

N-channel 950 V, 0.275  $\Omega$  typ., 17.5 A MDmesh™ K5  
Power MOSFETs in D<sup>2</sup>PAK, TO-220FP, TO-220 and TO-247

Datasheet - production data

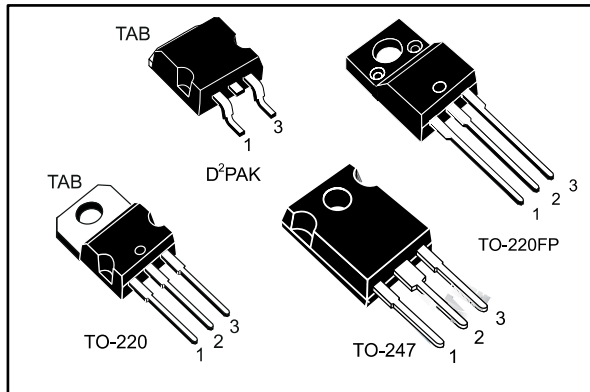
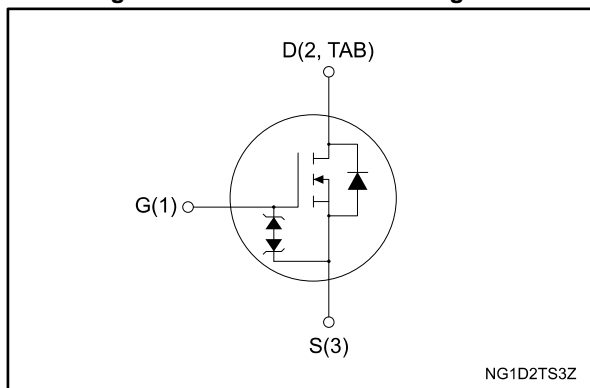


Figure 1: Internal schematic diagram



## Features

| Order code | V <sub>DS</sub> | R <sub>DS(on)</sub> max. | I <sub>D</sub> | P <sub>TOT</sub> |
|------------|-----------------|--------------------------|----------------|------------------|
| STB20N95K5 | 950 V           | 0.330 $\Omega$           | 17.5 A         | 250 W            |
| STF20N95K5 |                 |                          |                | 40 W             |
| STP20N95K5 |                 |                          |                | 250 W            |
| STW20N95K5 |                 |                          |                |                  |

- Industry's lowest R<sub>DS(on)</sub> x area
- Industry's best FoM (figure of merit)
- Ultra-low gate charge
- 100% avalanche tested
- Zener-protected

## Applications

- Switching applications

## Description

These very high voltage N-channel Power MOSFETs are designed using MDmesh™ K5 technology based on an innovative proprietary vertical structure. The result is a dramatic reduction in on-resistance and ultra-low gate charge for applications requiring superior power density and high efficiency.

Table 1: Device summary

| Order code | Marking | Package            | Packing       |
|------------|---------|--------------------|---------------|
| STB20N95K5 | 20N95K5 | D <sup>2</sup> PAK | Tape and reel |
| STF20N95K5 |         | TO-220FP           | Tube          |
| STP20N95K5 |         | TO-220             |               |
| STW20N95K5 |         | TO-247             |               |

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# 1 Electrical ratings

Table 2: Absolute maximum ratings

| Symbol                        | Parameter   | Value                                  |          | Unit |
|-------------------------------|---|--|----------|------|
|                               |   | D <sup>2</sup> PAK<br>TO-220<br>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  | 17.5                                   |          | A    |
| I <sub>D</sub>                | Drain current (continuous) at T <sub>C</sub> = 100 °C   | 11                                     |          | A    |
| I <sub>D</sub> <sup>(1)</sup> | Drain current (pulsed)  | 70                                     |          | A    |
| P <sub>TOT</sub>              | Total dissipation at T <sub>C</sub> = 25 °C   | 250                                    | 40       | W    |
| ESD                           | Gate-source human body model (R= 1,5 kΩ, C = 100 pF)  | 2                                      |          | kV   |
| 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>(2)</sup>          | Peak diode recovery voltage slope   | 6                                      |          | V/ns |
| dv/dt <sup>(3)</sup>          | MOSFET dv/dt ruggedness   | 50                                     |          |      |
| T <sub>j</sub>                | Operating junction temperature range  | -55 to 150                             |          | °C   |
| T <sub>stg</sub>              | Storage temperature range   |  |          |      |

**Notes:**

- (1) Pulse width limited by safe operating area.
- (2) I<sub>SD</sub> ≤ 17.5 A, di/dt ≤ 100 A/μs; V<sub>DS</sub> peak ≤ V<sub>(BR)DSS</sub>
- (3) V<sub>DS</sub> ≤ 760 V

Table 3: Thermal data

| Symbol                              | Parameter                           | Value              |        |        |          | Unit |
|-------------------------------------|-------------------------------------|--------------------|--------|--------|----------|------|
|                                     |                                     | D <sup>2</sup> PAK | TO-220 | TO-247 | TO-220FP |      |
| R <sub>thj-case</sub>               | Thermal resistance junction-case    | 0.5                |        |        | 3.1      | °C/W |
| R <sub>thj-amb</sub>                | Thermal resistance junction-ambient |                    | 62.5   | 50     | 62.5     |      |
| R <sub>thj-pcb</sub> <sup>(1)</sup> | Thermal resistance junction-pcb     | 30                 |        |        |          |      |

**Notes:**

- (1) When mounted on 1 inch<sup>2</sup> FR-4 board, 2 Oz Cu.

Table 4: Avalanche characteristics

| Symbol          | Parameter  | Value | Unit |
|-----------------|--|-------|------|
| I <sub>AR</sub> | Avalanche current, repetitive or not repetitive (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   |

## 2 Electrical characteristics

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

Table 5: On/off-state

| Symbol               | Parameter                         | Test conditions  | Min. | Typ.  | Max.  | Unit |
|----------------------|-----------------------------------|--|------|-------|-------|------|
| V <sub>(BR)DSS</sub> | Drain-source breakdown voltage    | V <sub>GS</sub> = 0 V, I <sub>D</sub> = 1 mA   | 950  |       |       | V    |
| I <sub>DSS</sub>     | Zero-gate voltage drain current   | V <sub>GS</sub> = 0 V, V <sub>DS</sub> = 950 V   |      |       | 1     | µA   |
|                      |                                   | V <sub>GS</sub> = 0 V, V <sub>DS</sub> = 950 V<br>T <sub>C</sub> = 125 °C <sup>(1)</sup> |      |       | 50    | µA   |
| I <sub>GSS</sub>     | Gate body leakage current         | V <sub>DS</sub> = 0 V, 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> = 100 µA                              | 3    | 4     | 5     | V    |
| R <sub>DS(on)</sub>  | Static drain-source on-resistance | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 9 A   |      | 0.275 | 0.330 | Ω    |

**Notes:**

<sup>(1)</sup>Defined by design, not subject to production test.

