



# STB10NK60Z, STP10NK60Z, STP10NK60ZFP, STW10NK60Z

N-channel 600 V, 0.65  $\Omega$  typ., 10 A SuperMESH™ Power MOSFET  
in I<sup>2</sup>PAK, D<sup>2</sup>PAK, TO-220, TO-220FP, TO-247 packages

Datasheet – production data

## Features

| Type         | V <sub>DSS</sub> | R <sub>DS(on) max</sub> | I <sub>D</sub> | P <sub>w</sub> |
|--------------|------------------|-------------------------|----------------|----------------|
| STB10NK60Z-1 | 600 V            | < 0.75 $\Omega$         | 10 A           | 115 W          |
| STB10NK60ZT4 | 600 V            | < 0.75 $\Omega$         | 10 A           | 115 W          |
| STP10NK60Z   | 600 V            | < 0.75 $\Omega$         | 10 A           | 115 W          |
| STP10NK60ZFP | 600 V            | < 0.75 $\Omega$         | 10 A           | 35 W           |
| STW10NK60Z   | 600 V            | < 0.75 $\Omega$         | 10 A           | 156 W          |

- Extremely high dv/dt capability
- 100% avalanche tested
- Gate charge minimized
- Zener-protected

## Applications

- Switching applications

## Description

These devices are N-channel Zener-protected Power MOSFET developed using STMicroelectronics' SuperMESH™ technology, achieved through optimization of ST's well-established strip-based PowerMESH™ layout. In addition to a significant reduction in on-resistance, this device is designed to ensure a high level of dv/dt capability for the most demanding applications.

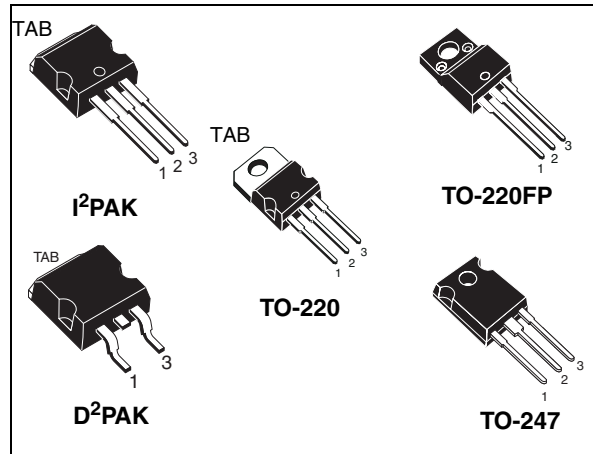


Figure 1. Internal schematic diagram

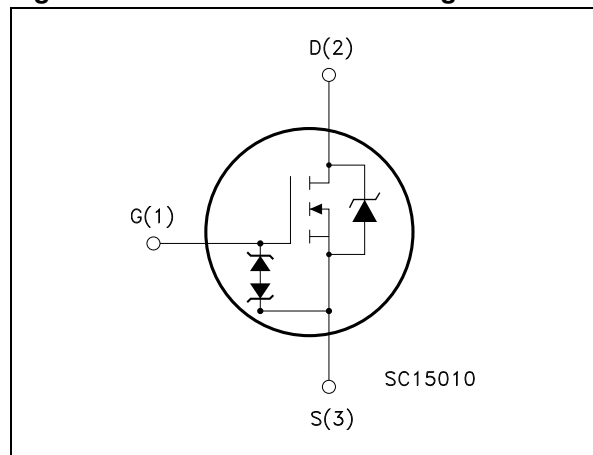


Table 1. Device summary

| Order codes  | Marking    | Package            | Packaging     |
|--------------|------------|--------------------|---------------|
| STB10NK60Z-1 | B10NK60Z   | I <sup>2</sup> PAK | Tube          |
| STB10NK60ZT4 | B10NK60Z   | D <sup>2</sup> PAK | Tape and reel |
| STP10NK60Z   | P10NK60Z   | TO-220             | Tube          |
| STP10NK60ZFP | P10NK60ZFP | TO-220FP           | Tube          |
| STW10NK60Z   | W10NK60Z   | TO-247             | Tube          |

## Contents

|          |   |           |
|----------|---|-----------|
| <b>1</b> | <b>Electrical ratings</b> .....               | <b>3</b>  |
| <b>2</b> | <b>Electrical characteristics</b> .....       | <b>5</b>  |
|          | 2.1 Electrical characteristics (curves) ..... | 7         |
| <b>3</b> | <b>Test circuits</b> .....                    | <b>10</b> |
| <b>4</b> | <b>Package mechanical data</b> .....          | <b>11</b> |
| <b>5</b> | <b>Packaging mechanical data</b> .....        | <b>21</b> |
| <b>6</b> | <b>Revision history</b> .....                 | <b>23</b> |

# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol                             | Parameter  | Value  |                    |        | Unit |
|------------------------------------|--|--|--------------------|--------|------|
|                                    |  | I <sup>2</sup> PAK<br>D <sup>2</sup> PAK<br>TO-220 | TO-220FP           | TO-247 |      |
| V <sub>DS</sub>                    | Drain-source voltage   | 600  |                    |        | V    |
| V <sub>GS</sub>                    | Gate-source voltage  | ± 30   |                    |        | V    |
| I <sub>D</sub>                     | Drain current (continuous) at T <sub>C</sub> = 25 °C   | 10   | 10 <sup>(1)</sup>  | 10     | A    |
| I <sub>D</sub>                     | Drain current (continuous) at T <sub>C</sub> = 100 °C  | 5.7  | 5.7 <sup>(1)</sup> | 5.7    | A    |
| I <sub>DM</sub> <sup>(2)</sup>     | Drain current (pulsed)   | 36   | 36 <sup>(1)</sup>  | 36     | A    |
| P <sub>TOT</sub>                   | Total dissipation at T <sub>C</sub> = 25 °C  | 115  | 35                 | 156    | W    |
|                                    | Derating factor  | 0.92   | 0.28               | 1.25   | W/°C |
| ESD                                | Gate-source human body model<br>(R = 1,5 kΩ, C = 100 pF)   | 4  |                    |        | kV   |
| dv/dt <sup>(3)</sup>               | Peak diode recovery voltage slope  | 4.5  |                    |        | V/ns |
| V <sub>ISO</sub>                   | Insulation withstand voltage (RMS) from<br>all three leads to external heat sink<br>(t=1 s; T <sub>C</sub> =25 °C) | --   | 2500               | --     | V    |
| T <sub>j</sub><br>T <sub>stg</sub> | Operating junction temperature<br>Storage temperature  | -55 to 150   |                    |        | °C   |

1. Limited by maximum junction temperature
2. Pulse width limited by safe operating area
3. I<sub>SD</sub> < 10A, di/dt < 200A/μs, V<sub>DD</sub> = 80% V<sub>(BR)DSS</sub>

**Table 3. Thermal data**

| Symbol                | Parameter  | Value                                    |        |          |        | Unit |
|-----------------------|--|--|--------|----------|--------|------|
|                       |  | I <sup>2</sup> PAK<br>D <sup>2</sup> PAK | TO-220 | TO-220FP | TO-247 |      |
| R <sub>thj-case</sub> | Thermal resistance junction-case max                                       | 1.09                                     |        | 3.6      | 0.8    | °C/W |
| R <sub>thj-pcb</sub>  | Thermal resistance junction-pcb max<br>(when mounted on minimum footprint) | 35                                       |        |          |        | °C/W |
| R <sub>thj-amb</sub>  | Thermal resistance junction-amb max  | 62.5                                     |        |          | 50     | °C/W |

