

N-channel 600 V, 0.168  $\Omega$  typ., 18 A MDmesh II Plus™ low  $Q_g$   
Power MOSFET in D<sup>2</sup>PAK, I<sup>2</sup>PAK, TO-220 and TO-247 packages

Datasheet – production data

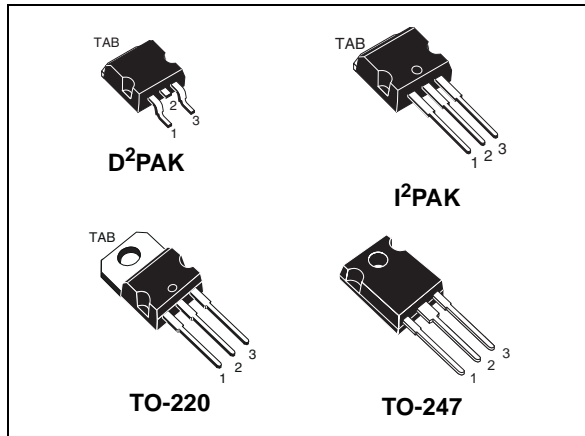
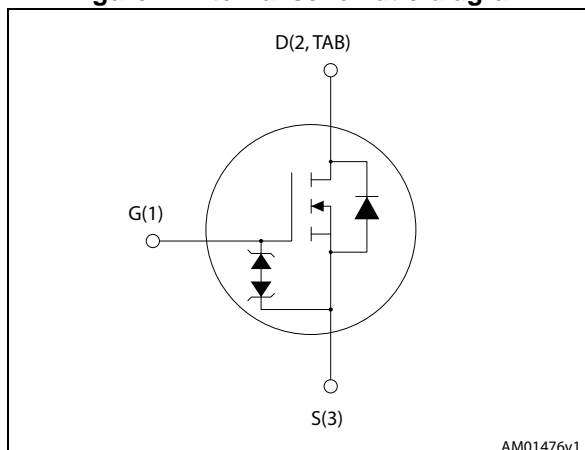


Figure 1. Internal schematic diagram



## Features

| Order codes | $V_{DS} @ T_{Jmax}$ | $R_{DS(on) max}$ | $I_D$ |
|-------------|---------------------|------------------|-------|
| STB24N60M2  | 650 V               | 0.19 $\Omega$    | 18 A  |
| STI24N60M2  |                     |                  |       |
| STP24N60M2  |                     |                  |       |
| STW24N60M2  |                     |                  |       |

- Extremely low gate charge
- Lower  $R_{DS(on)}$  x area vs previous generation
- Low gate input resistance
- 100% avalanche tested
- Zener-protected

## Applications

- Switching applications

## Description

These devices are N-channel Power MOSFETs developed using a new generation of MDmesh™ technology: MDmesh II Plus™ low  $Q_g$ . These revolutionary Power MOSFETs associate a vertical structure to the company's strip layout to yield one of the world's lowest on-resistance and gate charge. They are therefore suitable for the most demanding high efficiency converters.

Table 1. Device summary

| Order codes | Marking | Package            | Packaging     |
|-------------|---------|--------------------|---------------|
| STB24N60M2  | 24N60M2 | D <sup>2</sup> PAK | Tape and reel |
| STI24N60M2  |         | I <sup>2</sup> PAK | Tube          |
| STP24N60M2  |         | TO-220             |               |
| STW24N60M2  |         | TO-247             |               |

# Contents

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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 $T_C = 25\text{ }^\circ\text{C}$  | 18          | A                |
| $I_D$          | Drain current (continuous) at $T_C = 100\text{ }^\circ\text{C}$ | 12          | A                |
| $I_{DM}^{(1)}$ | Drain current (pulsed)  | 72          | A                |
| $P_{TOT}$      | Total dissipation at $T_C = 25\text{ }^\circ\text{C}$           | 150         | 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   | - 55 to 150 | $^\circ\text{C}$ |
| $T_j$          | Max. operating junction temperature                             |             |                  |

1. Pulse width limited by safe operating area.
2.  $I_{SD} \leq 18\text{ A}$ ,  $di/dt \leq 400\text{ A}/\mu\text{s}$ ;  $V_{DS\text{ peak}} < V_{(BR)DSS}$ ;  $V_{DD}=400\text{ V}$ .
3.  $V_{DS} \leq 480\text{ V}$

**Table 3. Thermal data**

| Symbol         | Parameter  | Value              |                    |        |        | Unit                      |
|----------------|--|--------------------|--------------------|--------|--------|---------------------------|
|                |  | D <sup>2</sup> PAK | I <sup>2</sup> PAK | TO-220 | TO-247 |                           |
| $R_{thj-case}$ | Thermal resistance junction-case max               | 0.83               |                    |        |        | $^\circ\text{C}/\text{W}$ |
| $R_{thj-pcb}$  | Thermal resistance junction-pcb max <sup>(1)</sup> | 30                 |                    |        |        | $^\circ\text{C}/\text{W}$ |
| $R_{thj-amb}$  | Thermal resistance junction-ambient max            |                    | 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 $T_{jmax}$ )                    | 3.5   | A    |
| $E_{AS}$ | Single pulse avalanche energy (starting $T_j=25\text{ }^\circ\text{C}$ , $I_D = I_{AR}$ ; $V_{DD}=50$ ) | 180   | 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                   | $I_D = 1\text{ mA}$ , $V_{GS} = 0$   | 600  |       |          | V                              |
| $I_{DSS}$     | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = 600\text{ V}$<br>$V_{DS} = 600\text{ V}$ , $T_C = 125\text{ °C}$ |      |       | 1<br>100 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$     | 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                | $V_{GS} = 10\text{ V}$ , $I_D = 9\text{ A}$                                |      | 0.168 | 0.19     | $\Omega$                       |

