

N-channel 600 V, 0.078  $\Omega$  typ., 34 A MDmesh M2  
Power MOSFETs in D<sup>2</sup>PAK, TO-220 and TO-247 packages

Datasheet – production data

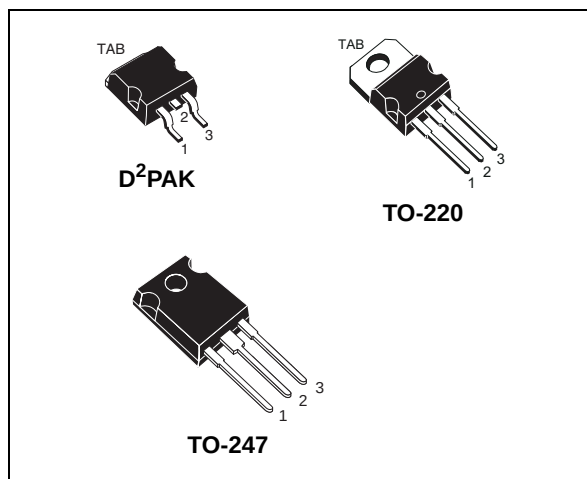
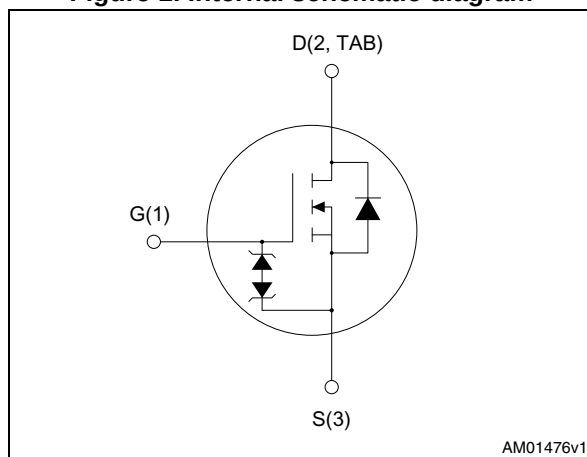


Figure 1. Internal schematic diagram



## Features

| Order code | $V_{DS} @ T_{Jmax}$ | $R_{DS(on)}$ max | $I_D$ |
|------------|---------------------|------------------|-------|
| STB40N60M2 | 650 V               | 0.088 $\Omega$   | 34 A  |
| STP40N60M2 |                     |                  |       |
| STW40N60M2 |                     |                  |       |

- Extremely low gate charge
- Excellent output capacitance ( $C_{oss}$ ) profile
- 100% avalanche tested
- Zener-protected

## Applications

- Switching applications
- LLC converters, resonant converters

## Description

These devices are N-channel Power MOSFETs developed using MDmesh™ M2 technology. Thanks to their strip layout and improved vertical structure, the devices exhibit low on-resistance and optimized switching characteristics, rendering them suitable for the most demanding high efficiency converters.

Table 1. Device summary

| Order code | Marking | Packages           | Packing       |
|------------|---------|--------------------|---------------|
| STB40N60M2 | 40N60M2 | D <sup>2</sup> PAK | Tape and reel |
| STP40N60M2 |         | TO-220             | Tube          |
| STW40N60M2 |         | TO-247             |               |

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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 $T_C = 25\text{ }^{\circ}\text{C}$  | 34          | A                  |
| $I_D$          | Drain current (continuous) at $T_C = 100\text{ }^{\circ}\text{C}$ | 22          | A                  |
| $I_{DM}^{(1)}$ | Drain current (pulsed)                                            | 136         | A                  |
| $P_{TOT}$      | Total dissipation at $T_C = 25\text{ }^{\circ}\text{C}$           | 250         | W                  |
| $dv/dt^{(2)}$  | Peak diode recovery voltage slope                                 | 15          | V/ns               |
| $dv/dt^{(3)}$  | MOSFET $dv/dt$ ruggedness                                         | 50          | V/ns               |
| $T_{stg}$      | Storage temperature range                                         | - 55 to 150 | $^{\circ}\text{C}$ |
| $T_j$          | Operating junction temperature range                              |             | $^{\circ}\text{C}$ |

1. Pulse width limited by safe operating area.
2.  $I_{SD} \leq 34\text{ A}$ ,  $di/dt \leq 400\text{ A}/\mu\text{s}$ ;  $V_{DS\text{ peak}} < V_{(BR)DSS}$ ,  $V_{DD} = 400\text{ V}$ .
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               | 0.50               |        |        | $^{\circ}\text{C}/\text{W}$ |
| $R_{thj-pcb}$  | Thermal resistance junction-pcb <sup>(1)</sup> | 30                 |        |        | $^{\circ}\text{C}/\text{W}$ |
| $R_{thj-amb}$  | Thermal resistance junction-ambient            |                    | 62.5   | 50     | $^{\circ}\text{C}/\text{W}$ |

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

**Table 4. Avalanche characteristics**

| Symbol   | Parameter                                                                                                      | Value | Unit |
|----------|----------------------------------------------------------------------------------------------------------------|-------|------|
| $I_{AR}$ | Avalanche current, repetitive or not repetitive (pulse width limited by $T_{jmax}$ )                           | 6     | A    |
| $E_{AS}$ | Single pulse avalanche energy (starting $T_j = 25^{\circ}\text{C}$ , $I_D = I_{AR}$ ; $V_{DD} = 50\text{ V}$ ) | 500   | mJ   |

## 2 Electrical characteristics

( $T_C = 25\text{ °C}$  unless otherwise specified)

**Table 5. On /off states**

| Symbol        | Parameter                         | Test conditions                                                | Min. | Typ.  | Max.     | Unit          |
|---------------|-----------------------------------|----------------------------------------------------------------|------|-------|----------|---------------|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage    | $V_{GS} = 0, I_D = 1\text{ mA}$                                | 600  |       |          | V             |
| $I_{DSS}$     | Zero gate voltage drain current   | $V_{GS} = 0, V_{DS} = 600\text{ V}$                            |      |       | 1        | $\mu\text{A}$ |
|               |                                   | $V_{GS} = 0, V_{DS} = 600\text{ V}, T_C = 125\text{ °C}^{(1)}$ |      |       | 100      | $\mu\text{A}$ |
| $I_{GSS}$     | Gate-body leakage current         | $V_{DS} = 0, V_{GS} = \pm 25\text{ V}$                         |      |       | $\pm 10$ | $\mu\text{A}$ |
| $V_{GS(th)}$  | Gate threshold voltage            | $V_{DS} = V_{GS}, I_D = 250\text{ }\mu\text{A}$                | 2    | 3     | 4        | V             |
| $R_{DS(on)}$  | Static drain-source on-resistance | $V_{GS} = 10\text{ V}, I_D = 17\text{ A}$                      |      | 0.078 | 0.088    | $\Omega$      |