**Table 4. Avalanche characteristics**

| Symbol   | Parameter   | Max value | Unit |
|----------|---|-----------|------|
| $I_{AR}$ | Avalanche current, repetitive or not-repetitive<br>(pulse width limited by $T_j$ max)                 | 9         | A    |
| $E_{AS}$ | Single pulse avalanche energy<br>(starting $T_j=25\text{ °C}$ , $I_D=I_{AR}$ , $V_{DD}=50\text{ V}$ ) | 300       | mJ   |
| $E_{AR}$ | Repetitive avalanche energy<br>(pulse width limited by $T_j$ max)                                     | 3.5       | mJ   |

## 2 Electrical characteristics

(T<sub>case</sub> = 25 °C unless otherwise specified)

**Table 5. On /off states**

| Symbol               | Parameter   | Test conditions  | Min. | Typ. | Max.    | Unit     |
|----------------------|---|--|------|------|---------|----------|
| V <sub>(BR)DSS</sub> | Drain-source breakdown voltage                        | I <sub>D</sub> = 250 μA, V <sub>GS</sub> = 0                                 | 600  |      |         | V        |
| I <sub>DSS</sub>     | Zero gate voltage drain current (V <sub>GS</sub> = 0) | V <sub>DS</sub> = 600 V,<br>V <sub>DS</sub> = 600 V, T <sub>C</sub> = 125 °C |      |      | 1<br>50 | μA<br>μA |
| I <sub>GSS</sub>     | Gate body leakage current (V <sub>DS</sub> = 0)       | V <sub>GS</sub> = ± 20 V   |      |      | ±10     | μA       |
| V <sub>GS(th)</sub>  | Gate threshold voltage                                | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250 μA                  | 3    | 3.75 | 4.5     | V        |
| R <sub>DS(on)</sub>  | Static drain-source on-resistance                     | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 4.5 A                               |      | 0.65 | 0.75    | Ω        |

**Table 6. Dynamic**

| Symbol   | Parameter   | Test conditions   | Min. | Typ.              | Max. | Unit           |
|--|---|---|------|-------------------|------|----------------|
| g <sub>fs</sub> <sup>(1)</sup>                           | Forward transconductance  | V <sub>DS</sub> = 15 V, I <sub>D</sub> = 4.5 A  |      | 7.8               |      | S              |
| C <sub>iss</sub><br>C <sub>oss</sub><br>C <sub>rss</sub> | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | V <sub>DS</sub> = 25 V, f = 1 MHz, V <sub>GS</sub> = 0                                  |      | 1370<br>156<br>37 |      | pF<br>pF<br>pF |
| C <sub>oss eq</sub> <sup>(2)</sup>                       | Equivalent output capacitance   | V <sub>GS</sub> = 0, V <sub>DS</sub> = 0 to 480 V                                       |      | 90                |      | pF             |
| Q <sub>g</sub><br>Q <sub>gs</sub><br>Q <sub>gd</sub>     | Total gate charge<br>Gate-source charge<br>Gate-drain charge            | V <sub>DD</sub> = 480 V, I <sub>D</sub> = 8 A<br>V <sub>GS</sub> = 10 V (see Figure 20) |      | 50<br>10<br>25    | 70   | nC<br>nC<br>nC |

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

2. C<sub>oss eq</sub> is defined as a constant equivalent capacitance giving the same charging time as C<sub>oss</sub> when V<sub>DS</sub> increases from 0 to 80%

**Table 7. Switching times**

| Symbol                | Parameter                        | Test conditions   | Min. | Typ.     | Max. | Unit     |
|-----------------------|----------------------------------|---|------|----------|------|----------|
| $t_{d(on)}$<br>$t_r$  | Turn-on delay time<br>Rise time  | $V_{DD}=300\text{ V}$ , $I_D=4\text{ A}$ ,<br>$R_G=4.7\ \Omega$ , $V_{GS}=10\text{ V}$<br>(see Figure 19) | -    | 20<br>20 | -    | ns<br>ns |
| $t_{d(off)}$<br>$t_f$ | Turn-off delay time<br>Fall time | $V_{DD}=300\text{ V}$ , $I_D=4\text{ A}$ ,<br>$R_G=4.7\ \Omega$ , $V_{GS}=10\text{ V}$<br>(see Figure 19) | -    | 55<br>30 | -    | ns<br>ns |

**Table 8. Source drain diode**

| Symbol          | Parameter                     | Test conditions  | Min. | Typ. | Max. | Unit          |
|-----------------|-------------------------------|--|------|------|------|---------------|
| $I_{SD}$        | Source-drain current          |  | -    |      | 10   | A             |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |  | -    |      | 36   | A             |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD}=10\text{ A}$ , $V_{GS}=0$  | -    |      | 1.6  | V             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD}=8\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ ,<br>$V_{DD}=40\text{ V}$ , $T_j=150\text{ }^\circ\text{C}$ | -    | 570  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |  | -    | 4.3  |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |  | -    | 15   |      | A             |

1. Pulse width limited by safe operating area
2. Pulsed: pulse duration = 300 $\mu\text{s}$ , duty cycle 1.5%

**Table 9. 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-to-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 I<sup>2</sup>PAK, D<sup>2</sup>PAK and TO-220

