

N-channel 600 V, 0.13  $\Omega$  typ., 21 A MDmesh™ DM2  
Power MOSFETs in D<sup>2</sup>PAK, TO-220 and TO-247 packages

Datasheet - production data

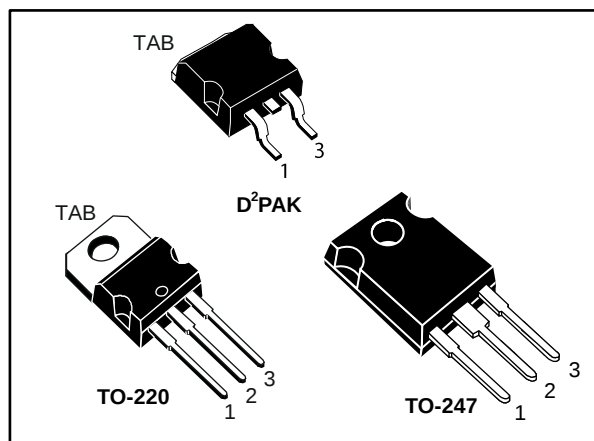
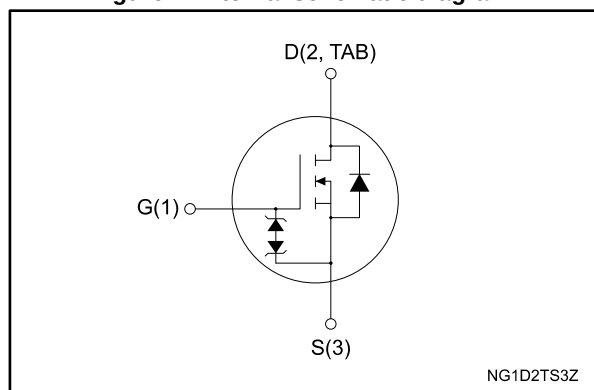


Figure 1: Internal schematic diagram



## Features

| Order code  | V <sub>DS</sub> @<br>T <sub>Jmax.</sub> | R <sub>DS(on)</sub><br>max. | I <sub>D</sub> | P <sub>TOT</sub> |
|-------------|-----------------------------------------|-----------------------------|----------------|------------------|
| STB28N60DM2 | 650 V                                   | 0.16 $\Omega$               | 21 A           | 170 W            |
| STP28N60DM2 |                                         |                             |                |                  |
| STW28N60DM2 |                                         |                             |                |                  |

- Fast-recovery body diode
- Extremely low gate charge and input capacitance
- Low on-resistance
- 100% avalanche tested
- Extremely high dv/dt ruggedness
- Zener-protected

## Applications

- Switching applications

## Description

These high voltage N-channel Power MOSFETs are part of the MDmesh™ DM2 fast recovery diode series. They offer very low recovery charge ( $Q_{rr}$ ) and time ( $t_{rr}$ ) combined with low  $R_{DS(on)}$ , rendering them suitable for the most demanding high efficiency converters and ideal for bridge topologies and ZVS phase-shift converters.

Table 1: Device summary

| Order code  | Marking  | Package            | Packing       |
|-------------|----------|--------------------|---------------|
| STB28N60DM2 | 28N60DM2 | D <sup>2</sup> PAK | Tape and reel |
| STP28N60DM2 |          | TO-220             | Tube          |
| STW28N60DM2 |          | TO-247             | Tube          |

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# 1 Electrical ratings

Table 2: Absolute maximum ratings

| Symbol         | Parameter                                                              | Value      | Unit               |
|----------------|------------------------------------------------------------------------|------------|--------------------|
| $V_{GS}$       | Gate-source voltage                                                    | $\pm 25$   | V                  |
| $I_D$          | Drain current (continuous) at $T_{case} = 25\text{ }^{\circ}\text{C}$  | 21         | A                  |
|                | Drain current (continuous) at $T_{case} = 100\text{ }^{\circ}\text{C}$ | 14         |                    |
| $I_{DM}^{(1)}$ | Drain current (pulsed)                                                 | 84         | A                  |
| $P_{TOT}$      | Total dissipation at $T_{case} = 25\text{ }^{\circ}\text{C}$           | 170        | W                  |
| $dv/dt^{(2)}$  | Peak diode recovery voltage slope                                      | 50         | V/ns               |
| $dv/dt^{(3)}$  | MOSFET $dv/dt$ ruggedness                                              | 50         |                    |
| $T_{stg}$      | Storage temperature range                                              | -55 to 150 | $^{\circ}\text{C}$ |
| $T_j$          | Operating junction temperature range                                   |            |                    |

**Notes:**

(1) Pulse width is limited by safe operating area.

(2)  $I_{SD} \leq 21\text{ A}$ ,  $di/dt=900\text{ A}/\mu\text{s}$ ;  $V_{DS}\text{ peak} < V_{(BR)DSS}$ ,  $V_{DD} = 400\text{ V}$

(3)  $V_{DS} \leq 480\text{ V}$ .

Table 3: Thermal data

| Symbol              | Parameter                           | Value              |        |        | Unit                        |
|---------------------|-------------------------------------|--------------------|--------|--------|-----------------------------|
|                     |                                     | D <sup>2</sup> PAK | TO-220 | TO-247 |                             |
| $R_{thj-case}$      | Thermal resistance junction-case    | 0.74               |        |        | $^{\circ}\text{C}/\text{W}$ |
| $R_{thj-pcb}^{(1)}$ | Thermal resistance junction-pcb     | 30                 |        |        |                             |
| $R_{thj-amb}$       | Thermal resistance junction-ambient |                    | 62.5   | 50     |                             |

**Notes:**

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

Table 4: Avalanche characteristics

| Symbol         | Parameter                                       | Value | Unit |
|----------------|-------------------------------------------------|-------|------|
| $I_{AR}^{(1)}$ | Avalanche current, repetitive or not repetitive | 4     | A    |
| $E_{AS}^{(2)}$ | Single pulse avalanche energy                   | 350   | mJ   |

**Notes:**

(1) pulse width limited by  $T_{jmax}$

(2) starting  $T_j = 25\text{ }^{\circ}\text{C}$ ,  $I_D = I_{AR}$ ,  $V_{DD} = 50\text{ V}$ .

