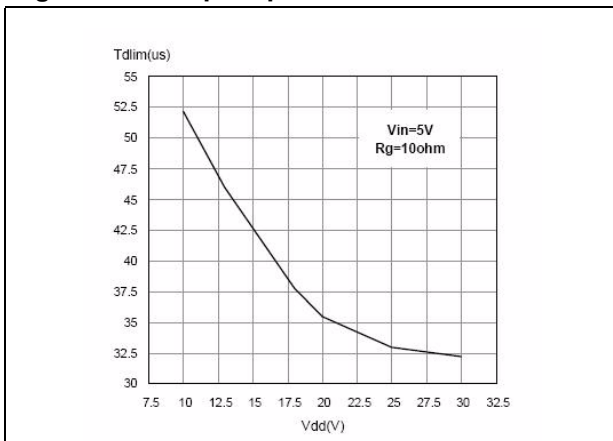
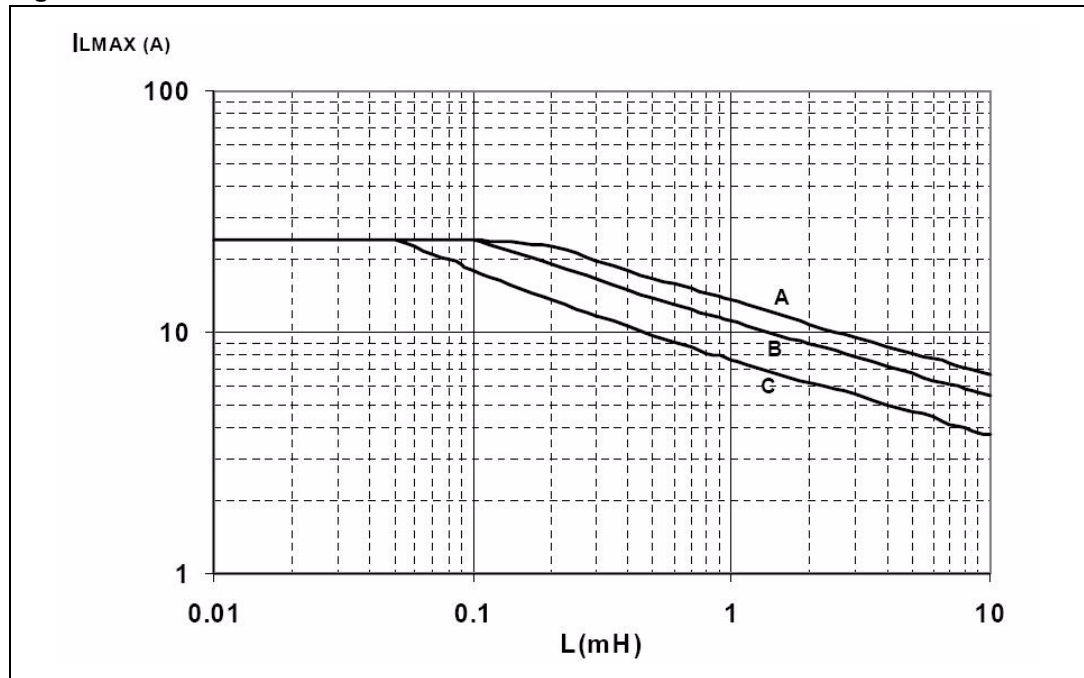


Figure 29. DPAK maximum turn-off current versus load inductance



Legend:

A= Single pulse at $T_{Jstart}=150^{\circ}C$

B= Repetitive pulse at $T_{Jstart}=100^{\circ}C$

C= Repetitive pulse at $T_{Jstart}=125^{\circ}C$

Conditions:

$V_{CC}=13.5\text{ V}$

Values are generated with $R_L=0\Omega$

In case of repetitive pulses, T_{Jstart} (at beginning of each demagnetization) of every pulse must not exceed the temperature specified above for curves B and C.