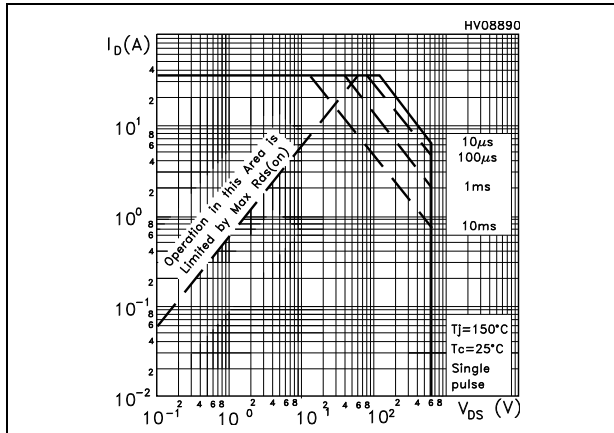


Figure 3. Thermal impedance for I<sup>2</sup>PAK, D<sup>2</sup>PAK and TO-220

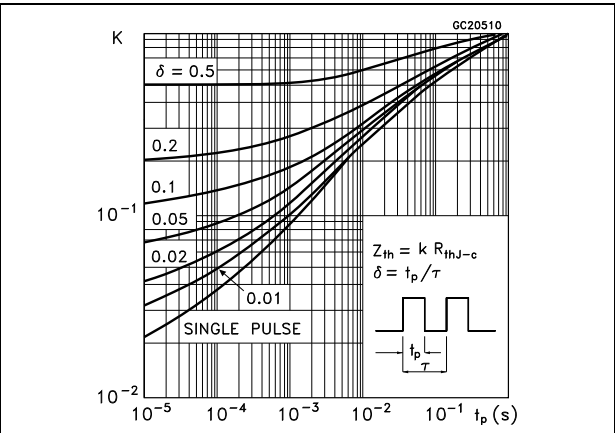


Figure 4. Safe operating area for TO-220FP

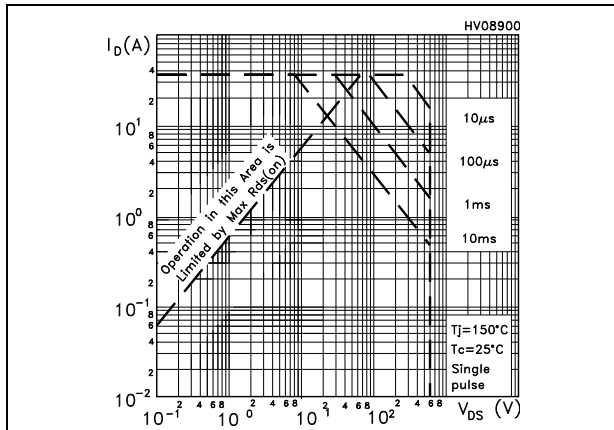


Figure 5. Thermal impedance for TO-220FP

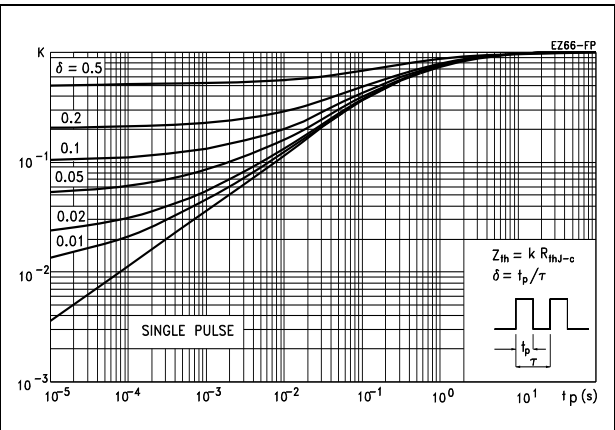


Figure 6. Safe operating area for TO-247

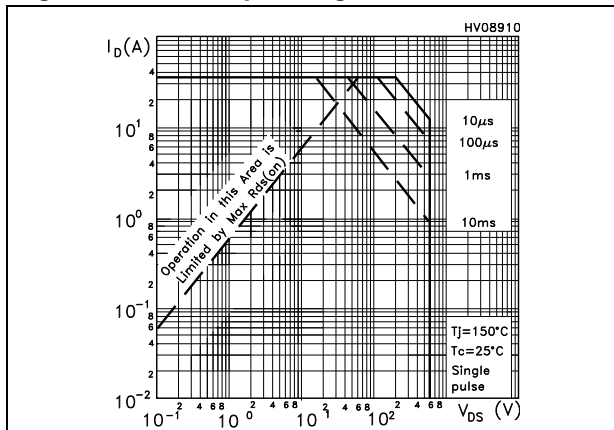


Figure 7. Thermal impedance for TO-247

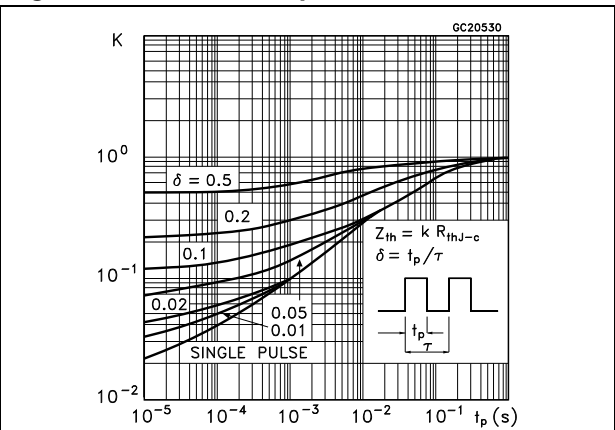


Figure 8. Output characteristics

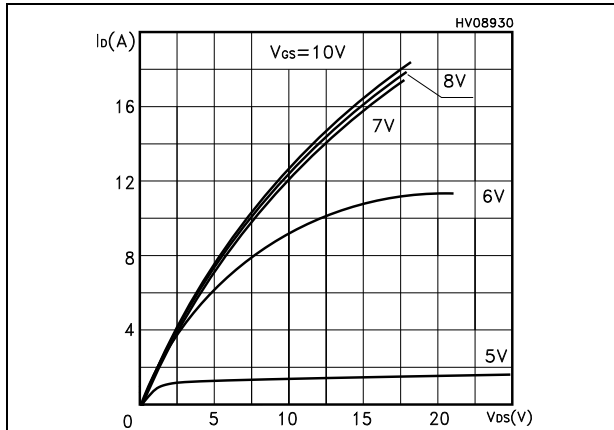


Figure 9. Transfer characteristics

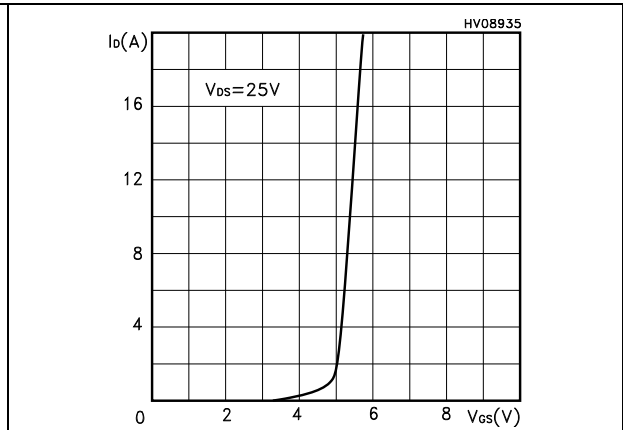


Figure 10. Transconductance

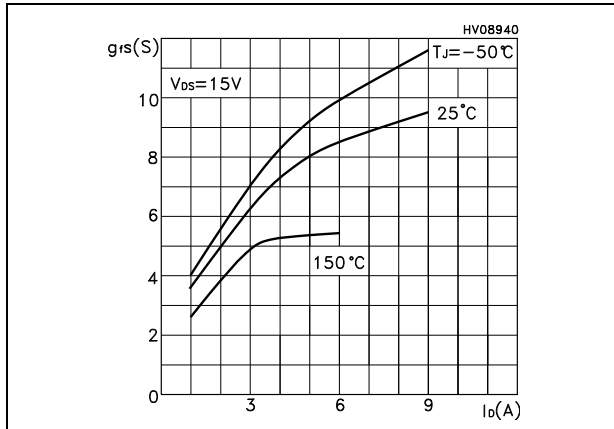


Figure 11. Static drain-source on-resistance

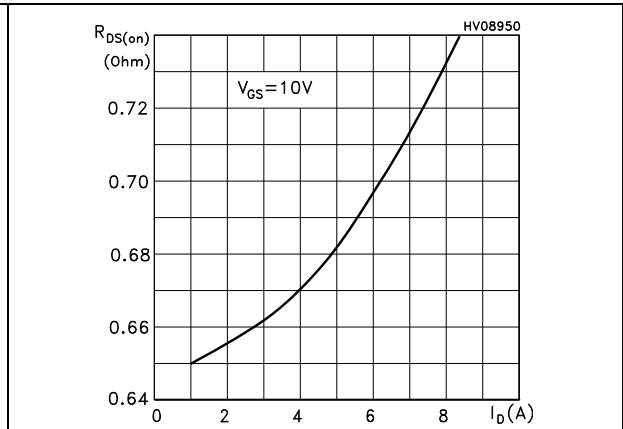


Figure 12. Gate charge vs gate-source voltage Figure 13. Capacitance variations

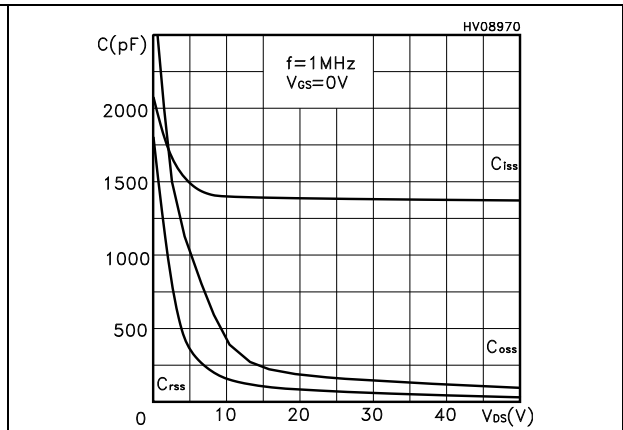
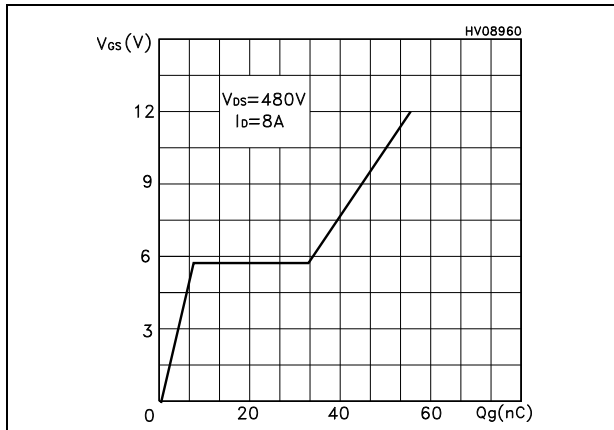