## 2 Electrical characteristics

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

Table 5: Static

| 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                                              | 600  |      |      | V    |
| I <sub>DSS</sub>     | Zero gate voltage drain current   | V <sub>GS</sub> = 0 V, V <sub>DS</sub> = 600 V                                            |      |      | 1    | μA   |
|                      |                                   | V <sub>GS</sub> = 0 V, V <sub>DS</sub> = 600 V, T <sub>case</sub> = 125 °C <sup>(1)</sup> |      |      | 100  |      |
| I <sub>GSS</sub>     | Gate-body leakage current         | V <sub>DS</sub> = 0 V, V <sub>GS</sub> = ±25 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    | 4    | 5    | V    |
| R <sub>DS(on)</sub>  | Static drain-source on-resistance | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 10.5 A                                           |      | 0.13 | 0.16 | 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, V <sub>GS</sub> = 0 V                                                                                             | -    | 1500 | -    | pF   |
| C <sub>oss</sub>                    | Output capacitance            |                                                                                                                                                       | -    | 70   | -    |      |
| C <sub>rss</sub>                    | Reverse transfer capacitance  |                                                                                                                                                       | -    | 1.6  | -    |      |
| C <sub>oss eq.</sub> <sup>(1)</sup> | Equivalent output capacitance | V <sub>DS</sub> = 0 to 480 V, V <sub>GS</sub> = 0 V                                                                                                   | -    | 134  | -    | pF   |
| R <sub>G</sub>                      | Intrinsic gate resistance     | f = 1 MHz, I <sub>D</sub> = 0 A                                                                                                                       | -    | 4.6  | -    | Ω    |
| Q <sub>g</sub>                      | Total gate charge             | V <sub>DD</sub> = 480 V, I <sub>D</sub> = 21 A, V <sub>GS</sub> = 0 to 10 V (see <a href="#">Figure 19: "Test circuit for gate charge behavior"</a> ) | -    | 34   | -    | nC   |
| Q <sub>gs</sub>                     | Gate-source charge            |                                                                                                                                                       | -    | 8    | -    |      |
| Q <sub>gd</sub>                     | Gate-drain charge             |                                                                                                                                                       | -    | 18.5 | -    |      |

**Notes:**

<sup>(1)</sup> 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% V<sub>DSS</sub>.

Table 7: Switching times

| Symbol       | Parameter           | Test conditions                                                                                                                                                                                                                              | Min. | Typ. | Max. | Unit |
|--------------|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|
| $t_{d(on)}$  | Turn-on delay time  | $V_{DD} = 300\text{ V}$ , $I_D = 10.5\text{ A}$<br>$R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$ (see <a href="#">Figure 18: "Test circuit for resistive load switching times"</a> and <a href="#">Figure 23: "Switching time waveform"</a> ) | -    | 16   | -    | ns   |
| $t_r$        | Rise time           |                                                                                                                                                                                                                                              | -    | 7.3  | -    |      |
| $t_{d(off)}$ | Turn-off delay time |                                                                                                                                                                                                                                              | -    | 53   | -    |      |
| $t_f$        | Fall time           |                                                                                                                                                                                                                                              | -    | 9.3  | -    |      |

Table 8: Source-drain diode

| Symbol          | Parameter                     | Test conditions                                                                                                                                                                                                                    | Min. | Typ. | Max. | Unit          |
|-----------------|-------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|---------------|
| $I_{SD}^{(1)}$  | Source-drain current          |                                                                                                                                                                                                                                    | -    |      | 21   | A             |
| $I_{SDM}^{(2)}$ | Source-drain current (pulsed) |                                                                                                                                                                                                                                    | -    |      | 84   | A             |
| $V_{SD}^{(3)}$  | Forward on voltage            | $V_{GS} = 0\text{ V}$ , $I_{SD} = 21\text{ A}$                                                                                                                                                                                     | -    |      | 1.6  | V             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 21\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ ,<br>$V_{DD} = 60\text{ V}$ (see <a href="#">Figure 20: "Test circuit for inductive load switching and diode recovery times"</a> )                                     | -    | 140  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                                                                                                                    | -    | 0.5  |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                                                                                                                    | -    | 7.4  |      | A             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 21\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ ,<br>$V_{DD} = 60\text{ V}$ , $T_J = 150\text{ }^\circ\text{C}$ (see <a href="#">Figure 20: "Test circuit for inductive load switching and diode recovery times"</a> ) | -    | 309  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                                                                                                                    | -    | 2.6  |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                                                                                                                    | -    | 16.8 |      | A             |

**Notes:**

- (1) Limited by maximum junction temperature.  
 (2) Pulse width is limited by safe operating area.  
 (3) Pulse test: 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 | $I_{GS} = \pm 250\ \mu\text{A}$ , $I_D = 0\text{ A}$ | $\pm 25$ | -    | -    | 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)

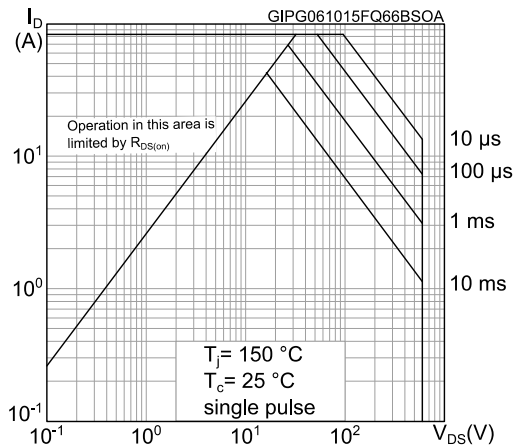
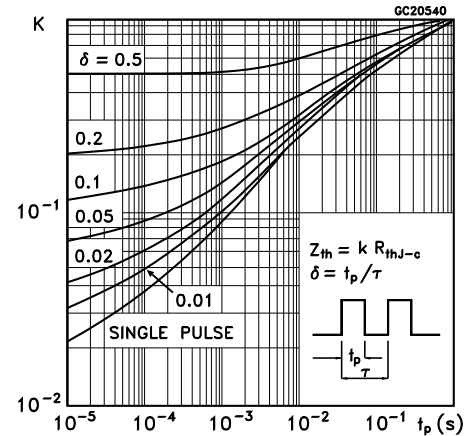
Figure 2: Safe operating area for D<sup>2</sup>PAKFigure 3: Thermal impedance for D<sup>2</sup>PAK