Table 6: Dynamic

| Symbol                            | Parameter                             | Test conditions   | Min. | Typ. | Max. | Unit |
|-----------------------------------|---------------------------------------|---|------|------|------|------|
| C <sub>iSS</sub>                  | Input capacitance                     | V <sub>DS</sub> = 100 V, f = 1 MHz,<br>V <sub>GS</sub> = 0 V  | -    | 1550 | -    | pF   |
| C <sub>oSS</sub>                  | Output capacitance                    |   | -    | 140  | -    | pF   |
| C <sub>rSS</sub>                  | Reverse transfer capacitance          |   | -    | 1    | -    | pF   |
| C <sub>o(er)</sub> <sup>(1)</sup> | Equivalent capacitance energy related | V <sub>GS</sub> = 0 V, V <sub>DS</sub> = 0 to<br>760 V  | -    | 65   | -    | pF   |
| C <sub>o(tr)</sub> <sup>(2)</sup> | Equivalent capacitance time related   |   |      | 178  | -    | pF   |
| R <sub>g</sub>                    | Intrinsic gate resistance             | f = 1 MHz, I <sub>D</sub> = 0 A   | -    | 3.5  | -    | Ω    |
| Q <sub>g</sub>                    | Total gate charge                     | V <sub>DD</sub> = 760 V,<br>I <sub>D</sub> = 17.5 A<br>V <sub>GS</sub> = 10 V<br>(see Figure 20: "Test circuit for gate charge behavior") | -    | 48   | -    | nC   |
| Q <sub>gs</sub>                   | Gate-source charge                    |   | -    | 9    | -    | nC   |
| Q <sub>gd</sub>                   | Gate-drain charge                     |   | -    | 32.5 | -    | nC   |

**Notes:**

<sup>(1)</sup>C<sub>o(er)</sub> is a constant capacitance value that gives the same stored energy as C<sub>oSS</sub> while V<sub>DS</sub> is rising from 0 to 80% V<sub>DSS</sub>.

<sup>(2)</sup>C<sub>o(tr)</sub> is a constant capacitance value that gives the same charging time as C<sub>oSS</sub> while V<sub>DS</sub> is rising from 0 to 80% V<sub>DSS</sub>.

Table 7: Switching times

| Symbol       | Parameter           | Test conditions   | Min. | Typ. | Max. | Unit |
|--------------|---------------------|---|------|------|------|------|
| $t_{d(on)}$  | Turn-on delay time  | $V_{DD} = 475\text{ V}$ , $I_D = 9\text{ A}$ , $R_G = 4.7\ \Omega$<br>$V_{GS} = 10\text{ V}$<br>(see <a href="#">Figure 19</a> : "Test circuit for resistive load switching times" and <a href="#">Figure 24</a> : "Switching time waveform") | -    | 18   | -    | ns   |
| $t_r$        | Rise time           |   | -    | 9    | -    | ns   |
| $t_{d(off)}$ | Turn-off delay time |   | -    | 65   | -    | ns   |
| $t_f$        | Fall time           |   | -    | 18   | -    | ns   |

Table 8: Source-drain diode

| Symbol          | Parameter                     | Test conditions   | Min. | Typ. | Max. | Unit          |
|-----------------|-------------------------------|---|------|------|------|---------------|
| $I_{SD}$        | Source-drain current          |   | -    |      | 17.5 | A             |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |   | -    |      | 70   | A             |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD} = 17.5\text{ A}$ , $V_{GS} = 0\text{ V}$  | -    |      | 1.5  | V             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 17.5\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ ,<br>$V_{DD} = 60\text{ V}$<br>(see <a href="#">Figure 21</a> : "Test circuit for inductive load switching and diode recovery times")                                   | -    | 513  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |   | -    | 12   |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |   | -    | 46   |      | A             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 17.5\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$<br>$V_{DD} = 60\text{ V}$ , $T_j = 150\text{ }^\circ\text{C}$<br>(see <a href="#">Figure 21</a> : "Test circuit for inductive load switching and diode recovery times") | -    | 670  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |   | -    | 15   |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |   | -    | 44   |      | A             |

**Notes:**

(1)Pulse width limited by safe operating area

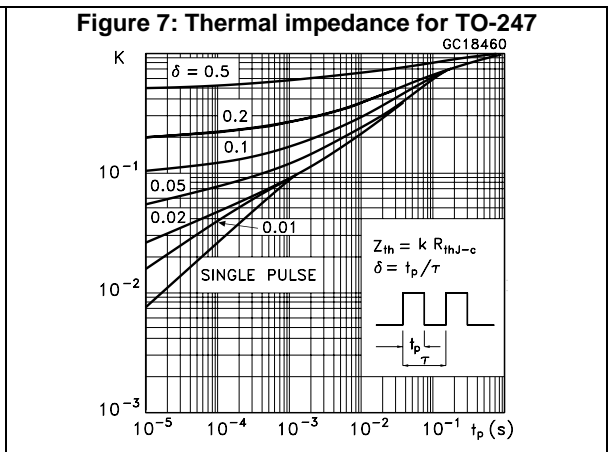
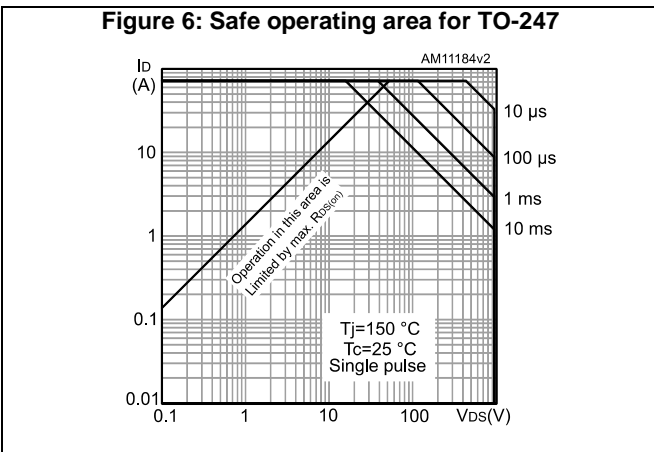
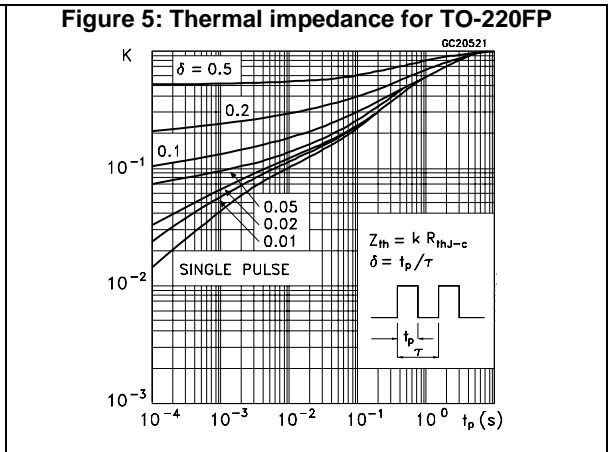
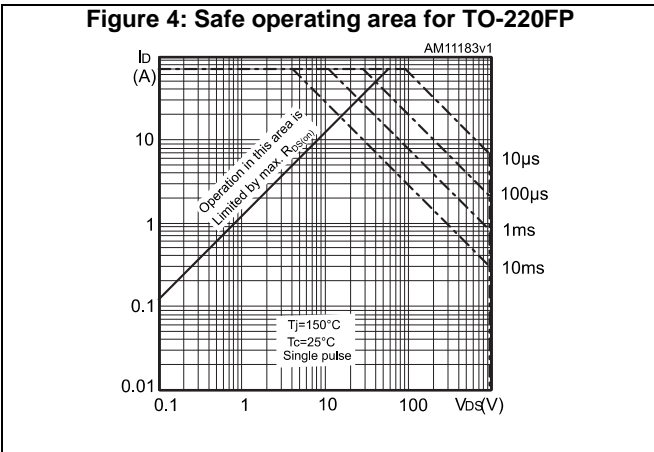
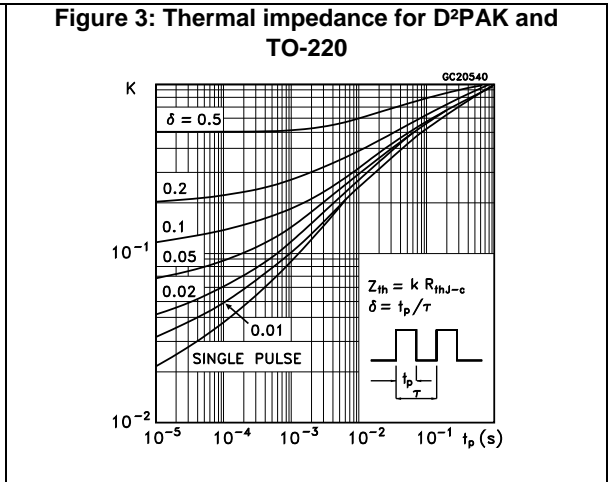
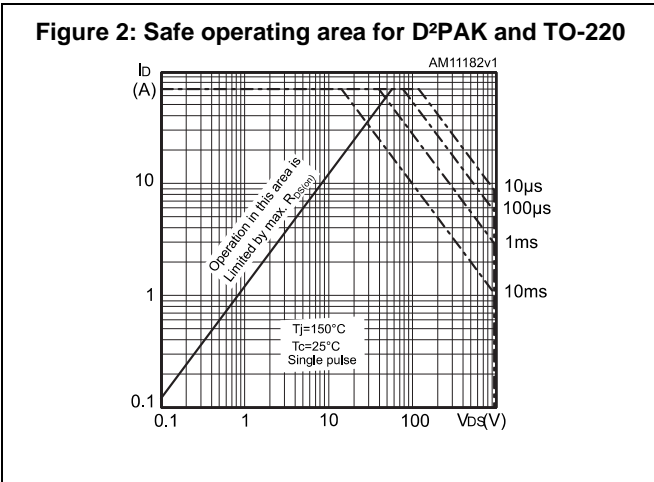
(2)Pulsed: pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%