**Table 6. Dynamic**

| Symbol                     | Parameter                     | Test conditions   | Min. | Typ. | Max. | Unit     |
|----------------------------|-------------------------------|---|------|------|------|----------|
| $C_{iss}$                  | Input capacitance             | $V_{DS} = 100\text{ V}$ , $f = 1\text{ MHz}$ ,<br>$V_{GS} = 0$  | -    | 1060 | -    | pF       |
| $C_{oss}$                  | Output capacitance            |   | -    | 55   | -    | pF       |
| $C_{riss}$                 | Reverse transfer capacitance  |   | -    | 2.2  | -    | pF       |
| $C_{oss\text{ eq.}}^{(1)}$ | Equivalent output capacitance | $V_{DS} = 0\text{ to }480\text{ V}$ , $V_{GS} = 0$  | -    | 258  | -    | pF       |
| $R_G$                      | Intrinsic gate resistance     | $f = 1\text{ MHz}$ , $I_D = 0$  | -    | 7    | -    | $\Omega$ |
| $Q_g$                      | Total gate charge             | $V_{DD} = 480\text{ V}$ , $I_D = 18\text{ A}$ ,<br>$V_{GS} = 10\text{ V}$<br>(see <a href="#">Figure 17</a> ) | -    | 29   | -    | nC       |
| $Q_{gs}$                   | Gate-source charge            |   | -    | 6    | -    | nC       |
| $Q_{gd}$                   | Gate-drain charge             |   | -    | 12   | -    | 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  | $V_{DD} = 300\text{ V}$ , $I_D = 9\text{ A}$ ,<br>$R_G = 4.7\text{ }\Omega$ , $V_{GS} = 10\text{ V}$<br>(see <a href="#">Figure 16</a> and <a href="#">21</a> ) | -    | 14   | -    | ns   |
| $t_r$        | Rise time           |   | -    | 9    | -    | ns   |
| $t_{d(off)}$ | Turn-off delay time |   | -    | 60   | -    | ns   |
| $t_{f(l)}$   | Fall time           |   | -    | 15   | -    | ns   |

Table 8. Source drain diode

| Symbol          | Parameter                     | Test conditions   | Min. | Typ. | Max. | Unit |
|-----------------|-------------------------------|---|------|------|------|------|
| $I_{SD}$        | Source-drain current          |   | -    |      | 18   | A    |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |   | -    |      | 72   | A    |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD} = 18\text{ A}$ , $V_{GS} = 0$   | -    |      | 1.6  | V    |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 18\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$<br>$V_{DD} = 60\text{ V}$ (see <a href="#">Figure 18</a> )                            | -    | 332  |      | ns   |
| $Q_{rr}$        | Reverse recovery charge       |   | -    | 4    |      | nC   |
| $I_{RRM}$       | Reverse recovery current      |   | -    | 24   |      | A    |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 18\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$<br>$V_{DD} = 60\text{ V}$ , $T_j = 150\text{ °C}$<br>(see <a href="#">Figure 18</a> ) | -    | 450  |      | ns   |
| $Q_{rr}$        | Reverse recovery charge       |   | -    | 5.5  |      | nC   |
| $I_{RRM}$       | Reverse recovery current      |   | -    | 25   |      | 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, I<sup>2</sup>PAK and TO-220 Figure 3. Thermal impedance D<sup>2</sup>PAK, I<sup>2</sup>PAK and TO-220