1. Defined by design, not subject to production test

**Table 6. Dynamic**

| Symbol                     | Parameter                     | Test conditions                                                                                      | Min. | Typ. | Max. | Unit     |
|----------------------------|-------------------------------|------------------------------------------------------------------------------------------------------|------|------|------|----------|
| $C_{iss}$                  | Input capacitance             | $V_{DS} = 100\text{ V}, f = 1\text{ MHz}, V_{GS} = 0$                                                | -    | 2500 | -    | pF       |
| $C_{oss}$                  | Output capacitance            |                                                                                                      | -    | 117  | -    | pF       |
| $C_{rss}$                  | Reverse transfer capacitance  |                                                                                                      | -    | 2.4  | -    | pF       |
| $C_{oss\text{ eq.}}^{(1)}$ | Equivalent output capacitance | $V_{DS} = 0\text{ to }480\text{ V}, V_{GS} = 0$                                                      | -    | 342  | -    | pF       |
| $R_G$                      | Intrinsic gate resistance     | $f = 1\text{ MHz}, I_D = 0$                                                                          | -    | 4.4  | -    | $\Omega$ |
| $Q_g$                      | Total gate charge             | $V_{DD} = 480\text{ V}, I_D = 34\text{ A}, V_{GS} = 10\text{ V}$<br>(see <a href="#">Figure 17</a> ) | -    | 57   | -    | nC       |
| $Q_{gs}$                   | Gate-source charge            |                                                                                                      | -    | 10   | -    | nC       |
| $Q_{gd}$                   | Gate-drain charge             |                                                                                                      | -    | 25.5 | -    | nC       |

1.  $C_{oss\text{ eq.}}$  is defined as a constant equivalent capacitance giving the same charging time as  $C_{oss}$  when  $V_{DS}$  increases from 0 to 80%  $V_{DSS}$

Table 7. Switching times

| Symbol       | Parameter           | Test conditions                                                                                                                                                      | Min. | Typ. | Max. | Unit |
|--------------|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|
| $t_{d(on)}$  | Turn-on delay time  | $V_{DD} = 300\text{ V}$ , $I_D = 34\text{ A}$ ,<br>$R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$<br>(see <a href="#">Figure 16</a> and<br><a href="#">Figure 21</a> ) | -    | 20.5 | -    | ns   |
| $t_r$        | Rise time           |                                                                                                                                                                      | -    | 13.5 | -    | ns   |
| $t_{d(off)}$ | Turn-off-delay time |                                                                                                                                                                      | -    | 96   | -    | ns   |
| $t_f$        | Fall time           |                                                                                                                                                                      | -    | 11   | -    | ns   |

Table 8. Source drain diode

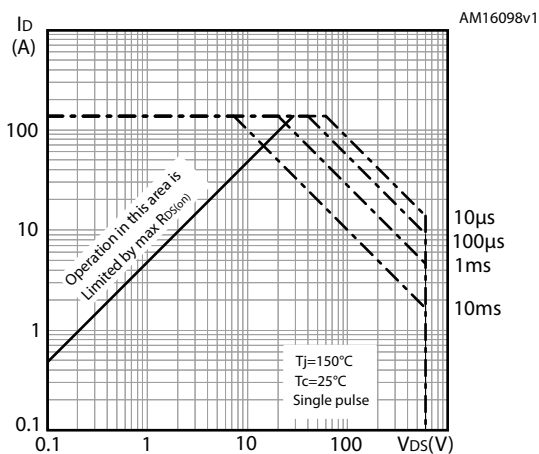
| Symbol          | Parameter                     | Test conditions                                                                                                                                               | Min. | Typ. | Max. | Unit          |
|-----------------|-------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|---------------|
| $I_{SD}$        | Source-drain current          |                                                                                                                                                               | -    | 34   |      | A             |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |                                                                                                                                                               | -    | 136  |      | A             |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD} = 34\text{ A}$ , $V_{GS} = 0$                                                                                                                         | -    |      | 1.6  | V             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 34\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$<br>$V_{DD} = 60\text{ V}$ (see <a href="#">Figure 18</a> )                                        | -    | 440  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                                               | -    | 8.2  |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                                               | -    | 37   |      | A             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 34\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$<br>$V_{DD} = 60\text{ V}$ , $T_J = 150\text{ }^\circ\text{C}$<br>(see <a href="#">Figure 18</a> ) | -    | 568  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                                               | -    | 11.5 |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                                               | -    | 40.5 |      | A             |

1. Pulse width limited by safe operating area.

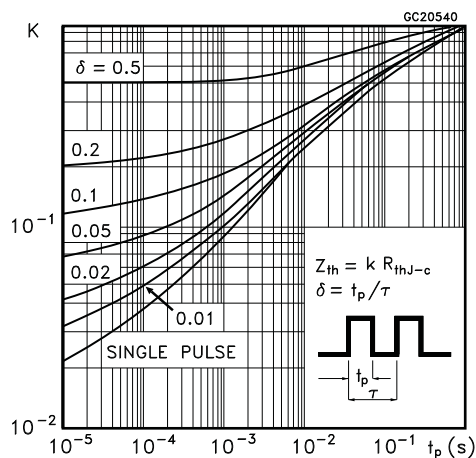
2. Pulsed: pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%

