



# STB21N90K5, STF21N90K5, STP21N90K5, STW21N90K5

N-channel 900 V, 0.25  $\Omega$  typ., 18.5 A Zener-protected SuperMESH™ 5 Power MOSFET in a D<sup>2</sup>PAK, TO-220FP, TO-220 and TO-247 packages

Datasheet — production data

## Features

| Order codes | V <sub>DSS</sub> | R <sub>DS(on)</sub> max | I <sub>D</sub> | P <sub>W</sub> |
|-------------|------------------|-------------------------|----------------|----------------|
| STB21N90K5  | 900 V            | < 0.299 $\Omega$        | 18.5 A         | 250 W          |
| STF21N90K5  |                  |                         |                | 40 W           |
| STP21N90K5  |                  |                         |                | 250 W          |
| STW21N90K5  |                  |                         |                |                |

- TO-220 worldwide best R<sub>DS(on)</sub>
- Worldwide best FOM (figure of merit)
- Ultra low gate charge
- 100% avalanche tested
- Zener-protected

## Applications

- Switching applications

## Description

These devices are N-channel Power MOSFETs developed using SuperMESH™ 5 technology. This revolutionary, avalanche-rugged, high voltage Power MOSFET technology is based on an innovative proprietary vertical structure. The result is a drastic reduction in on-resistance and ultra low gate charge for applications which require superior power density and high efficiency.

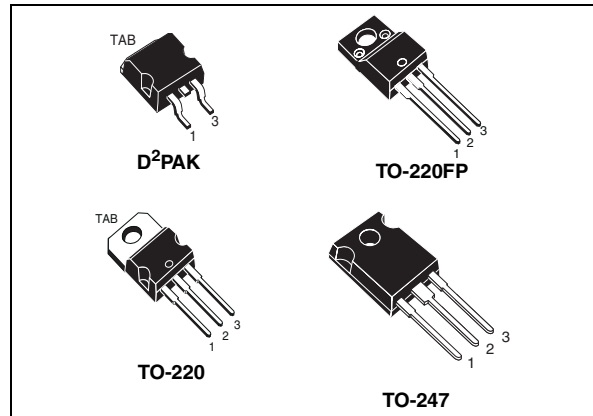


Figure 1. Internal schematic diagram

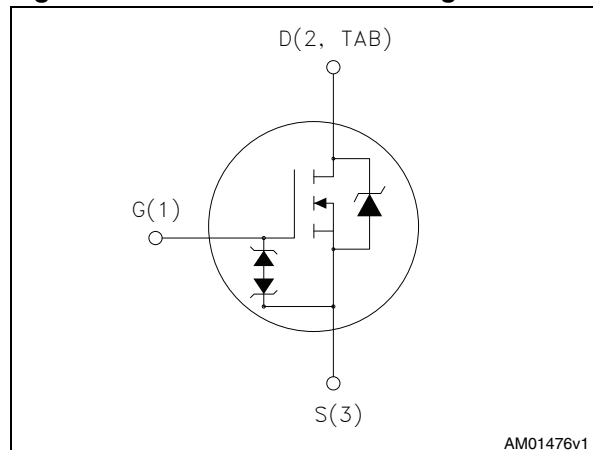


Table 1. Device summary

| Order codes | Marking | Package            | Packaging     |
|-------------|---------|--------------------|---------------|
| STB21N90K5  | 21N90K5 | D <sup>2</sup> PAK | Tape and reel |
| STF21N90K5  |         | TO-220FP           | Tube          |
| STP21N90K5  |         | TO-220             |               |
| STW21N90K5  |         | TO-247             |               |

# Contents

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol                             | Parameter   | Value                                 |                     | Unit |
|------------------------------------|---|---------------------------------------|---------------------|------|
|                                    |   | D <sup>2</sup> PAK,<br>TO-220, TO-247 | TO-220FP            |      |
| V <sub>GS</sub>                    | Gate- source voltage  | ± 30                                  |                     | V    |
| I <sub>D</sub>                     | Drain current (continuous) at T <sub>C</sub> = 25 °C  | 18.5                                  | 18.5 <sup>(1)</sup> | A    |
| I <sub>D</sub>                     | Drain current (continuous) at T <sub>C</sub> = 100 °C   | 11.6                                  | 11.6 <sup>(1)</sup> | A    |
| I <sub>DM</sub> <sup>(2)</sup>     | Drain current (pulsed)  | 74                                    | 74 <sup>(1)</sup>   | A    |
| P <sub>TOT</sub>                   | Total dissipation at T <sub>C</sub> = 25 °C   | 250                                   | 40                  | W    |
| I <sub>AR</sub>                    | Max current during repetitive or single pulse avalanche (pulse width limited by T <sub>jmax</sub> )                       | 6                                     |                     | A    |
| E <sub>AS</sub>                    | Single pulse avalanche energy (starting T <sub>J</sub> = 25 °C, I <sub>D</sub> =I <sub>AR</sub> , V <sub>DD</sub> = 50 V) | 200                                   |                     | mJ   |
| V <sub>iso</sub>                   | Insulation withstand voltage (RMS) from all three leads to external heat sink (t=1 s; T <sub>C</sub> =25 °C)              |                                       | 2500                | V    |
| dv/dt <sup>(3)</sup>               | Peak diode recovery voltage slope   | 6                                     |                     | V/ns |
| T <sub>j</sub><br>T <sub>stg</sub> | Operating junction temperature<br>Storage temperature   | -55 to 150                            |                     | °C   |

- Limited by package.
- Pulse width limited by safe operating area.
- $I_{SD} \leq 18.5 \text{ A}$ ,  $di/dt \leq 100 \text{ A}/\mu\text{s}$ ,  $V_{DS(\text{peak})} \leq V_{(BR)DSS}$

**Table 3. Thermal data**

| Symbol                | Parameter                            | Value              |          |        |        | Unit |
|-----------------------|--------------------------------------|--------------------|----------|--------|--------|------|
|                       |                                      | D <sup>2</sup> PAK | TO-220FP | TO-220 | TO-247 |      |
| R <sub>thj-case</sub> | Thermal resistance junction-case max | 0.5                | 3.13     | 0.5    |        | °C/W |
| R <sub>thj-amb</sub>  | Thermal resistance junction-amb max  |                    | 62.5     |        | 50     |      |
| R <sub>thj-pcb</sub>  | Thermal resistance junction-pcb max  | 30                 |          |        |        |      |

## 2 Electrical characteristics

( $T_{CASE} = 25\text{ °C}$  unless otherwise specified).

**Table 4. On/off states**

| Symbol        | Parameter  | Test conditions   | Min. | Typ. | Max.     | Unit                           |
|---------------|--|---|------|------|----------|--------------------------------|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage ( $V_{GS} = 0$ )  | $I_D = 1\text{ mA}$   | 900  |      |          | V                              |
| $I_{DSS}$     | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = 900\text{ V}$<br>$V_{DS} = 900\text{ V}, T_c = 125\text{ °C}$ |      |      | 1<br>50  | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$     | Gate body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20\text{ V}$  |      |      | $\pm 10$ | $\mu\text{A}$                  |
| $V_{GS(th)}$  | Gate threshold voltage                           | $V_{DS} = V_{GS}, I_D = 100\text{ }\mu\text{A}$                         | 3    | 4    | 5        | V                              |
| $R_{DS(on)}$  | Static drain-source on resistance                | $V_{GS} = 10\text{ V}, I_D = 9\text{ A}$                                |      | 0.25 | 0.299    | $\Omega$                       |