Figure 14. Normalized gate threshold voltage vs temperature

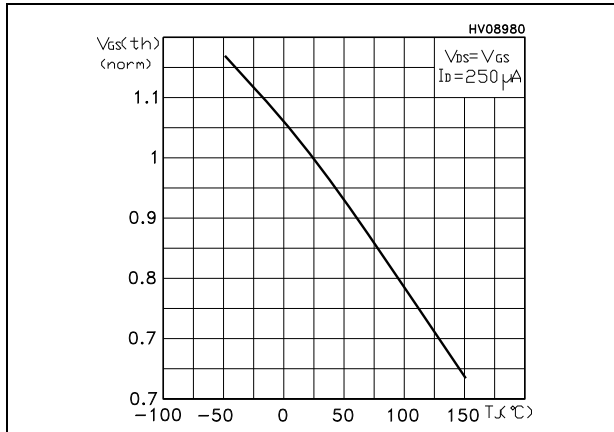


Figure 15. Normalized on-resistance vs temperature

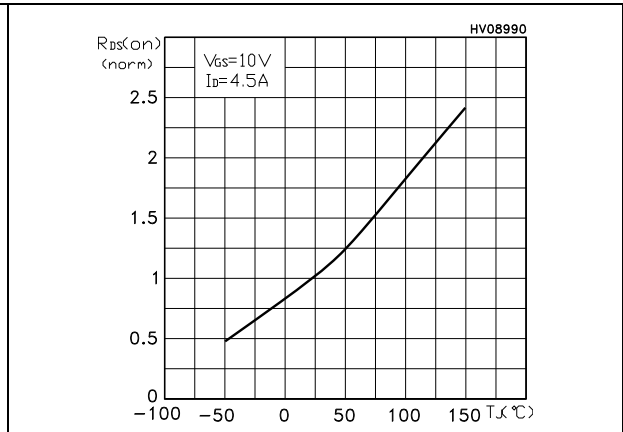


Figure 16. Source-drain diode forward characteristics

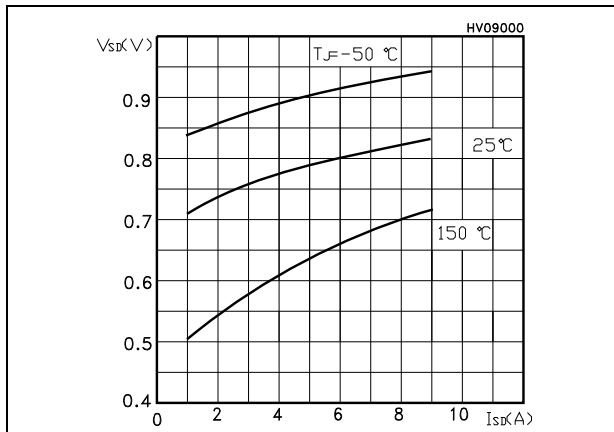


Figure 17. Maximum avalanche energy vs temperature

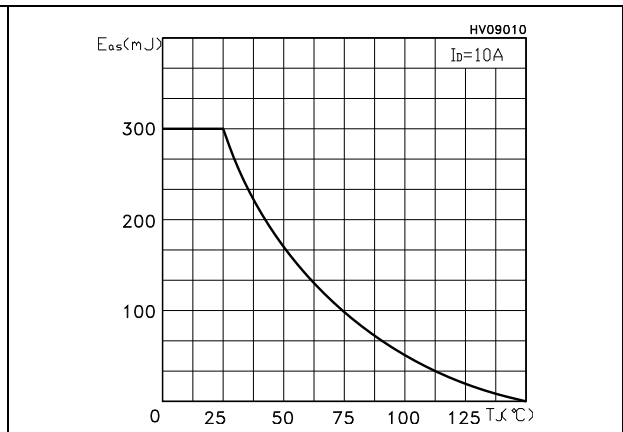
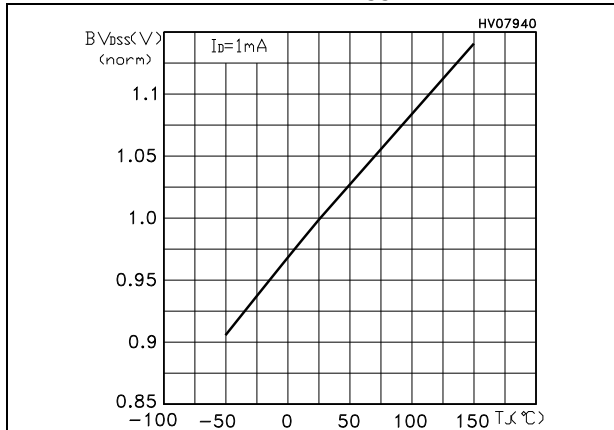
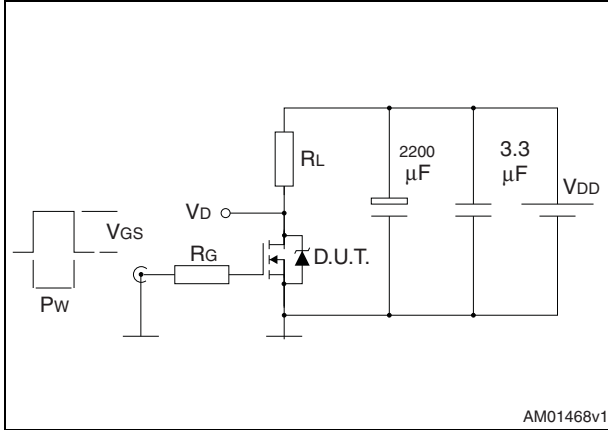


Figure 18. Normalized B<sub>V</sub>DSS vs temperature

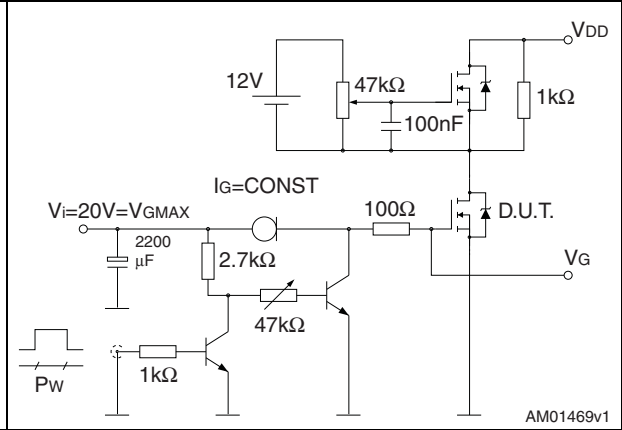


### 3 Test circuits

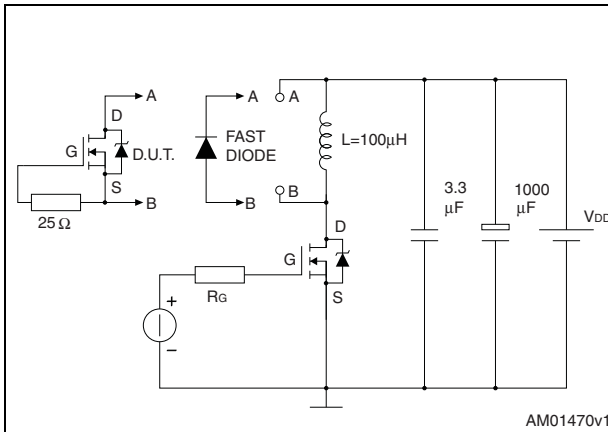
**Figure 19. Switching times test circuit for resistive load**