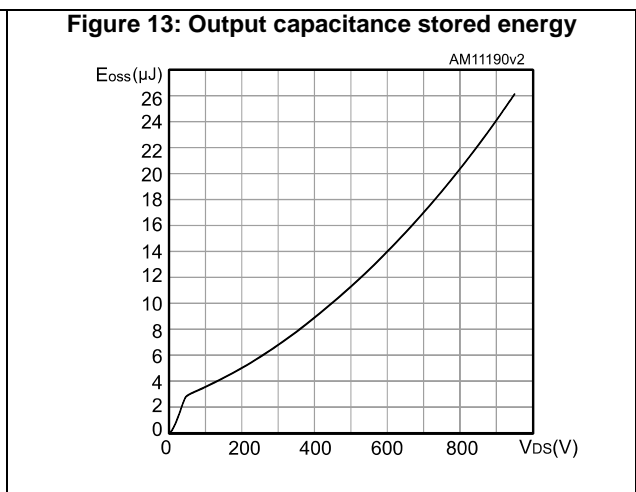
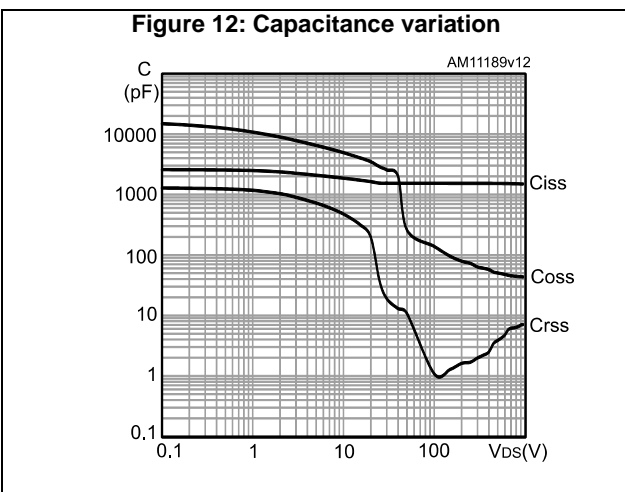
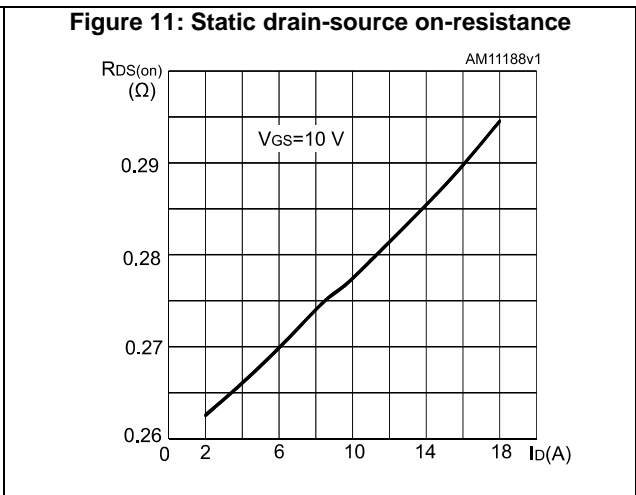
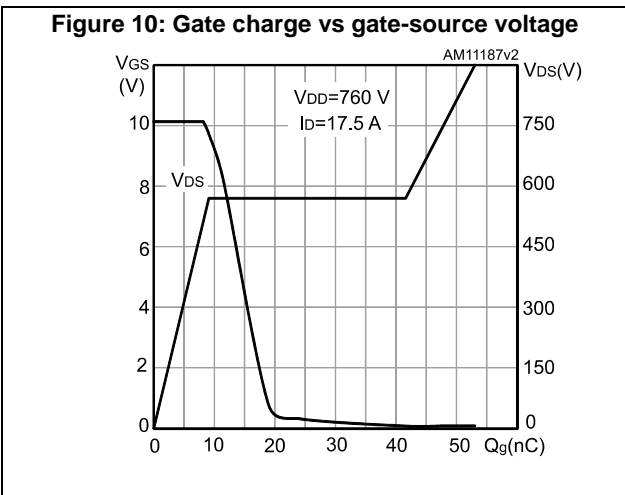
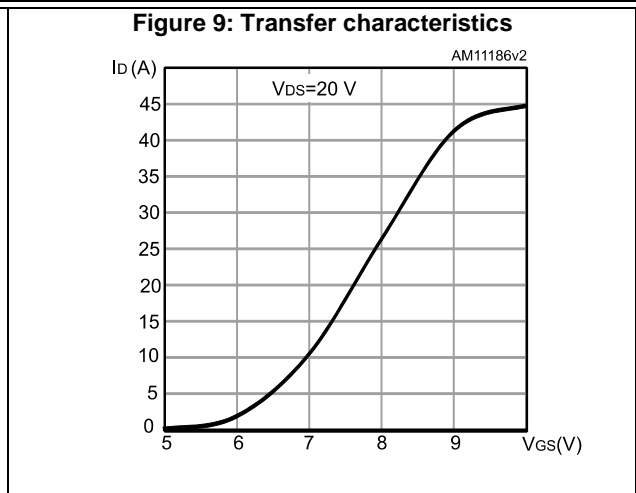
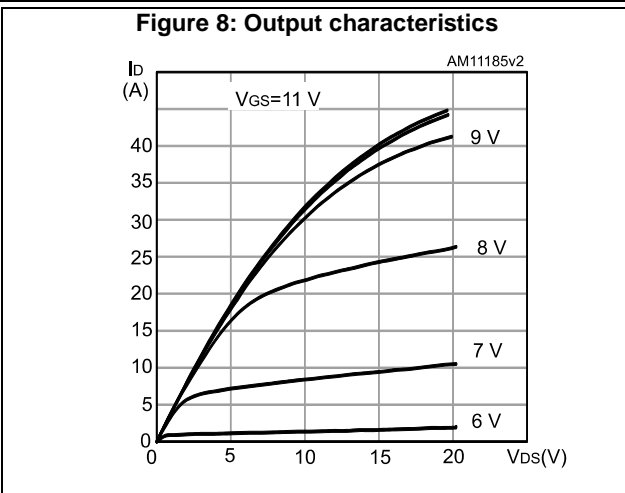
Table 9: Gate-source Zener diode