**Table 5. Dynamic**

| Symbol            | Parameter                             | Test conditions  | Min. | Typ. | Max. | Unit     |
|-------------------|---------------------------------------|--|------|------|------|----------|
| $C_{iss}$         | Input capacitance                     |  |      | 1645 |      | pF       |
| $C_{oss}$         | Output capacitance                    | $V_{DS} = 100\text{ V}, f = 1\text{ MHz}, V_{GS} = 0$  | -    | 112  | -    | pF       |
| $C_{rss}$         | Reverse transfer capacitance          |  |      | 2    |      |          |
| $C_{o(tr)}^{(1)}$ | Equivalent capacitance time related   | $V_{GS} = 0, V_{DS} = 0\text{ to }720\text{ V}$  | -    | 133  | -    | pF       |
| $C_{o(er)}^{(2)}$ | Equivalent capacitance energy related |  |      | 16   |      |          |
| $R_G$             | Intrinsic gate resistance             | $f = 1\text{ MHz}$ open drain  | -    | 4    | -    | $\Omega$ |
| $Q_g$             | Total gate charge                     | $V_{DD} = 720\text{ V}, I_D = 18.5\text{ A}$<br>$V_{GS} = 10\text{ V}$<br>(see <a href="#">Figure 20</a> ) | -    | 43   | -    | nC       |
| $Q_{gs}$          | Gate-source charge                    |  |      | 12   |      |          |
| $Q_{gd}$          | Gate-drain charge                     |  |      | 25   |      |          |

1. Time related is defined as a constant equivalent capacitance giving the same charging time as  $C_{oss}$  when  $V_{DS}$  increases from 0 to 80%  $V_{DSS}$
2. Energy related is defined as a constant equivalent capacitance giving the same stored energy as  $C_{oss}$  when  $V_{DS}$  increases from 0 to 80%  $V_{DSS}$

**Table 6. Switching times**

| Symbol       | Parameter           | Test conditions   | Min. | Typ. | Max. | Unit |
|--------------|---------------------|---|------|------|------|------|
| $t_{d(on)}$  | Turn-on delay time  | $V_{DD} = 720\text{ V}$ , $I_D = 10\text{ A}$ ,<br>$R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$<br>(see <a href="#">Figure 22</a> ) |      | 17   |      | ns   |
| $t_r$        | Rise time           |   |      | 27   |      | ns   |
| $t_{d(off)}$ | Turn-off delay time |   |      | 52   |      | ns   |
| $t_f$        | Fall time           |   |      | 40   |      | ns   |

**Table 7. Source drain diode**

| Symbol         | Parameter                     | Test conditions  | Min. | Typ. | Max. | Unit          |
|----------------|-------------------------------|--|------|------|------|---------------|
| $I_{SD}$       | Source-drain current          |  |      |      | 19   | A             |
| $I_{SDM}$      | Source-drain current (pulsed) |  |      |      | 76   | A             |
| $V_{SD}^{(1)}$ | Forward on voltage            | $I_{SD} = 18.5\text{ A}$ , $V_{GS} = 0$  |      |      | 1.5  | V             |
| $t_{rr}$       | Reverse recovery time         | $I_{SD} = 18.5\text{ A}$ , $V_{DD} = 60\text{ V}$<br>$di/dt = 100\text{ A}/\mu\text{s}$ ,<br>(see <a href="#">Figure 21</a> )                                      |      | 548  |      | ns            |
| $Q_{rr}$       | Reverse recovery charge       |  |      | 12   |      | $\mu\text{C}$ |
| $I_{RRM}$      | Reverse recovery current      |  |      | 46   |      | A             |
| $t_{rr}$       | Reverse recovery time         | $I_{SD} = 18.5\text{ A}$ , $V_{DD} = 60\text{ V}$<br>$di/dt = 100\text{ A}/\mu\text{s}$ ,<br>$T_J = 150\text{ }^\circ\text{C}$<br>(see <a href="#">Figure 21</a> ) |      | 660  |      | ns            |
| $Q_{rr}$       | Reverse recovery charge       |  |      | 15   |      | $\mu\text{C}$ |
| $I_{RRM}$      | Reverse recovery current      |  |      | 45   |      | A             |

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

**Table 8. Gate-source Zener diode**

| Symbol        | Parameter                     | Test conditions                        | Min. | Typ. | Max. | Unit |
|---------------|-------------------------------|--|------|------|------|------|
| $V_{(BR)GSO}$ | Gate-source breakdown voltage | $I_{GS} = \pm 1\text{ mA}$ , $I_D = 0$ | 30   | -    | -    | V    |

The built-in-back Zener diodes have specifically been designed to enhance not only the device's ESD capability, but also to make them safely absorb possible voltage transients that may occasionally be applied from gate to source. In this respect the Zener voltage is appropriate to achieve an efficient and cost-effective intervention to protect the device's integrity. These integrated Zener diodes thus avoid the usage of external components.