## 2.1 Electrical characteristics (curves)

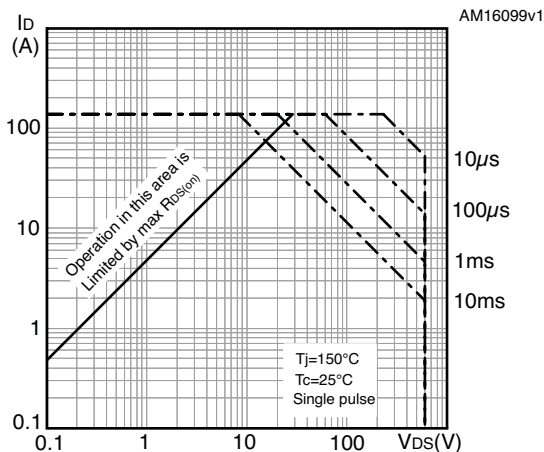
**Figure 2. Safe operating area for D<sup>2</sup>PAK and TO-220**



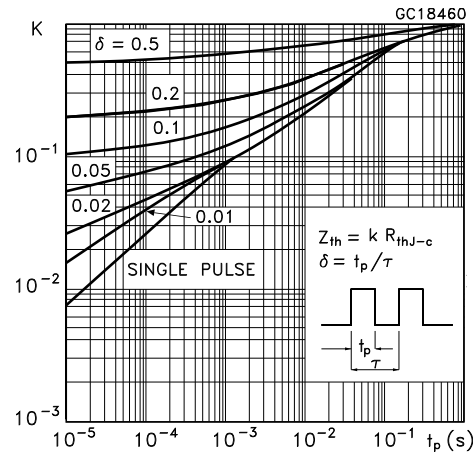
**Figure 3. Thermal impedance D<sup>2</sup>PAK and TO-220**



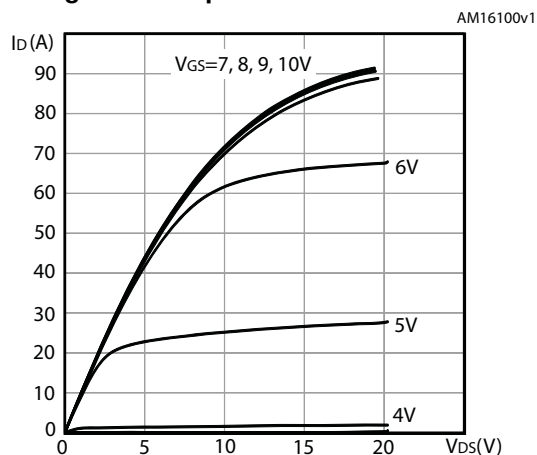
**Figure 4. Safe operating area for TO-247**