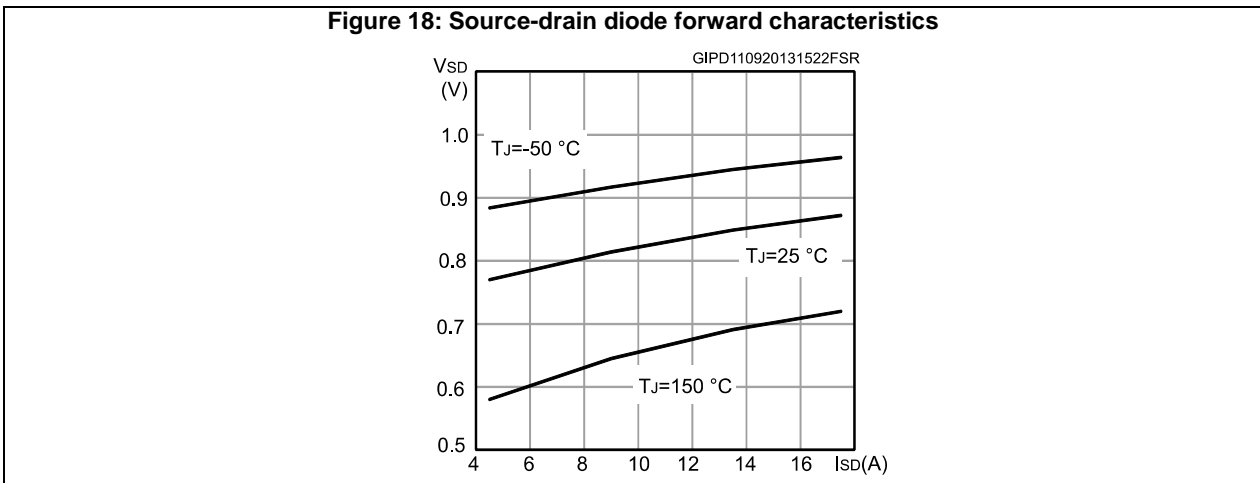
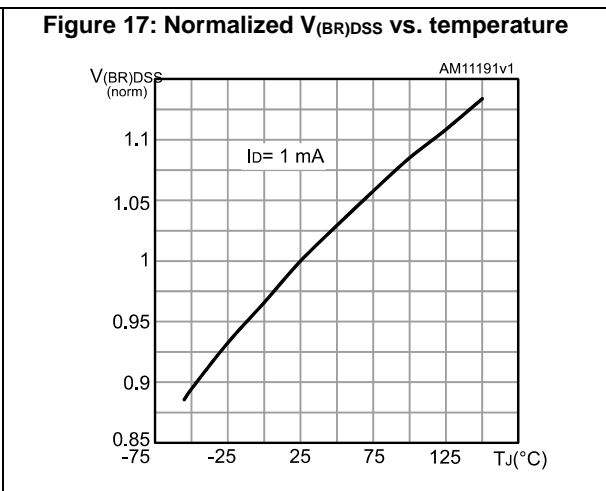
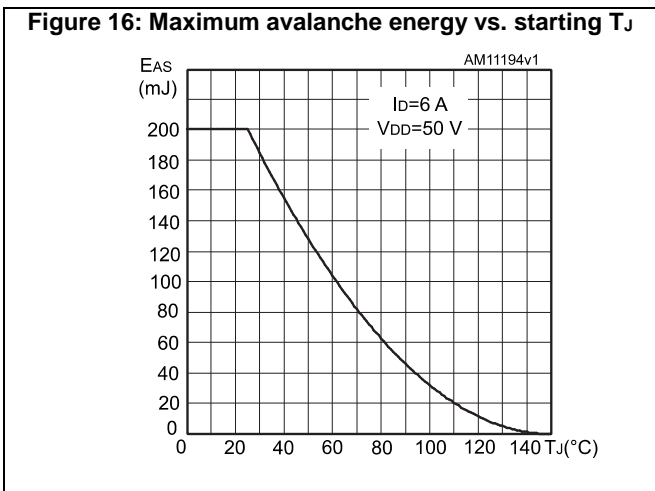
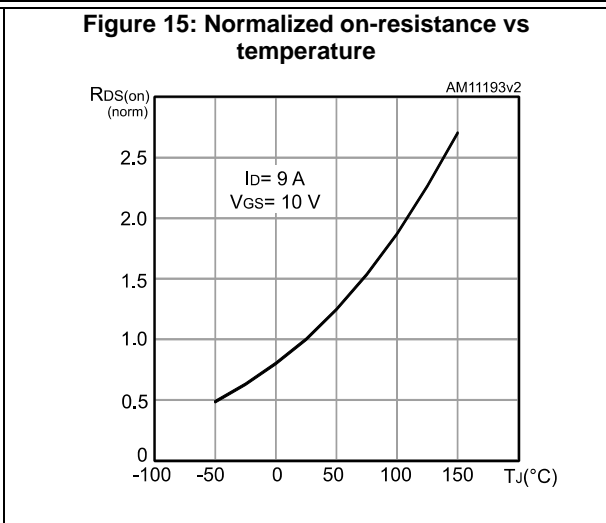
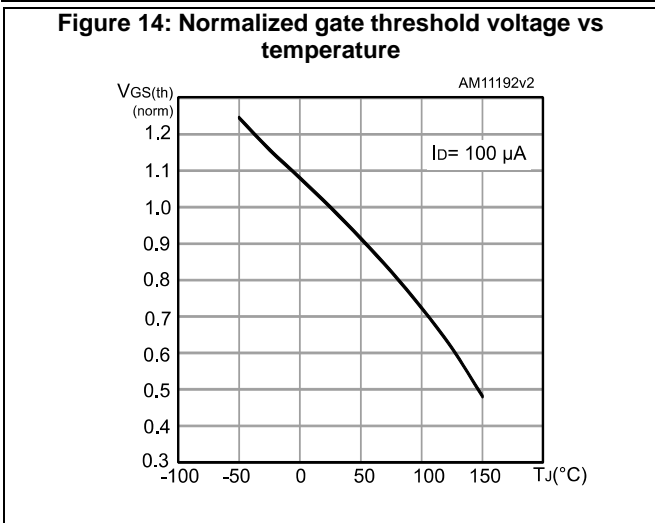
| Symbol        | Parameter                     | Test conditions                                 | Min. | Typ. | Max. | Unit |
|---------------|-------------------------------|---|------|------|------|------|
| $V_{(BR)GSO}$ | Gate-source breakdown voltage | $I_{GS} = \pm 1\text{ mA}$ , $I_D = 0\text{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

The built-in back-to-back Zener diodes are specifically designed to enhance the ESD performance of the device. The Zener voltage facilitates efficient and cost-effective device integrity protection, thus eliminating the need for additional external componentry.