## 2.1 Electrical characteristics (curves)

Figure 2. Safe operating area for TO-220 / D<sup>2</sup>PAK

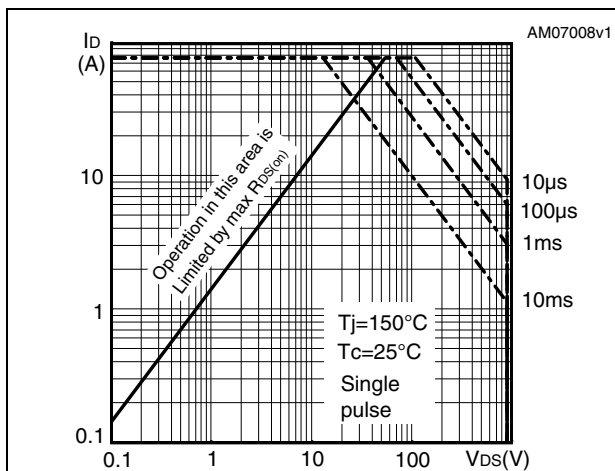


Figure 3. Thermal impedance for TO-220 / D<sup>2</sup>PAK

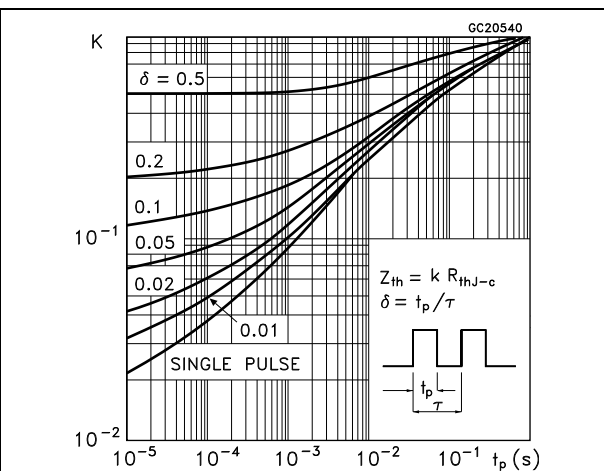


Figure 4. Safe operating area for TO-220FP

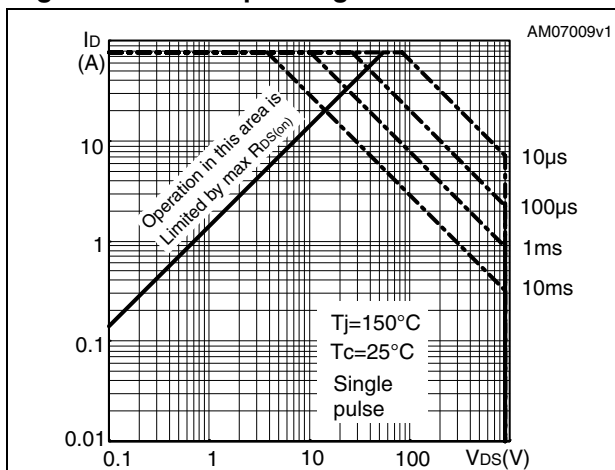


Figure 5. Thermal impedance for TO-220FP

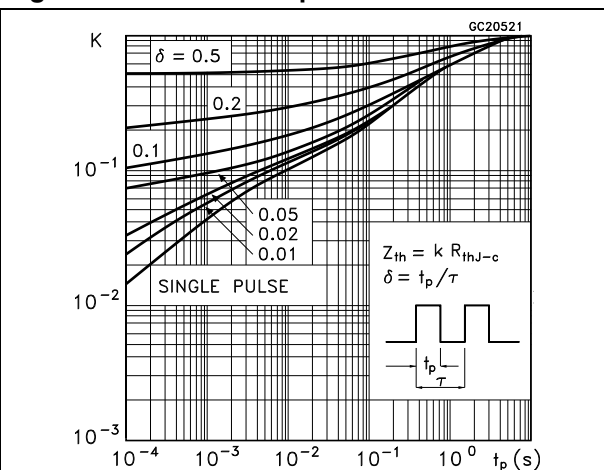


Figure 6. Safe operating area for TO-247

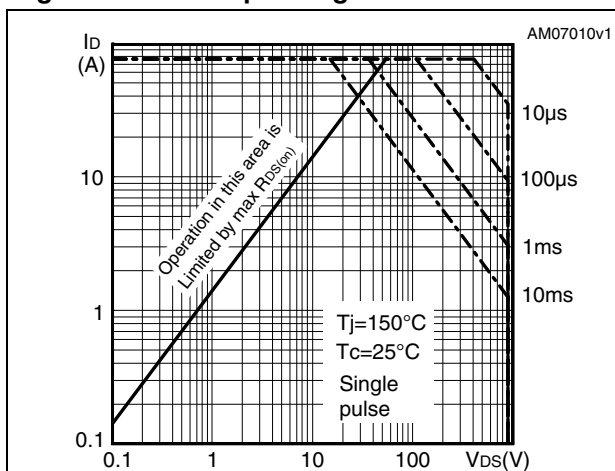


Figure 7. Thermal impedance for TO-247

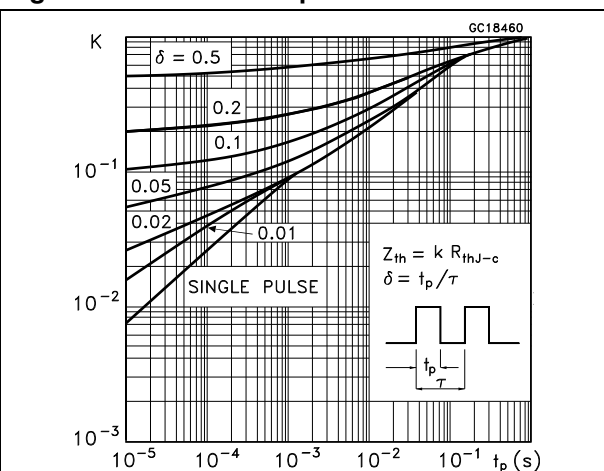


Figure 8. Output characteristics

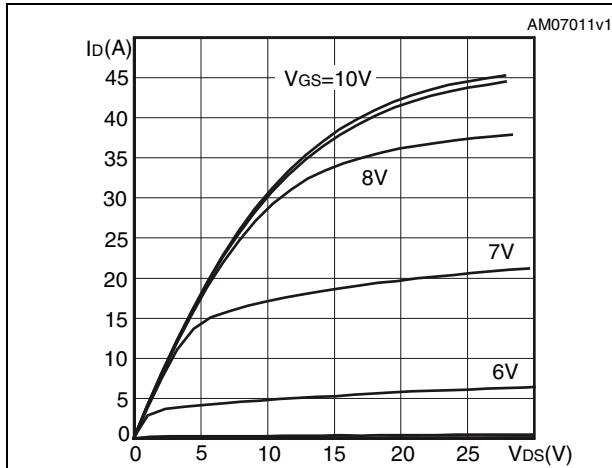


Figure 9. Transfer characteristics

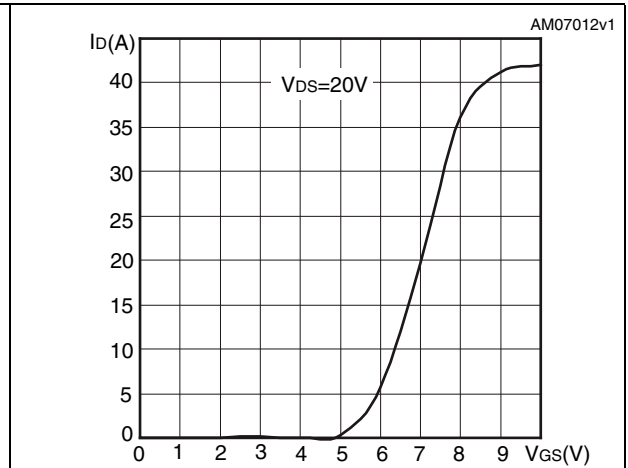


Figure 10. Gate charge vs gate-source voltage Figure 11. Static drain-source on resistance

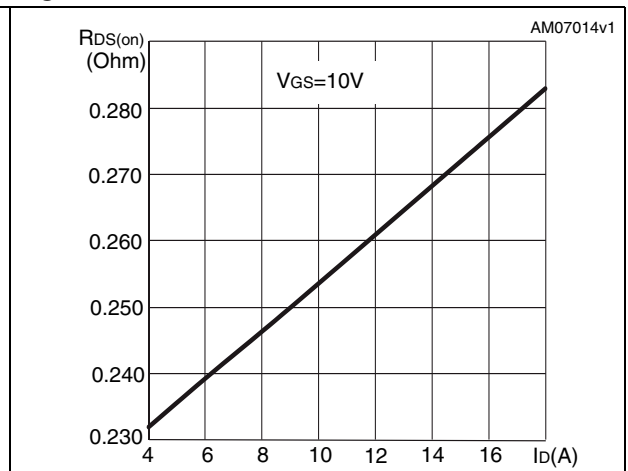
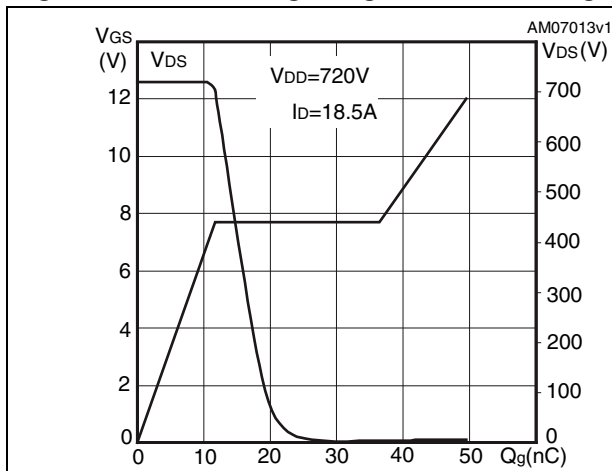