Figure 30. DPAK demagnetization

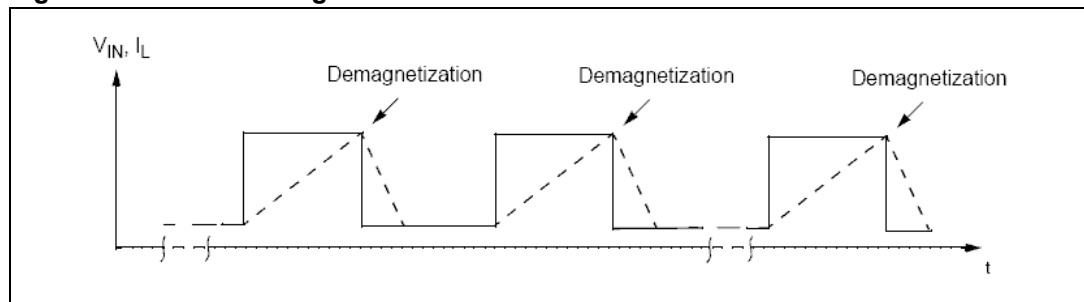
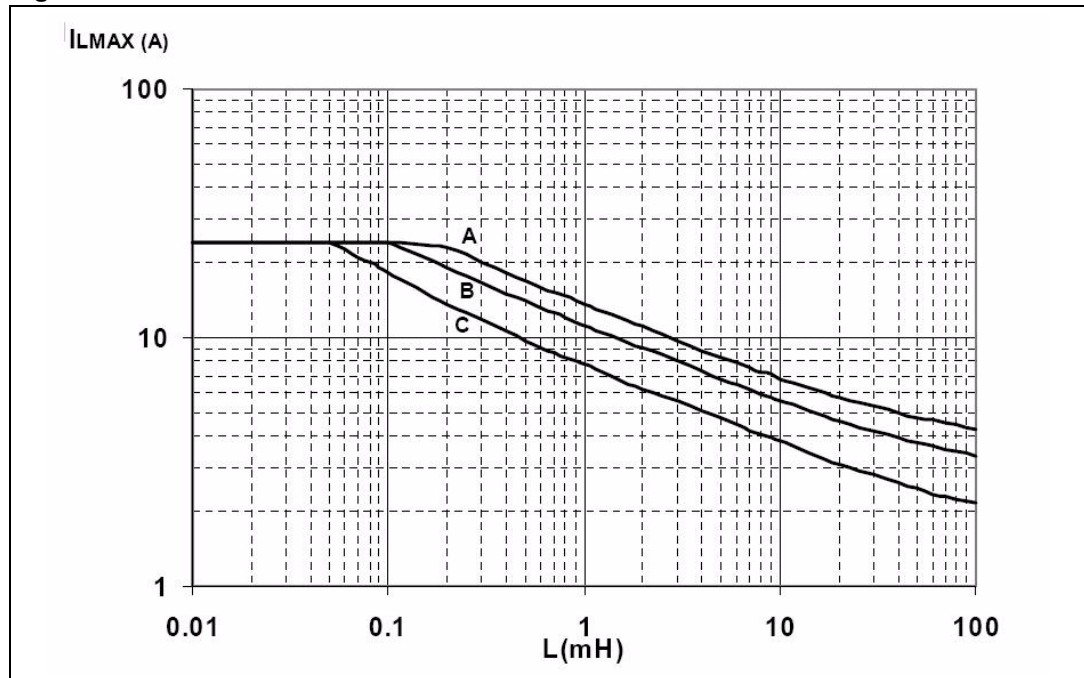


Figure 31. D²PAK maximum turn-off current versus load inductance



Legend:

A= Single pulse at $T_{Jstart}=150^{\circ}C$

B= Repetitive pulse at $T_{Jstart}=100^{\circ}C$

C= Repetitive pulse at $T_{Jstart}=125^{\circ}C$

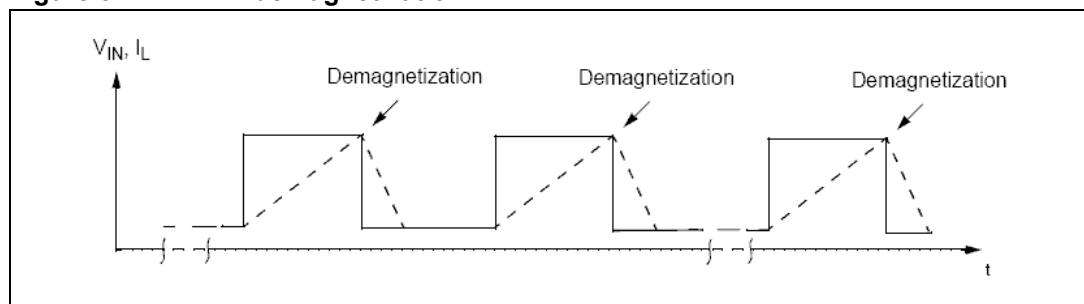
Conditions:

$V_{CC}=13.5\text{ V}$

Values are generated with $R_L=0\Omega$

In case of repetitive pulses, T_{jstart} (at beginning of each demagnetization) of every pulse must not exceed the temperature specified above for curves B and C.

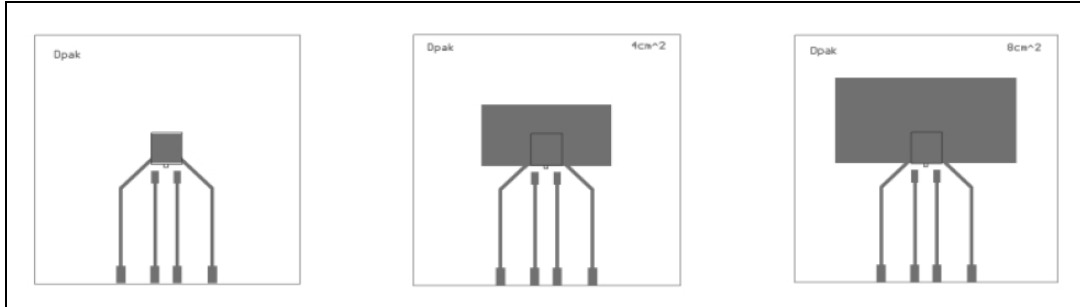
Figure 32. D²PAK demagnetization



4 Package thermal data

4.1 DPAK thermal data

Figure 33. DPAK PC board⁽¹⁾



1. Layout condition of R_{th} and Z_{th} measurements (PCB FR4 area = 60 mm x 60 mm, PCB thickness=2 mm, Cu thickness=35 μ m, Copper areas: from minimum pad lay-out to 8 cm²).