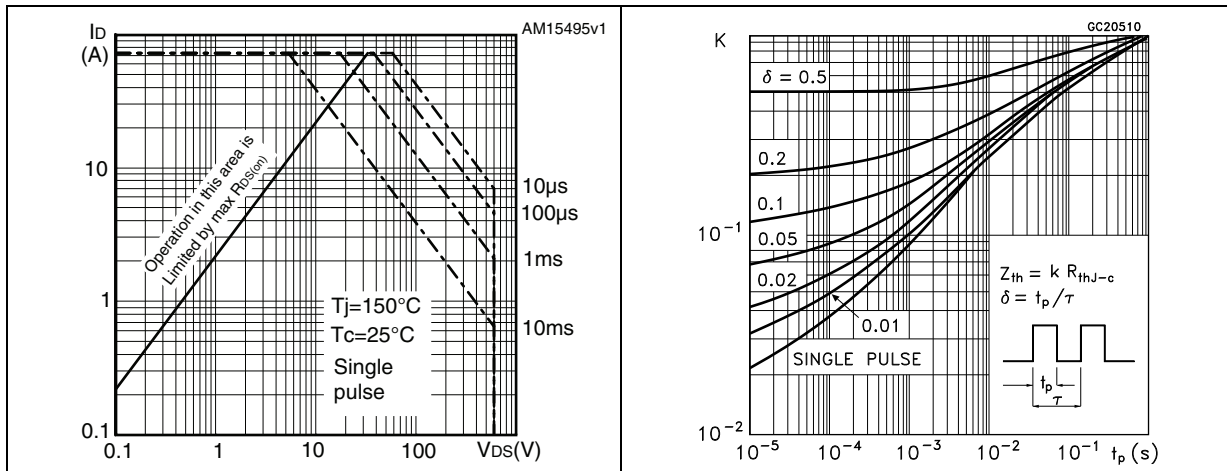


Figure 4. Safe operating area for TO-247

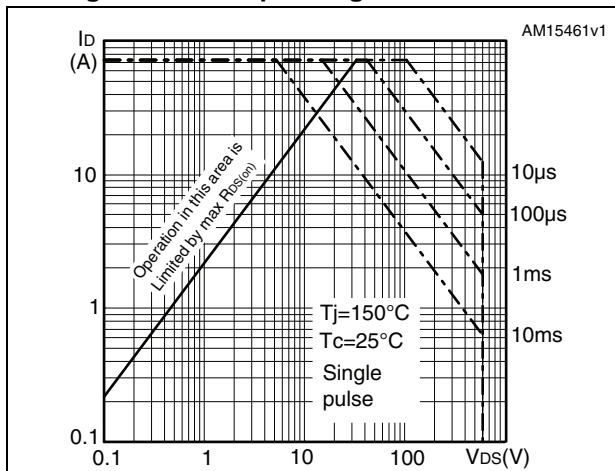


Figure 5. Thermal impedance for TO-247

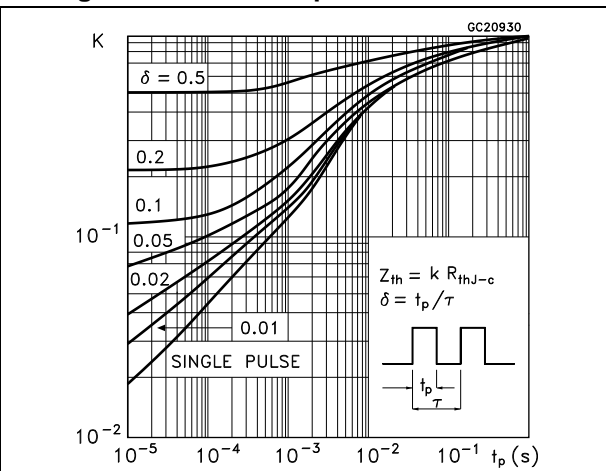


Figure 6. Output characteristics

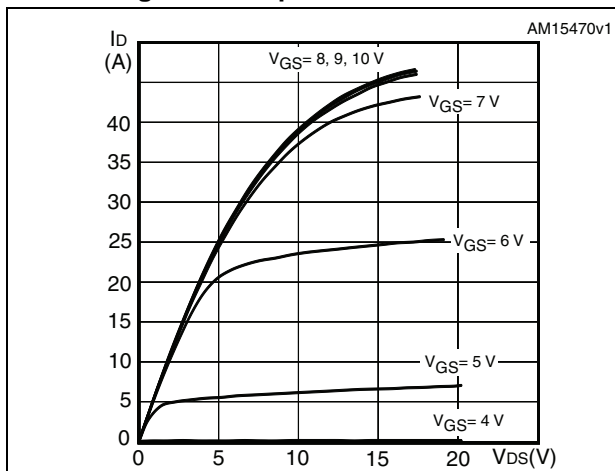


Figure 7. Transfer characteristics

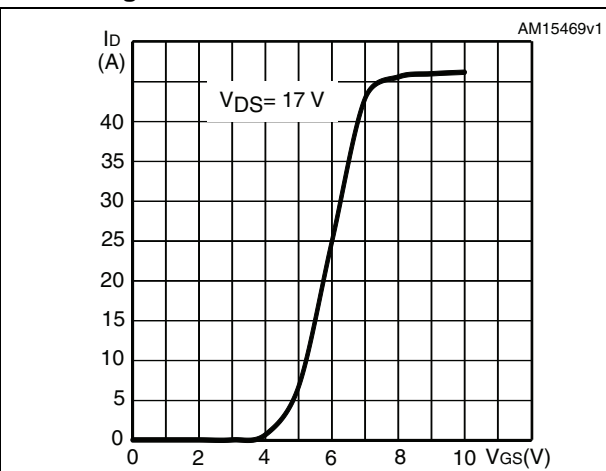


Figure 8. Gate charge vs gate-source voltage

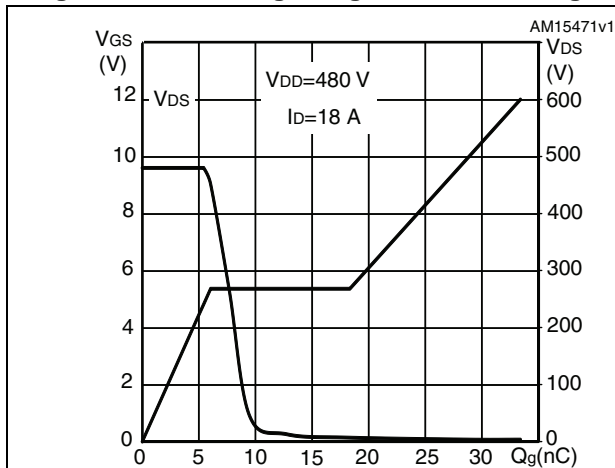


Figure 9. Static drain-source on-resistance

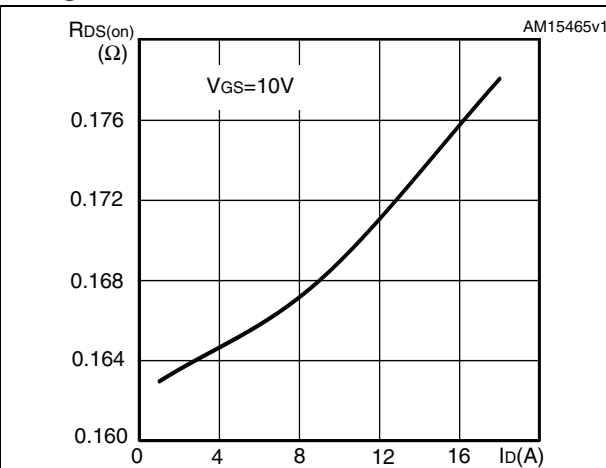