Figure 12. Capacitance variations

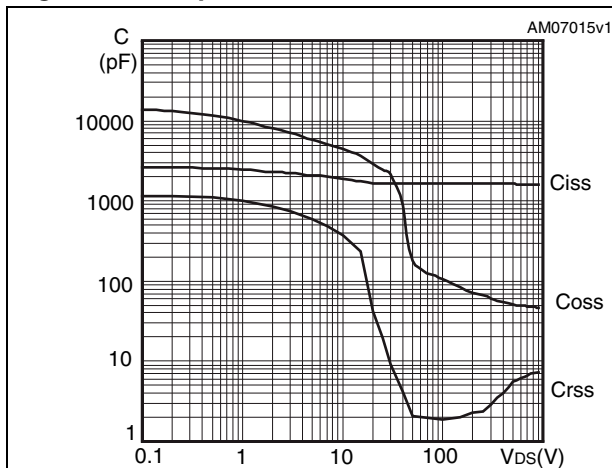


Figure 13. Output capacitance stored energy

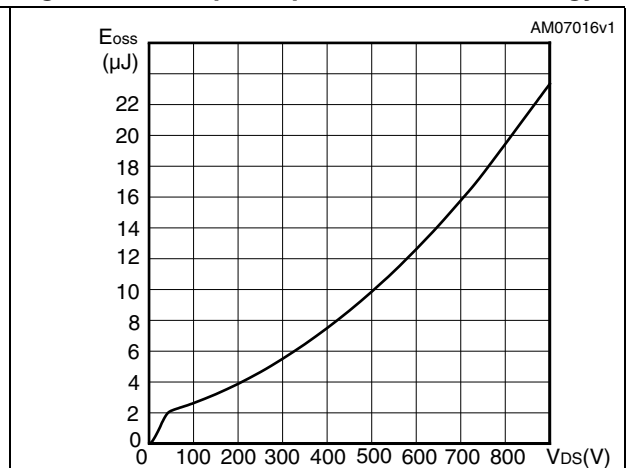


Figure 14. Normalized gate threshold voltage vs temperature

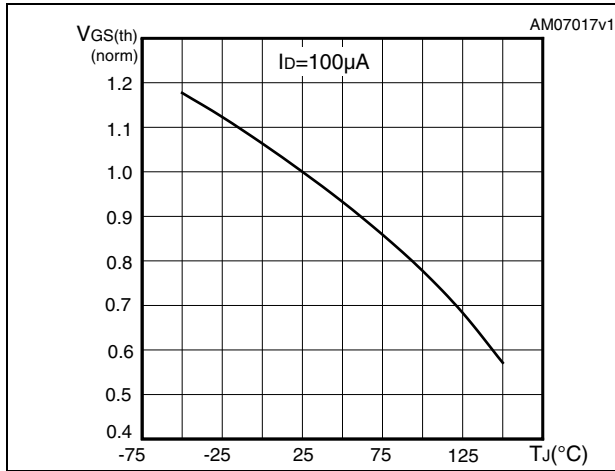


Figure 15. Normalized on-resistance vs temperature

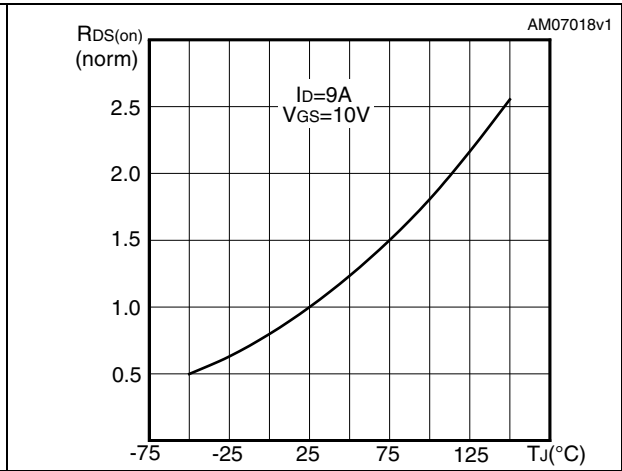


Figure 16. Source-drain diode forward characteristics

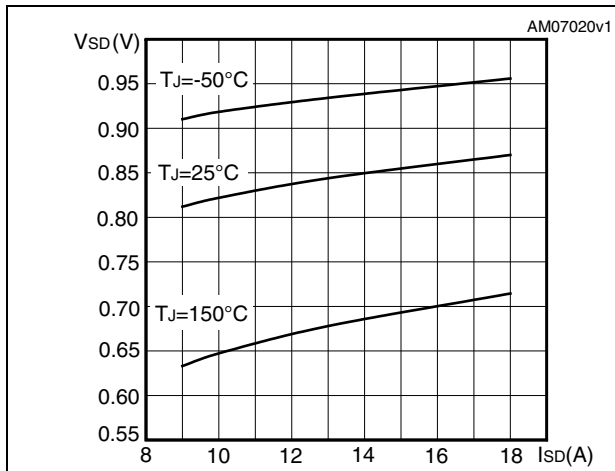


Figure 17. Normalized BV<sub>DSS</sub> vs temperature

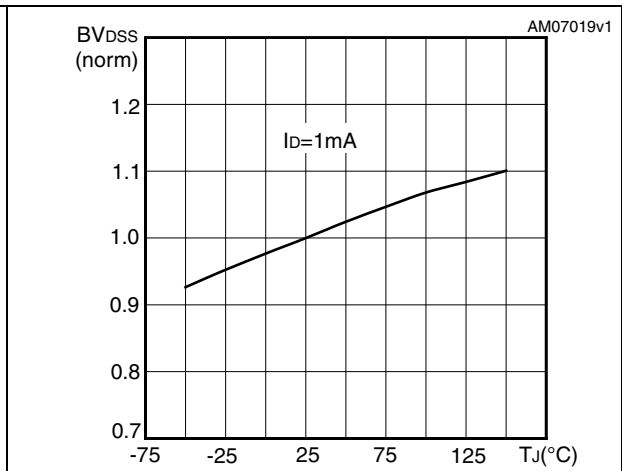
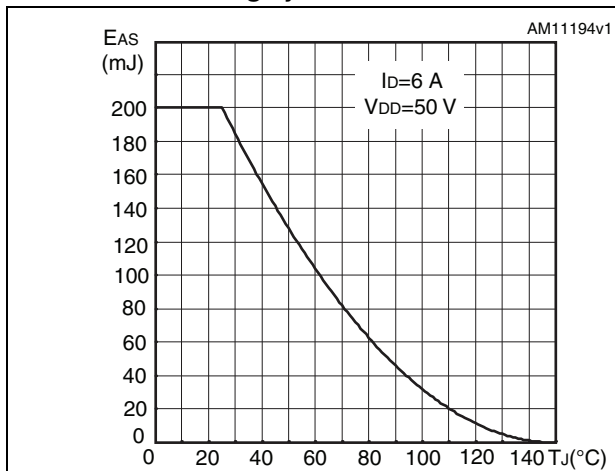


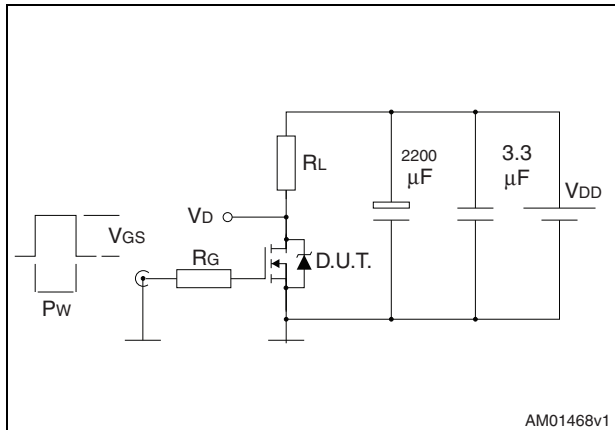
Figure 18. Maximum avalanche energy vs starting T<sub>j</sub>