## 2.1 Electrical characteristics (curves)



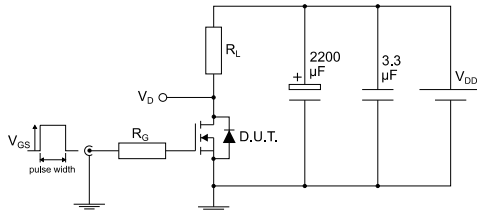






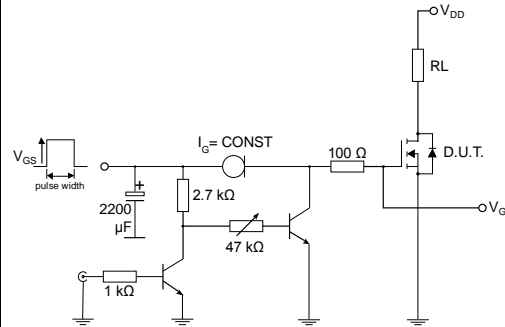
### 3 Test circuits

**Figure 19: Test circuit for resistive load switching times**



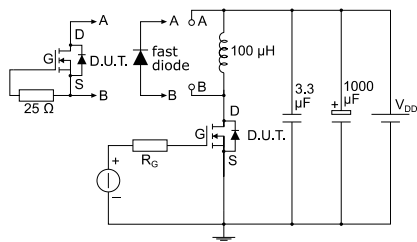
AM01468v1

**Figure 20: Test circuit for gate charge behavior**



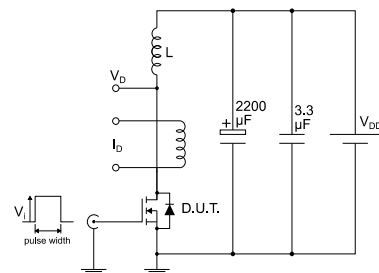
AM01469v10

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



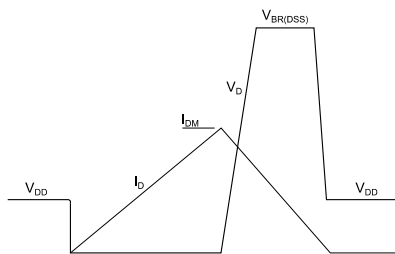
AM01470v1

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



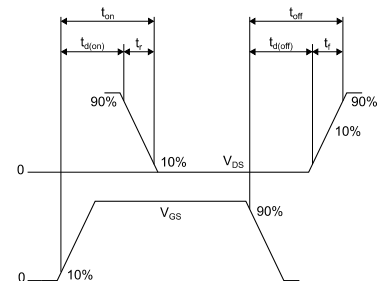
AM01471v1

**Figure 23: Unclamped inductive waveform**



AM01472v1

**Figure 24: Switching time waveform**



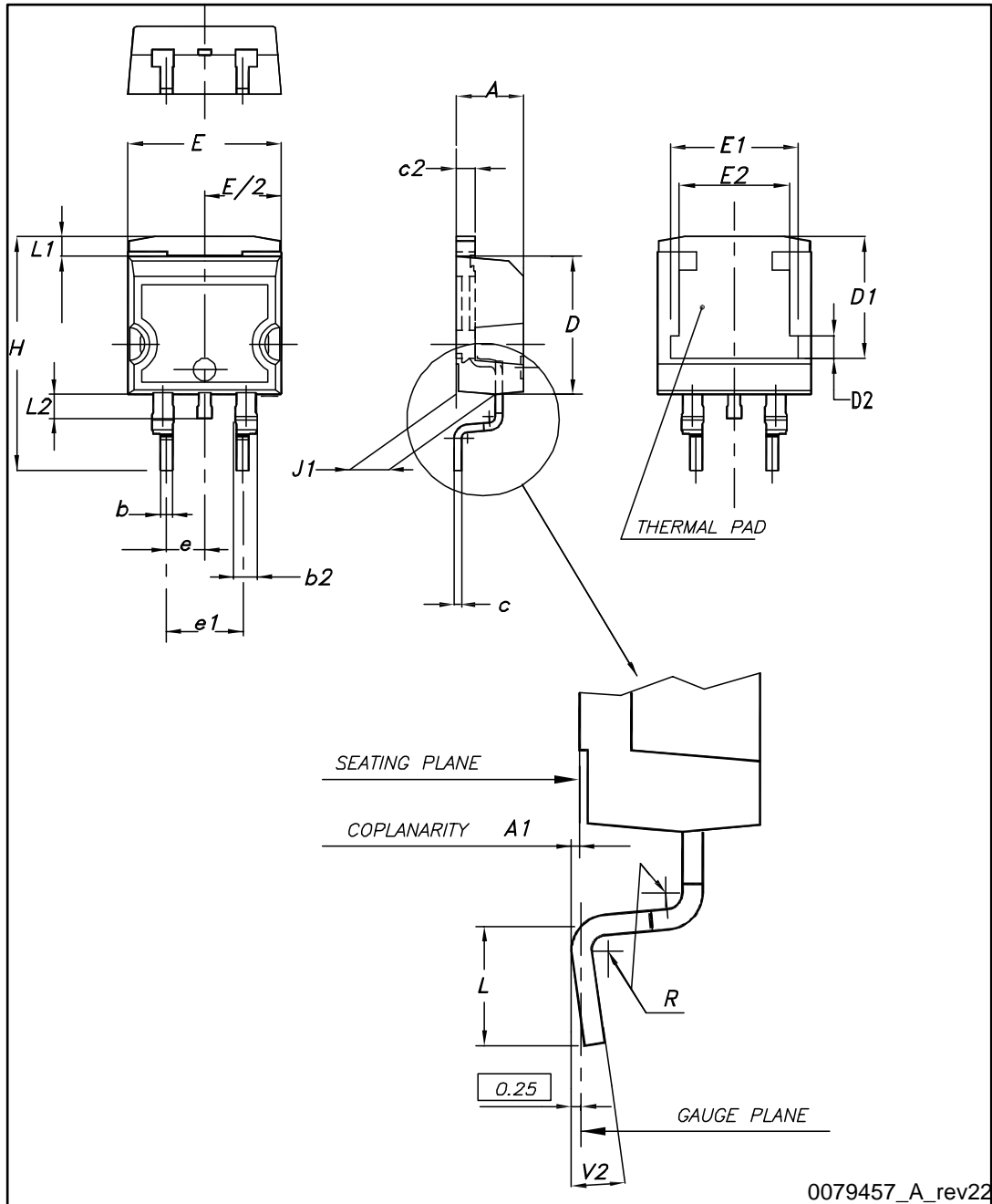
AM01473v1

## 4 Package information

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.