Figure 34. DPAK $R_{thj-amb}$ vs PCB copper area in open box free air condition

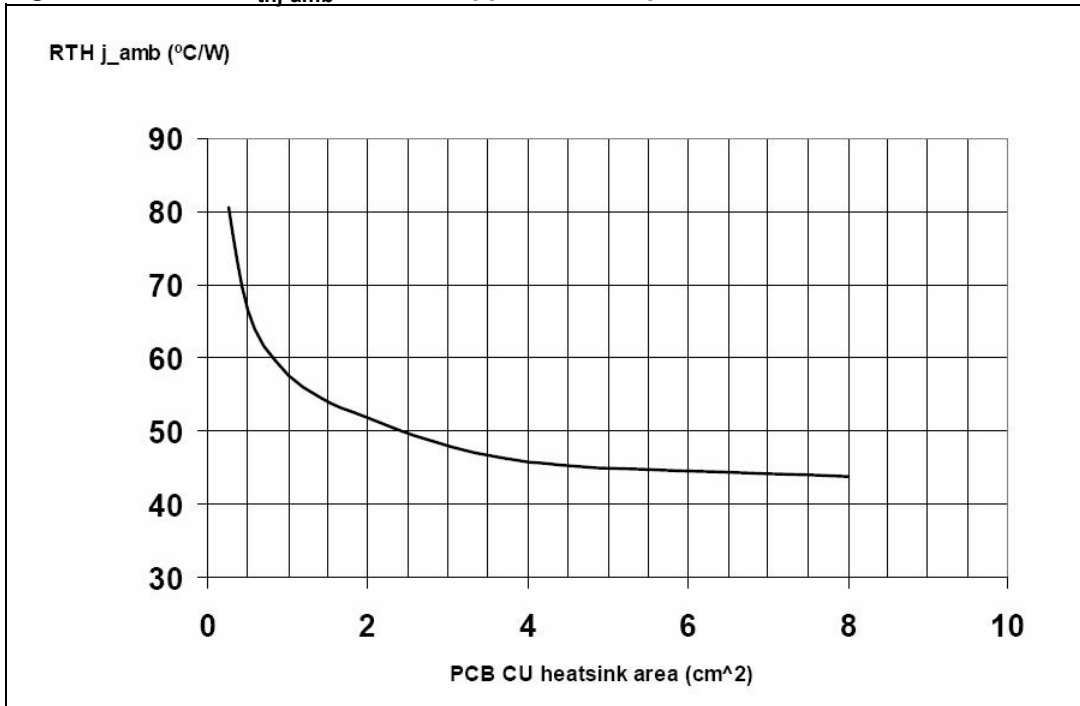


Figure 35. DPAK thermal impedance junction ambient single pulse

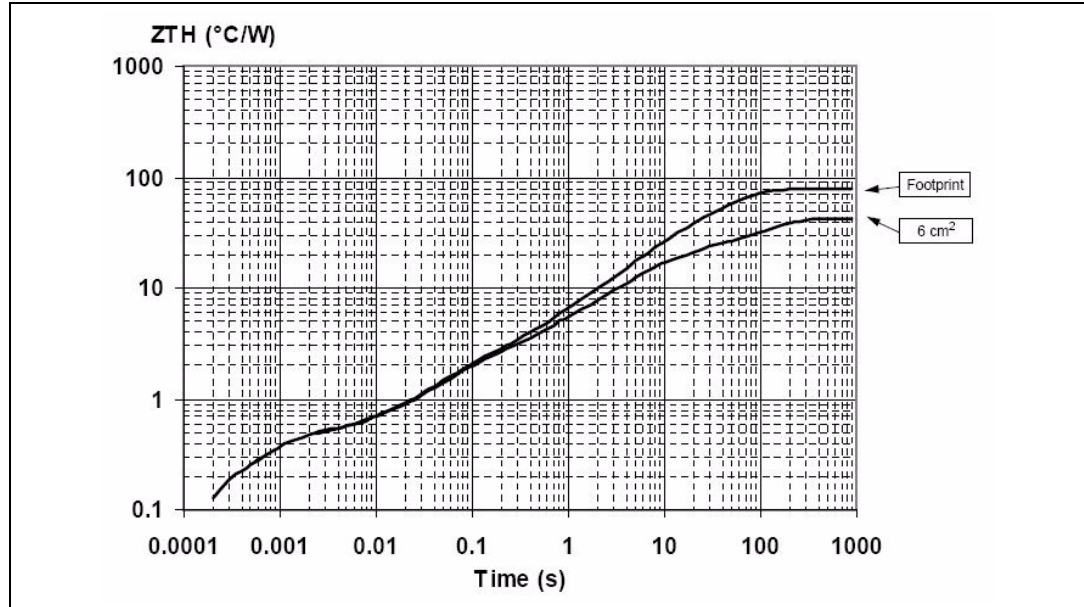
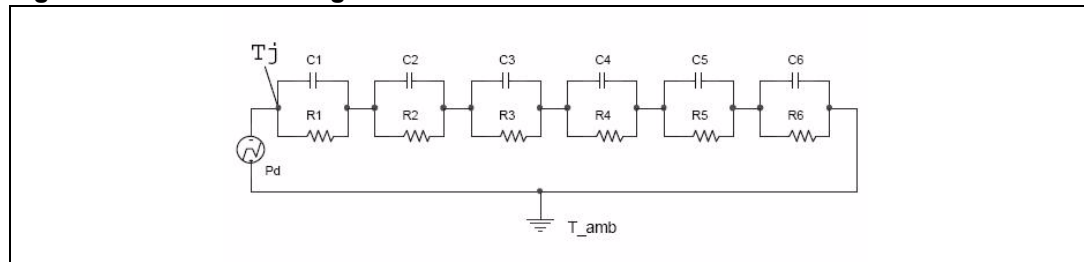


Figure 36. Thermal fitting model of an OMNIFET II in DPAK



Pulse calculation formula

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

where $\delta = t_p/T$

Table 5. DPAK thermal parameter

| Area/island(cm ²) | Footprint | 6 |
|-------------------------------|-----------|----|
| R1 (°C/W) | 0.1 | |
| R2 (°C/W) | 0.35 | |
| R3 (°C/W) | 1.20 | |
| R4 (°C/W) | 2 | |
| R5 (°C/W) | 15 | |
| R6 (°C/W) | 61 | 24 |
| C1 (W.s/°C) | 0.0006 | |
| C2 (W.s/°C) | 0.0021 | |
| C3 (W.s/°C) | 0.05 | |