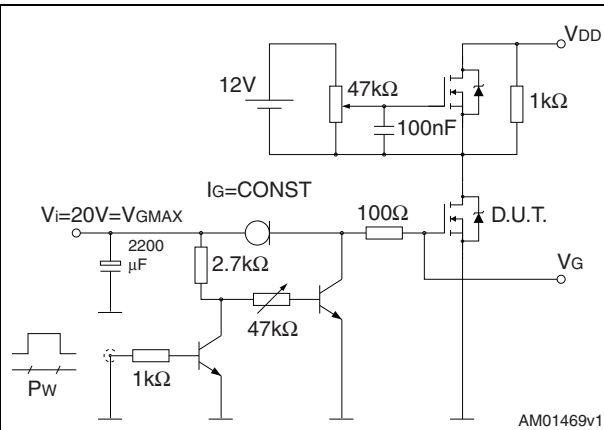
### 3 Test circuits

**Figure 19. Switching times test circuit for resistive load**



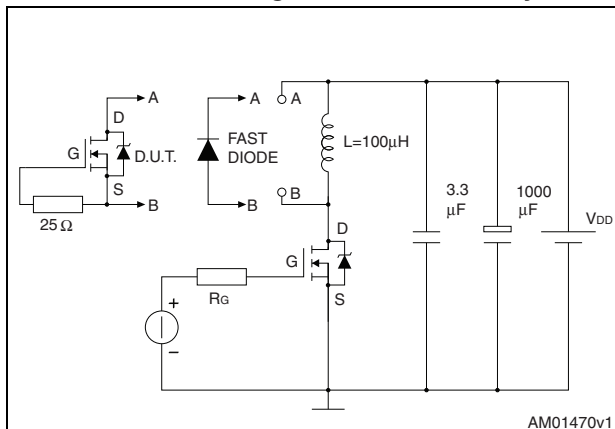
AM01468v1

**Figure 20. Gate charge test circuit**



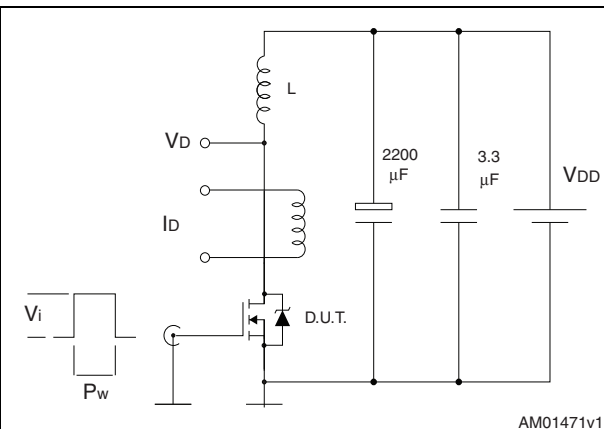
AM01469v1

**Figure 21. Test circuit for inductive load switching and diode recovery times**



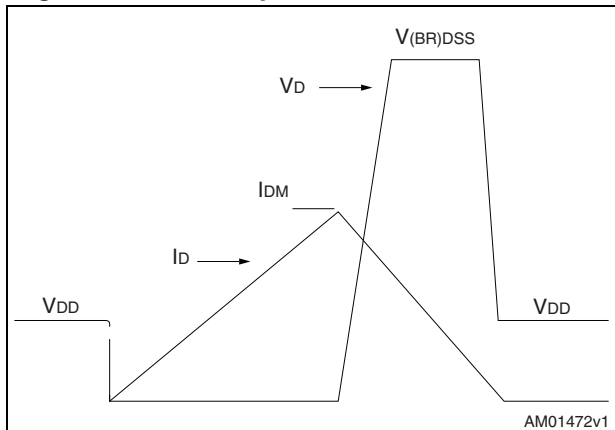
AM01470v1

**Figure 22. Unclamped inductive load test circuit**



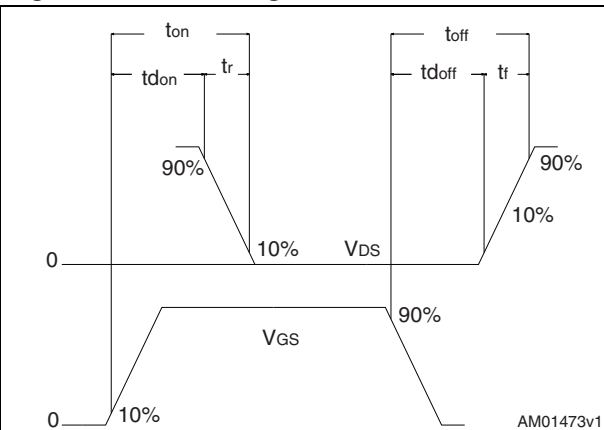
AM01471v1

**Figure 23. Unclamped inductive waveform**



AM01472v1

**Figure 24. Switching time waveform**



AM01473v1

## 4 Package mechanical data

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). ECOPACK<sup>®</sup> is an ST trademark.

Table 9. D<sup>2</sup>PAK (TO-263) 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 25. D<sup>2</sup>PAK (TO-263) drawing

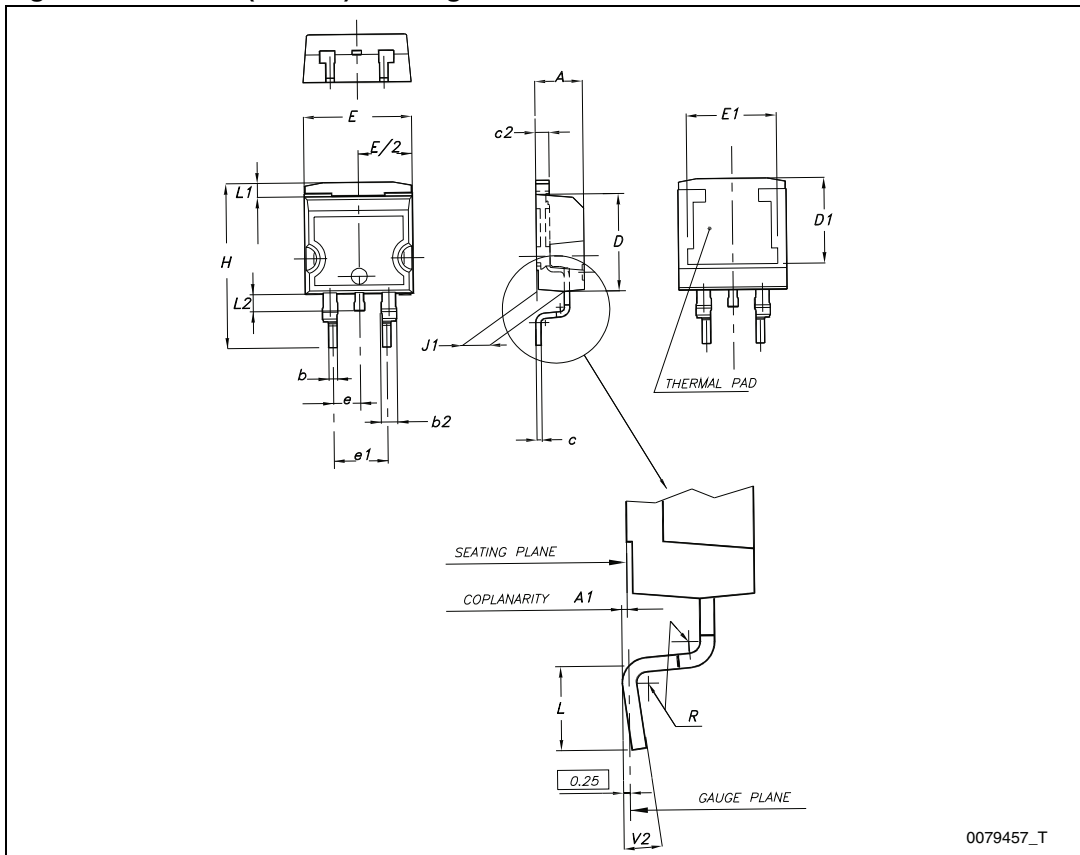
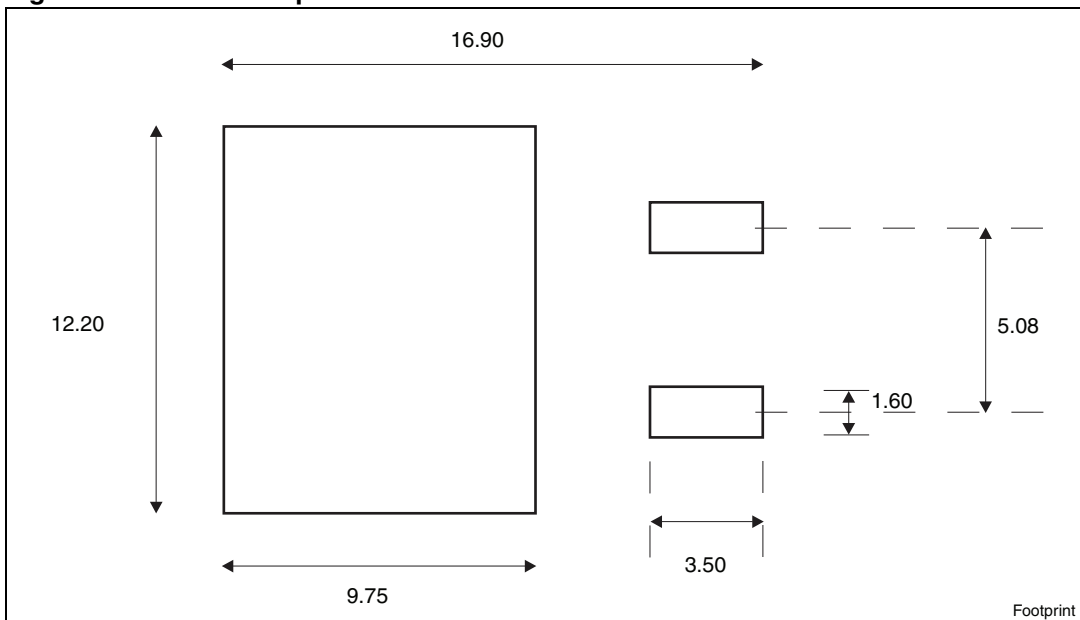