**Figure 5. Thermal impedance for TO-247**



**Figure 6. Output characteristics**



**Figure 7. Transfer characteristics**

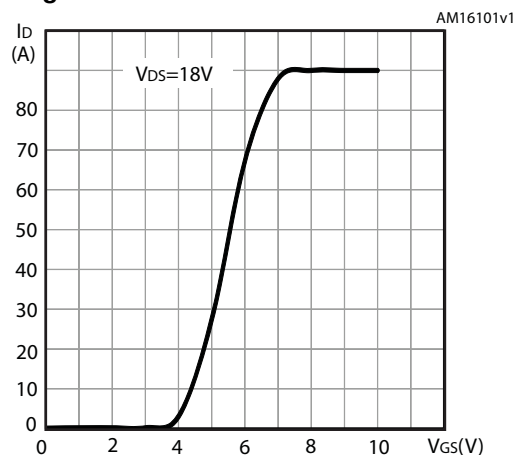


Figure 8. Gate charge vs gate-source voltage

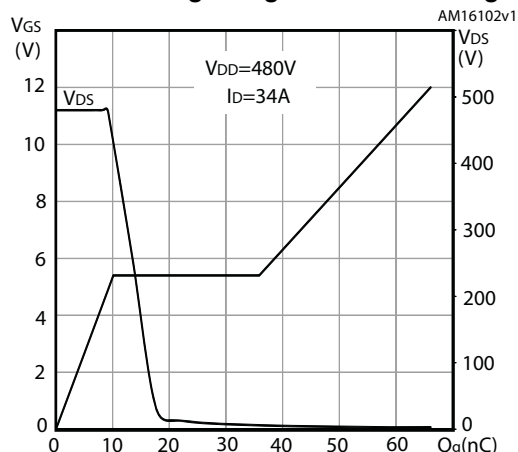


Figure 9. Static drain-source on-resistance

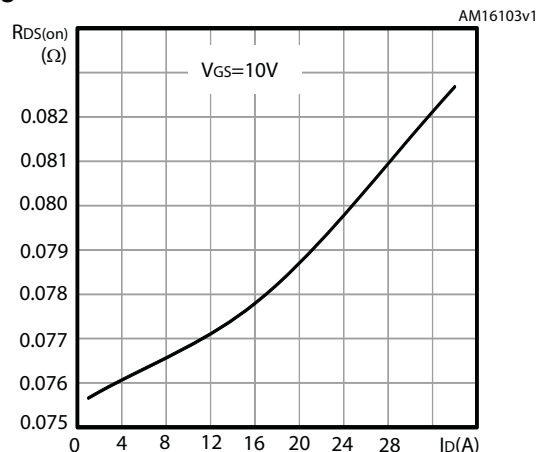


Figure 10. Capacitance variations

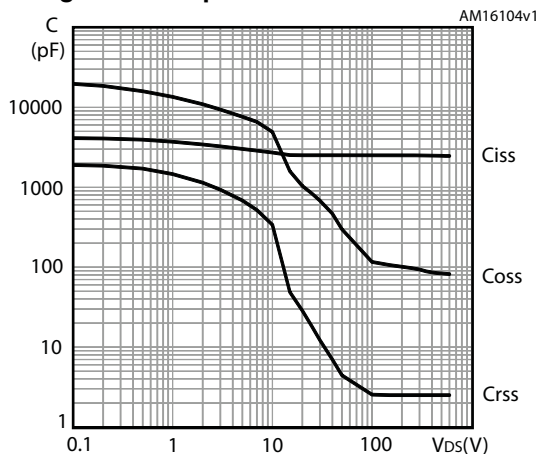


Figure 11. Output capacitance stored energy

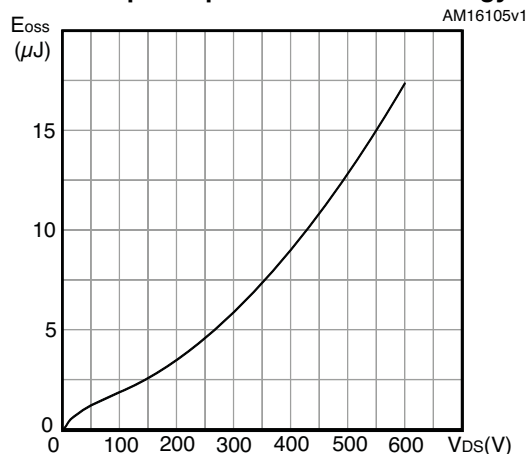


Figure 12. Normalized gate threshold voltage vs temperature

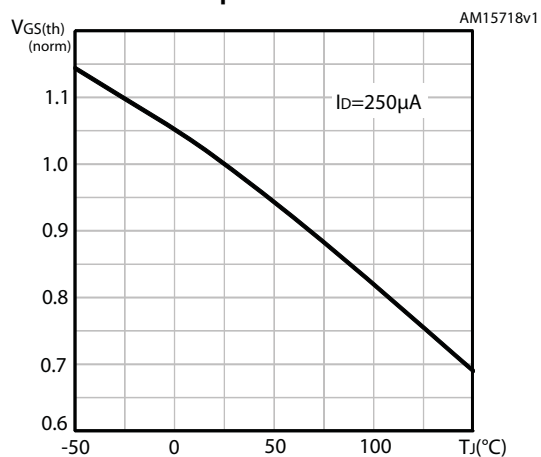


Figure 13. Normalized on-resistance vs temperature

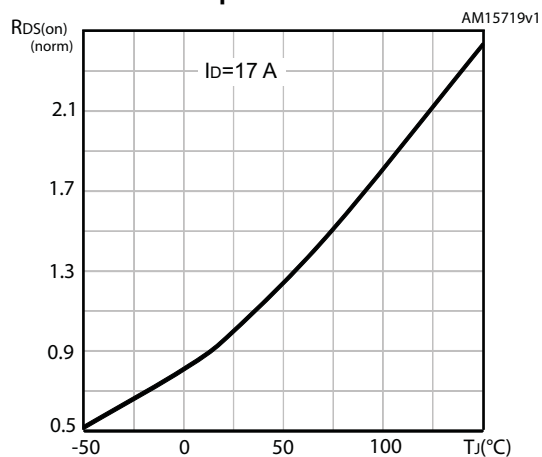


Figure 14. Normalized  $V_{(BR)DSS}$  vs temperature

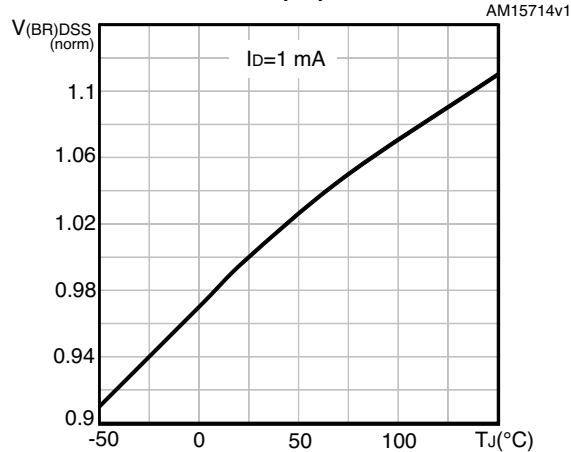
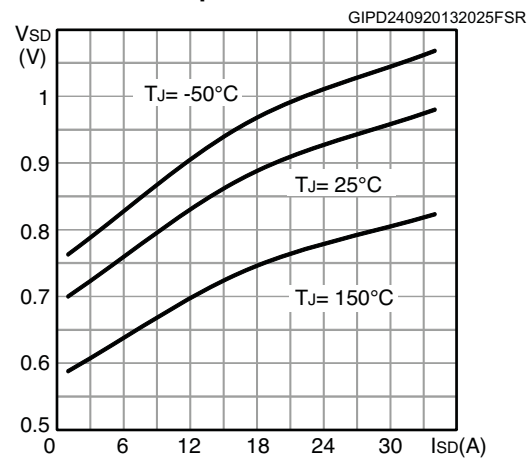


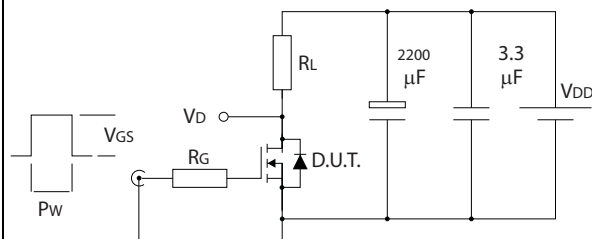
Figure 15. Source-drain diode forward vs temperature