Table 5. DPAK thermal parameter (continued)

| Area/island(cm ²) | Footprint | 6 |
|-------------------------------|-----------|---|
| C4 (W.s/°C) | 0.3 | |
| C5 (W.s/°C) | 0.45 | |
| C6 (W.s/°C) | 0.8 | 5 |

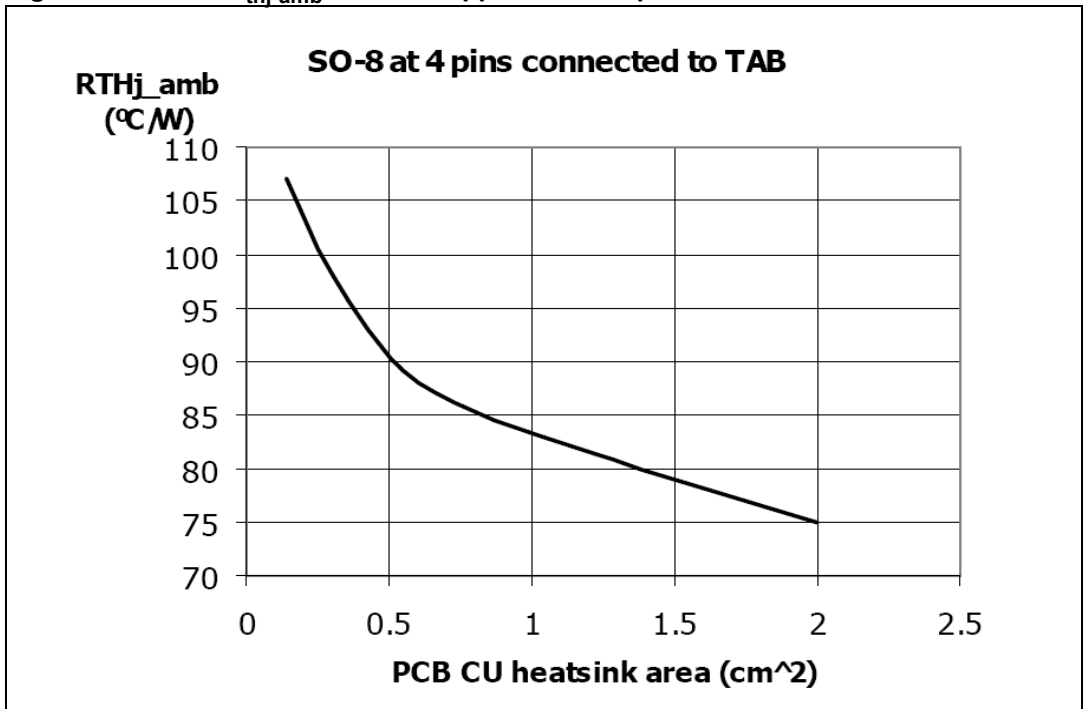
4.2 SO-8 thermal data

Figure 37. SO-8 PC board⁽¹⁾



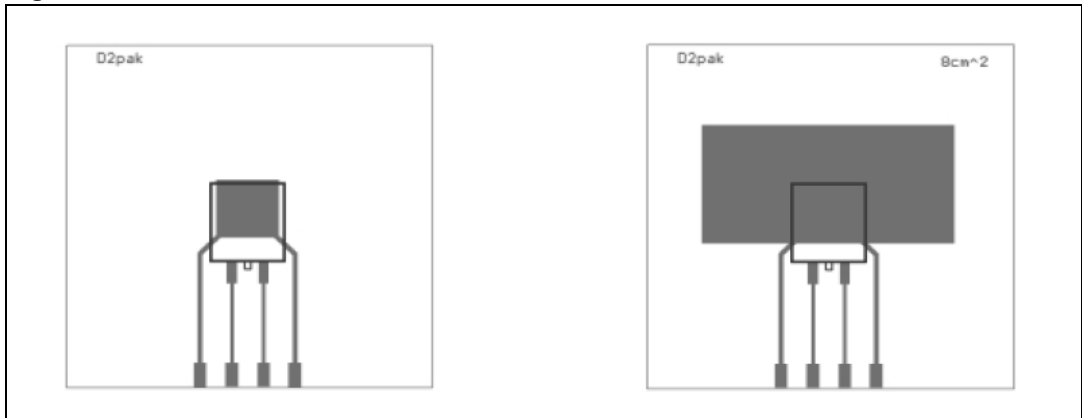
1. Layout condition of R_{th} and Z_{th} measurements (PCB FR4 area = 58 mm x 58 mm, PCB thickness=2 mm, Cu thickness=35 μm, Copper areas: 0.14 cm², 0.6 cm², 1.6 cm²).

Figure 38. SO-8 R_{thj-amb} vs PCB copper area in open box free air condition



4.3 D²PAK thermal data

Figure 39. D²PAK PC board⁽¹⁾



1. Layout condition of R_{th} and Z_{th} measurements (PCB FR4 area = 60 mm x 60 mm, PCB thickness=2 mm, Cu thickness=35 μ m, Copper areas: from minimum pad lay-out to 8 cm²).