Figure 10. Capacitance variations

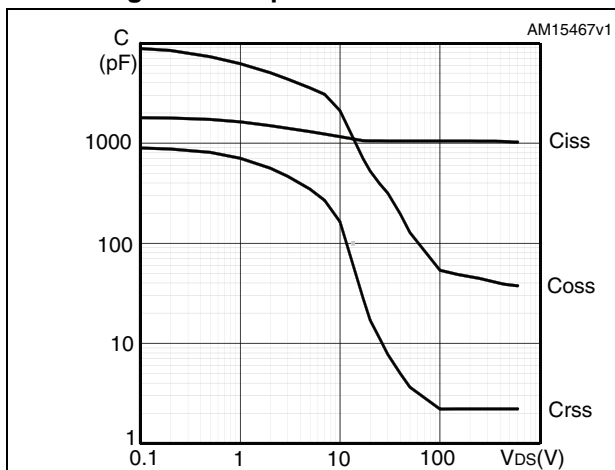


Figure 11. Output capacitance stored energy

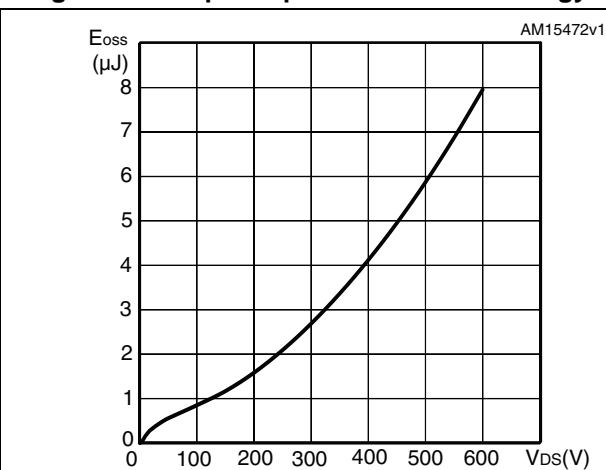


Figure 12. Normalized gate threshold voltage vs temperature

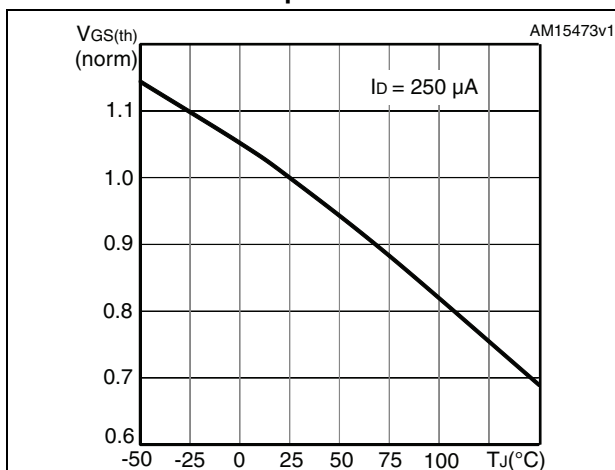


Figure 13. Normalized on-resistance vs temperature

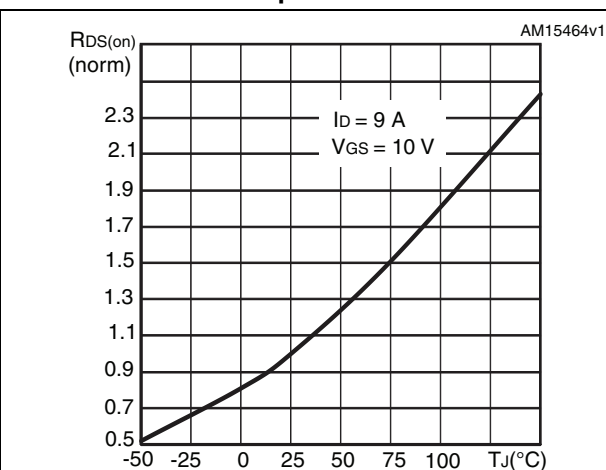


Figure 14. Source-drain diode forward characteristics

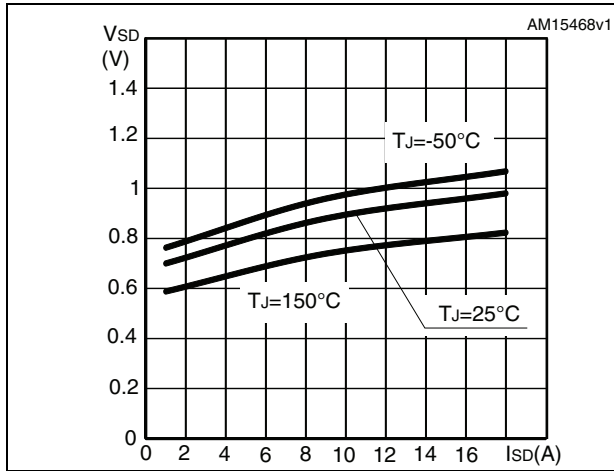
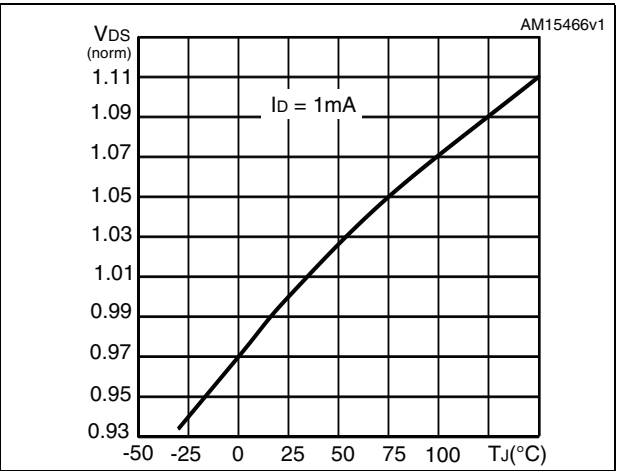


