



# VNB35NV04 VNV35NV04

## OMNIFET II fully autoprotected Power MOSFET

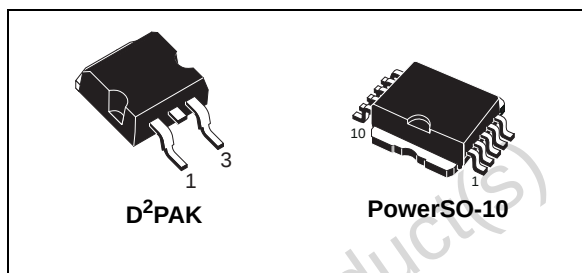
Datasheet — production data

### Features

| Type                   | $R_{DS(on)}$                 | $I_{lim}$ | $V_{clamp}$ |
|------------------------|------------------------------|-----------|-------------|
| VNB35NV04<br>VNV35NV04 | 10 m $\Omega$ <sup>(1)</sup> | 30 A      | 40 V        |

1. For PowerSO-10 only

- Linear current limitation
- Thermal shut down
- 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 VNB35NV04 and VNV35NV04 are monolithic devices designed in STMicroelectronics® VIPower® M0-3 Technology, intended for replacement of standard Power MOSFETs from DC up to 25 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    | Order codes |               |
|------------|-------------|---------------|
|            | Tube        | Tape and reel |
| D²PAK      | VNB35NV04   | VNB35NV0413TR |
| PowerSO-10 | VNV35NV04   | VNV35NV0413TR |

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# 1 Block diagram and pin connection

Figure 1. Block diagram

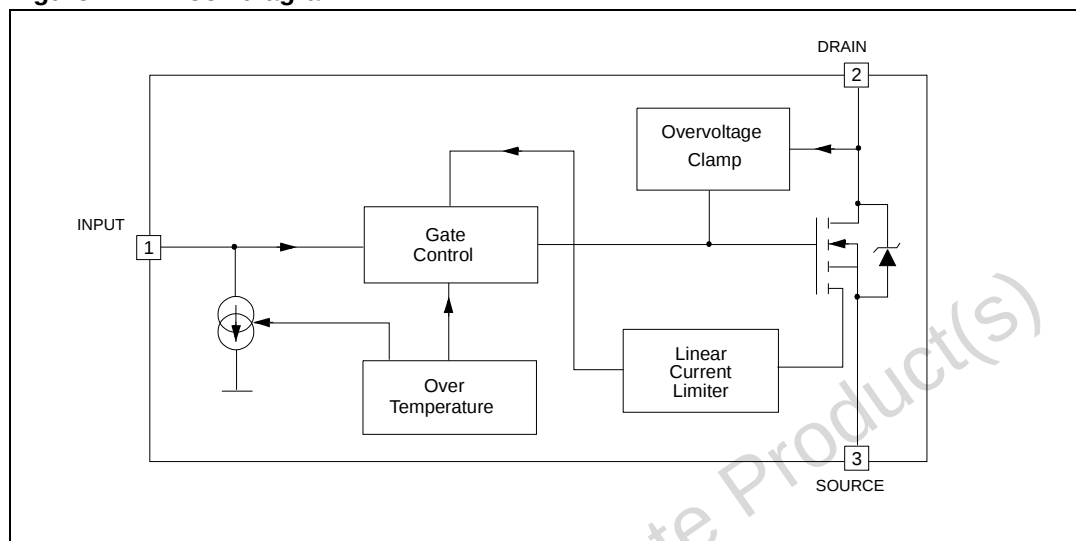
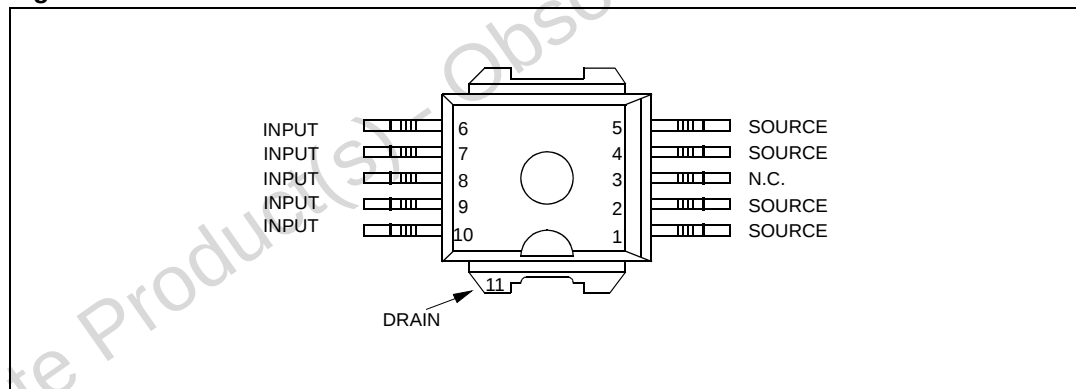


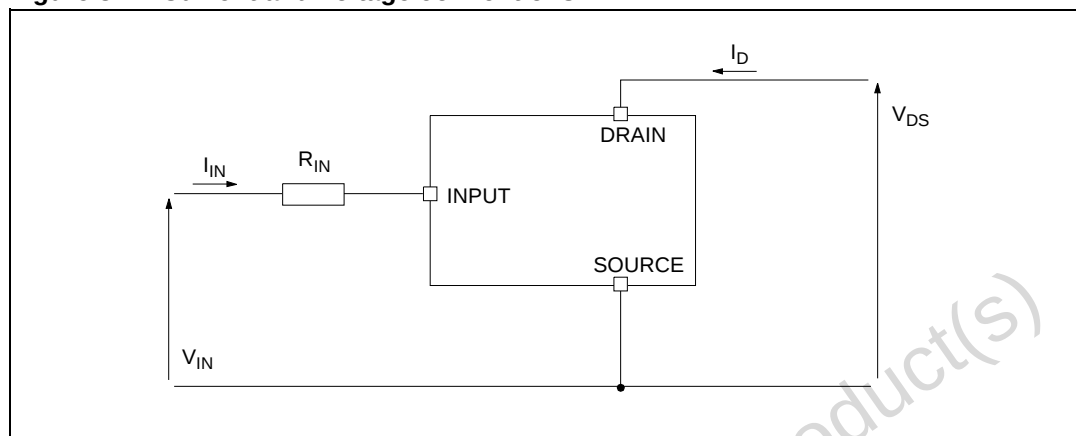
Figure 2. Pin connection



1. For the pins configuration related to D<sup>2</sup>PAK, see [Figure 1](#).

## 2 Electrical specification

Figure 3. Current and voltage conventions



### 2.1 Absolute maximum ratings

Stressing the device above the rating listed in [Table 2](#) 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 the conditions in table below for extended periods may affect device reliability

Table 2. Absolute maximum ratings

| Symbol        | Parameter                                                                       | Value              |                    | Unit             |
|---------------|---------------------------------------------------------------------------------|--------------------|--------------------|------------------|
|               |                                                                                 | PowerSO-10         | D <sup>2</sup> 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                                                  | 4.7                |                    | $\Omega$         |
| $I_D$         | Drain current                                                                   | Internally limited |                    | A                |
| $I_R$         | Reverse DC output current                                                       | -30                |                    | A                |
| $V_{ESD1}$    | Electrostatic discharge ( $R = 1.5$ K $\Omega$ , $C = 100$ pF)                  | 4000               |                    | V                |
| $V_{ESD2}$    | Electrostatic discharge on output pin only ( $R = 330$ $\Omega$ , $C = 150$ pF) | 16500              |                    | V                |
| $P_{tot}$     | Total dissipation at $T_c = 25^\circ\text{C}$                                   | 125                | 125                | 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                                 | Value             |                    | Unit |
|----------------|-------------------------------------------|-------------------|--------------------|------|
|                |                                           | PowerSO-10        | D <sup>2</sup> PAK |      |
| $R_{thj-case}$ | Thermal resistance junction-case (max)    | 1                 | 1                  | °C/W |
| $R_{thj-amb}$  | Thermal resistance junction-ambient (max) | 50 <sup>(1)</sup> | 50 <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 mm thick) connected to all DRAIN pins.