Figure 40. D²PAK $R_{thj-amb}$ vs PCB copper area in open box free air condition

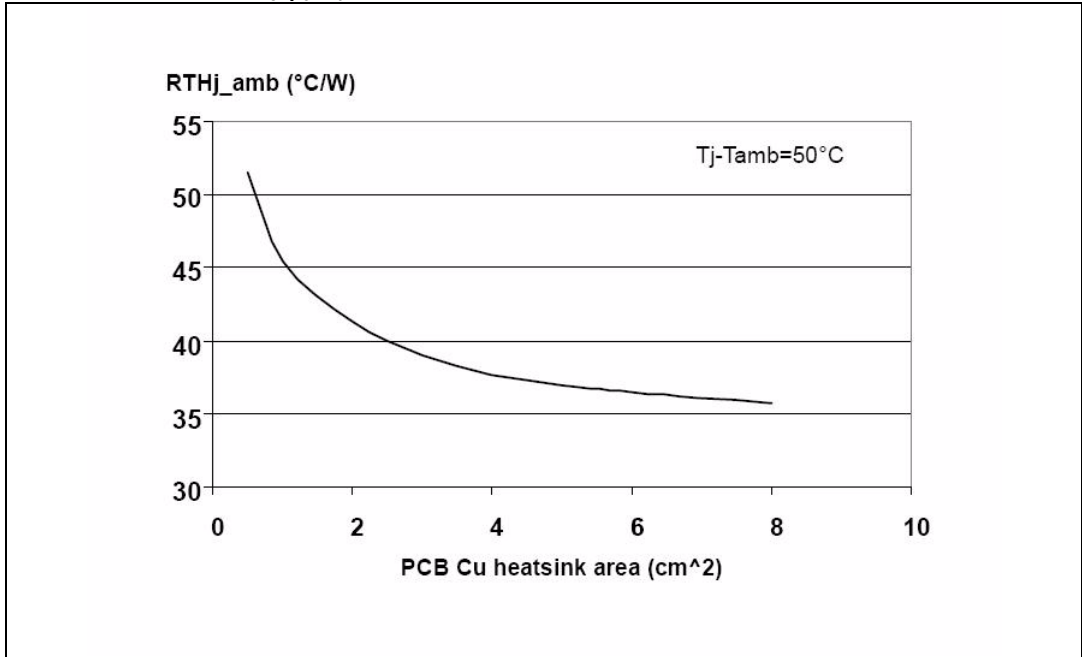


Figure 41. D²PAK thermal impedance junction ambient single pulse

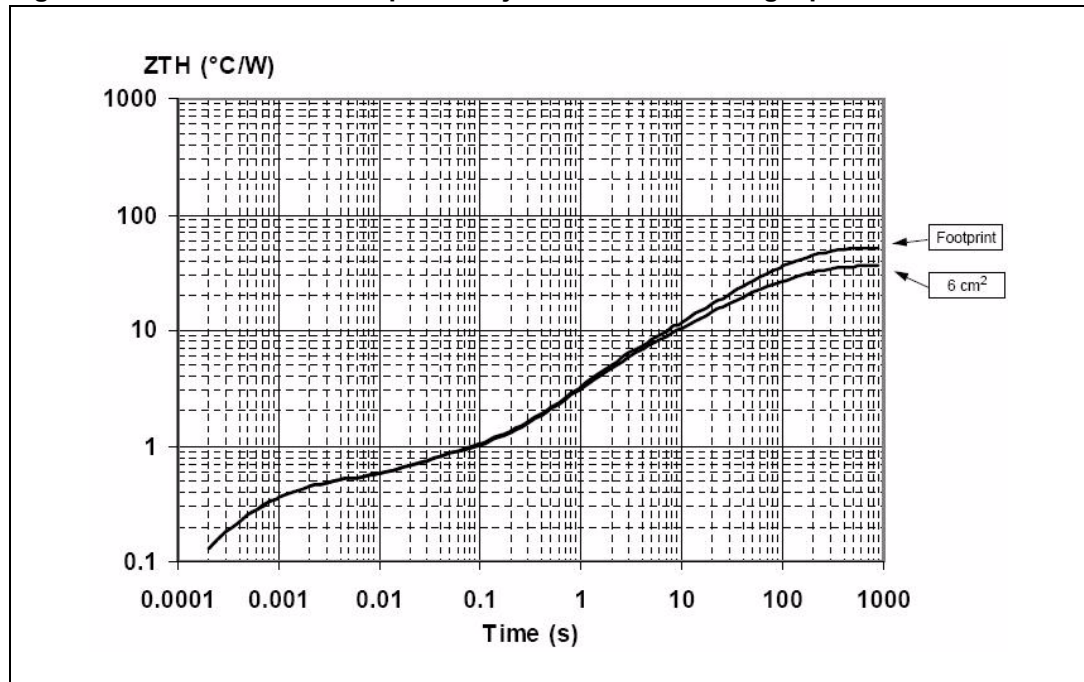
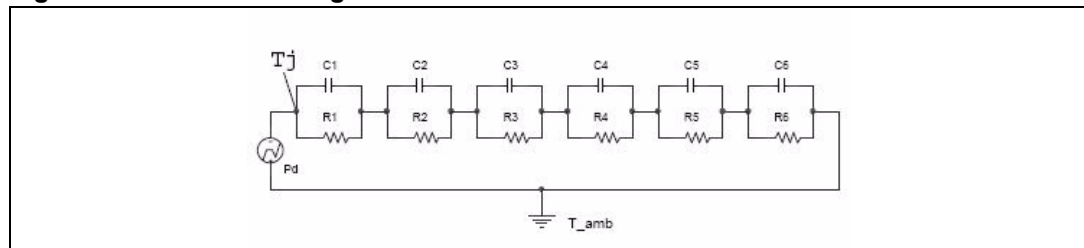