Figure 15. Normalized  $B_{VDSS}$  vs temperature





### 3 Test circuits

Figure 16. Switching times test circuit for resistive load

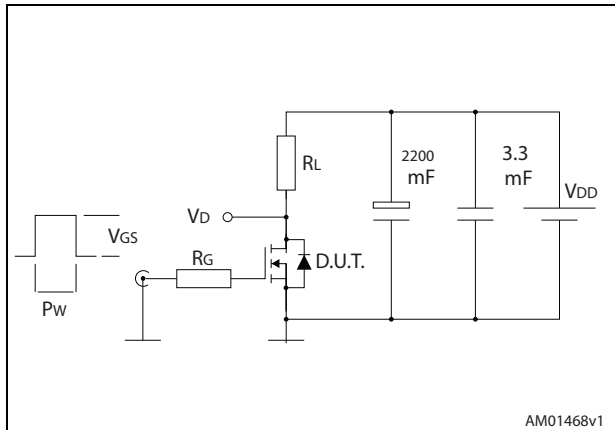


Figure 17. Gate charge test circuit

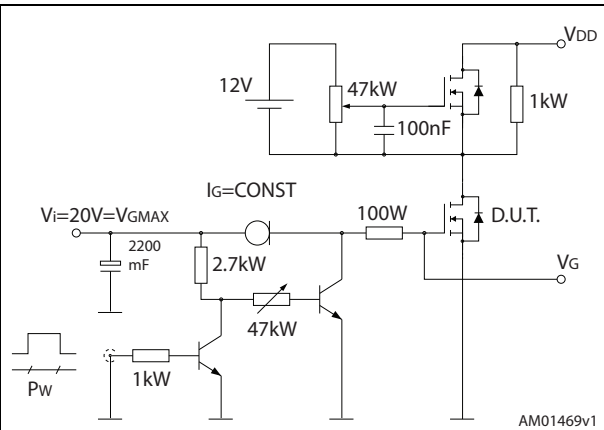


Figure 18. Test circuit for inductive load switching and diode recovery times

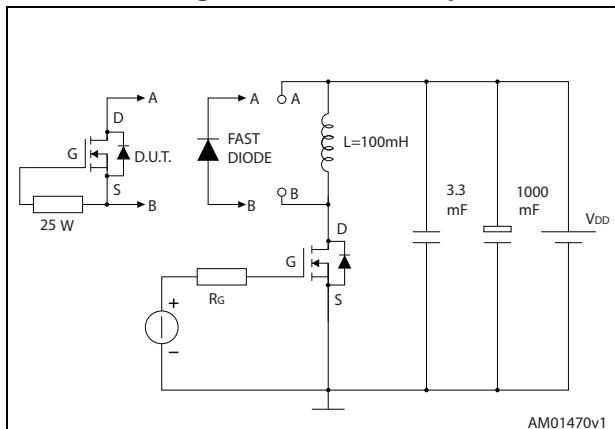


Figure 19. Unclamped inductive load test circuit

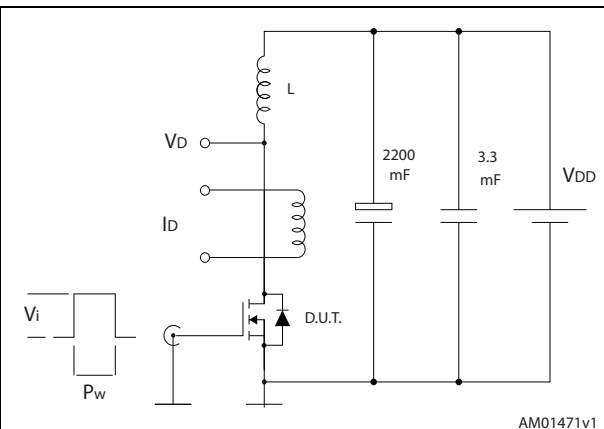


Figure 20. Unclamped inductive waveform

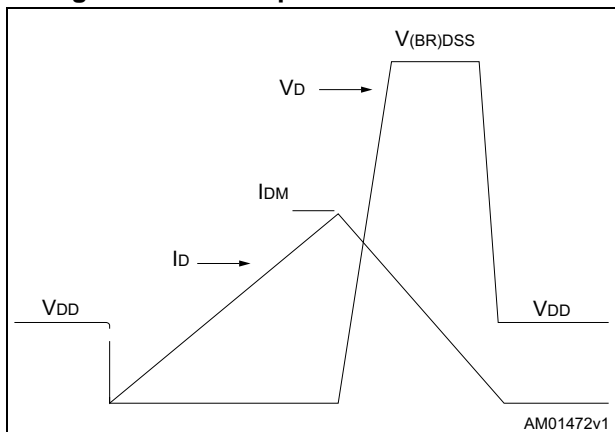
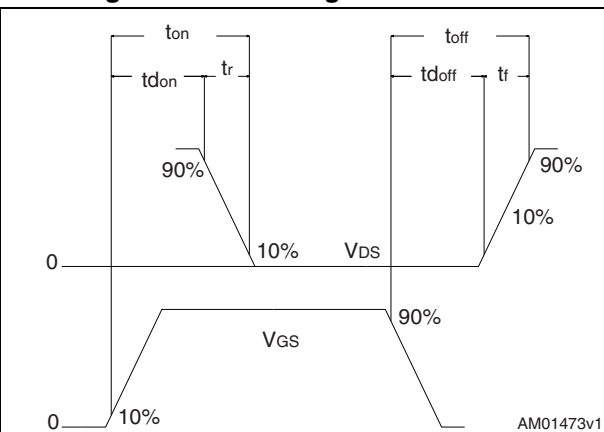