## 2.3 Electrical characteristics

-40°C < T<sub>j</sub> < 150°C, unless otherwise specified.

**Table 4. Off**

| Symbol             | Parameter                                                | Test conditions                                                          | Min  | Typ | Max  | Unit |
|--------------------|----------------------------------------------------------|--------------------------------------------------------------------------|------|-----|------|------|
| V <sub>CLAMP</sub> | Drain-source clamp voltage                               | V <sub>IN</sub> = 0 V; I <sub>D</sub> = 15 A                             | 40   | 45  | 55   | V    |
| V <sub>CLTH</sub>  | Drain-source clamp threshold voltage                     | V <sub>IN</sub> = 0 V; I <sub>D</sub> = 2 mA                             | 36   |     |      | V    |
| V <sub>INTH</sub>  | Input threshold voltage                                  | V <sub>DS</sub> = V <sub>IN</sub> ; I <sub>D</sub> = 1 mA                | 0.5  |     | 2.5  | V    |
| I <sub>ISS</sub>   | Supply current from input pin                            | V <sub>DS</sub> = 0 V; V <sub>IN</sub> = 5 V                             |      | 100 | 150  | μA   |
| V <sub>INCL</sub>  | Input-source clamp voltage                               | I <sub>IN</sub> = 1 mA                                                   | 6    | 6.8 | 8    | V    |
|                    |                                                          | I <sub>IN</sub> = -1 mA                                                  | -1.0 |     | -0.3 | V    |
| I <sub>DSS</sub>   | Zero input voltage drain current (V <sub>IN</sub> = 0 V) | V <sub>DS</sub> = 13 V; V <sub>IN</sub> = 0 V;<br>T <sub>j</sub> = 25 °C |      |     | 30   | μA   |
|                    |                                                          | V <sub>DS</sub> = 25 V; V <sub>IN</sub> = 0 V                            |      |     | 75   | μA   |

T<sub>j</sub> = 25°C, unless otherwise specified

**Table 5. Dynamic**

| Symbol                         | Parameter                | Test conditions                                          | Min | Typ  | Max | Unit |
|--------------------------------|--------------------------|----------------------------------------------------------|-----|------|-----|------|
| g <sub>fs</sub> <sup>(1)</sup> | Forward transconductance | V <sub>DD</sub> = 13 V; I <sub>D</sub> = 15 A            | —   | 35   | —   | S    |
| C <sub>OSS</sub>               | Output capacitance       | V <sub>DS</sub> = 13 V; f = 1 MHz; V <sub>IN</sub> = 0 V | —   | 1300 | —   | pF   |

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

**Table 6. Switching**

| Symbol         | Parameter             | Test conditions                                                                                                                                      | Min | Typ | Max  | Unit             |
|----------------|-----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|------|------------------|
| $t_{d(on)}$    | Turn-on delay time    | $V_{DD} = 15\text{ V}; I_D = 15\text{ A};$<br>$V_{gen} = 5\text{ V};$<br>$R_{gen} = R_{IN\text{ MIN}} = 4.7\ \Omega$ (see <a href="#">Figure 3</a> ) | —   | 150 | 500  | ns               |
| $t_r$          | Rise time             |                                                                                                                                                      | —   | 840 | 2500 | ns               |
| $t_{d(off)}$   | Turn-off delay time   |                                                                                                                                                      | —   | 980 | 3000 | ns               |
| $t_f$          | Fall time             |                                                                                                                                                      | —   | 600 | 1500 | ns               |
| $t_{d(on)}$    | Turn-on delay time    | $V_{DD} = 15\text{ V}; I_D = 15\text{ A};$<br>$V_{gen} = 5\text{ V}; R_{gen} = 2.2\text{ K}\Omega$ (see <a href="#">Figure 3</a> )                   | —   | 4   | 12   | $\mu\text{s}$    |
| $t_r$          | Rise time             |                                                                                                                                                      | —   | 27  | 100  | $\mu\text{s}$    |
| $t_{d(off)}$   | Turn-off delay time   |                                                                                                                                                      | —   | 34  | 120  | $\mu\text{s}$    |
| $t_f$          | Fall time             |                                                                                                                                                      | —   | 31  | 110  | $\mu\text{s}$    |
| $(di/dt)_{on}$ | Turn-on current slope | $V_{DD} = 15\text{ V}; I_D = 15\text{ A}; V_{gen} = 5\text{ V};$<br>$R_{gen} = R_{IN\text{ MIN}} = 4.7\ \Omega$                                      | —   | 18  |      | A/ $\mu\text{s}$ |
| $Q_i$          | Total input charge    | $V_{DD} = 12\text{ V}; I_D = 15\text{ A}; V_{IN} = 5\text{ V};$<br>$I_{gen} = 2.13\text{ mA}$ (see <a href="#">Figure 8</a> )                        | —   | 118 |      | nC               |

**Table 7. Source drain diode**

| Symbol         | Parameter                | Test Conditions                                                                                                                           | Min | Typ | Max | Unit          |
|----------------|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|-----|---------------|
| $V_{SD}^{(1)}$ | Forward on voltage       | $I_{SD} = 15\text{ A}; V_{IN} = 0\text{ V}$                                                                                               | —   | 0.8 | —   | V             |
| $t_{rr}$       | Reverse recovery time    | $I_{SD} = 15\text{ A}; di/dt = 100\text{ A}/\mu\text{s};$<br>$V_{DD} = 30\text{ V}; L = 200\ \mu\text{H}$ (see <a href="#">Figure 4</a> ) | —   | 400 | —   | ns            |
| $Q_{rr}$       | Reverse recovery charge  |                                                                                                                                           | —   | 1.4 | —   | $\mu\text{C}$ |
| $I_{RRM}$      | Reverse recovery current |                                                                                                                                           | —   | 7   | —   | A             |

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

**Table 8. Protections ( $-40^\circ\text{C} < T_j < 150^\circ\text{C}$ , unless otherwise specified)**

| Symbol     | Parameter                     | Test Conditions                                                                                                                                                                                                       | Min | Typ | Max | Unit             |
|------------|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|-----|------------------|
| $I_{lim}$  | Drain current limit           | $V_{IN} = 6\text{ V}; V_{DS} = 13\text{ V}$                                                                                                                                                                           | 30  | 45  | 60  | A                |
| $t_{dlim}$ | Step response current limit   | $V_{IN} = 6\text{ V}; V_{DS} = 13\text{ V}$                                                                                                                                                                           |     | 50  |     | $\mu\text{s}$    |
| $T_{jsh}$  | 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 $T_j = 25^\circ\text{C}; V_{DD} = 24\text{ V};$<br>$V_{IN} = 5\text{ V};$<br>$R_{gen} = R_{IN\text{ MIN}} = 4.7\ \Omega;$<br>$L = 24\text{ mH}$ (see <a href="#">Figure 6</a> and <a href="#">Figure 7</a> ) | 1.7 |     |     | J                |

## 2.4 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 25 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 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 is. 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  $T_{jsh}$ .
- **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°C 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 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 does 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 4. Switching time test circuit for resistive load