Figure 42. Thermal fitting model of an OMNIFET II in D²PAK



Pulse calculation formula

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

where $\delta = t_p/T$

Table 6. D²PAK thermal parameter

| Area/island(cm ²) | Footprint | 6 |
|-------------------------------|-----------|----|
| R1 (°C/W) | 0.1 | |
| R2 (°C/W) | 0.35 | |
| R3 (°C/W) | 0.3 | |
| R4 (°C/W) | 4 | |
| R5 (°C/W) | 9 | |
| R6 (°C/W) | 37 | 22 |
| C1 (W.s/°C) | 0.0006 | |
| C2 (W.s/°C) | 2.10E-03 | |

Table 6. D²PAK thermal parameter (continued)

| Area/island(cm ²) | Footprint | 6 |
|-------------------------------|-----------|---|
| C3 (W.s/°C) | 8.00E-02 | |
| C4 (W.s/°C) | 0.45 | |
| C5 (W.s/°C) | 2 | |
| C6 (W.s/°C) | 3 | 5 |

5 Package 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 TO-251 (IPAK) mechanical data

Figure 43. TO-251 (IPAK) package dimension

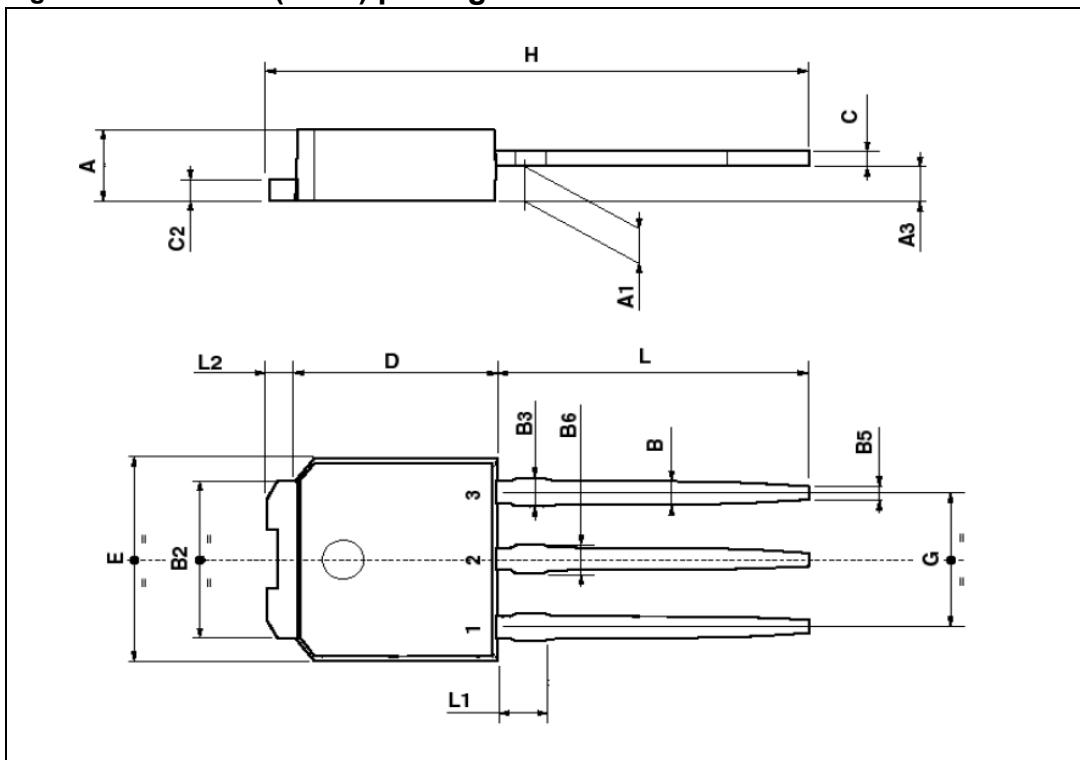


Table 7. TO-251 (IPAK) mechanical data

| Dim. | Millimeters | | |
|------|-------------|------|------|
| | Min. | Typ. | Max. |
| A | 2.2 | | 2.4 |
| A1 | 0.9 | | 1.1 |
| A3 | 0.7 | | 1.3 |
| B | 0.64 | | 0.9 |
| B2 | 5.2 | | 5.4 |

Table 7. TO-251 (IPAK) mechanical data (continued)

| Dim. | Millimeters | | |
|------|-------------|------|------|
| | Min. | Typ. | Max. |
| B3 | | | 0.85 |
| B5 | | 0.3 | |
| B6 | | | 0.95 |
| C | 0.45 | | 0.6 |
| C2 | 0.48 | | 0.6 |
| D | 6 | | 6.2 |
| E | 6.4 | | 6.6 |
| G | 4.4 | | 4.6 |
| H | 15.9 | | 16.3 |
| L | 9 | | 9.4 |
| L1 | 0.8 | | 1.2 |
| L2 | | 0.8 | 1 |