Figure 21. Switching time waveform



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

| Dim. | mm   |      |       |
|------|------|------|-------|
|      | Min. | Typ. | Max.  |
| A    | 4.40 |      | 4.60  |
| A1   | 0.03 |      | 0.23  |
| b    | 0.70 |      | 0.93  |
| b2   | 1.14 |      | 1.70  |
| c    | 0.45 |      | 0.60  |
| c2   | 1.23 |      | 1.36  |
| D    | 8.95 |      | 9.35  |
| D1   | 7.50 |      |       |
| E    | 10   |      | 10.40 |
| E1   | 8.50 |      |       |
| e    |      | 2.54 |       |
| e1   | 4.88 |      | 5.28  |
| H    | 15   |      | 15.85 |
| J1   | 2.49 |      | 2.69  |
| L    | 2.29 |      | 2.79  |
| L1   | 1.27 |      | 1.40  |
| L2   | 1.30 |      | 1.75  |
| R    |      | 0.4  |       |
| V2   | 0°   |      | 8°    |

Figure 22. D<sup>2</sup>PAK (TO-263) drawing

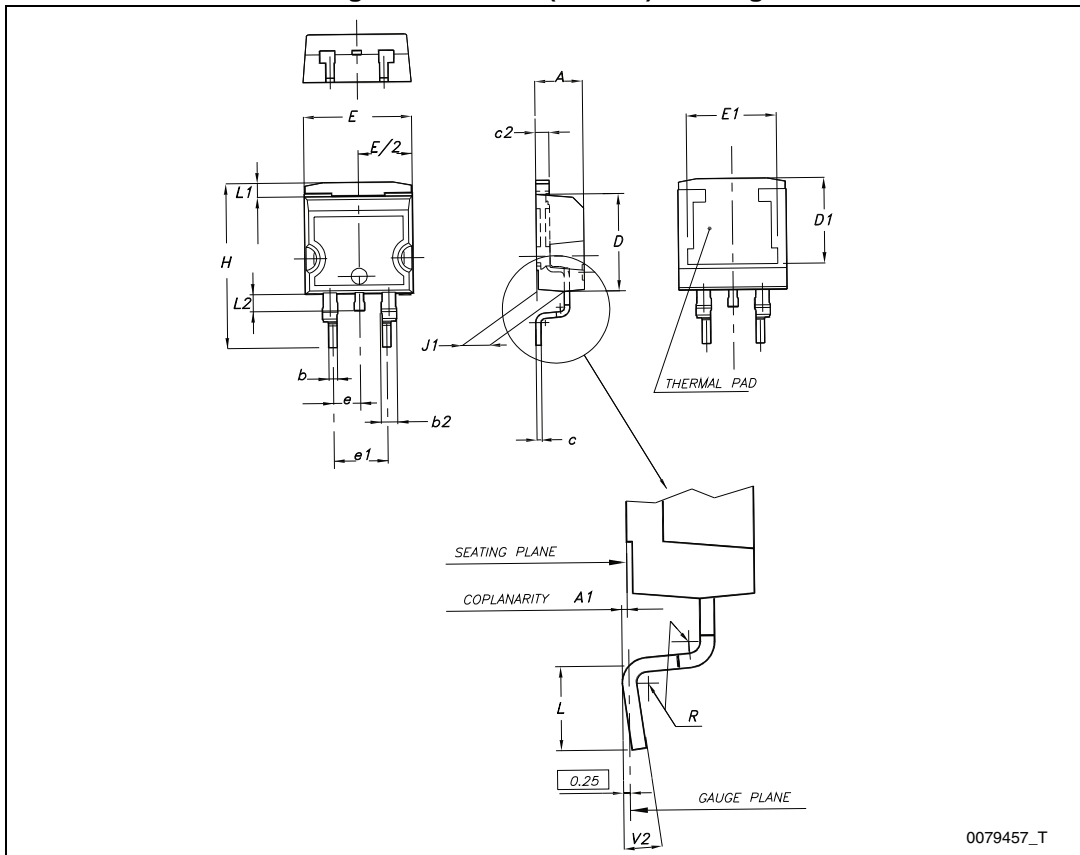
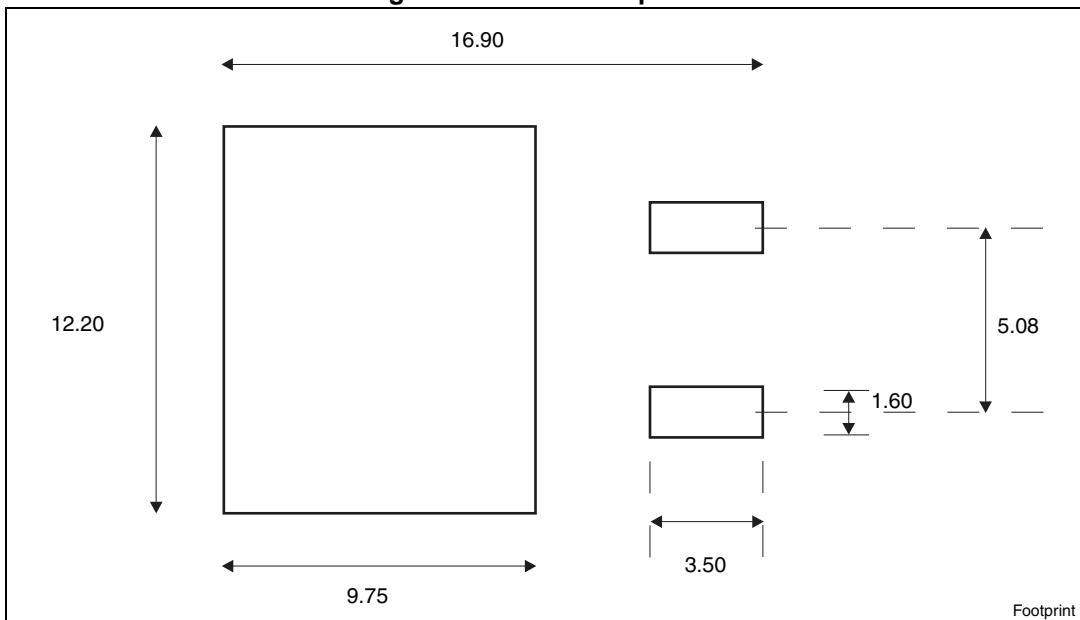