### 4.1 D<sup>2</sup>PAK package information

Figure 25: D<sup>2</sup>PAK (TO-263) type A package outline

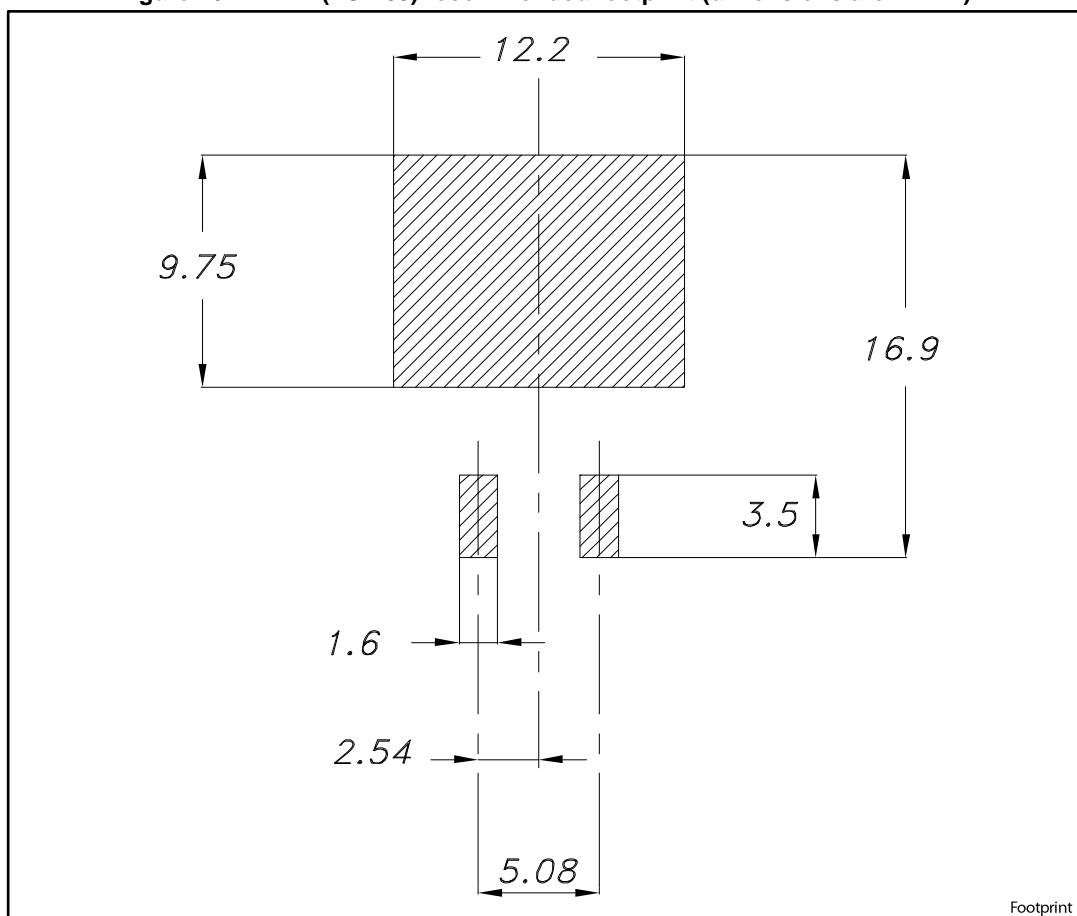


0079457\_A\_rev22

Table 10: D<sup>2</sup>PAK (TO-263) type A package mechanical data

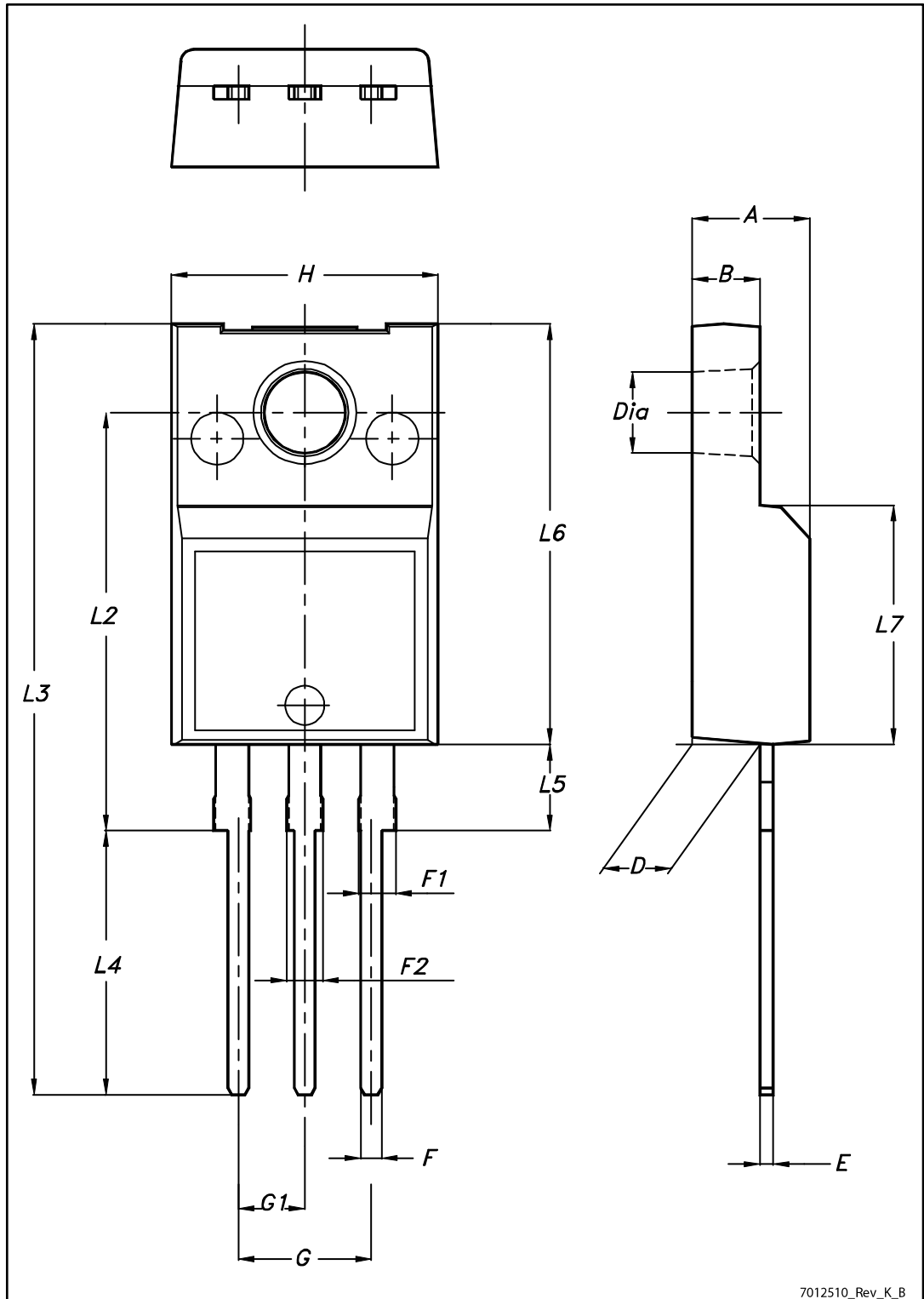
| Dim. | mm   |      |       |
|------|------|------|-------|
|      | Min. | Typ. | Max.  |
| A    | 4.40 |      | 4.60  |
| A1   | 0.03 |      | 0.23  |
| b    | 0.70 |      | 0.93  |
| b2   | 1.14 |      | 1.70  |
| c    | 0.45 |      | 0.60  |
| c2   | 1.23 |      | 1.36  |
| D    | 8.95 |      | 9.35  |
| D1   | 7.50 | 7.75 | 8.00  |
| D2   | 1.10 | 1.30 | 1.50  |
| E    | 10   |      | 10.40 |
| E1   | 8.50 | 8.70 | 8.90  |
| E2   | 6.85 | 7.05 | 7.25  |
| 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) recommended footprint (dimensions are in mm)



### 4.2 TO-220FP package information

Figure 27: TO-220FP package outline



7012510\_Rev\_K\_B

Table 11: TO-220FP package 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  |