Figure 4: Safe operating area for TO-220

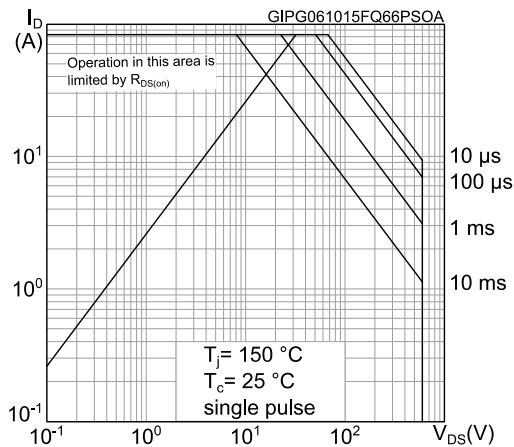


Figure 5: Thermal impedance for TO-220

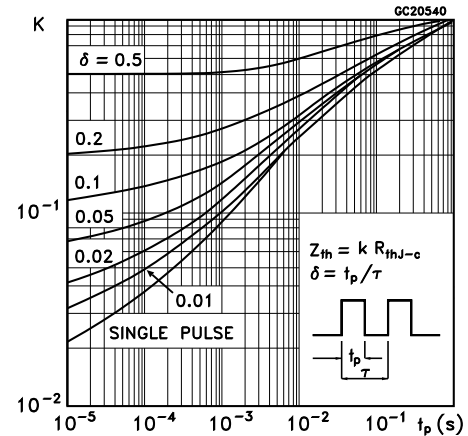


Figure 6: Safe operating area for TO-247

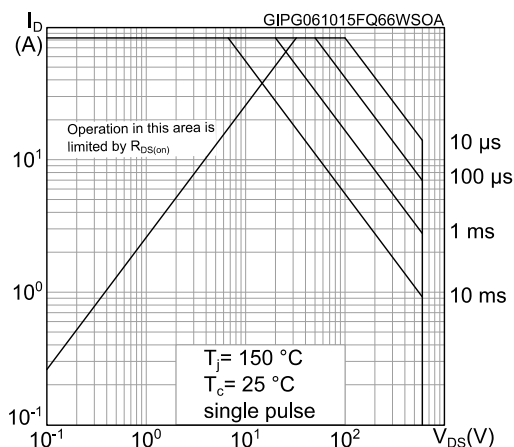


Figure 7: Thermal impedance for TO-247

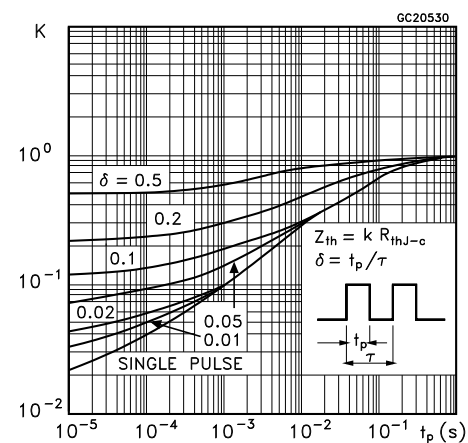


Figure 8: Output characteristics

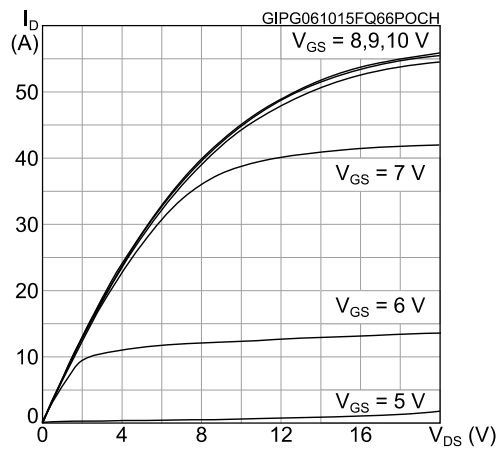


Figure 9: Transfer characteristics

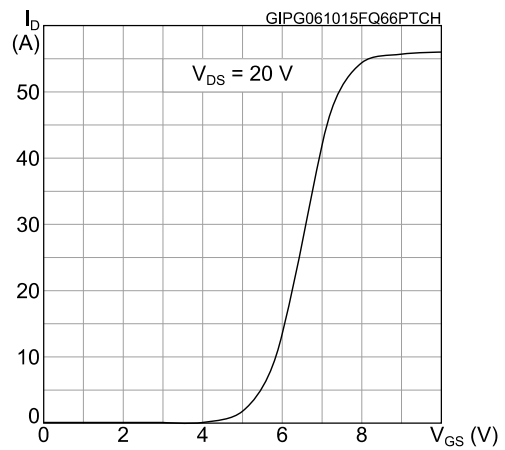


Figure 10: Gate charge vs gate-source voltage

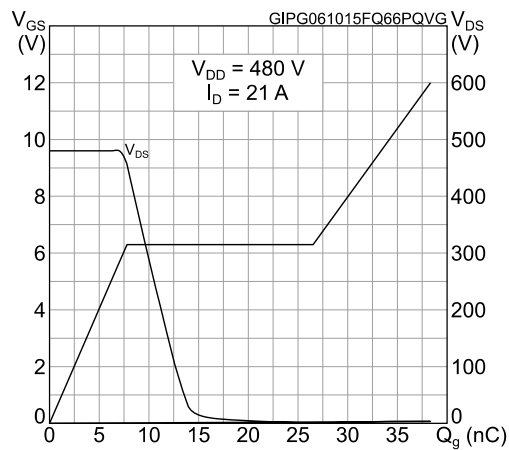


Figure 11: Static drain-source on-resistance