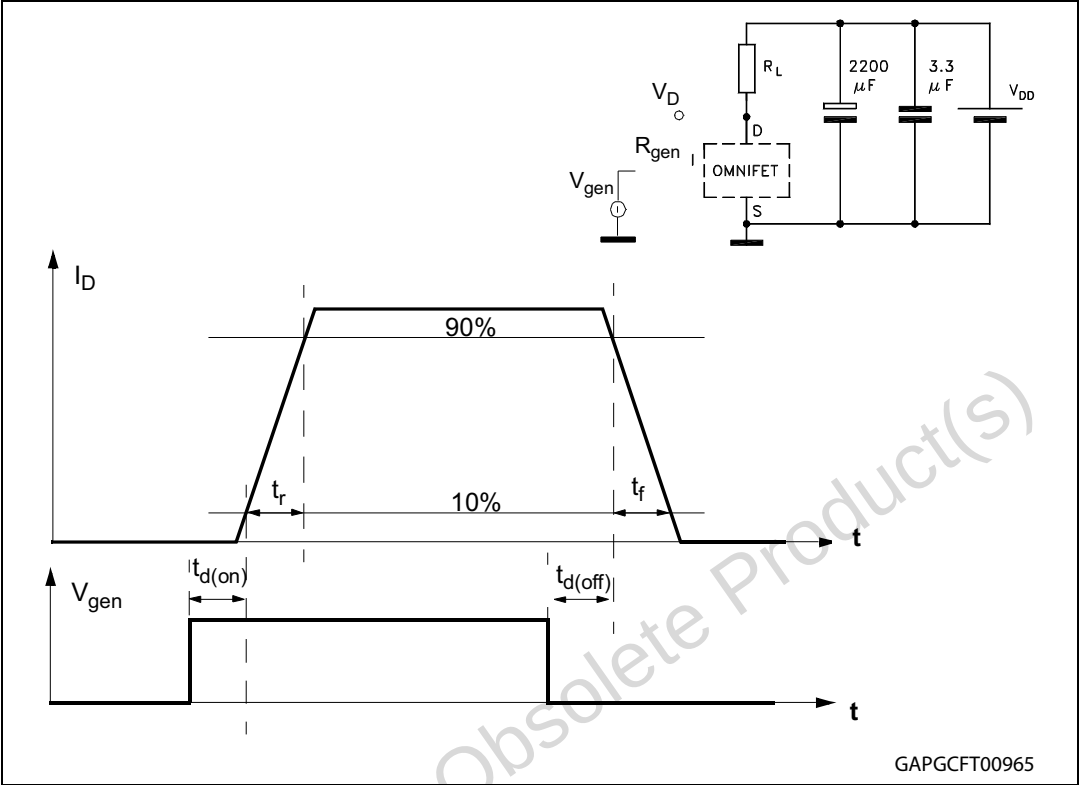


Figure 5. Test circuit for diode recovery times

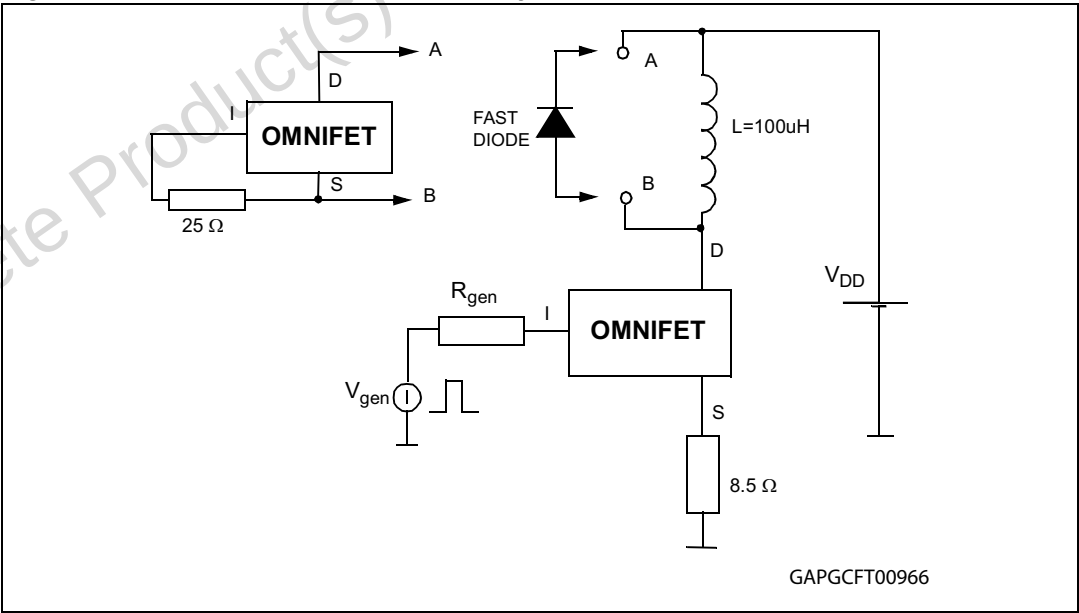


Figure 6. Unclamped inductive load test circuits

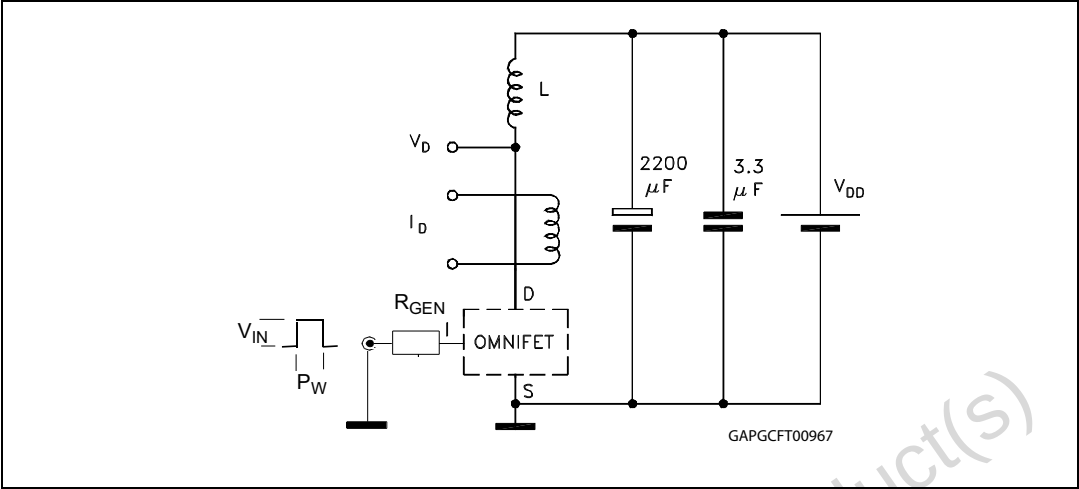


Figure 7. Unclamped inductive waveforms

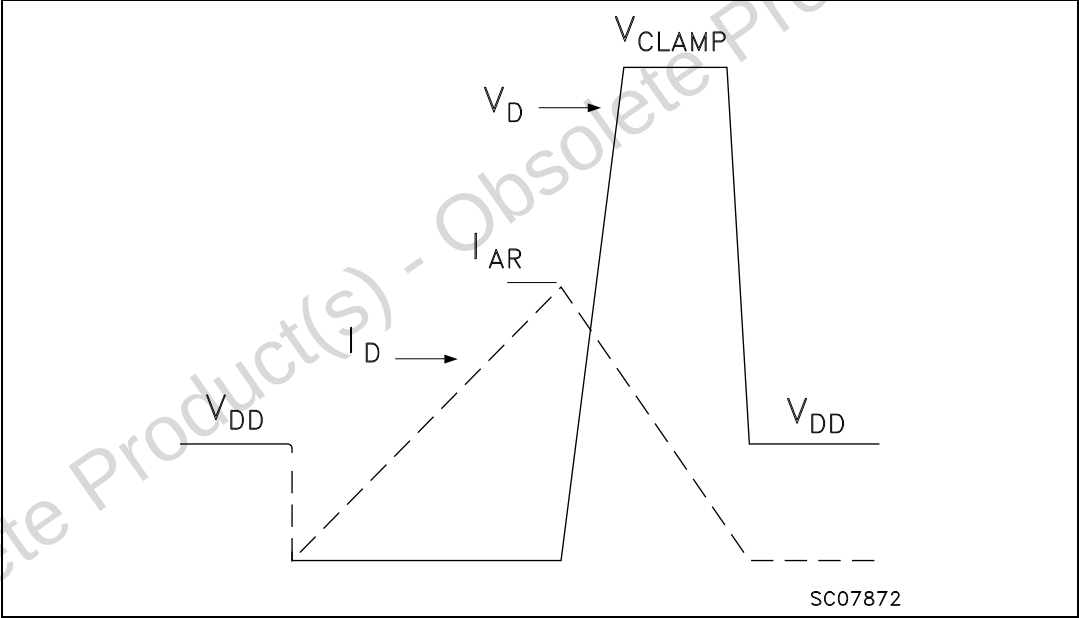
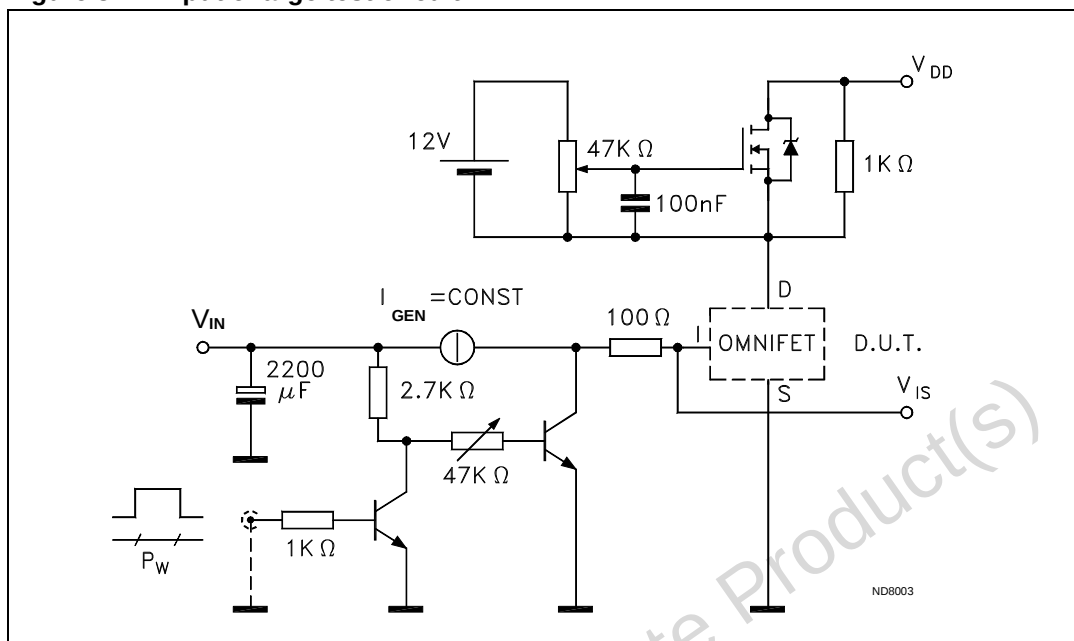
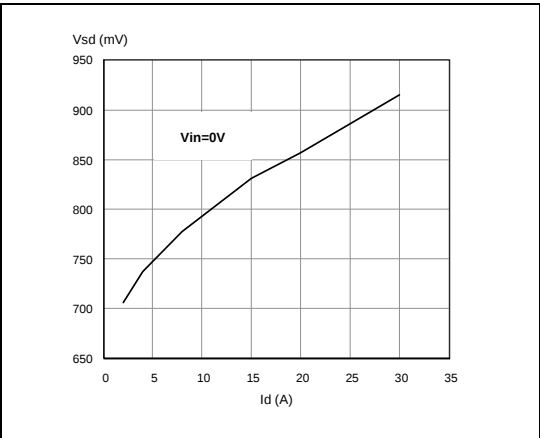


Figure 8. Input charge test circuit