### 4.3 TO-220 type A package information

Figure 28: TO-220 type A package outline

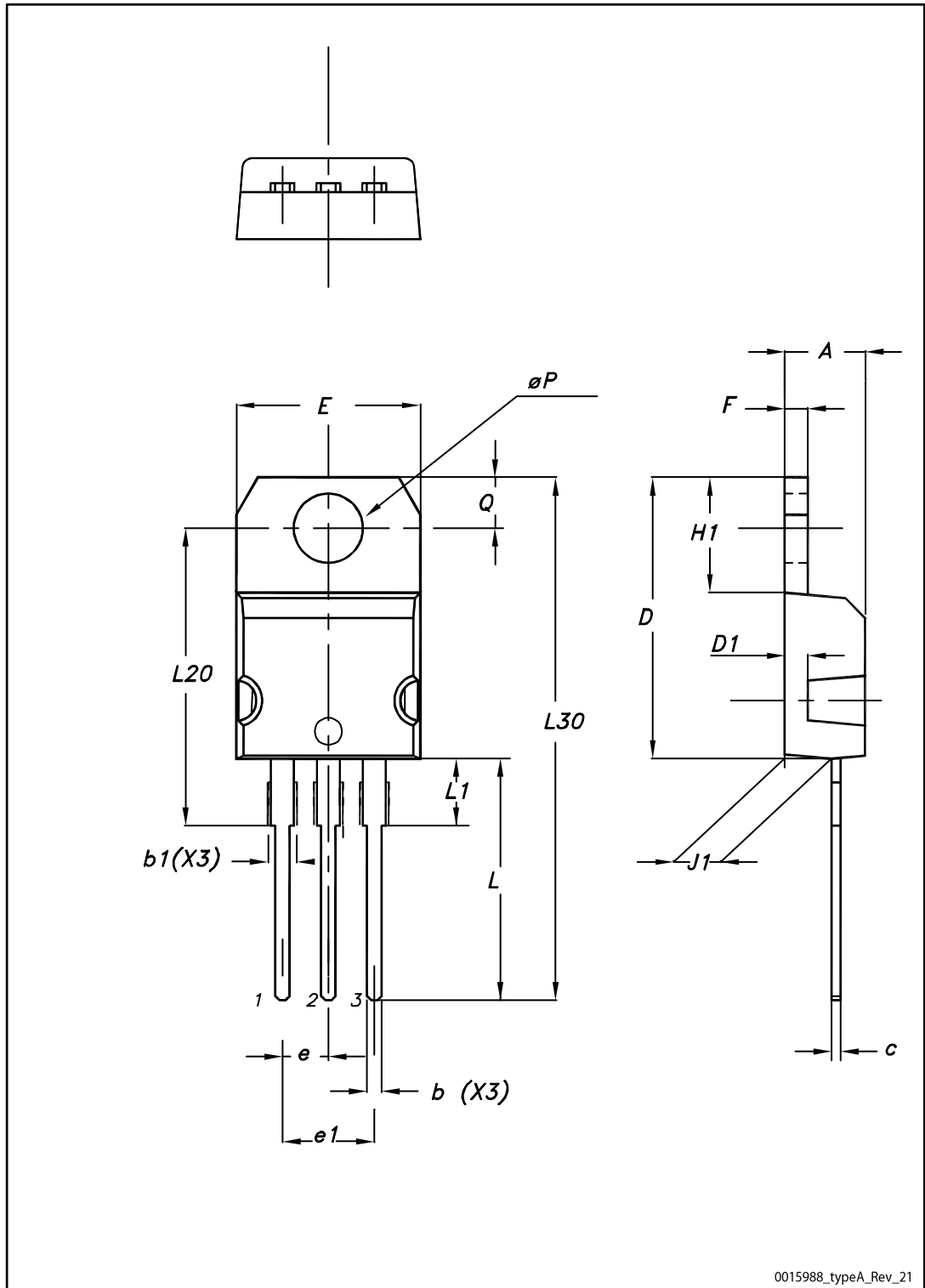


Table 12: TO-220 type A mechanical data

| Dim. | mm    |       |       |
|------|-------|-------|-------|
|      | Min.  | Typ.  | Max.  |
| A    | 4.40  |       | 4.60  |
| b    | 0.61  |       | 0.88  |
| b1   | 1.14  |       | 1.55  |
| c    | 0.48  |       | 0.70  |
| D    | 15.25 |       | 15.75 |
| D1   |       | 1.27  |       |
| E    | 10.00 |       | 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    | 13.00 |       | 14.00 |
| L1   | 3.50  |       | 3.93  |
| L20  |       | 16.40 |       |
| L30  |       | 28.90 |       |
| øP   | 3.75  |       | 3.85  |
| Q    | 2.65  |       | 2.95  |