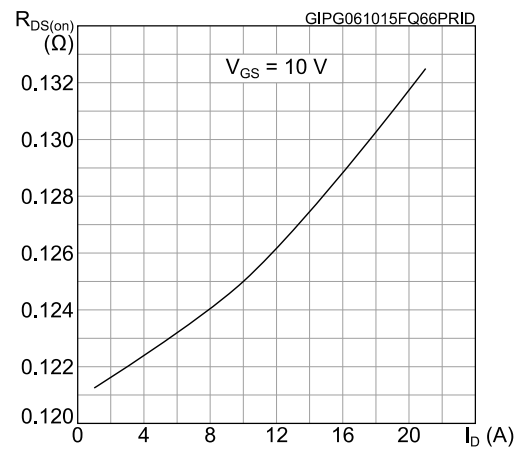


Figure 12: Capacitance variations

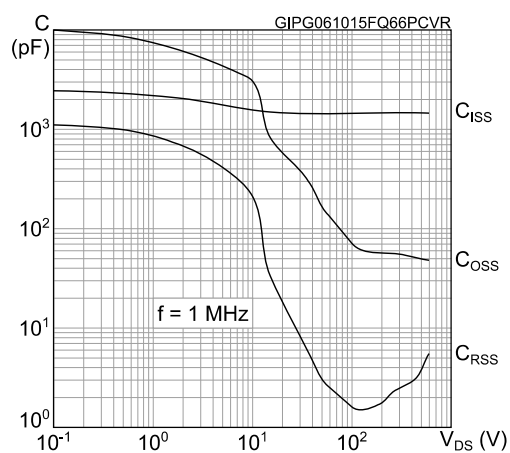


Figure 13: Normalized gate threshold voltage vs temperature

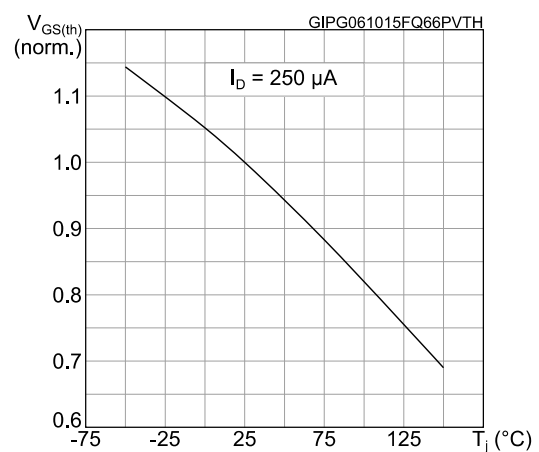


Figure 14: Normalized on-resistance vs temperature

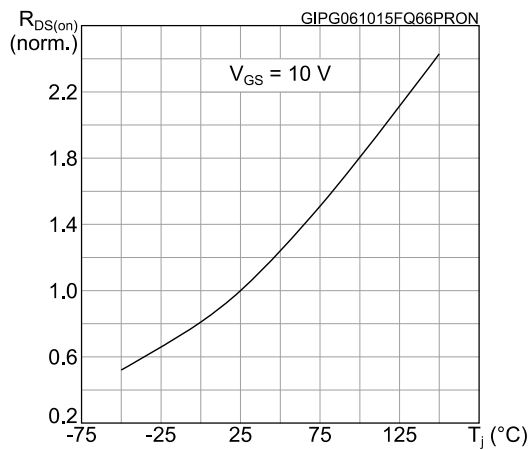
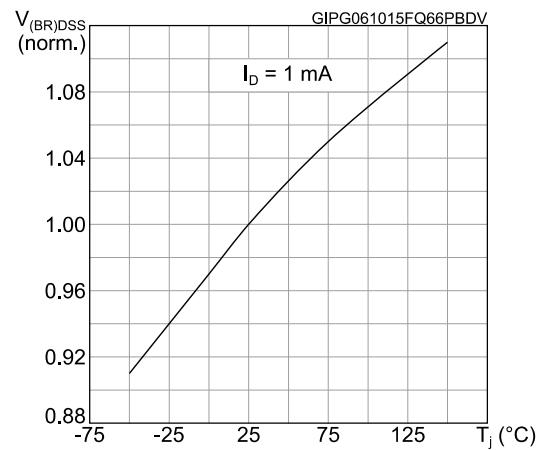
Figure 15: Normalized  $V_{(BR)DSS}$  vs temperature

Figure 16: Output capacitance stored energy

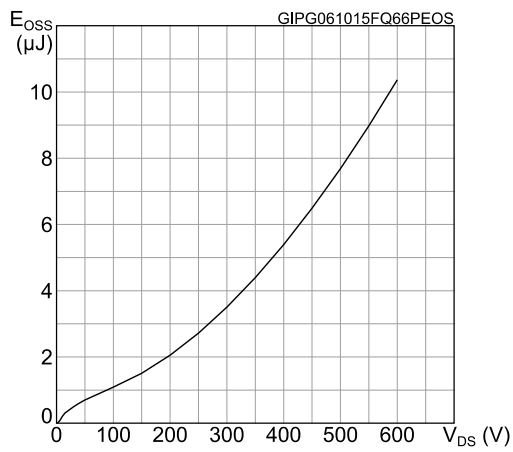
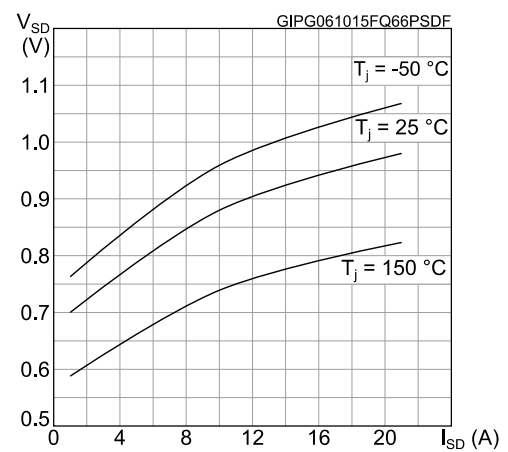
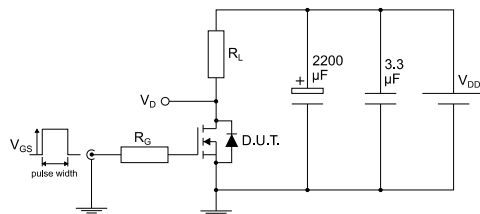