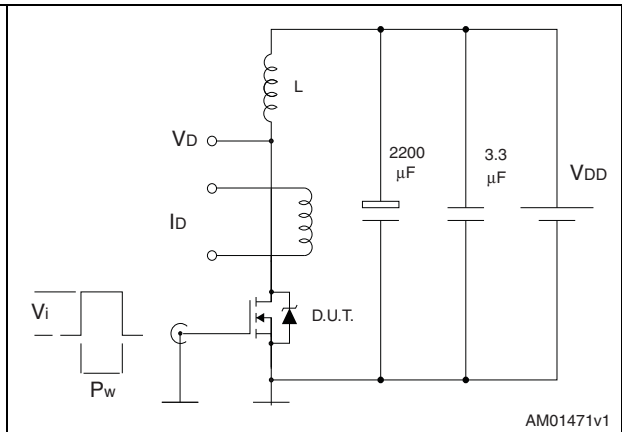
**Figure 20. Gate charge test circuit**



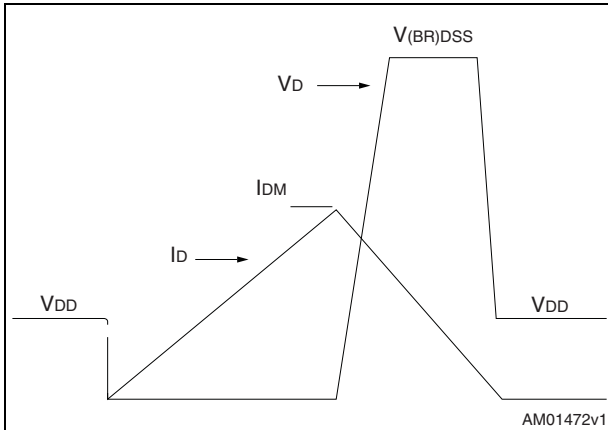
**Figure 21. Test circuit for inductive load switching and diode recovery times**



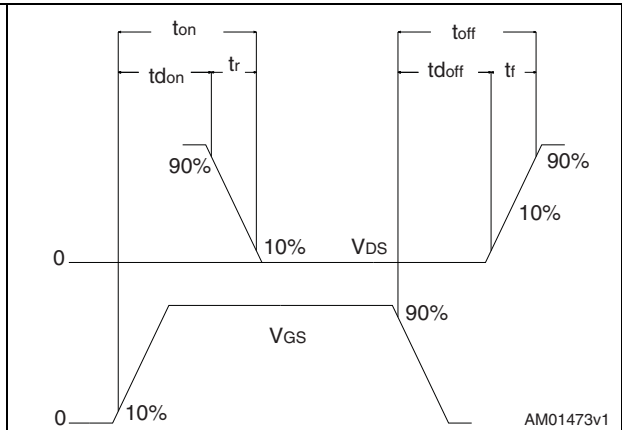
**Figure 22. Unclamped inductive load test circuit**



**Figure 23. Unclamped inductive waveform**



**Figure 24. Switching time waveform**



## 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 10. I<sup>2</sup>PAK (TO-262) mechanical data**

| DIM. | mm.  |     |       |
|------|------|-----|-------|
|      | min. | typ | max.  |
| A    | 4.40 |     | 4.60  |
| A1   | 2.40 |     | 2.72  |
| b    | 0.61 |     | 0.88  |
| b1   | 1.14 |     | 1.70  |
| c    | 0.49 |     | 0.70  |
| c2   | 1.23 |     | 1.32  |
| D    | 8.95 |     | 9.35  |
| e    | 2.40 |     | 2.70  |
| e1   | 4.95 |     | 5.15  |
| E    | 10   |     | 10.40 |
| L    | 13   |     | 14    |
| L1   | 3.50 |     | 3.93  |
| L2   | 1.27 |     | 1.40  |

Figure 25. I<sup>2</sup>PAK (TO-262) drawing

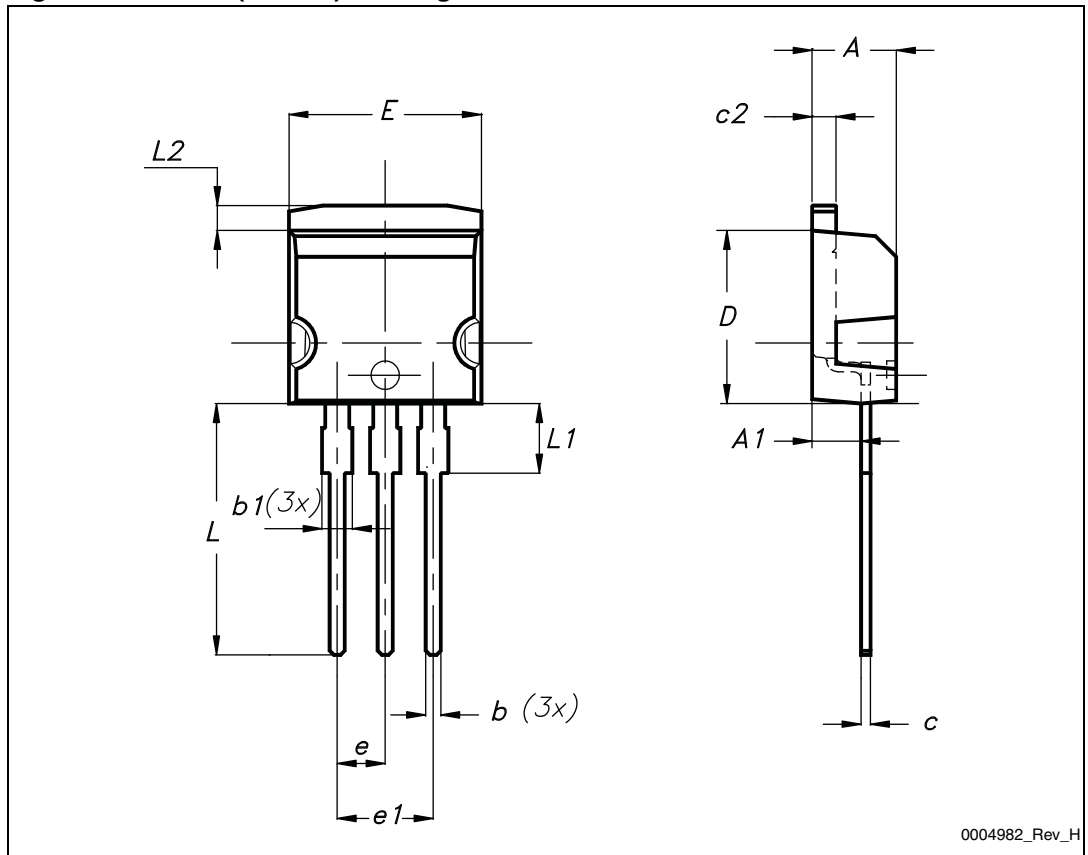


Table 11. D<sup>2</sup>PAK (TO-263) mechanical data

| 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 26. D<sup>2</sup>PAK (TO-263) drawing