Figure 26. D<sup>2</sup>PAK footprint<sup>(a)</sup>



a. All dimensions are in millimeters

Table 10. TO-220FP mechanical data

| Dim. | mm   |      |      |
|------|------|------|------|
|      | Min. | Typ. | Max. |
| A    | 4.4  |      | 4.6  |
| B    | 2.5  |      | 2.7  |
| D    | 2.5  |      | 2.75 |
| E    | 0.45 |      | 0.7  |
| F    | 0.75 |      | 1    |
| F1   | 1.15 |      | 1.70 |
| F2   | 1.15 |      | 1.70 |
| G    | 4.95 |      | 5.2  |
| G1   | 2.4  |      | 2.7  |
| H    | 10   |      | 10.4 |
| L2   |      | 16   |      |
| L3   | 28.6 |      | 30.6 |
| L4   | 9.8  |      | 10.6 |
| L5   | 2.9  |      | 3.6  |
| L6   | 15.9 |      | 16.4 |
| L7   | 9    |      | 9.3  |
| Dia  | 3    |      | 3.2  |

Figure 27. TO-220FP drawing

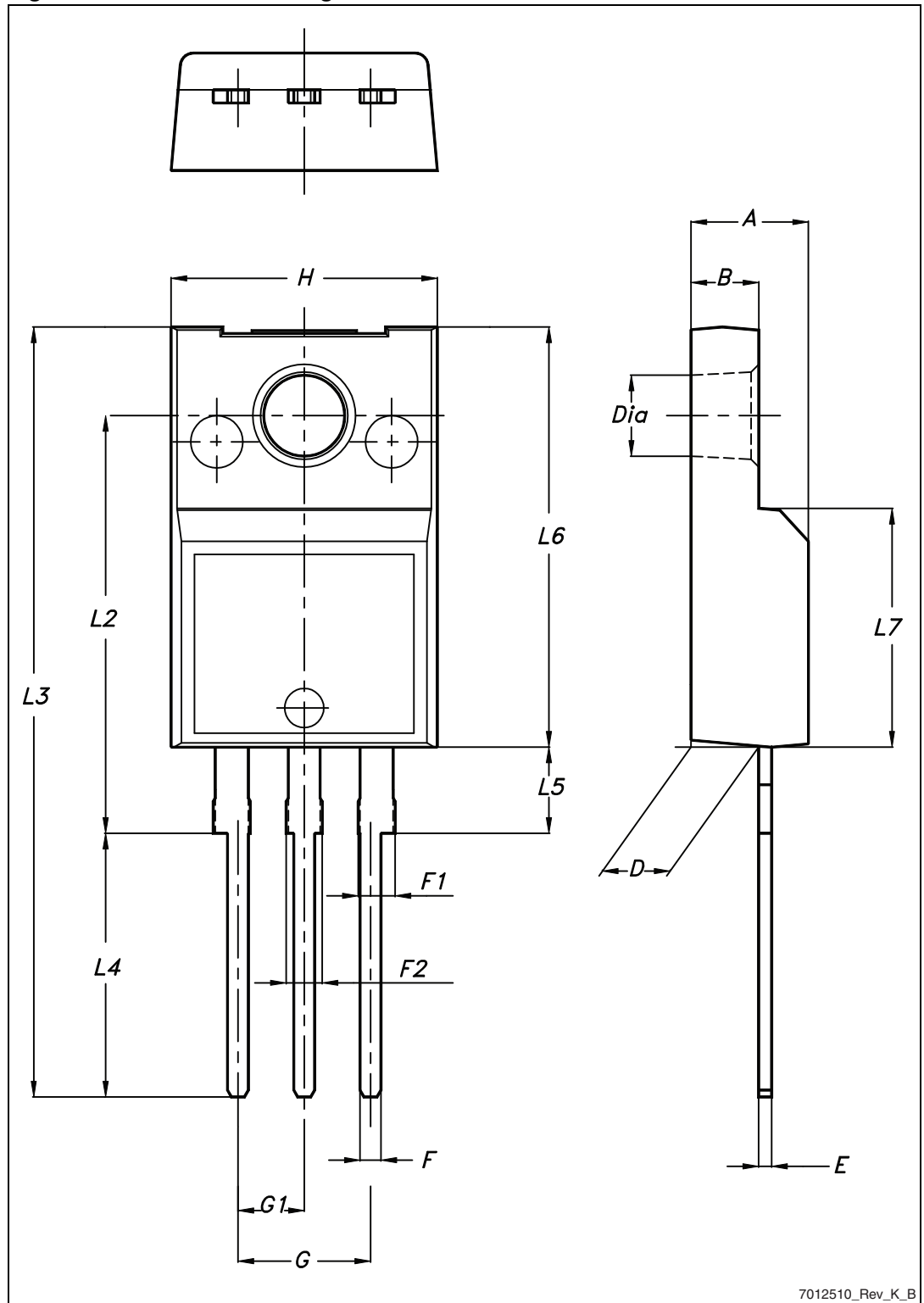


Table 11. TO-220 type A mechanical data

| Dim. | mm    |       |       |
|------|-------|-------|-------|
|      | Min.  | Typ.  | Max.  |
| A    | 4.40  |       | 4.60  |
| b    | 0.61  |       | 0.88  |
| b1   | 1.14  |       | 1.70  |
| c    | 0.48  |       | 0.70  |
| D    | 15.25 |       | 15.75 |
| D1   |       | 1.27  |       |
| E    | 10    |       | 10.40 |
| e    | 2.40  |       | 2.70  |
| e1   | 4.95  |       | 5.15  |
| F    | 1.23  |       | 1.32  |
| H1   | 6.20  |       | 6.60  |
| J1   | 2.40  |       | 2.72  |
| L    | 13    |       | 14    |
| L1   | 3.50  |       | 3.93  |
| L20  |       | 16.40 |       |
| L30  |       | 28.90 |       |
| ØP   | 3.75  |       | 3.85  |
| Q    | 2.65  |       | 2.95  |