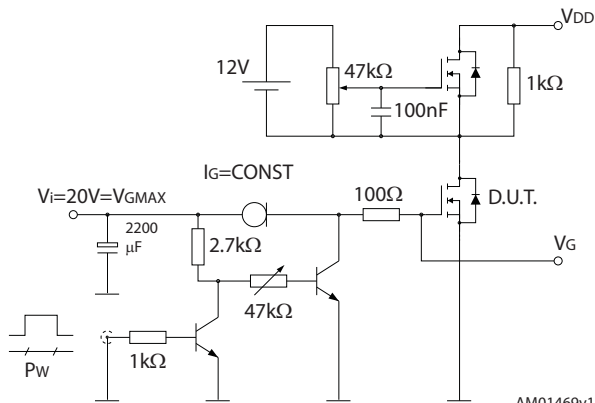
### 3 Test circuits

**Figure 16. Switching times test circuit for resistive load**



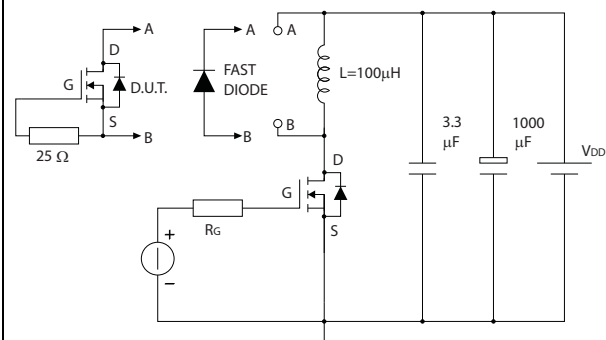
AM01468v1

**Figure 17. Gate charge test circuit**



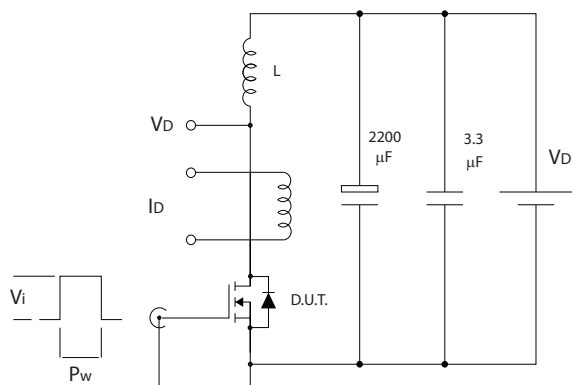
AM01469v1

**Figure 18. Test circuit for inductive load switching and diode recovery times**



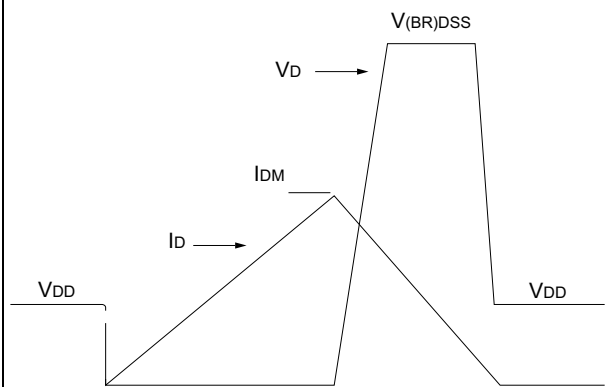
AM01470v1