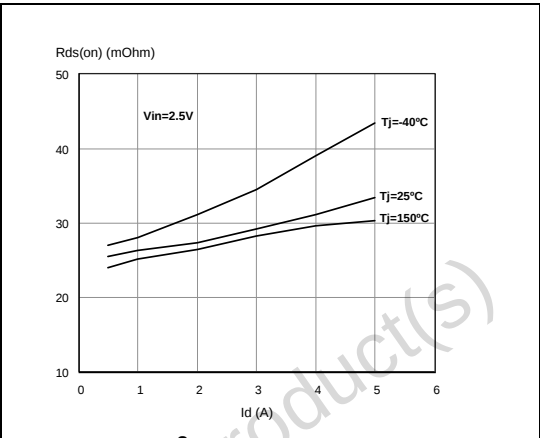


## 2.5 Electrical characteristics curves

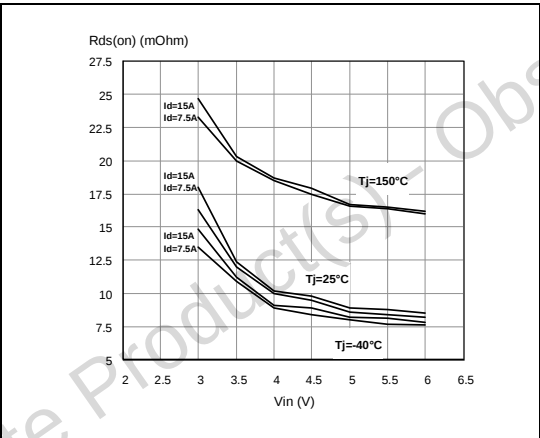
**Figure 9. Source-drain diode forward characteristics**



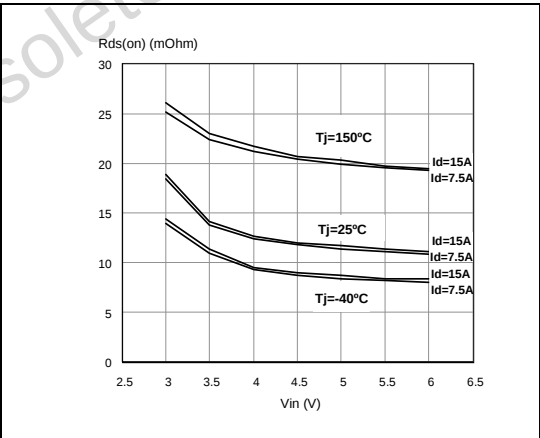
**Figure 10. Static drain source on resistance**



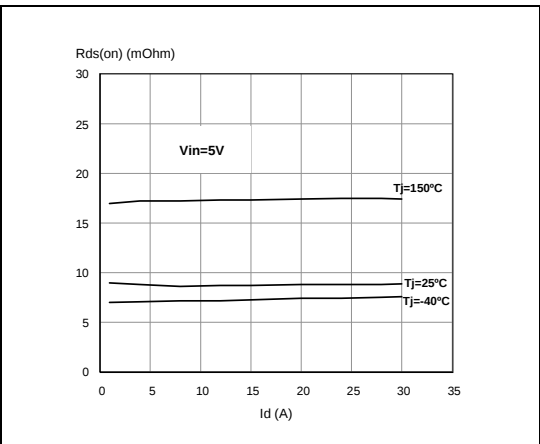
**Figure 11. PowerSO-10 static drain-source on resistance vs. input voltage**