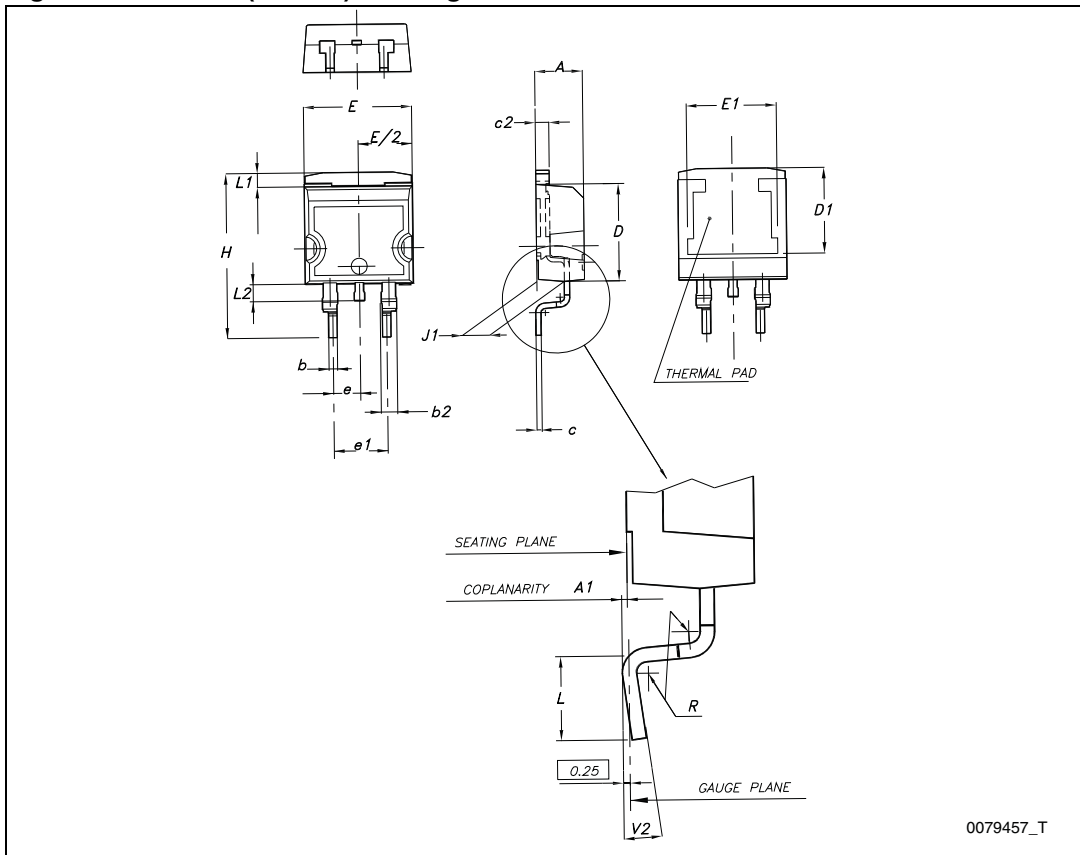
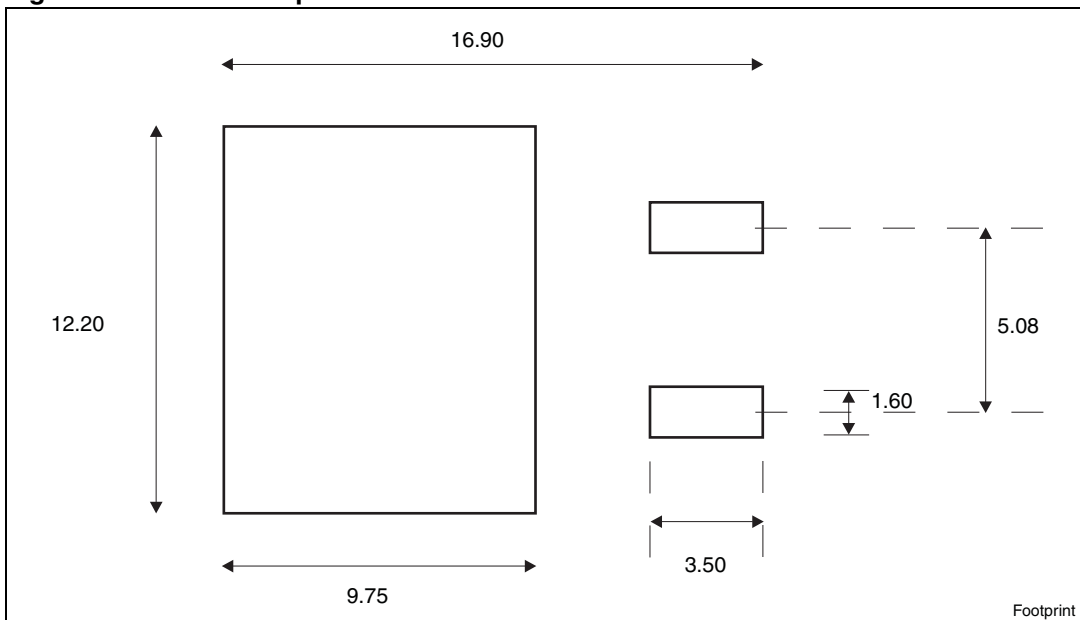