**Figure 19. Unclamped inductive load test circuit**



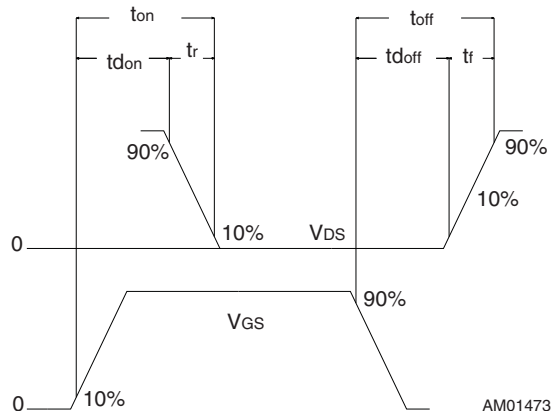
AM01471v1

**Figure 20. Unclamped inductive waveform**



AM01472v1

**Figure 21. Switching time waveform**



AM01473v1

## 4 Package information

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.

## 4.1 D<sup>2</sup>PAK (TO-263) package information

Figure 22. D<sup>2</sup>PAK (TO-263) type A package outline

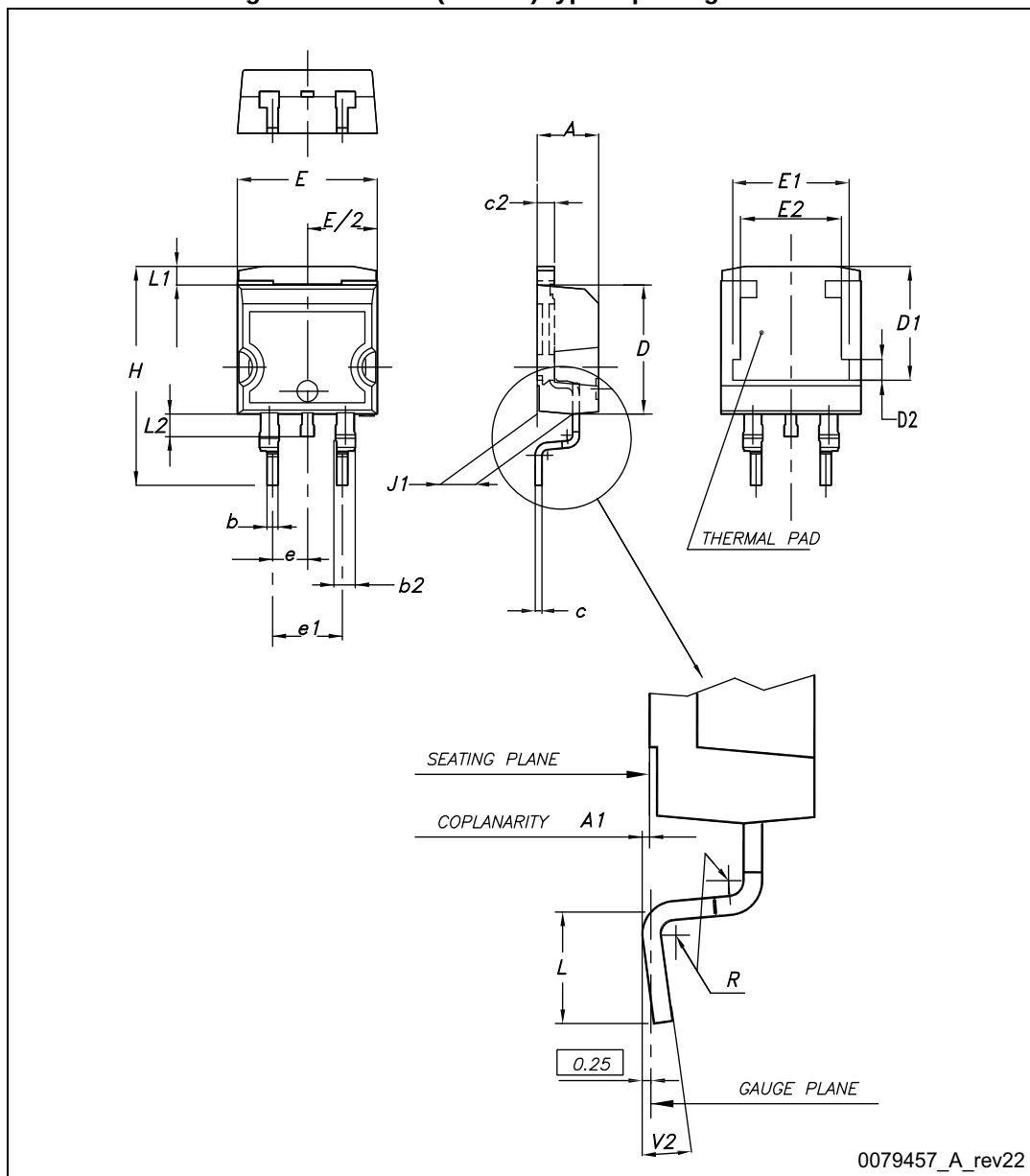
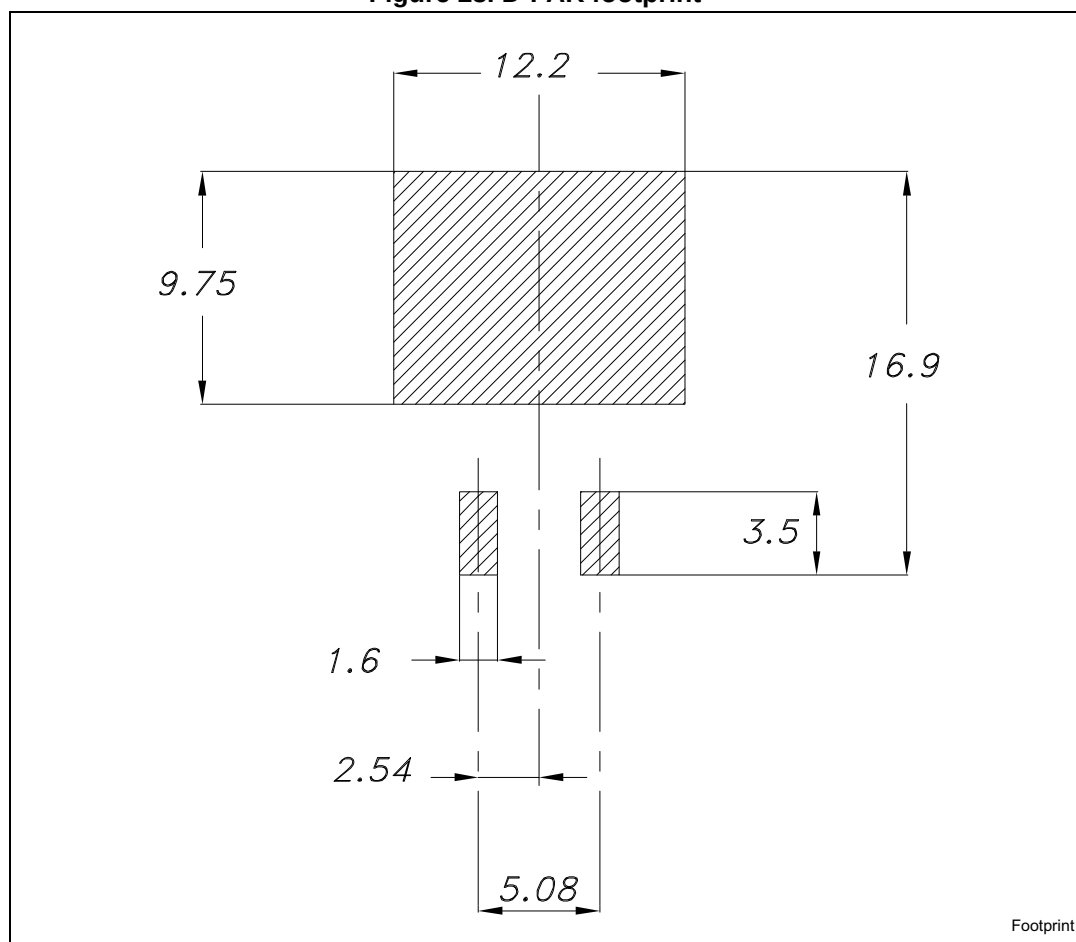