5.3 D²PAK mechanical data

Figure 44. D²PAK package dimension

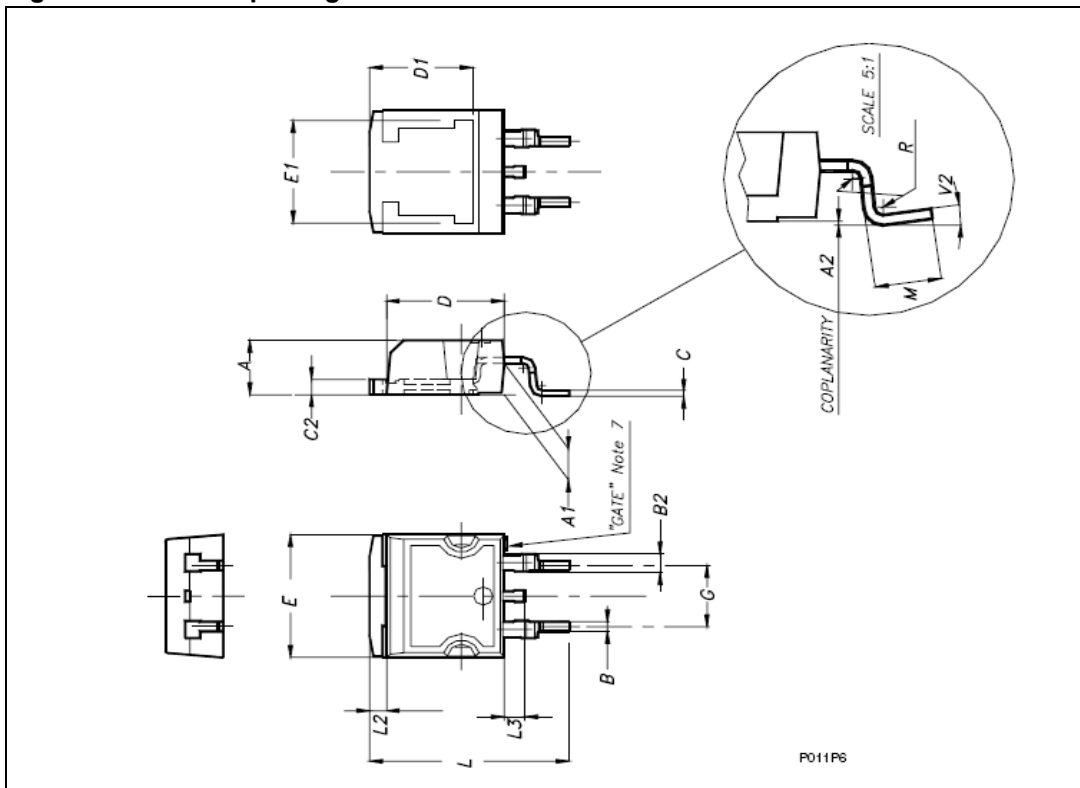


Table 8. D²PAK mechanical data

| Dim. | Millimeters | | |
|------|-------------|------|-------|
| | Min. | Typ. | Max. |
| A | 4.4 | | 4.6 |
| A1 | 2.49 | | 2.69 |
| A2 | 0.03 | | 0.23 |
| B | 0.7 | | 0.93 |
| B2 | 1.14 | | 1.7 |
| C | 0.45 | | 0.6 |
| C2 | 1.23 | | 1.36 |
| D | 8.95 | | 9.35 |
| D1 | | 8 | |
| E | 10 | | 10.4 |
| E1 | | 8.5 | |
| G | 4.88 | | 5.28 |
| L | 15 | | 15.85 |
| L2 | 1.27 | | 1.4 |
| L3 | 1.4 | | 1.75 |
| M | 2.4 | | 3.2 |
| R | | 0.4 | |
| V2 | 0° | | 8° |