Figure 17: Source-drain diode forward characteristics



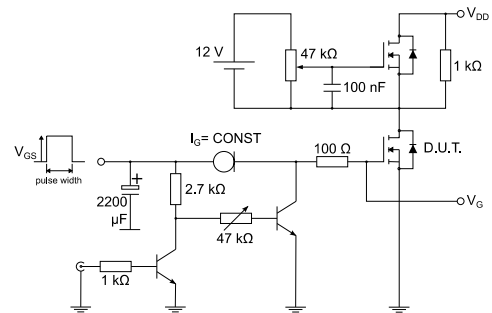
### 3 Test circuits

**Figure 18: Test circuit for resistive load switching times**



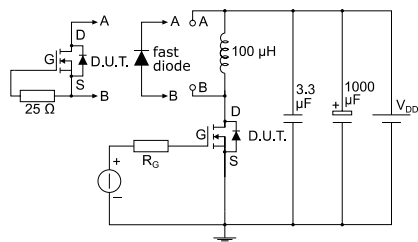
AM01468v1

**Figure 19: Test circuit for gate charge behavior**



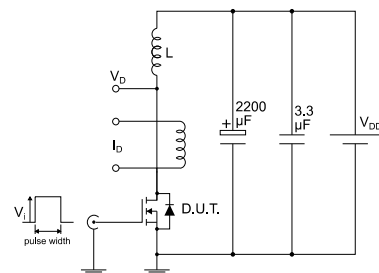
AM01469v1

**Figure 20: Test circuit for inductive load switching and diode recovery times**



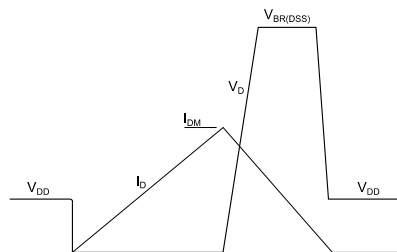
AM01470v1

**Figure 21: Unclamped inductive load test circuit**



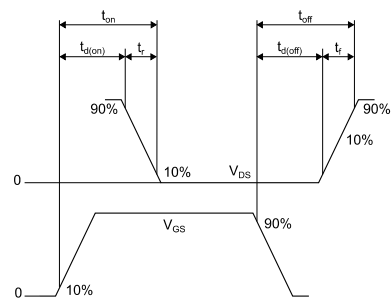
AM01471v1

**Figure 22: Unclamped inductive waveform**



AM01472v1

**Figure 23: Switching time waveform**



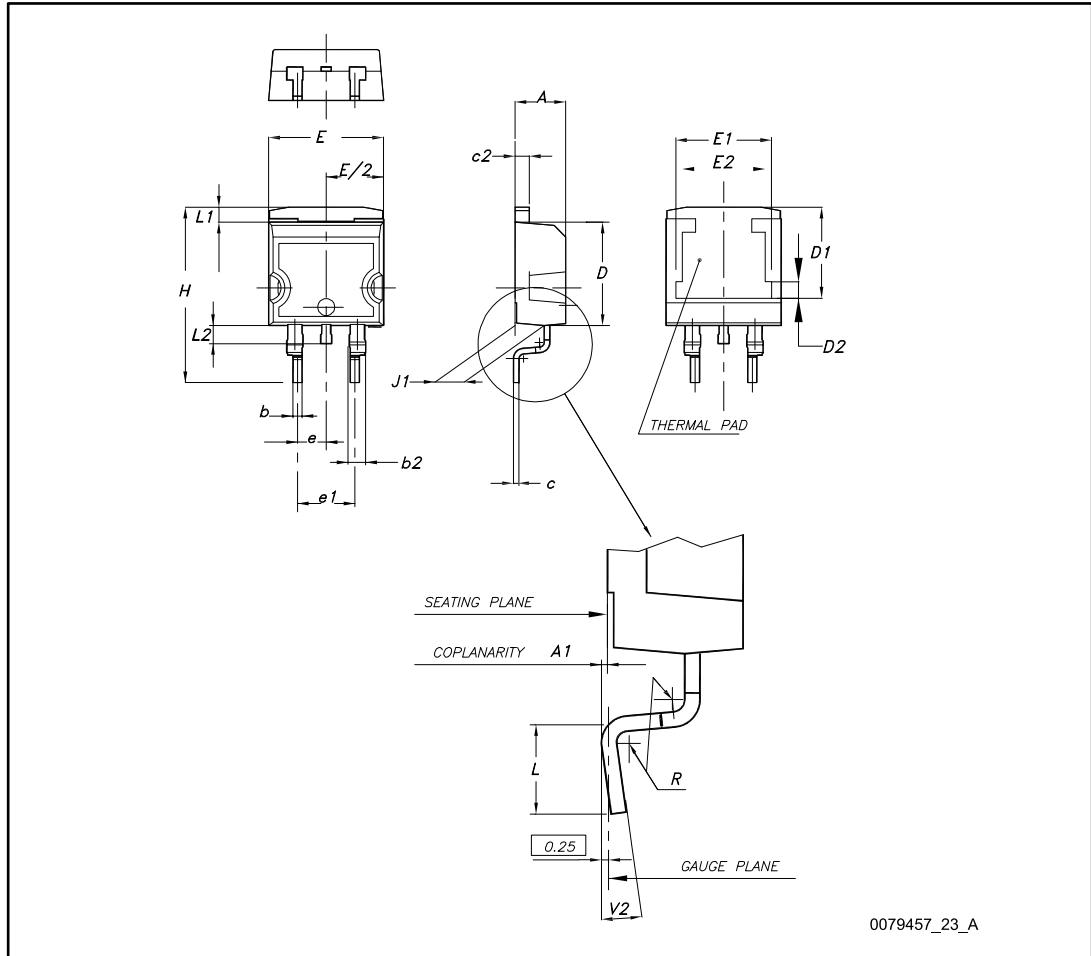
AM01473v1

## 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 (TO-263) type A package information

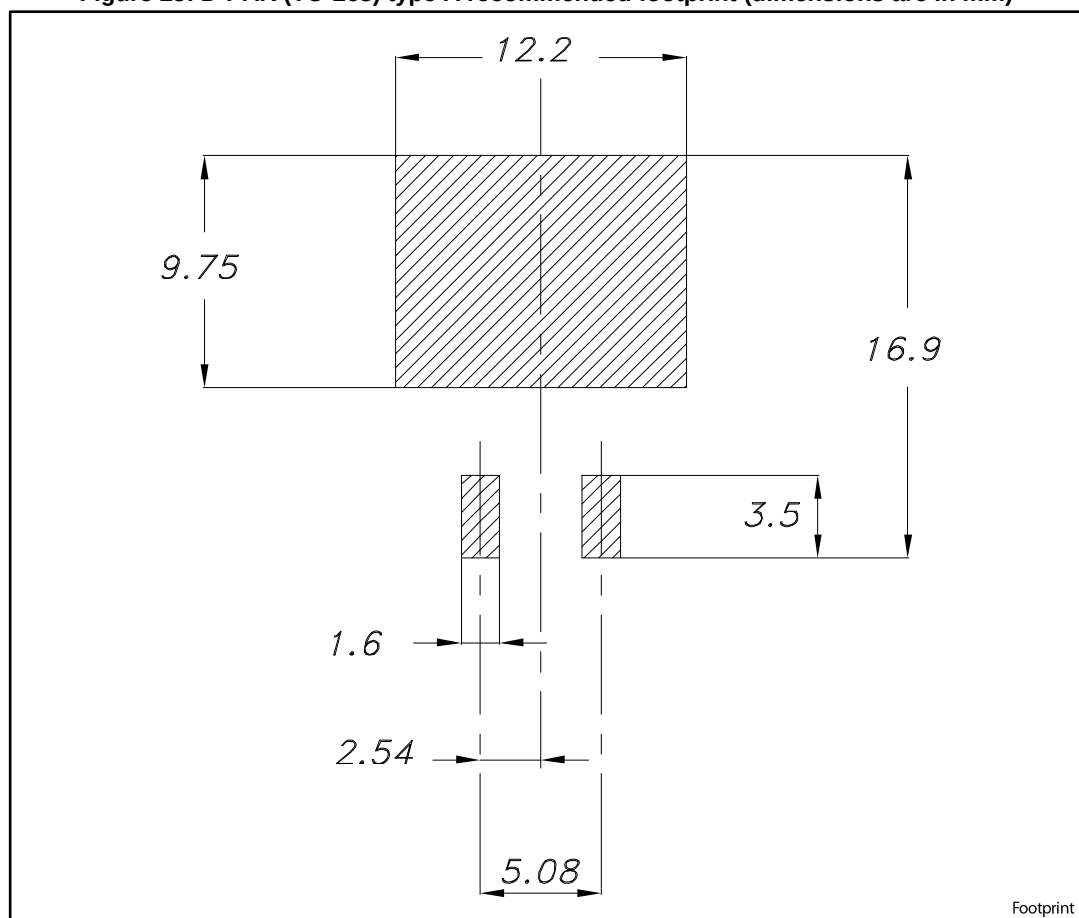
Figure 24: D<sup>2</sup>PAK (TO-263) type A package outline



0079457\_23\_A

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    | 10.00 |      | 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    | 15.00 |      | 15.85 |
| J1   | 2.49  |      | 2.69  |
| L    | 2.29  |      | 2.79  |
| L1   | 1.27  |      | 1.40  |
| L2   | 1.30  |      | 1.75  |
| R    |       | 0.40 |       |
| V2   | 0°    |      | 8°    |

Figure 25: D<sup>2</sup>PAK (TO-263) type A recommended footprint (dimensions are in mm)