Figure 23. D<sup>2</sup>PAK footprint<sup>(a)</sup>



a. All dimension are in millimeters

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

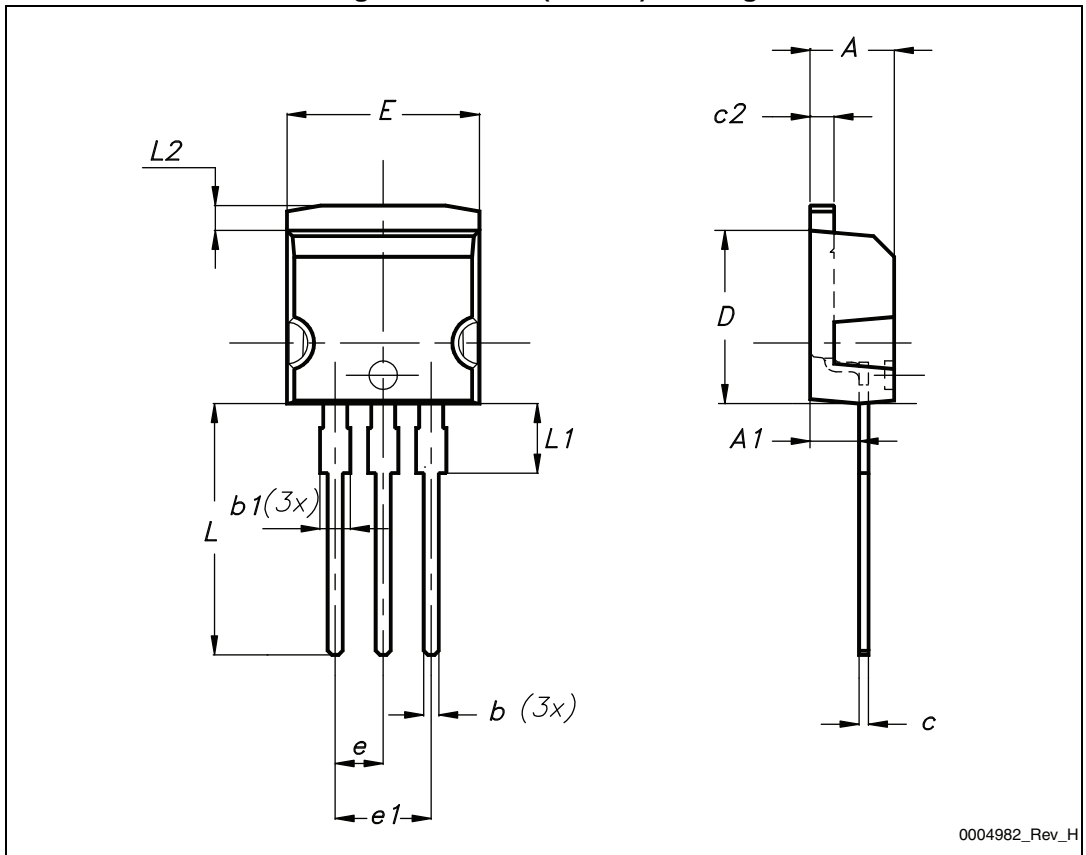
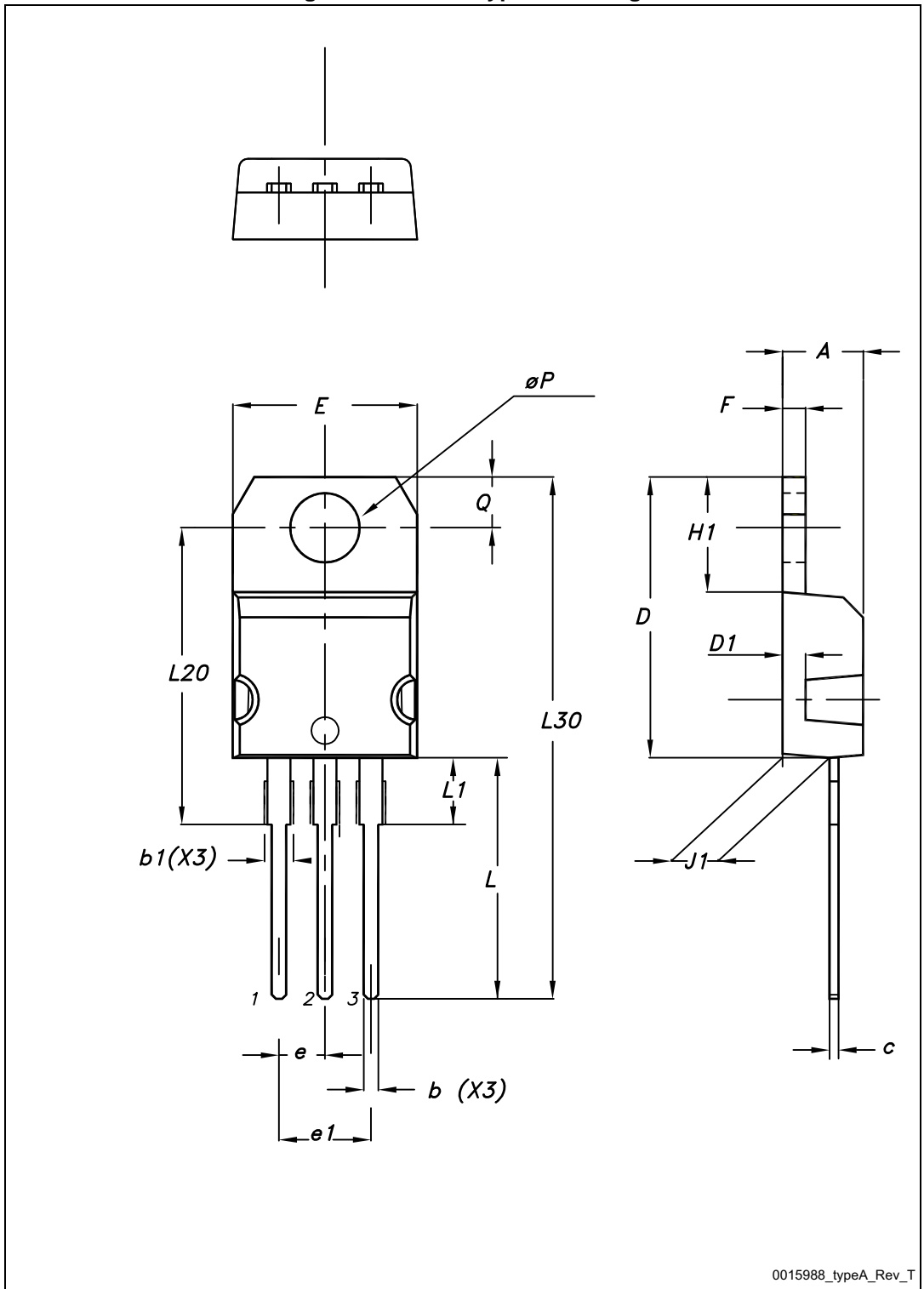