### 4.4 TO-247 package information

Figure 29: TO-247 package outline

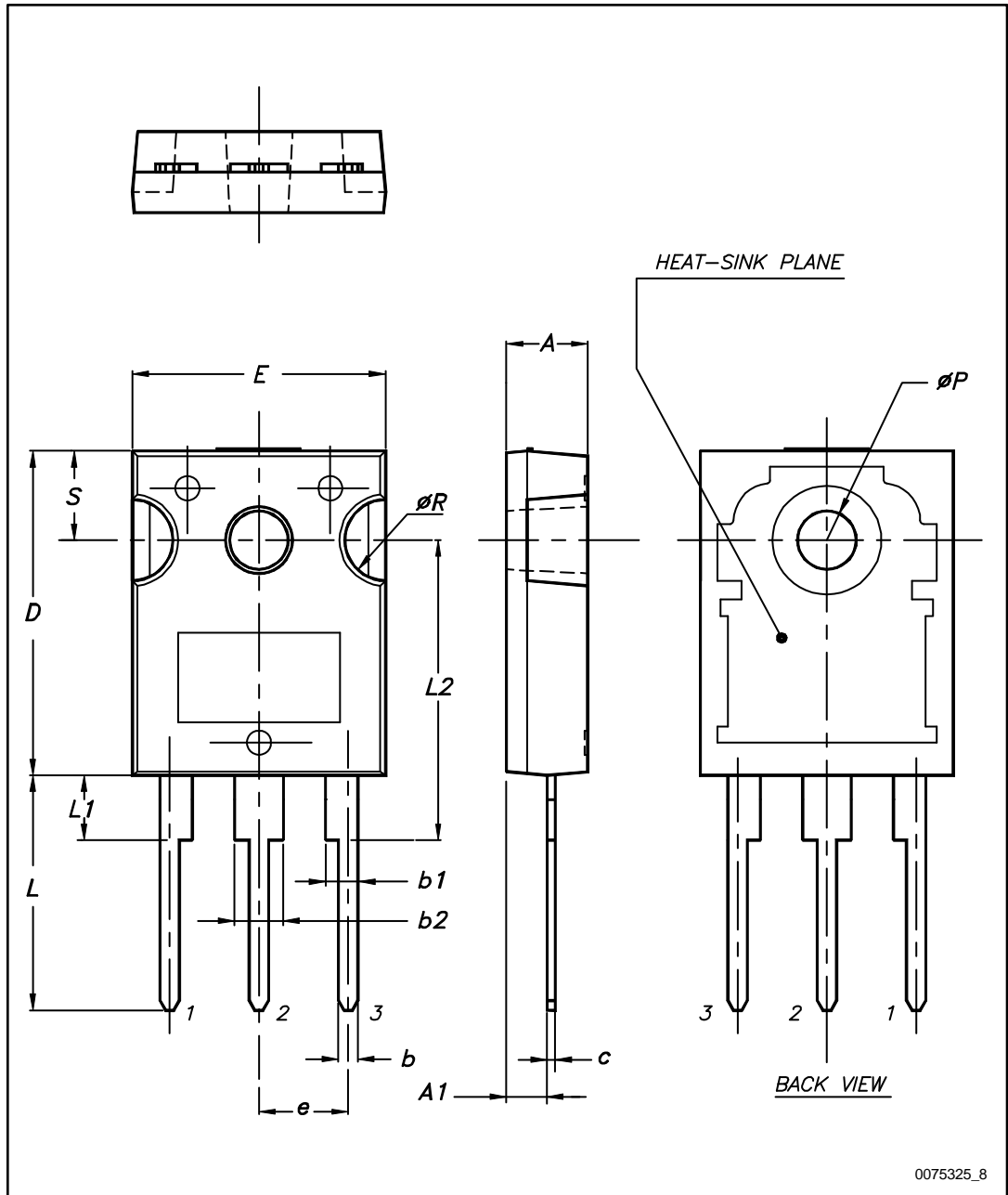


Table 13: TO-247 package mechanical data

| 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  |

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

Figure 30: Tape outline

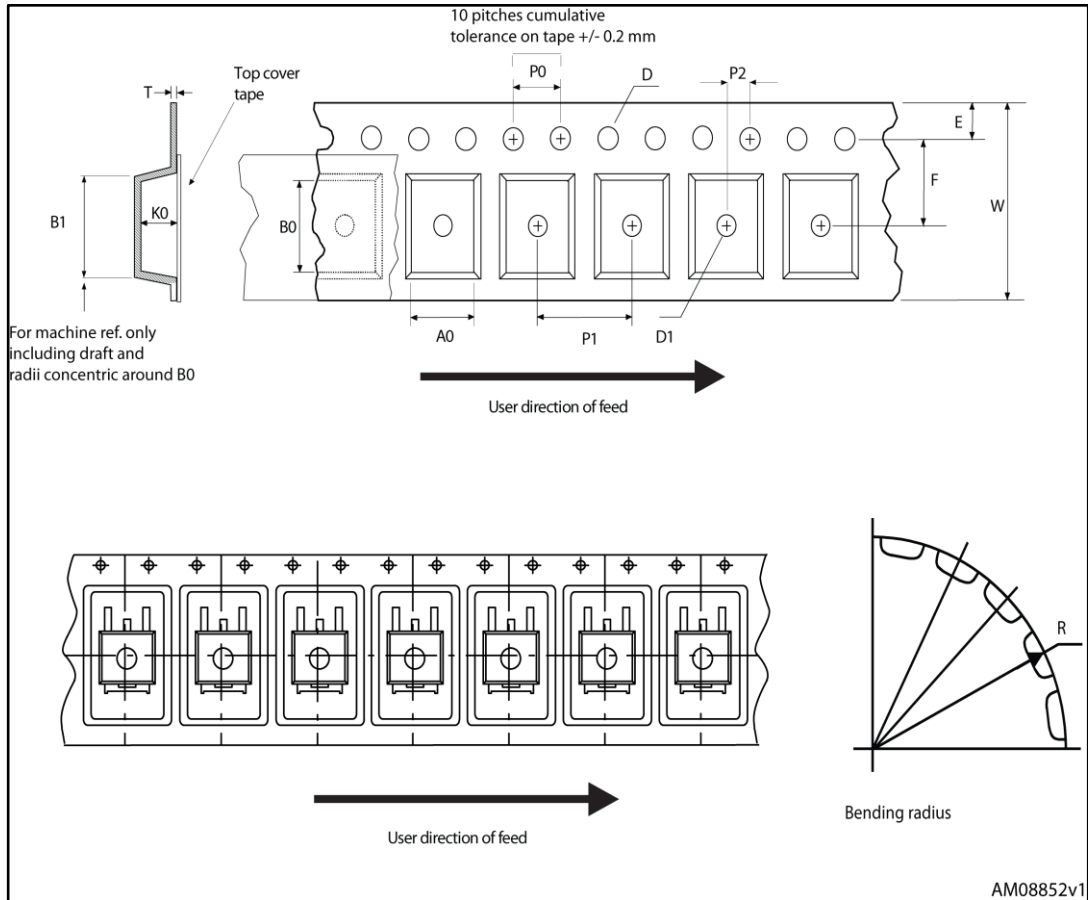
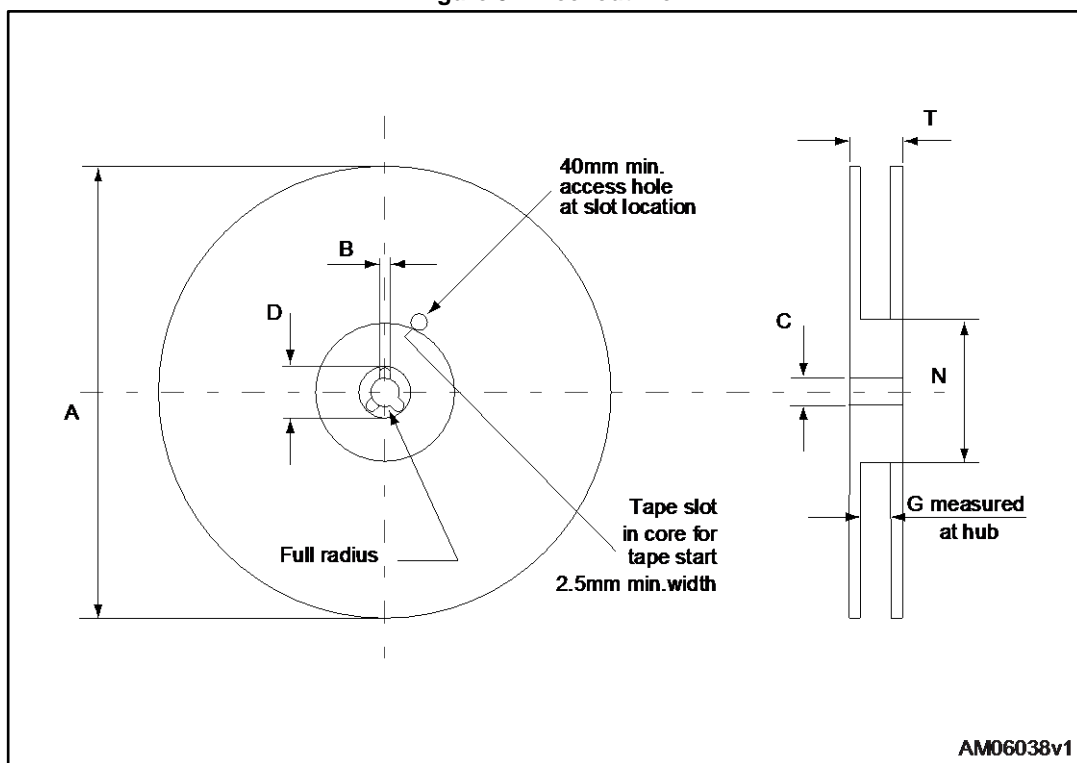


Figure 31: Reel outline



AM06038v1

Table 14: D<sup>2</sup>PAK 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 quantity |      | 1000 |
| P2   | 1.9  | 2.1  | Bulk quantity |      | 1000 |
| R    | 50   |      |               |      |      |
| T    | 0.25 | 0.35 |               |      |      |
| W    | 23.7 | 24.3 |               |      |      |

## 5 Revision history

Table 15: Document revision history

| Date        | Revision | Changes   |
|-------------|----------|---|
| 25-Nov-2009 | 1        | First release.  |
| 12-Jan-2010 | 2        | Corrected $V_{GS}$ value in <i>Table 2: Absolute maximum ratings</i> .  |
| 22-Dec-2011 | 3        | Inserted device in D <sup>2</sup> PAK.<br>Document status promoted from preliminary data to datasheet.<br>Added: <i>Section 2.1: Electrical characteristics (curves)</i><br>Updated <i>Section 4: Package mechanical data</i> .<br>Added <i>Section 5: Packaging mechanical data</i> . Minor text changes.  |
| 06-Jun-2012 | 4        | <i>Figure 9: Transfer characteristics</i> has been updated.   |
| 16-Jan-2017 | 5        | Updated title, features, description and schematic diagram in cover page.<br>Minor text changes in <i>Section 1: "Electrical ratings"</i> and <i>Section 2: "Electrical characteristics"</i> .<br>Updated <i>Section 2.1: "Electrical characteristics (curves)"</i><br>Updated package information section. |

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