## 4.2 TO-220 type A package information

Figure 26: TO-220 type A package outline

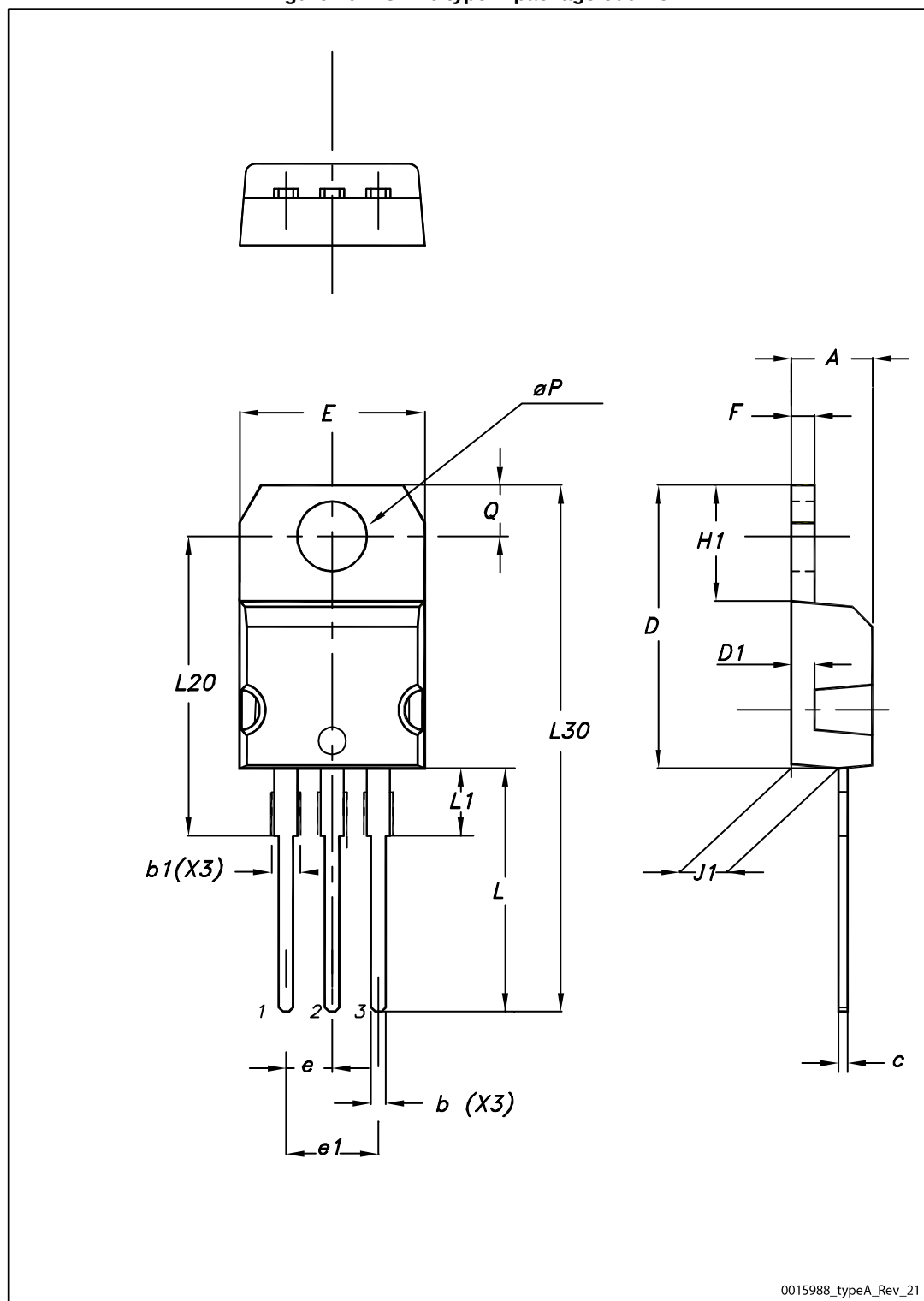


Table 11: TO-220 type A mechanical data

| Dim. | mm    |       |       |
|------|-------|-------|-------|
|      | Min.  | Typ.  | Max.  |
| A    | 4.40  |       | 4.60  |
| b    | 0.61  |       | 0.88  |
| b1   | 1.14  |       | 1.55  |
| 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  |