Table 9. D<sup>2</sup>PAK (TO-263) type A mechanical data

| 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    |       | 0.4  |       |
| V2   | 0°    |      | 8°    |

Figure 23. D<sup>2</sup>PAK footprint<sup>(a)</sup>

a. All dimension are in millimeters

## 4.2 TO-220 package information

Figure 24. TO-220 type A package outline

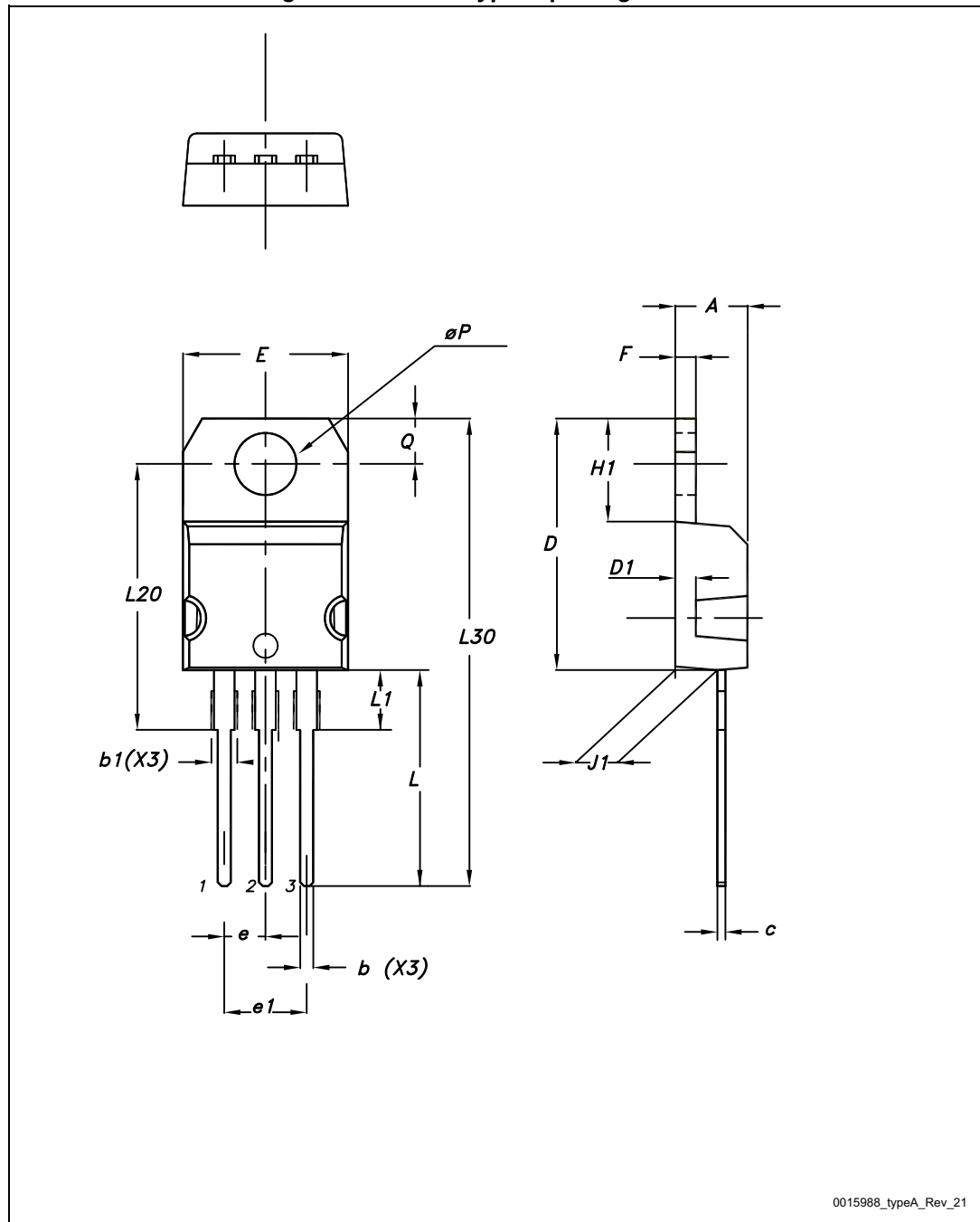


Table 10. TO-220 type A mechanical data

| 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  |

### 4.3 TO-247 package information

Figure 25. TO-247 package outline

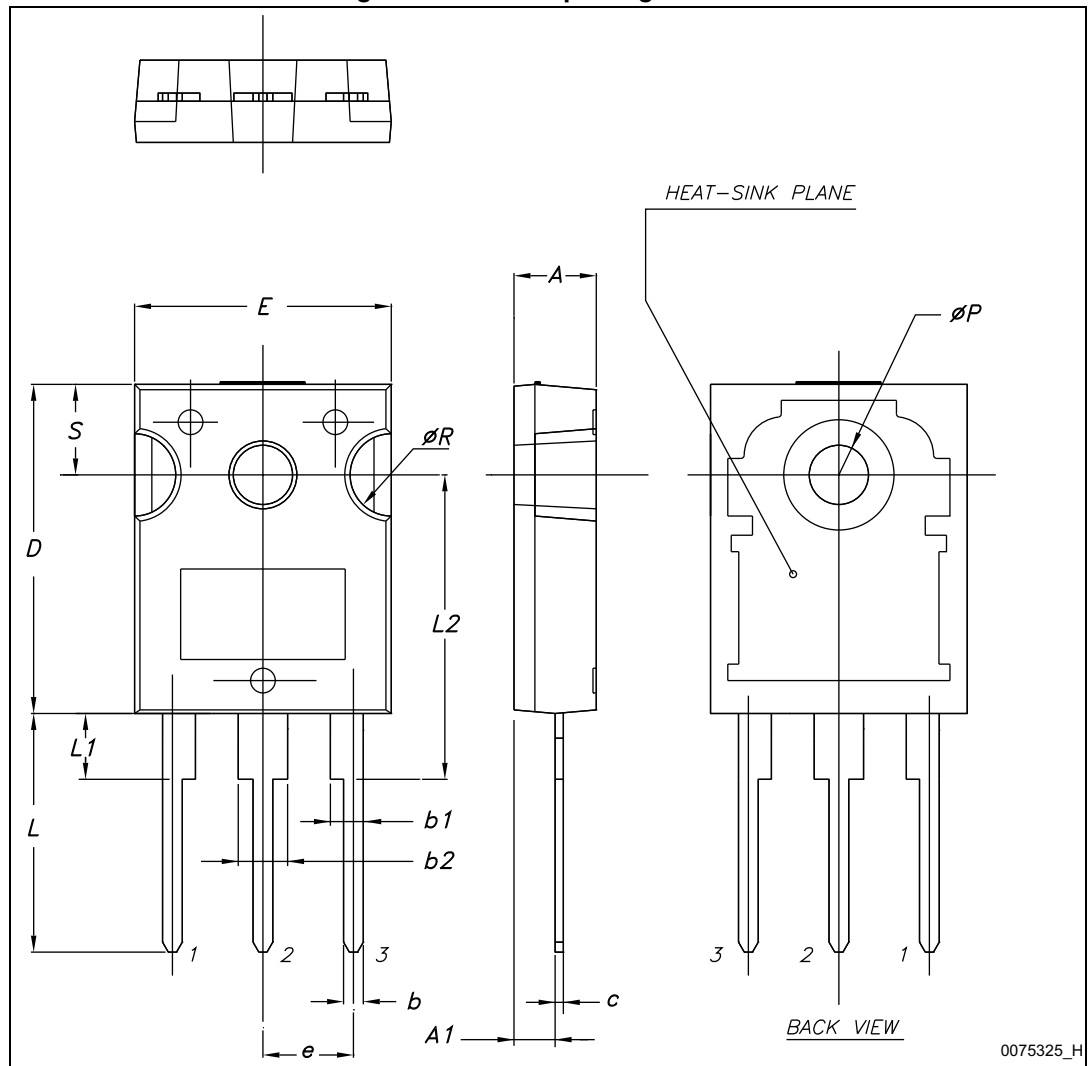




Table 11. TO-247 package mechanical data

| 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

Figure 26. Tape

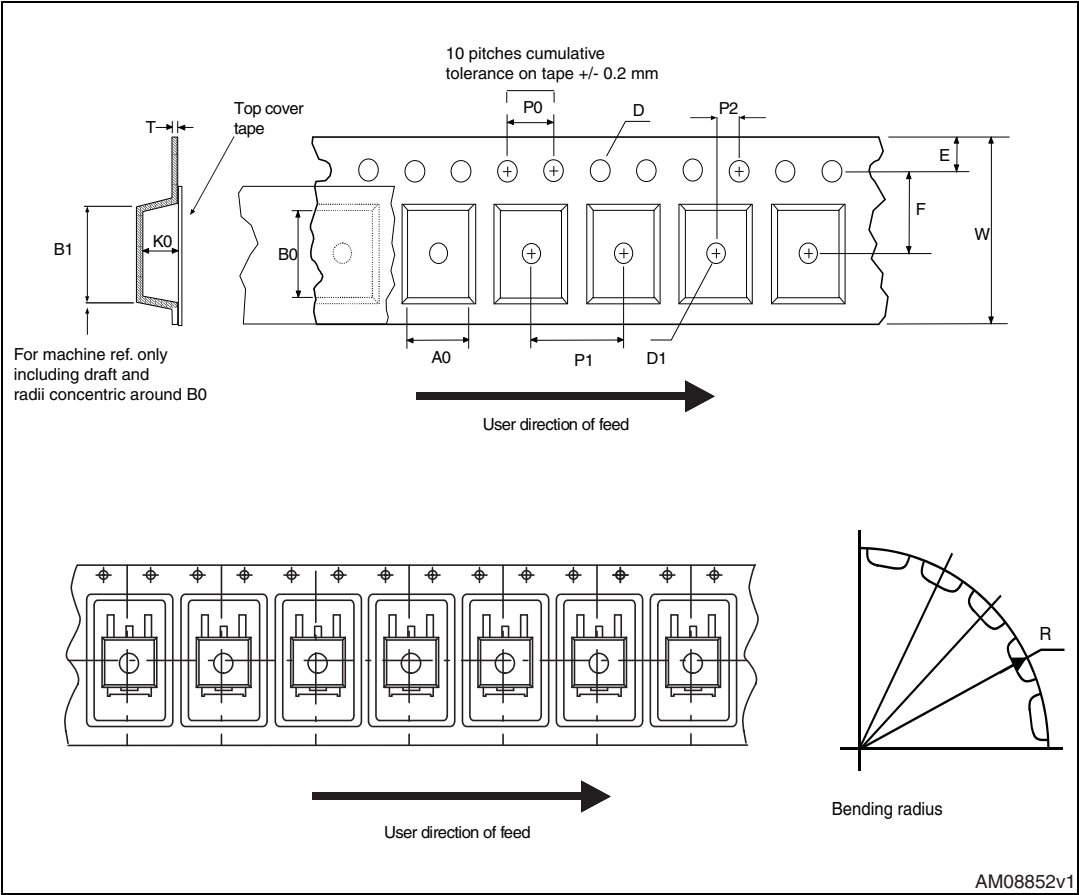
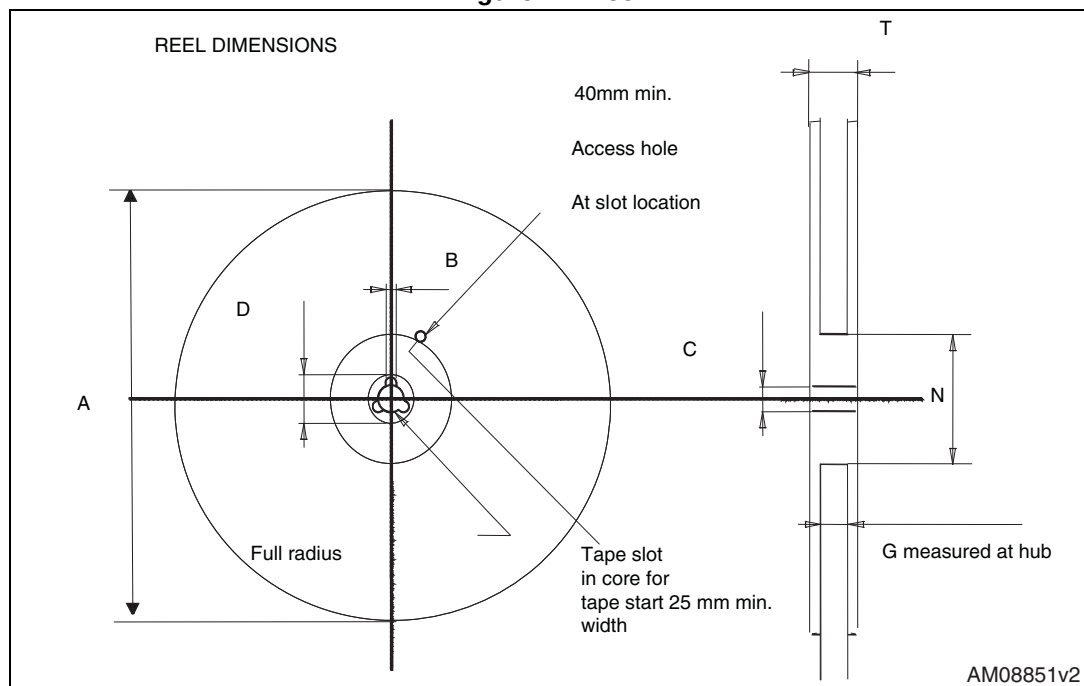


Figure 27. Reel

Table 12. 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 |          |      |      |

## 6 Revision history

**Table 13. Document revision history**

| Date        | Revision | Changes                                                                                                                                                                                                                                                                                                                                                                  |