Figure 28. TO-220 type A drawing

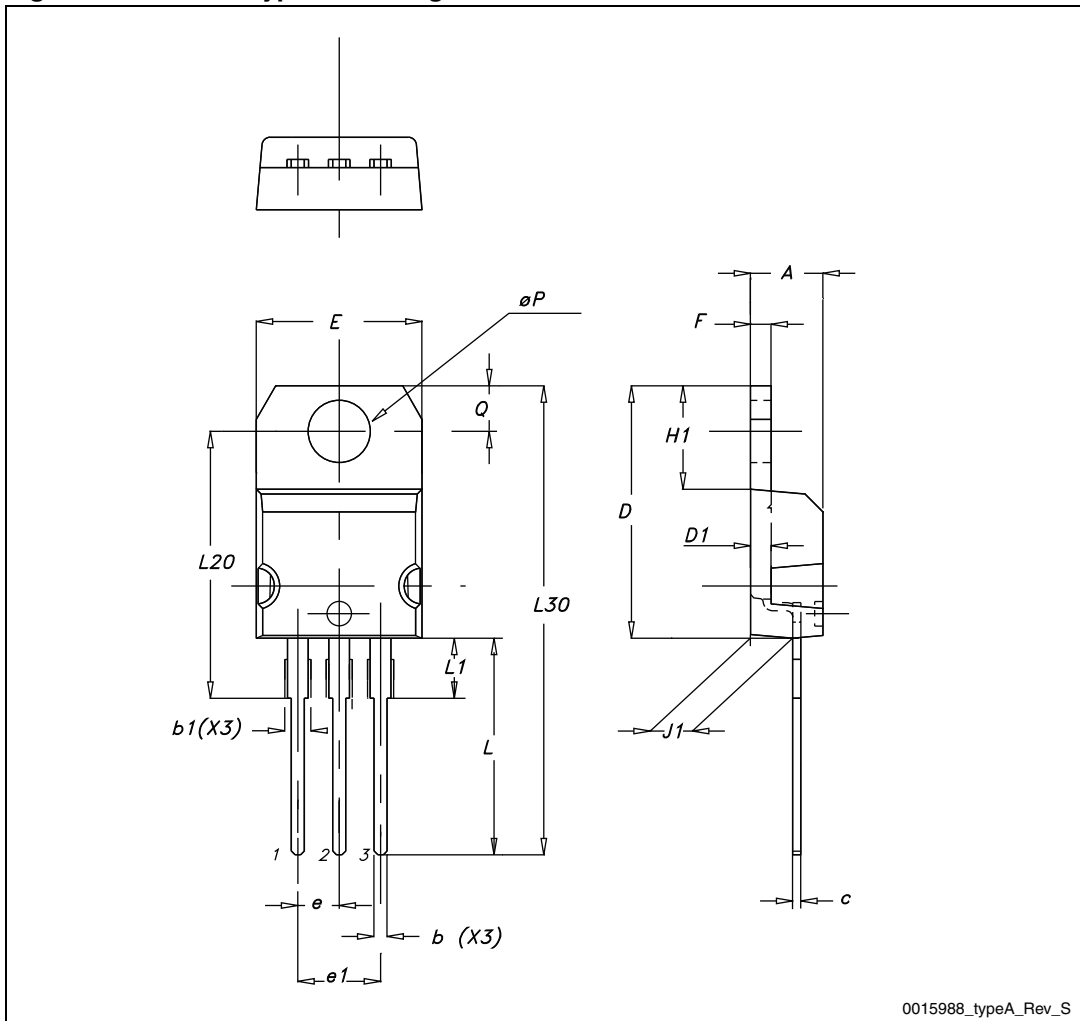
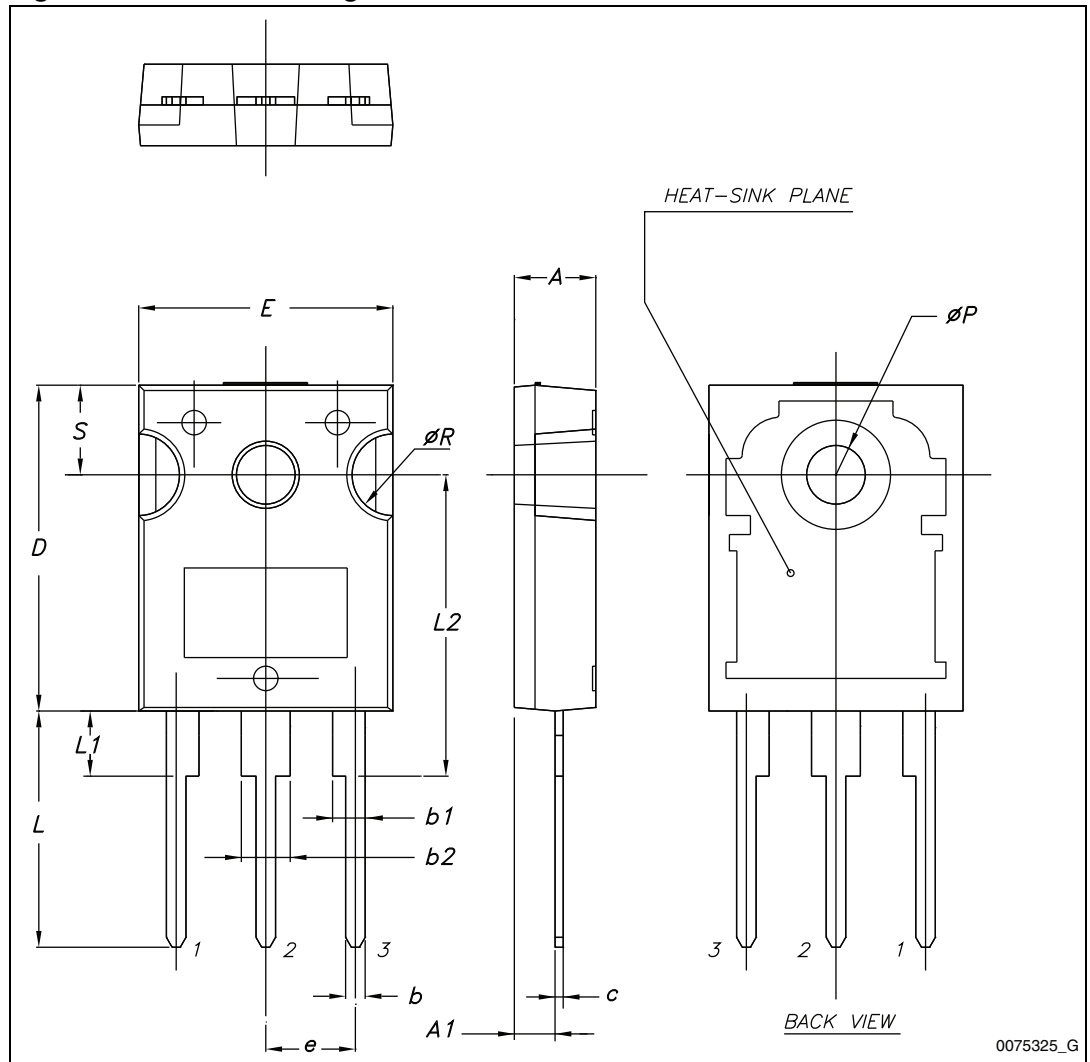




Table 12. TO-247 mechanical data

| Dim. | mm.   |       |       |
|------|-------|-------|-------|
|      | Min.  | Typ.  | Max.  |
| A    | 4.85  |       | 5.15  |
| A1   | 2.20  |       | 2.60  |
| b    | 1.0   |       | 1.40  |
| b1   | 2.0   |       | 2.40  |
| b2   | 3.0   |       | 3.40  |
| c    | 0.40  |       | 0.80  |
| D    | 19.85 |       | 20.15 |
| E    | 15.45 |       | 15.75 |
| e    | 5.30  | 5.45  | 5.60  |
| L    | 14.20 |       | 14.80 |
| L1   | 3.70  |       | 4.30  |
| L2   |       | 18.50 |       |
| ØP   | 3.55  |       | 3.65  |
| ØR   | 4.50  |       | 5.50  |
| S    | 5.30  | 5.50  | 5.70  |