**Figure 12. D<sup>2</sup>PAK static drain-source on resistance vs. input voltage**



**Figure 13. PowerSO-10 static drain-source on resistance vs. id**



**Figure 14. D<sup>2</sup>PAK static drain-source on resistance vs. id**

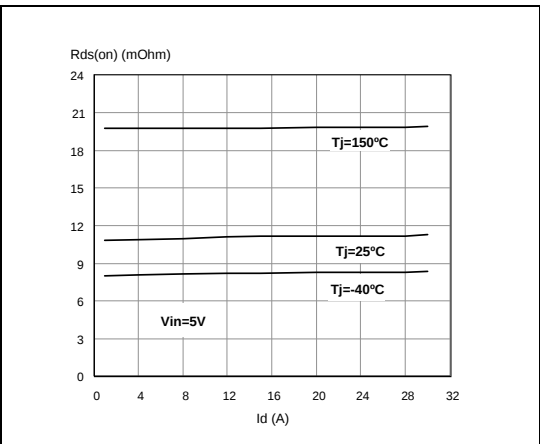


Figure 15. Transconductance

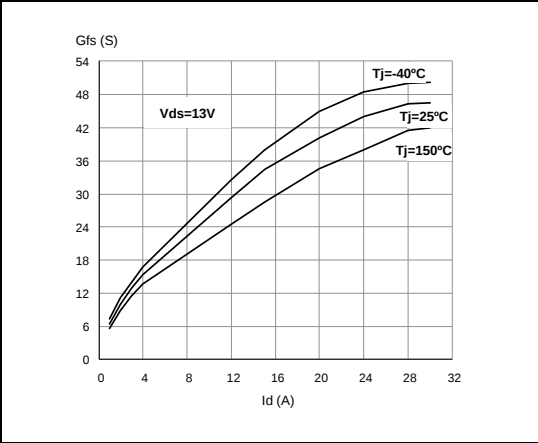


Figure 16. Transfer characteristics

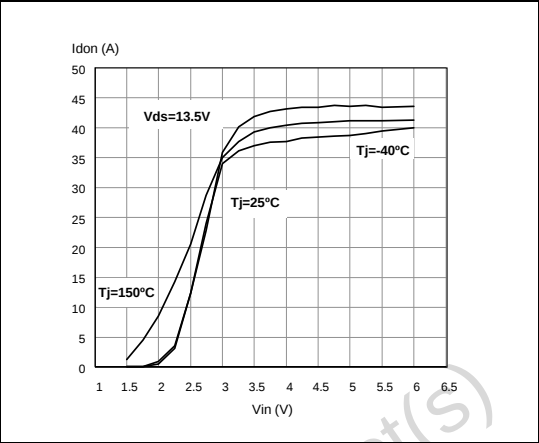


Figure 17. Output characteristics

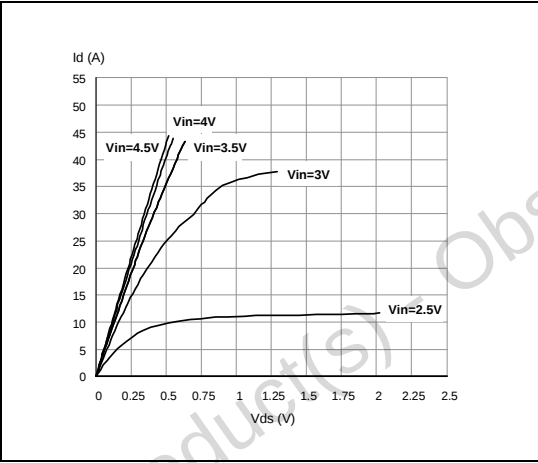


Figure 18. Normalized on resistance vs. temperature

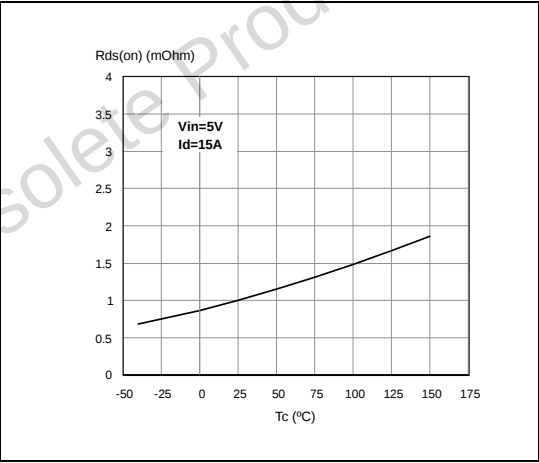


Figure 19. Turn-on current slope,  $V_{IN} = 5 V$

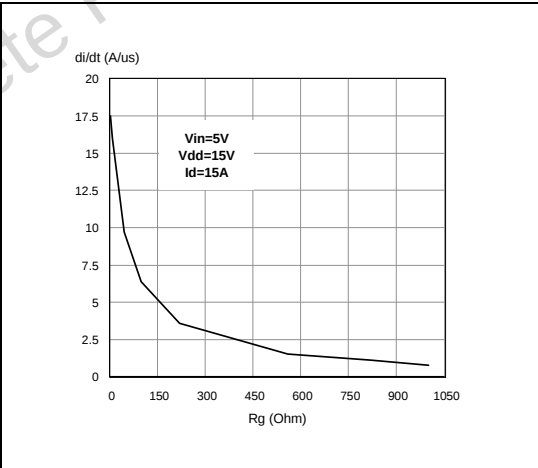


Figure 20. Turn-on current slope,  $V_{IN} = 3.5 V$

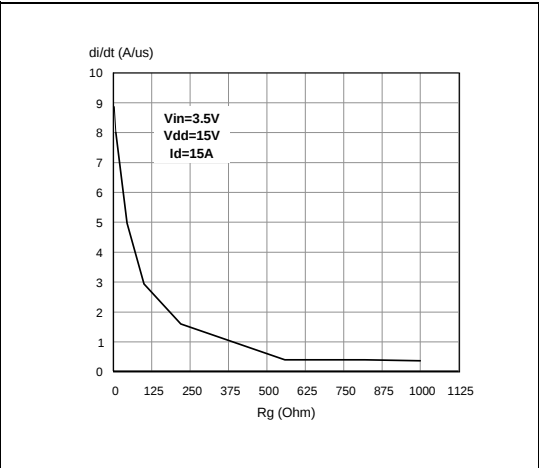


Figure 21. Input voltage vs. input charge Figure 22. Turn-off drain source voltage slope,  $V_{IN} = 5\text{ V}$

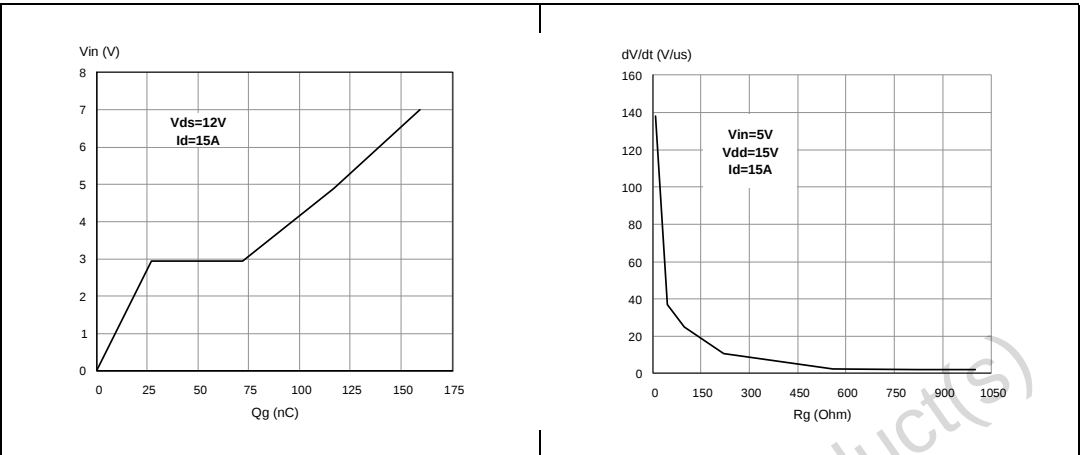


Figure 23. Turn-off drain-source voltage slope,  $V_{IN} = 3.5\text{ V}$  Figure 24. Switching time resistive load (part 1)

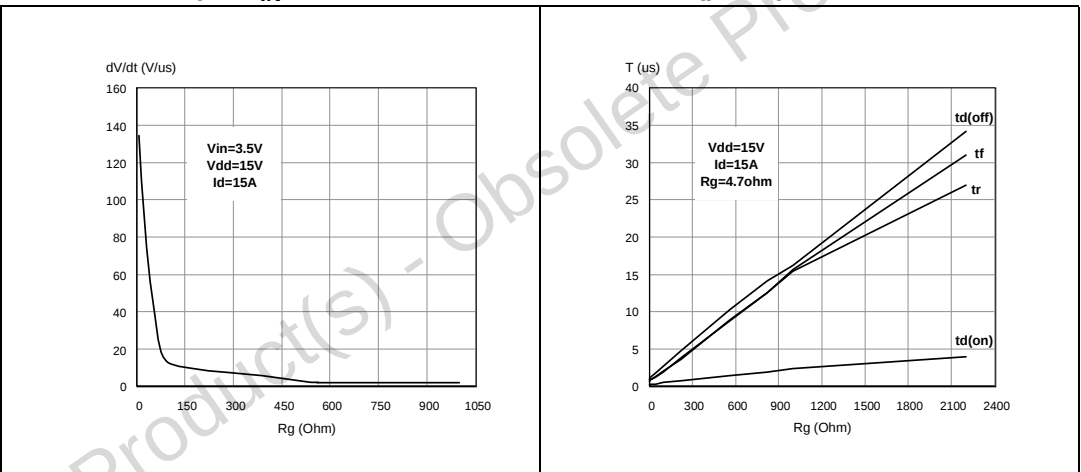


Figure 25. Switching time resistive load (part 2) Figure 26. Normalized input threshold voltage vs. temperature