Figure 27. D<sup>2</sup>PAK footprint<sup>(a)</sup>



a. All dimensions are in millimeters

Table 12. 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

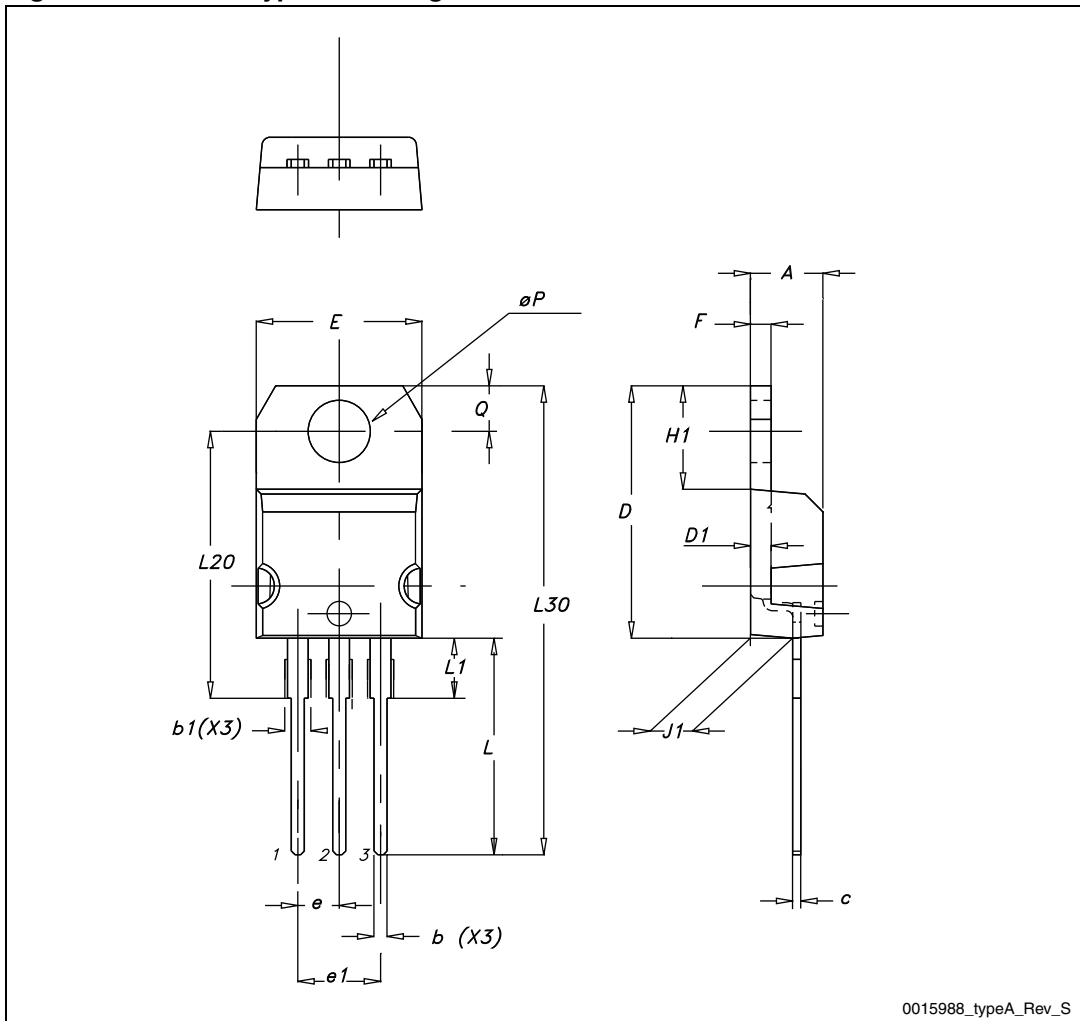
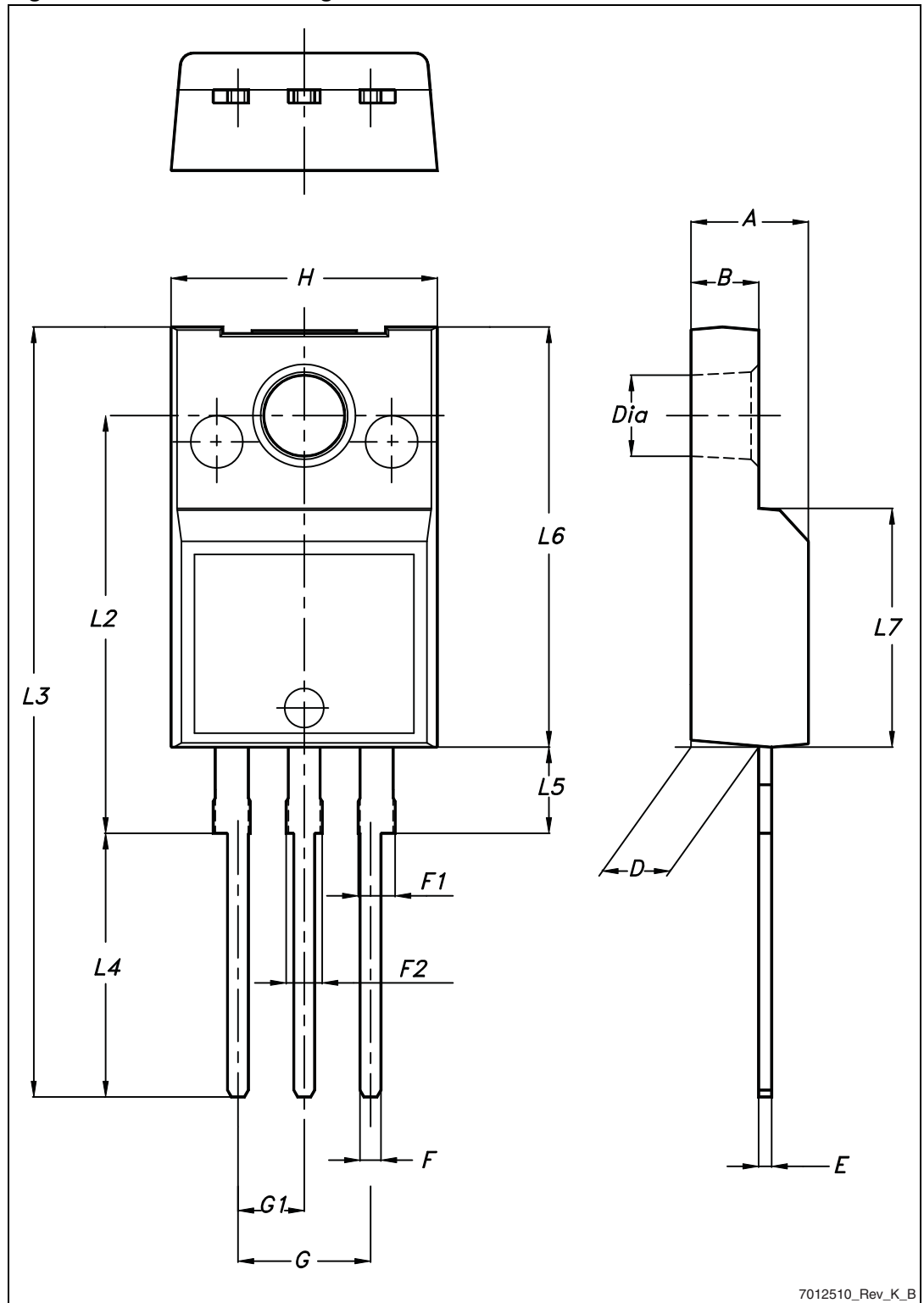




Table 13. TO-220FP mechanical data

| 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 29. TO-220FP drawing

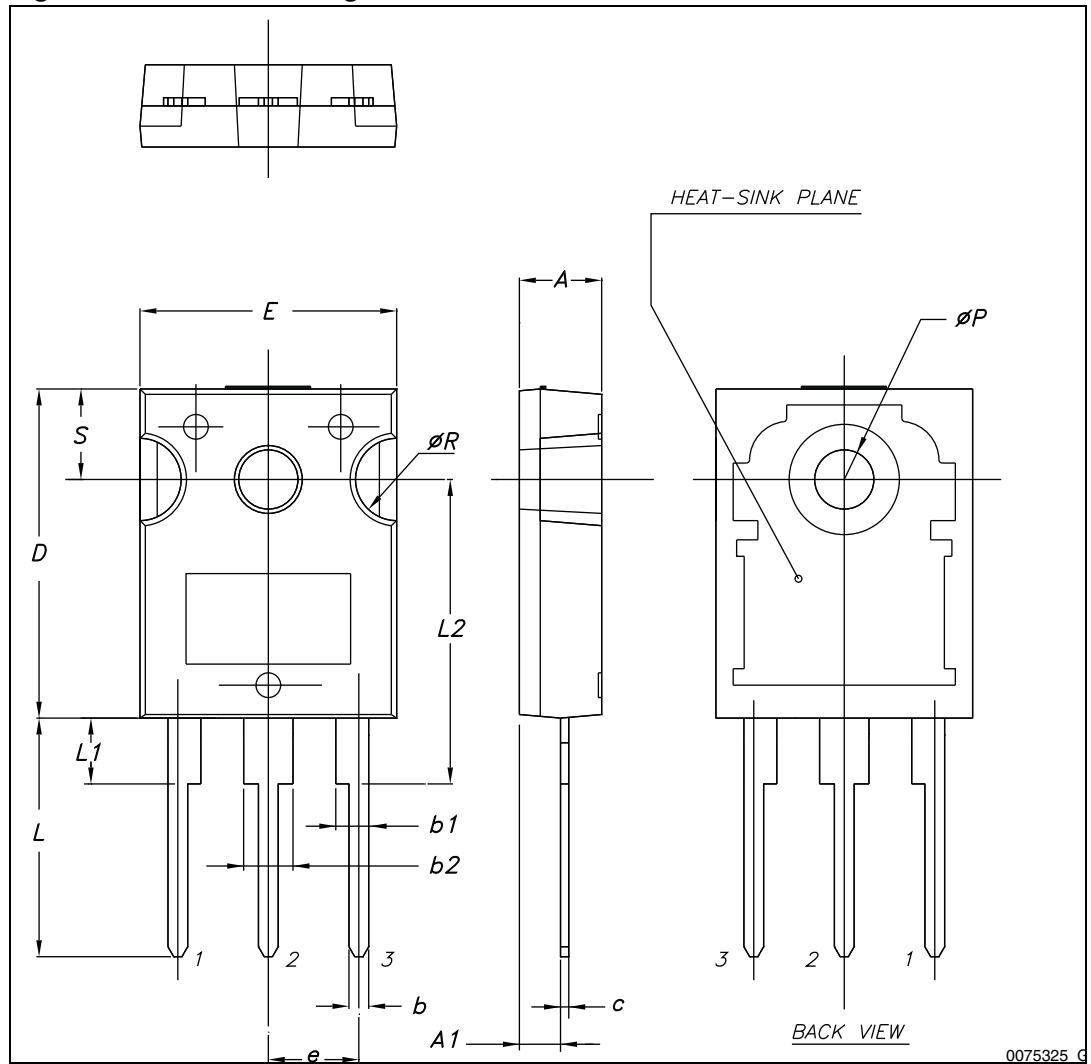


7012510\_Rev\_K\_B

Table 14. 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 30. TO-247 drawing