Figure 29. TO-247 drawing

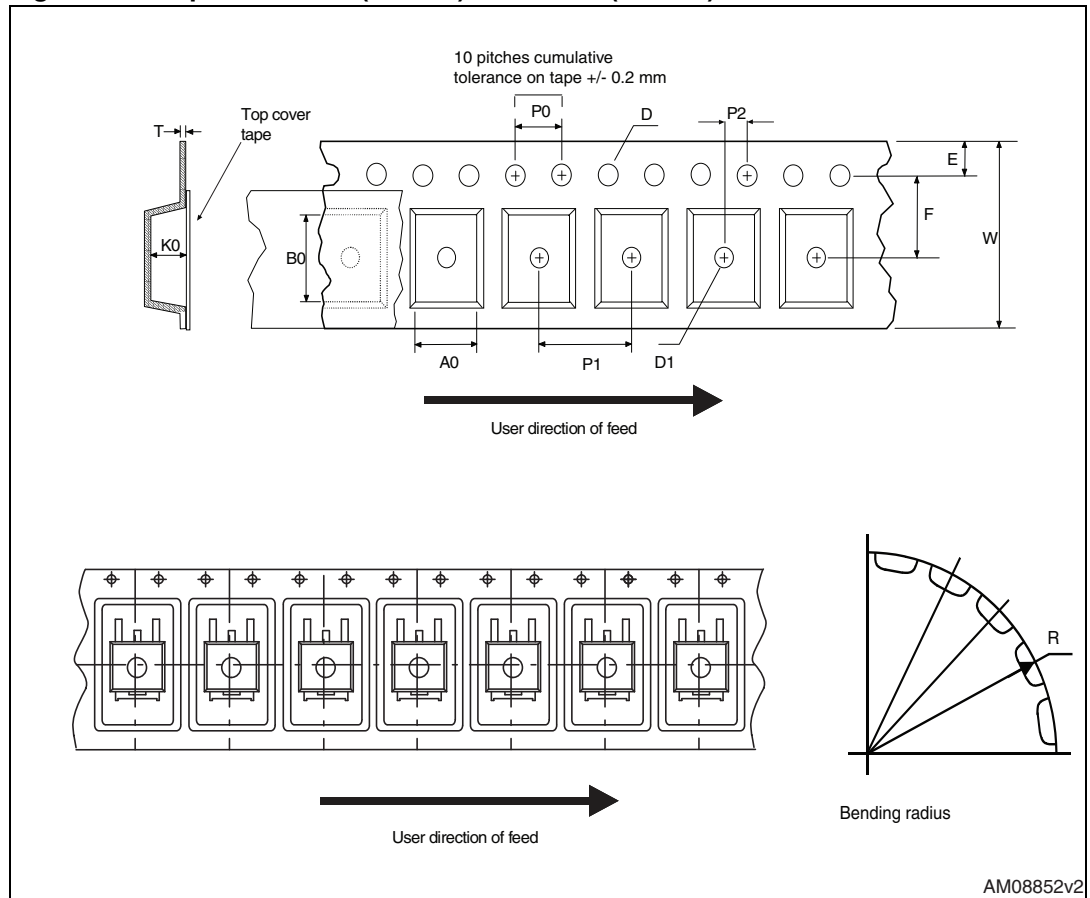


## 5 Packaging mechanical data

Table 13. D<sup>2</sup>PAK (TO-263) tape and reel mechanical data

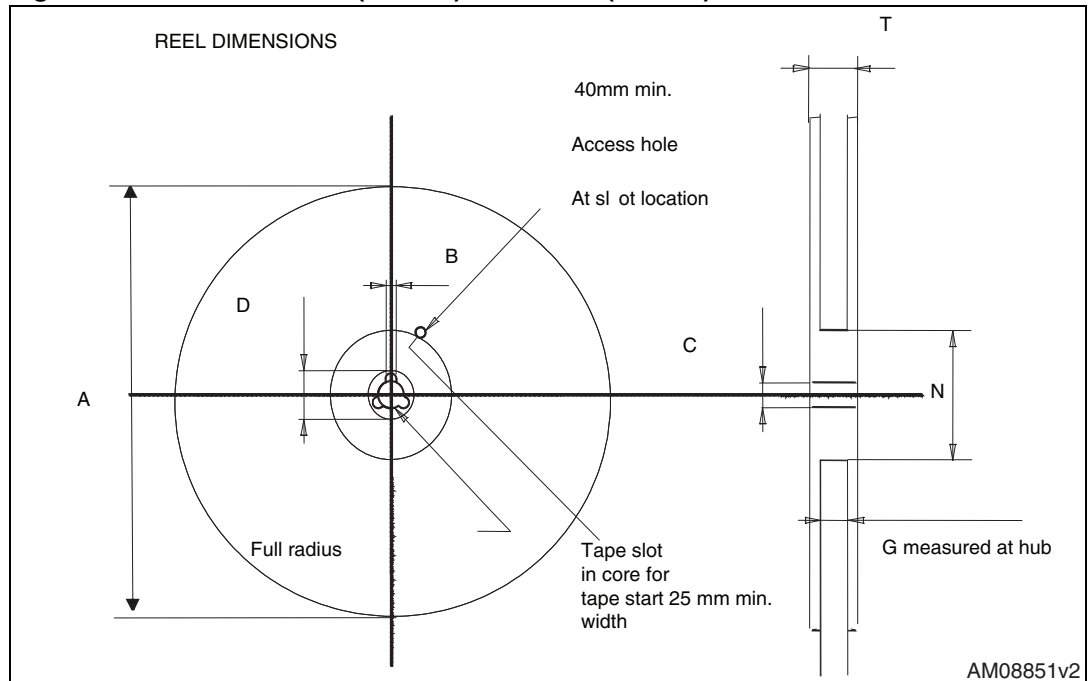
| Tape |      |      | Reel |          |      |
|------|------|------|------|----------|------|
| Dim. | mm   |      | Dim. | mm       |      |
|      | Min. | Max. |      | Min.     | Max. |
| A0   | 10.5 | 10.7 | A    |          | 330  |
| B0   | 15.7 | 15.9 | B    | 1.5      |      |
| D    | 1.5  | 1.6  | C    | 12.8     | 13.2 |
| D1   | 1.59 | 1.61 | D    | 20.2     |      |
| E    | 1.65 | 1.85 | G    | 24.4     | 26.4 |
| F    | 11.4 | 11.6 | N    | 100      |      |
| K0   | 4.8  | 5.0  | T    |          | 30.4 |
| P0   | 3.9  | 4.1  |      |          |      |
| P1   | 11.9 | 12.1 |      | Base qty | 1000 |
| P2   | 1.9  | 2.1  |      | Bulk qty | 1000 |
| R    | 50   |      |      |          |      |
| T    | 0.25 | 0.35 |      |          |      |
| W    | 23.7 | 24.3 |      |          |      |

Figure 30. Tape for D<sup>2</sup>PAK (TO-263) and DPAK (TO-252)



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Figure 31. Reel for D<sup>2</sup>PAK (TO-263) and DPAK (TO-252)



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## 6 Revision history

**Table 14. Document revision history**

| Date        | Revision | Changes   |
|-------------|----------|---|
| 05-Nov-2009 | 1        | First release.  |
| 18-Nov-2009 | 2        | Updated description on cover page   |
| 12-Jan-2010 | 3        | Corrected $V_{GS}$ value in <a href="#">Table 2: Absolute maximum ratings</a>   |
| 14-Jul-2010 | 4        | Document status promoted from preliminary data to datasheet.  |
| 21-Dec-2011 | 5        | <ul style="list-style-type: none"> <li>– Inserted device in D<sup>2</sup>PAK.</li> <li>– Updated <a href="#">Figure 2: Safe operating area for TO-220 / D2PAK</a>, <a href="#">Figure 4: Safe operating area for TO-220FP</a> and <a href="#">Figure 6: Safe operating area for TO-247</a>.</li> <li>– Inserted <a href="#">Section 5: Packaging mechanical data on page 19</a>.</li> <li>– Minor text changes.</li> </ul>  |
| 12-Oct-2012 | 6        | <ul style="list-style-type: none"> <li>– Updated: <math>Q_g</math> value (test conditions) in <a href="#">Table 5</a></li> <li>– Updated: <math>T_{d(on)}</math> value (test conditions) in <a href="#">Table 6</a></li> <li>– Updated: values (test conditions) in <a href="#">Table 8</a></li> <li>– Updated: <a href="#">Figure 10</a></li> <li>– Updated: <a href="#">Section 4: Package mechanical data</a></li> </ul> |

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