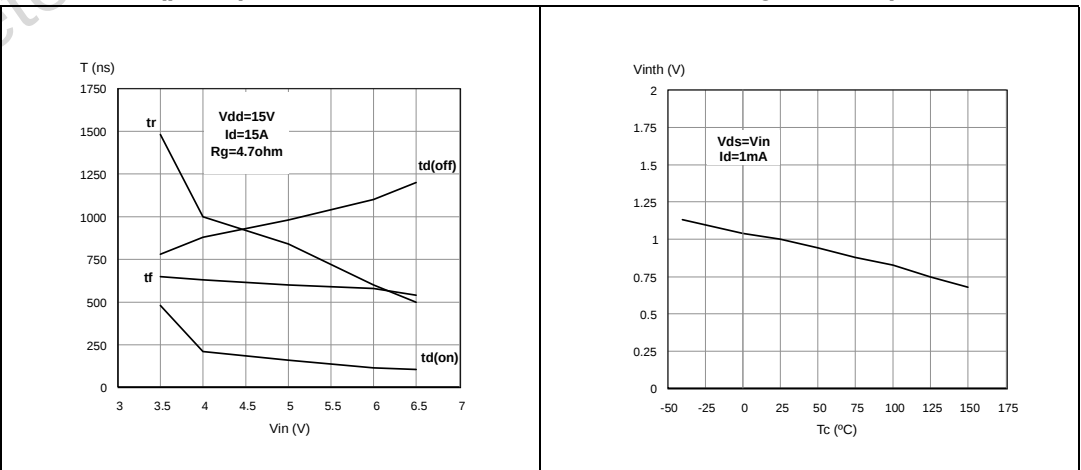


Figure 27. Current limit vs. junction temperature

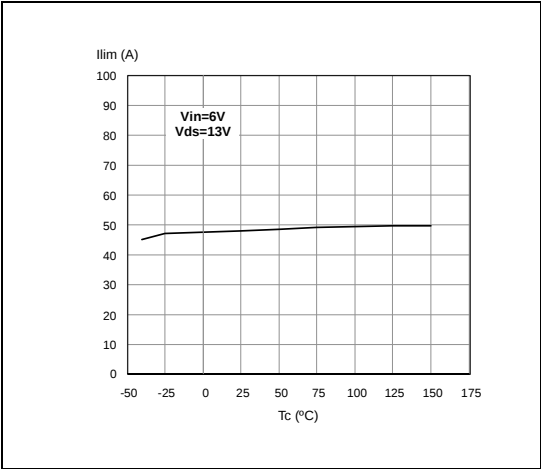


Figure 28. Step response current limit

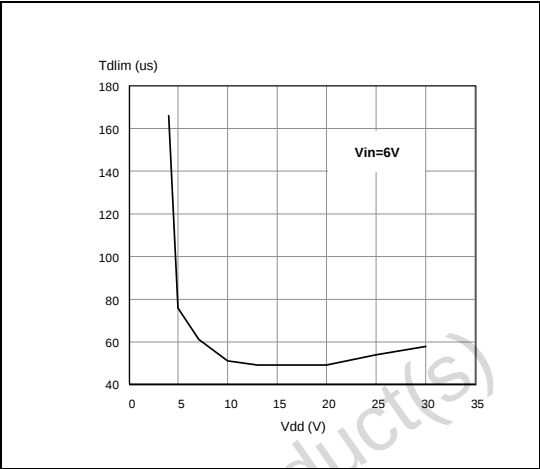
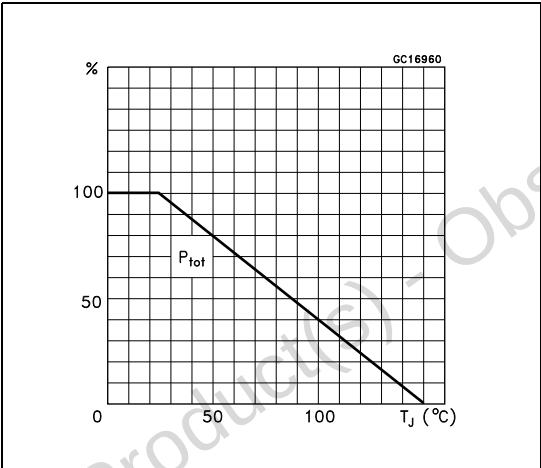


Figure 29. Derating curve



### 3 Package information

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

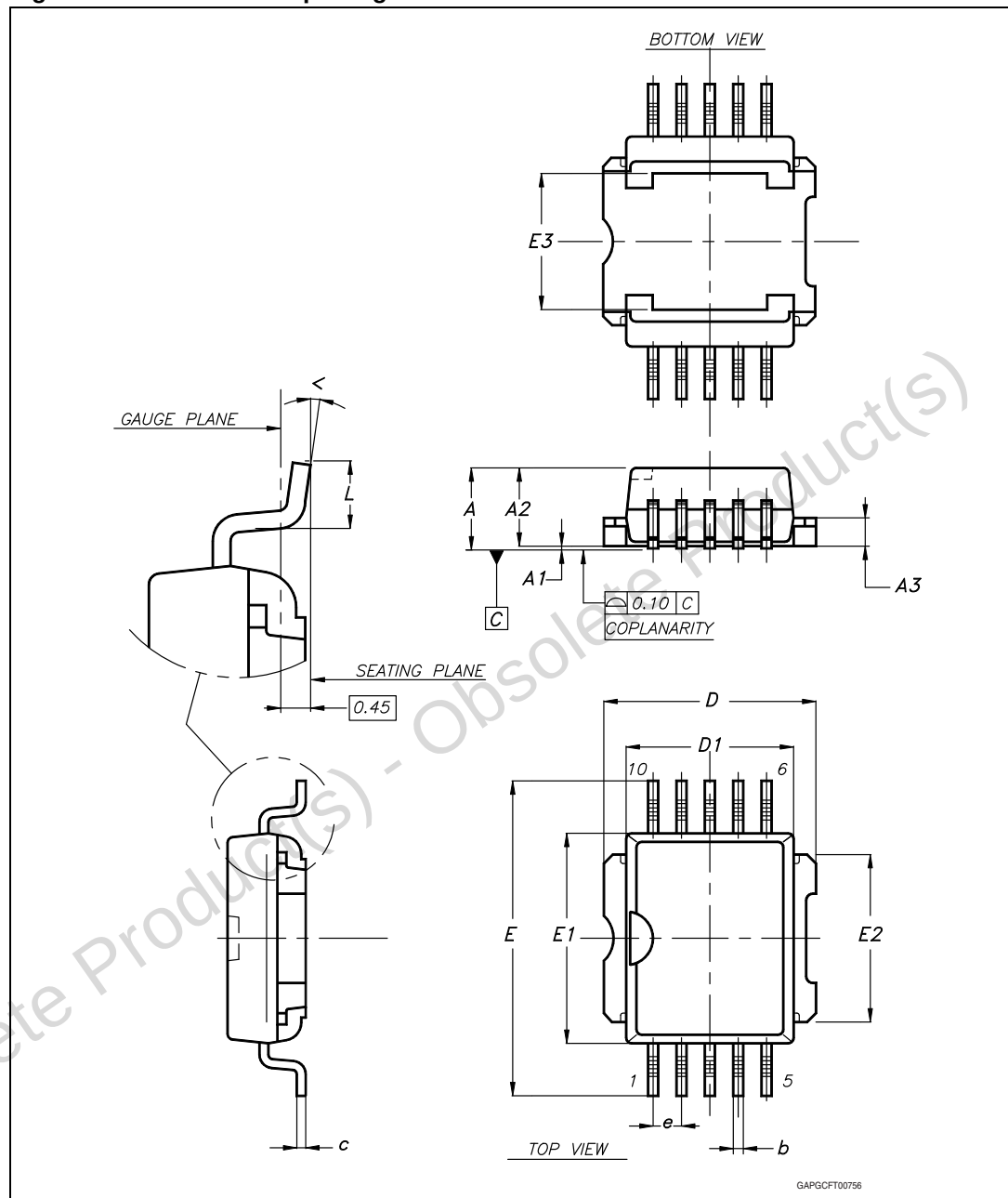
#### 3.2 PowerSO-10 mechanical data

Table 9. PowerSO-10 mechanical data

| Dim.              | mm.   |      |       |
|-------------------|-------|------|-------|
|                   | Min.  | Typ. | Max.  |
| A                 |       |      | 3.70  |
| A1                | 0.00  |      | 0.10  |
| A2                | 3.40  |      | 3.60  |
| A3                | 1.25  |      | 1.35  |
| b                 | 0.40  |      | 0.53  |
| c                 | 0.35  |      | 0.55  |
| D                 | 9.40  |      | 9.60  |
| D1 <sup>(1)</sup> | 7.40  |      | 7.60  |
| E                 | 13.80 |      | 14.40 |
| E1 <sup>(1)</sup> | 9.30  |      | 9.50  |
| E2                | 7.20  |      | 7.60  |
| E3                | 5.90  |      | 6.10  |
| e                 |       | 1.27 |       |
| L                 | 0.95  |      | 1.65  |
| <                 | 0°    |      | 8°    |