|-------------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 01-Jul-2013 | 1        | First release.                                                                                                                                                                                                                                                                                                                                                           |
| 23-Sep-2013 | 2        | <ul style="list-style-type: none"><li>– Added: TO-220FP and I<sup>2</sup>PAKFP packages</li><li>– Inserted: <math>V_{ISO}</math> in <i>Table 2</i></li><li>– Modified: values in <i>Table 4</i>, the entire typical values in <i>Table 6</i>, <i>7</i> and <i>8</i></li><li>– Updated: <i>Section 4: Package mechanical data</i>.</li><li>– Minor text changes</li></ul> |
| 13-May-2014 | 3        | <ul style="list-style-type: none"><li>– The part numbers STB40N60M2 and STF140N60M2 have been moved to a separate datasheet</li><li>– Minor text changes</li></ul>                                                                                                                                                                                                       |
| 09-Aug-2016 | 4        | <p>Updated title, features and description in cover page.</p> <p>Updated <i>Table 2: Absolute maximum ratings</i>, <i>Table 5: On /off states</i> and <i>Table 8: Source drain diode</i>.</p> <p>Updated <i>Section 4.1: D<sup>2</sup>PAK (TO-263) package information</i> and <i>Section 4.2: TO-220 package information</i>.</p> <p>Minor text changes.</p>            |

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