5.4 TO-252 (DPAK) mechanical data

Figure 45. TO-252 (DPAK) package dimension

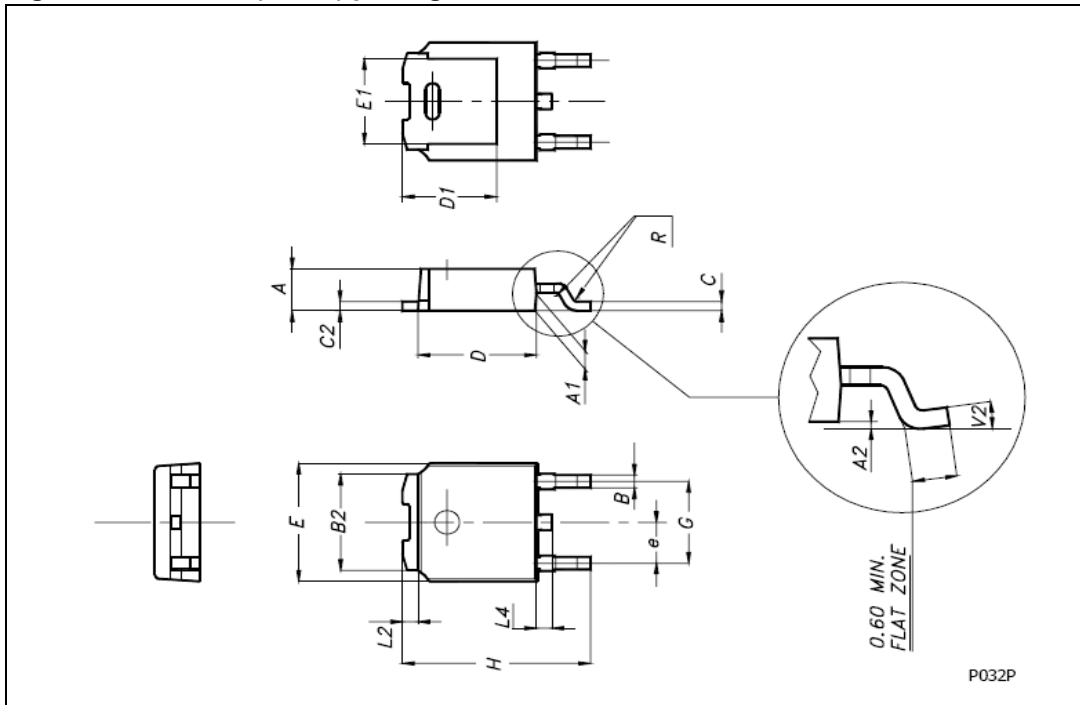


Table 9. TO-252 (DPAK) mechanical data

| Dim. | Millimeters | | |
|------|-------------|------|------|
| | Min. | Typ. | Max. |
| A | 2.20 | | 2.40 |
| A1 | 0.90 | | 1.10 |
| A2 | 0.03 | | 0.23 |
| B | 0.64 | | 0.90 |
| B2 | 5.20 | | 5.40 |
| C | 0.45 | | 0.6 |
| C2 | 0.48 | | 0.6 |
| D | 6 | | 6.20 |
| D1 | | 5.1 | |
| E | 6.4 | | 6.6 |
| E1 | | 4.7 | |
| e | | 2.28 | |
| G | 4.4 | | 4.6 |
| H | 9.35 | | 10.1 |
| L2 | | 0.8 | |

Table 9. TO-252 (DPAK) mechanical data (continued)

| Dim. | Millimeters | | |
|----------------|-------------|------|------|
| | Min. | Typ. | Max. |
| L4 | 0.6 | | 1 |
| R | | 0.2 | |
| V2 | 0° | 8° | |
| Package weight | Gr. 0.29 | | |

5.5 SO-8 mechanical data

Figure 46. SO-8 package dimension

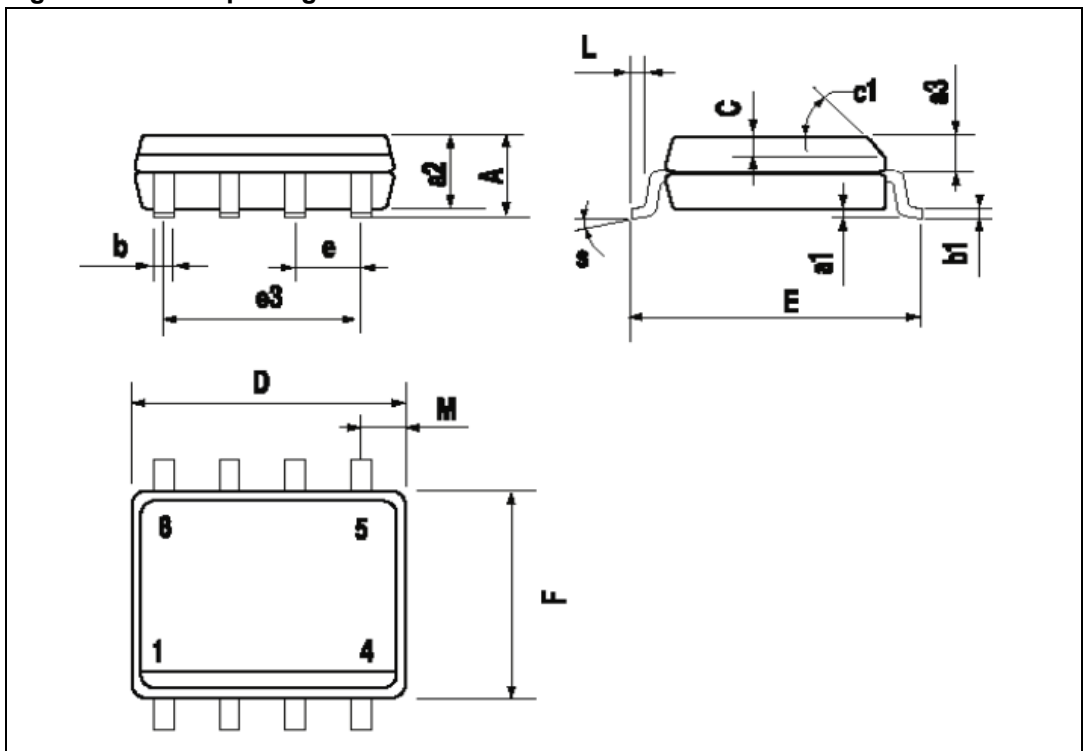


Table 10. SO-8 mechanical data

| Dim. | Millimeters | | |
|------|-------------|------|------|
| | Min. | Typ. | Max. |
| A | 1.75 | | 2.40 |
| a1 | 0.25 | | 0.1 |
| a2 | 1.65 | | |
| b | 0.85 | | 0.35 |
| b1 | 0.25 | | 0.19 |

Table 10. SO-8 mechanical data (continued)

| Dim. | Millimeters | | |
|------|-------------|------|------|
| | Min. | Typ. | Max. |
| C | 0.5 | | 0.25 |
| c1 | | 45 | |
| D | 5 | | 4.8 |
| E | 6.2 | | 5.8 |
| e | | 1.27 | |
| e3 | | 3.81 | |
| F | 4 | | 3.8 |
| L | 1.27 | | 0.4 |
| M | 0.6 | | |
| F | | | 8 |

6 Revision history

Table 11. Document revision history

| Date | Revision | Changes |
|-------------|----------|--|
| 21-Jun-2004 | 6 | Initial release. |
| 03-Apr-2009 | 7 | Document reformatted. Added Table 1: Device summary on page 1 . Updated Section 5: Package information on page 24 |
| 06-Apr-2010 | 8 | Added part number VNS14NV04. Added SO-8 package: – Updated Table 1: Device summary – Updated Table 2: Absolute maximum rating – Updated Table 3: Thermal data – Updated Chapter 4: Package thermal data – Updated Chapter 5: Package information |

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Тел: +7 (812) 336 43 04 (многоканальный)

Email: org@lifeelectronics.ru