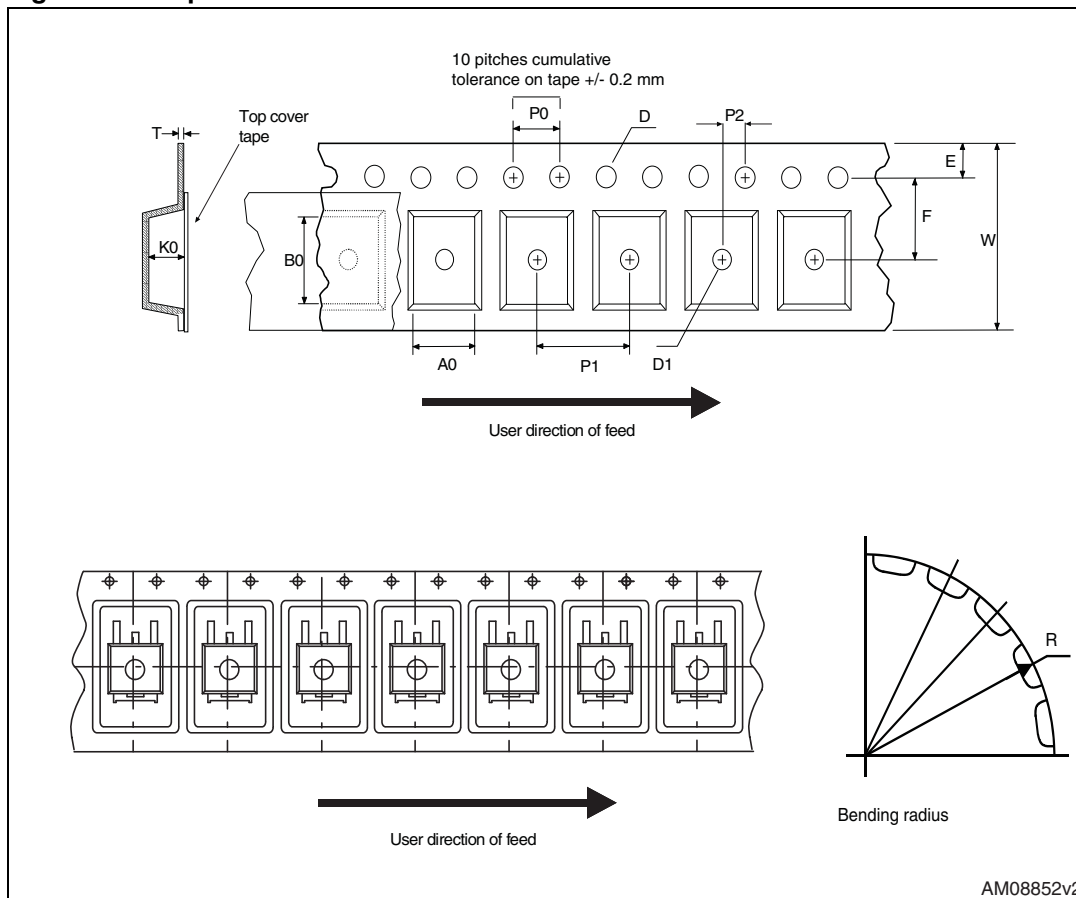
0075325 G

## 5 Packaging mechanical data

Table 15. D<sup>2</sup>PAK (TO-263) tape and reel mechanical data

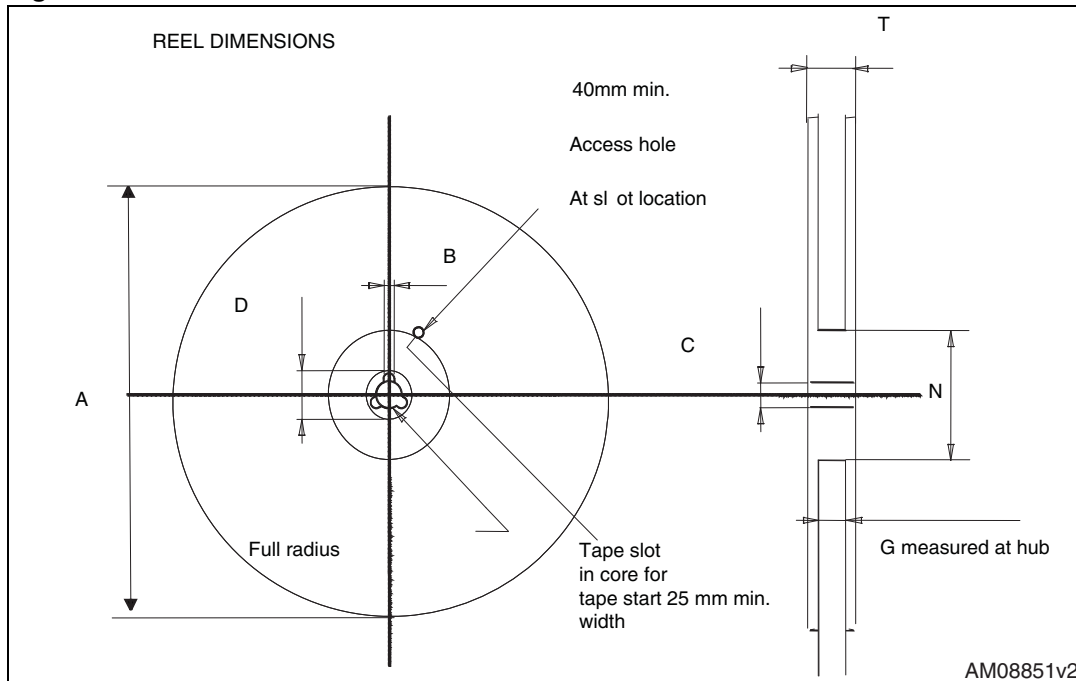
| Tape |      |      | Reel |          |      |
|------|------|------|------|----------|------|
| Dim. | mm   |      | Dim. | mm       |      |
|      | Min. | Max. |      | Min.     | Max. |
| A0   | 10.5 | 10.7 | A    |          | 330  |
| B0   | 15.7 | 15.9 | B    | 1.5      |      |
| D    | 1.5  | 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 31. Tape



AM08852v2

Figure 32. Reel



AM08851v2

## 6 Revision history

**Table 16. Document revision history**

| Date        | Revision | Changes  |
|-------------|----------|--|
| 29-Sep-2005 | 6        | Inserted ecopack indication  |
| 29-Oct-2005 | 7        | New value inserted in <a href="#">Table 6</a>  |
| 11-Apr-2006 | 8        | New template   |
| 19-Sep-2006 | 9        | Unit changed in <a href="#">Table 5</a>  |
| 17-Nov-2008 | 10       | Updated <a href="#">Section 4: Package mechanical data</a>   |
| 15-Nov-2012 | 11       | Updated <a href="#">Table 2: Absolute maximum ratings</a> , <a href="#">Table 3: Thermal data</a> , <a href="#">Table 5: On /off states</a> and <a href="#">Table 9: Gate-source Zener diode</a> .<br>Updated <a href="#">Section 4: Package mechanical data</a> and <a href="#">Section 5: Packaging mechanical data</a> .<br>Minor text changes. |

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