1. Resin protrusion not included (max value: 0.20 mm per side)

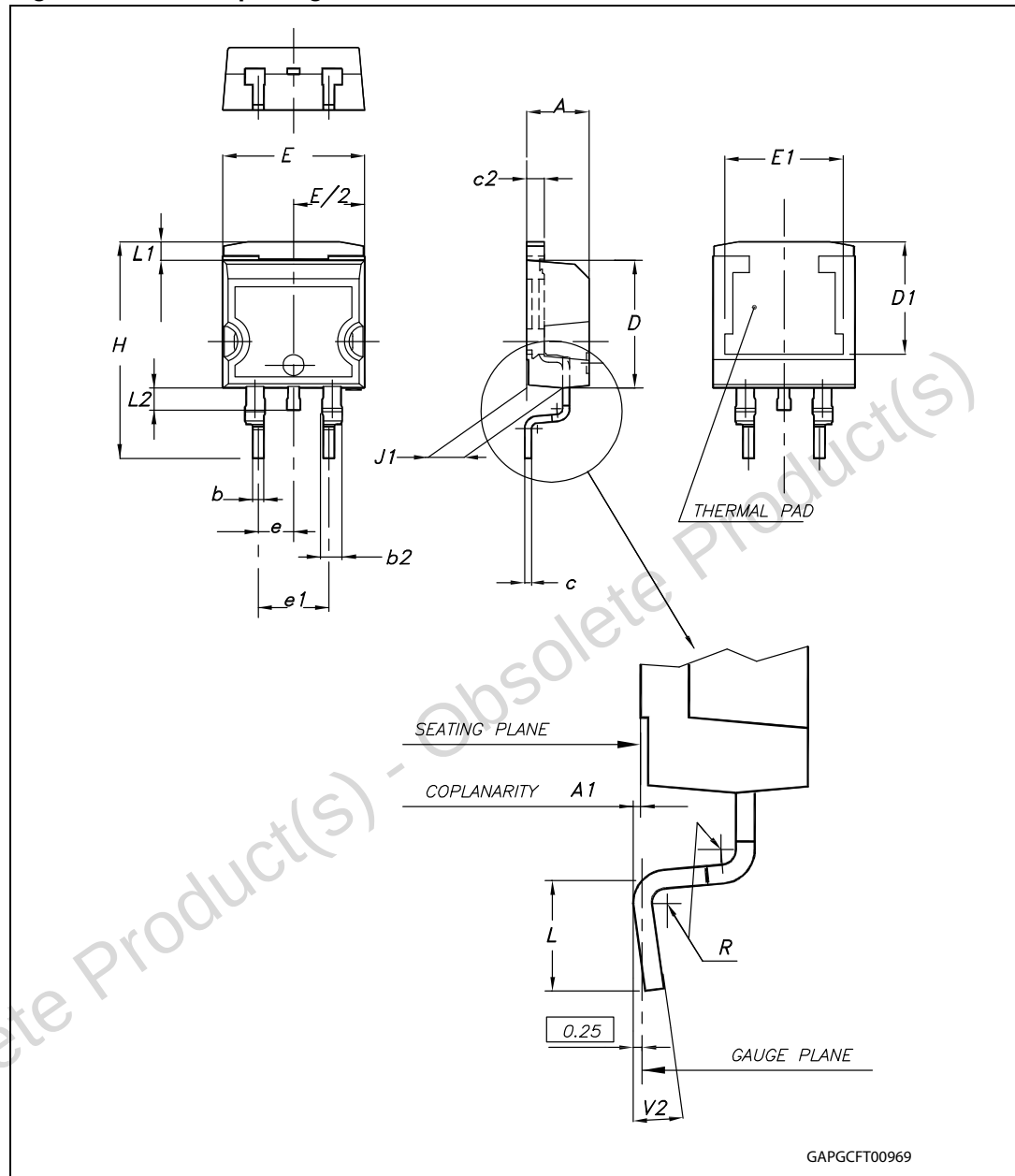
Figure 30. PowerSO-10 package dimensions



### 3.3 D<sup>2</sup>PAK mechanical data

Table 10. D<sup>2</sup>PAK mechanical data

| Dim. | mm.  |      |       |
|------|------|------|-------|
|      | Min. | Typ  | Max.  |
| A    | 4.40 |      | 4.60  |
| A1   | 0.03 |      | 0.23  |
| b    | 0.70 |      | 0.93  |
| b2   | 1.14 |      | 1.70  |
| c    | 0.45 |      | 0.60  |
| c2   | 1.23 |      | 1.36  |
| D    | 8.95 |      | 9.35  |
| D1   | 7.50 |      |       |
| E    | 10   |      | 10.40 |
| E1   | 8.50 |      |       |
| e    |      | 2.54 |       |
| e1   | 4.88 |      | 5.28  |
| H    | 15   |      | 15.85 |
| J1   | 2.49 |      | 2.69  |
| L    | 2.29 |      | 2.79  |
| L1   | 1.27 |      | 1.40  |
| L2   | 1.30 |      | 1.75  |
| R    |      | 0.4  |       |
| V2   | 0°   |      | 8°    |

Figure 31. D<sup>2</sup>PAK package dimensions

### 3.4 PowerSO-10 packing information

Figure 32. PowerSO-10 suggested pad layout

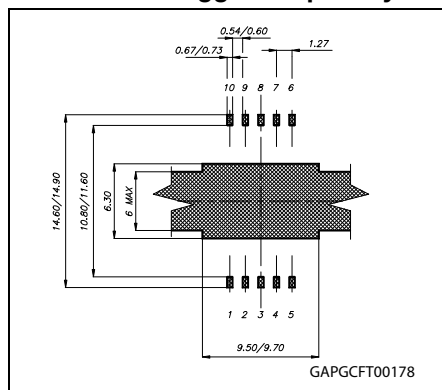


Figure 33. Tube shipment (no suffix)