### 4.3 TO-247 package information

Figure 27: TO-247 package outline

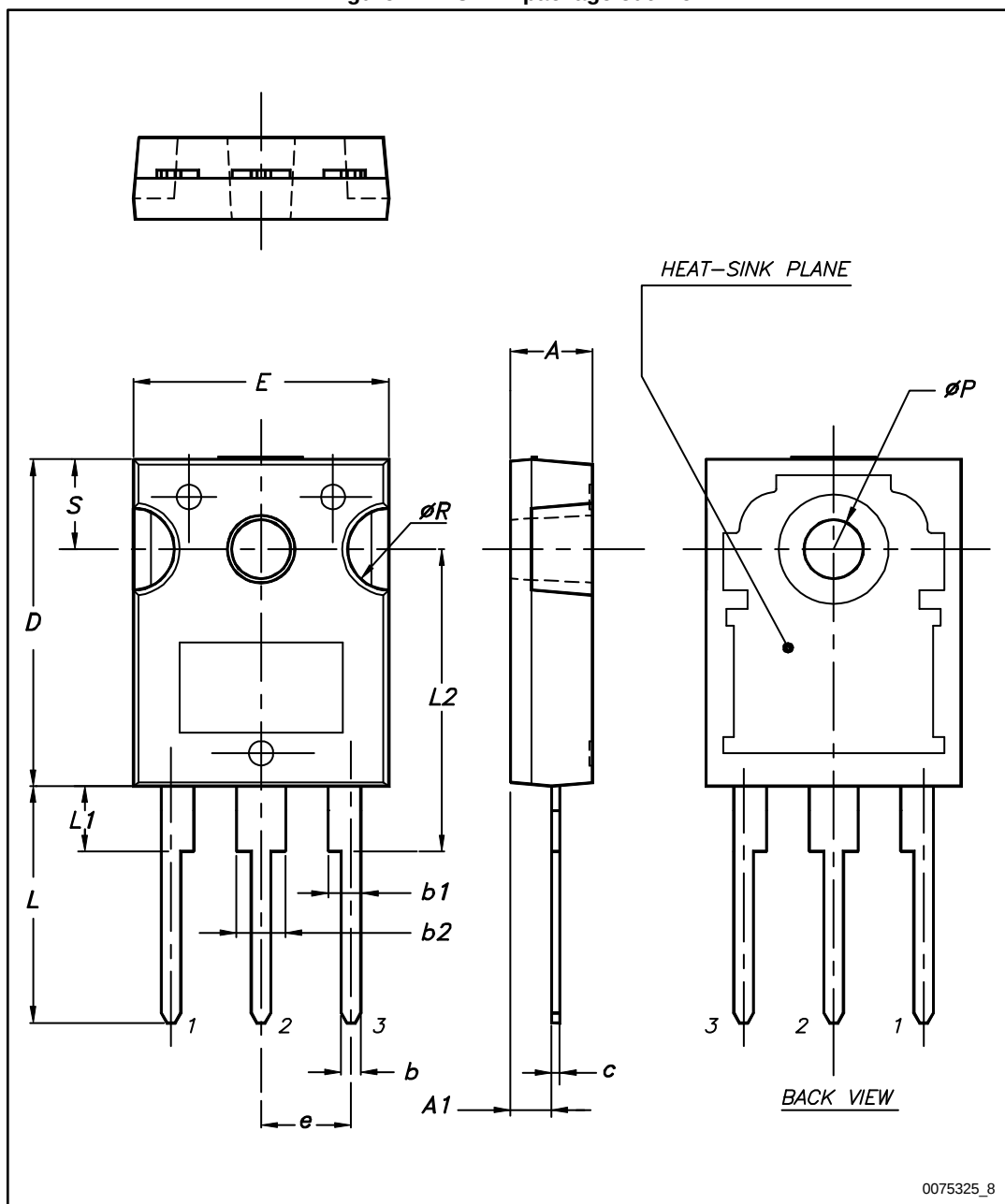


Table 12: TO-247 package mechanical data

| 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  |

## 5 Packing information

### 5.1 D<sup>2</sup>PAK type A packing information

Figure 28: D<sup>2</sup>PAK type A tape outline

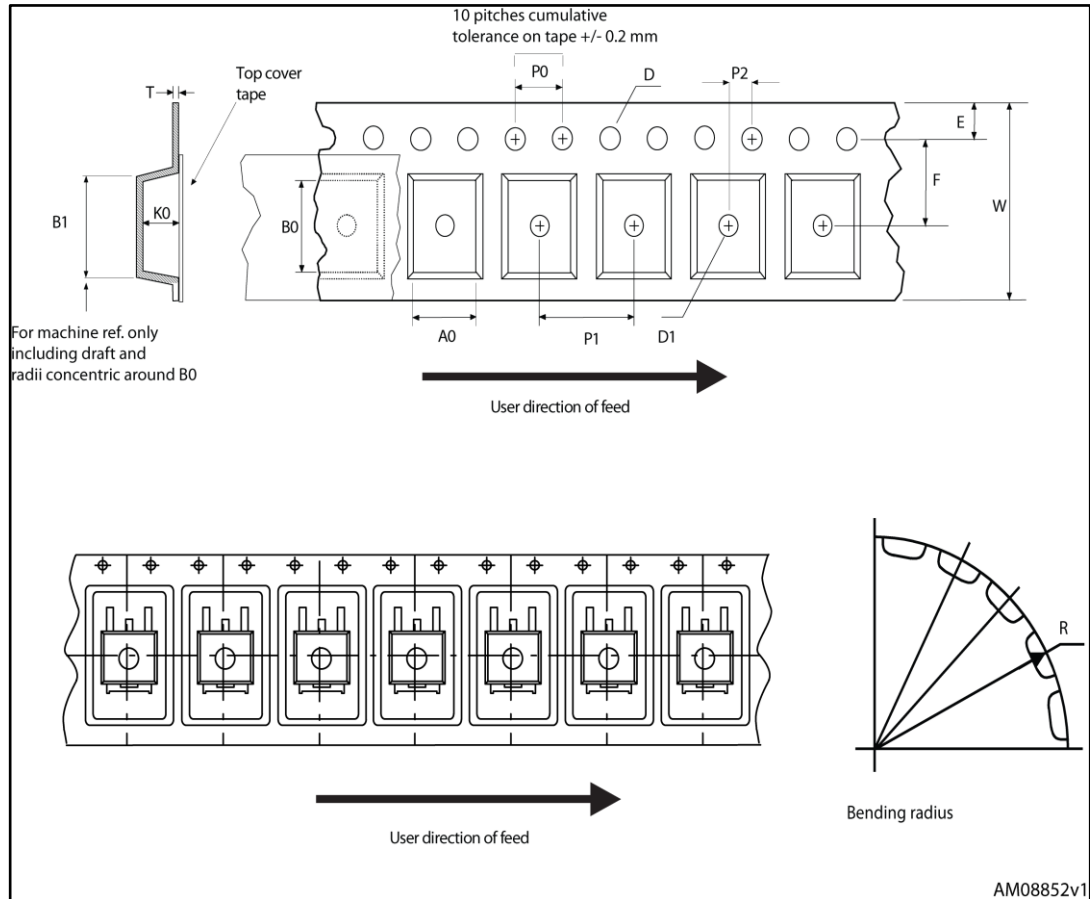
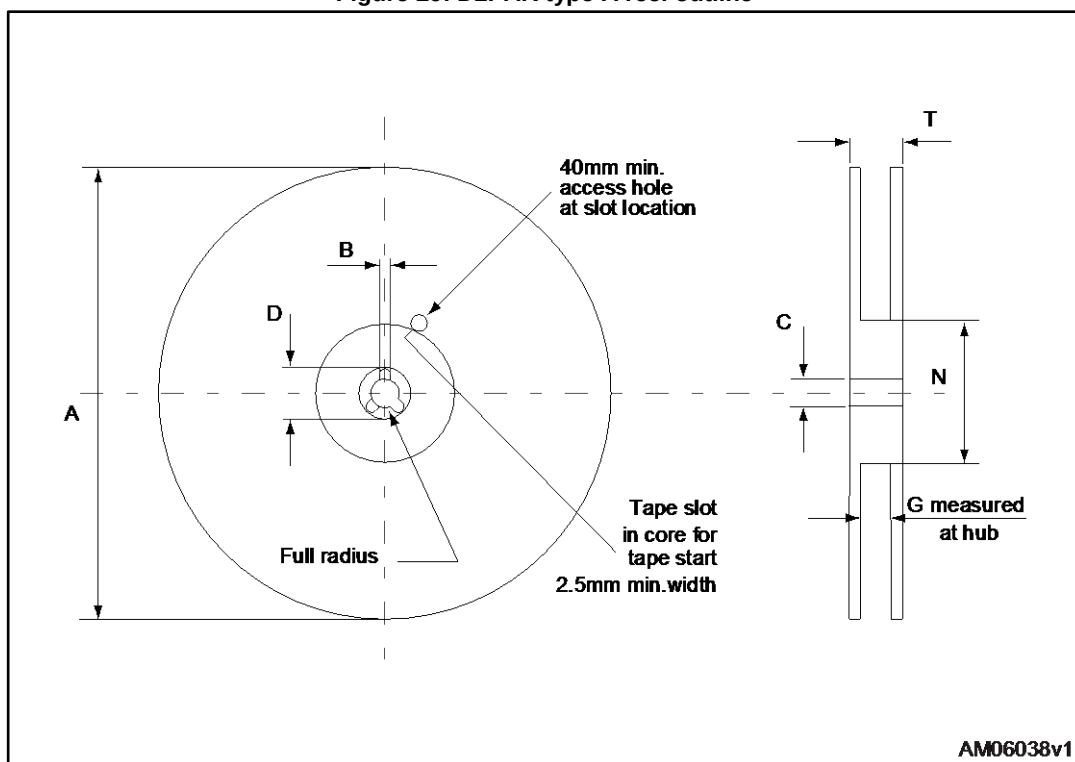


Figure 29: D2PAK type A reel outline

Table 13: D<sup>2</sup>PAK type A 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 |               |      |      |

## 6 Revision history

Table 14: Document revision history

| Date        | Revision | Changes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|-------------|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 21-Oct-2014 | 1        | First release.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 05-Oct-2015 | 2        | Text and formatting changes throughout document<br>On cover page:<br>- updated title and Features table<br>In section Electrical ratings:<br>- updated all table data<br>In section Electrical characteristics:<br>- updated all table data<br>- renamed table Static (was On /off states)<br>- added table Gate-source Zener diode<br>Added section Electrical characteristics (curves)<br>Updated and renamed section Package mechanical data (was Package information)<br>Datasheet promoted from preliminary to production data |
| 30-Oct-2015 | 3        | Minor text changes in <i>Section 2.1: "Electrical characteristics (curves)"</i> .                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 09-Dec-2015 | 4        | Updated features and <i>Table 1: "Device summary"</i> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| 24-Apr-2017 | 5        | Updated features in cover page.<br>Updated <a href="#">Section 4: "Package information"</a><br>Minor text changes.                                                                                                                                                                                                                                                                                                                                                                                                                  |

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