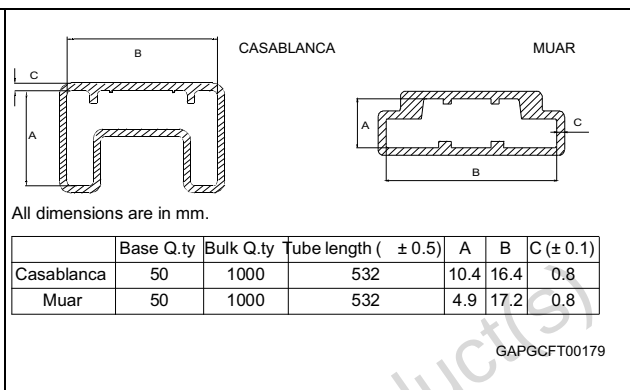
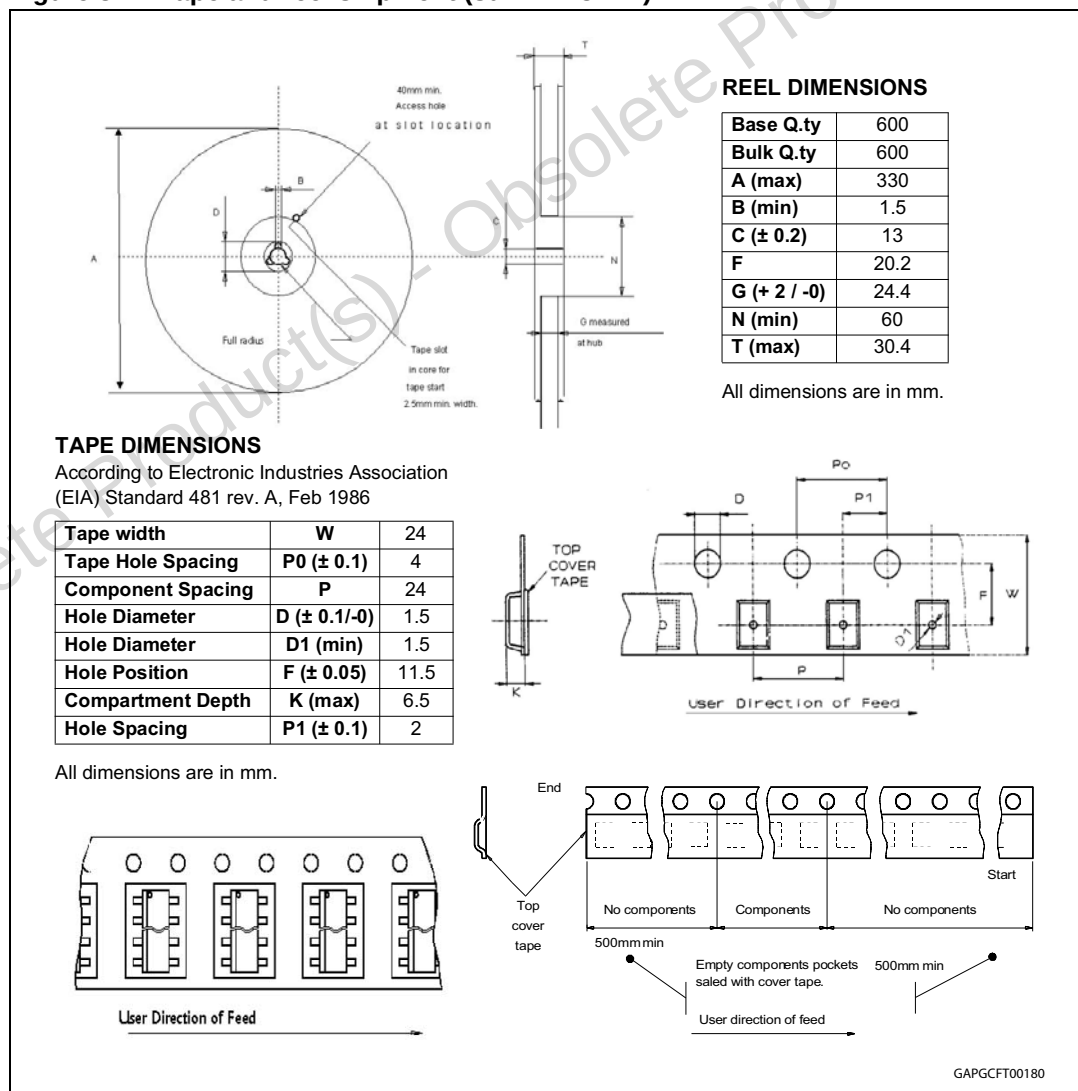


Figure 34. Tape and reel shipment (suffix "13TR")



### 3.5 D<sup>2</sup>PAK packing information

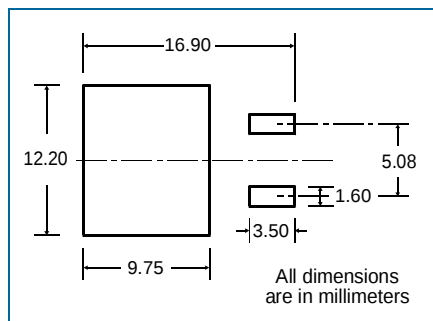
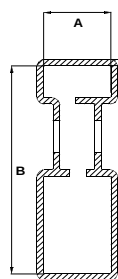
Figure 35. D<sup>2</sup>PAK footprint

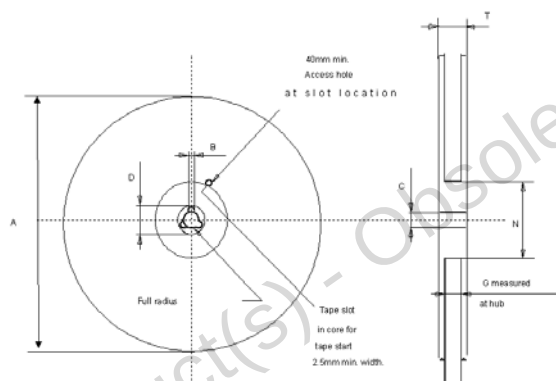
Figure 36. Tube shipment (no suffix)



|                           |      |
|---------------------------|------|
| Base Q.ty                 | 50   |
| Bulk Q.ty                 | 500  |
| Tube length ( $\pm 0.5$ ) | 532  |
| A                         | 6    |
| B                         | 21.3 |
| C ( $\pm 0.1$ )           | 0.6  |

All dimensions are in mm.

Figure 37. Tape and reel shipment (suffix "13TR")



#### REEL DIMENSIONS

|                 |      |
|-----------------|------|
| Base Q.ty       | 1000 |
| Bulk Q.ty       | 1000 |
| A (max)         | 330  |
| B (min)         | 1.5  |
| C ( $\pm 0.2$ ) | 13   |
| F               | 20.2 |
| G (+ 2 / -0)    | 24.4 |
| N (min)         | 60   |
| T (max)         | 30.4 |

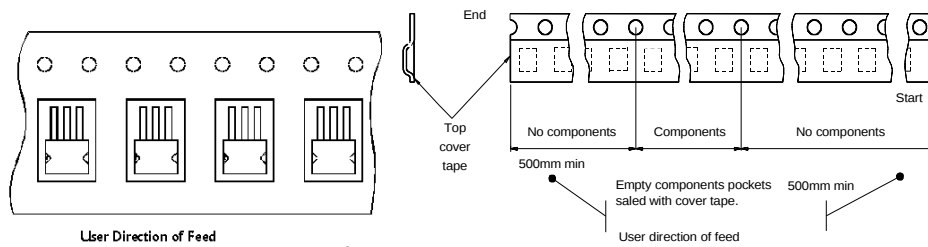
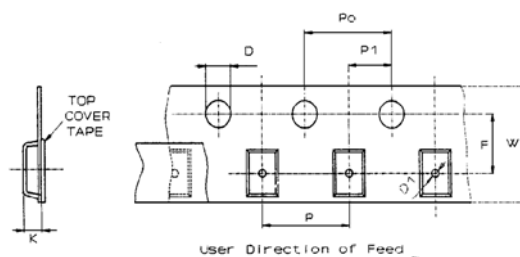
All dimensions are in mm.

#### TAPE DIMENSIONS

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

|                   |                    |      |
|-------------------|--------------------|------|
| Tape width        | W                  | 24   |
| Tape Hole Spacing | P0 ( $\pm 0.1$ )   | 4    |
| Component Spacing | P                  | 16   |
| Hole Diameter     | D ( $\pm 0.1/-0$ ) | 1.5  |
| Hole Diameter     | D1 (min)           | 1.5  |
| Hole Position     | F ( $\pm 0.05$ )   | 11.5 |
| Compartment Depth | K (max)            | 6.5  |
| Hole Spacing      | P1 ( $\pm 0.1$ )   | 2    |

All dimensions are in mm.



## 4 Revision history

Table 11. Document revision history

| Date        | Revision | Changes                                                                                                                                                                                                                                                                               |
|-------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 19-Sep-2012 | 1        | Initial release.<br>VNB35NV04 and VNV35NV04 were previously in document CD00002200 (Doc ID 7374) revision 5.<br>Added <a href="#">Section 3.1: ECOPACK®</a><br>Updated <a href="#">Section 3.2: PowerSO-10 mechanical data</a> and <a href="#">Section 3.3: D2PAK mechanical data</a> |
| 17-Sep-2013 | 2        | Updated disclaimer.                                                                                                                                                                                                                                                                   |

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