Table 11. TO-220 type A mechanical data

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

Figure 25. TO-220 type A drawing



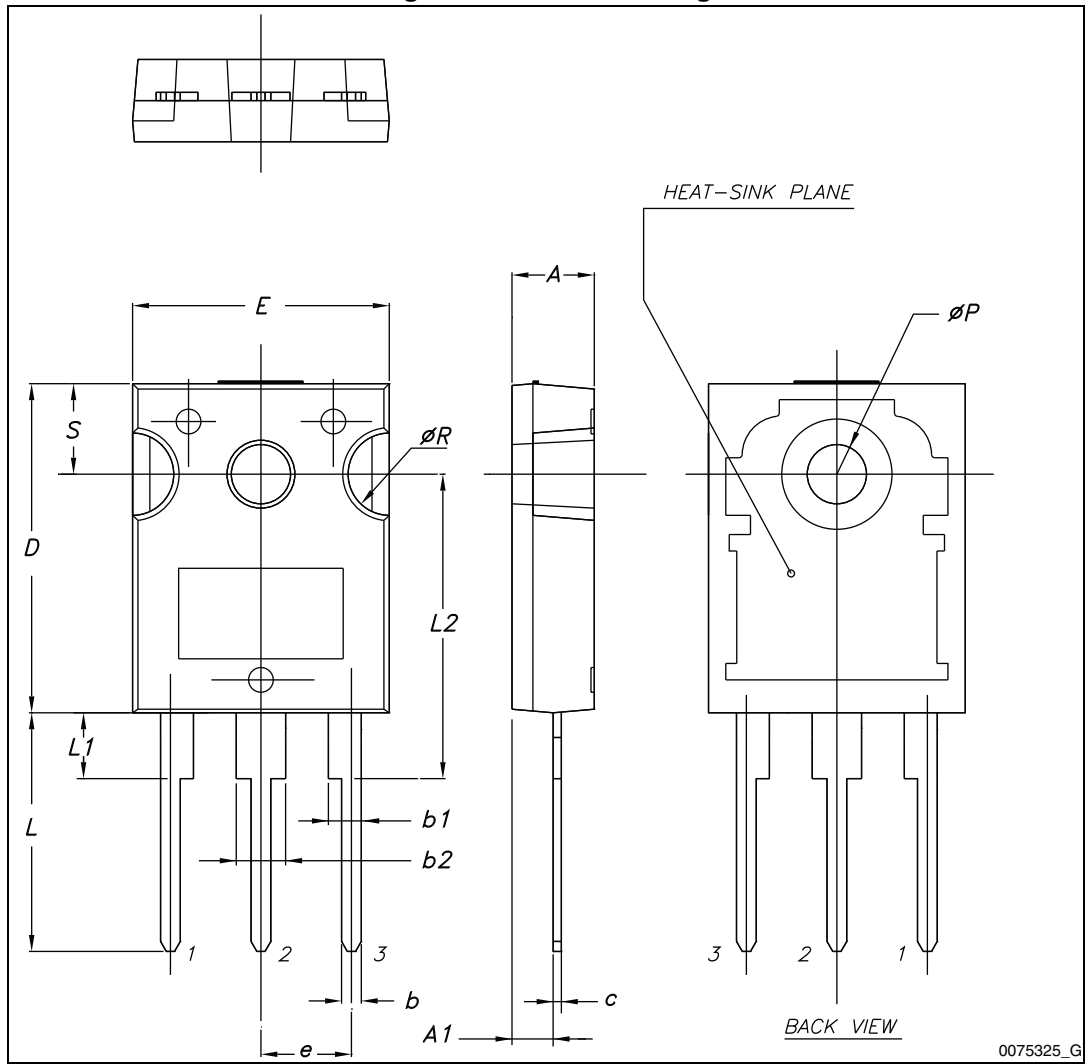
0015988\_typeA\_Rev\_T



Table 12. TO-247 mechanical data

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

Figure 26. TO-247 drawing



## 5 Packaging mechanical data

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

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

Figure 27. Tape

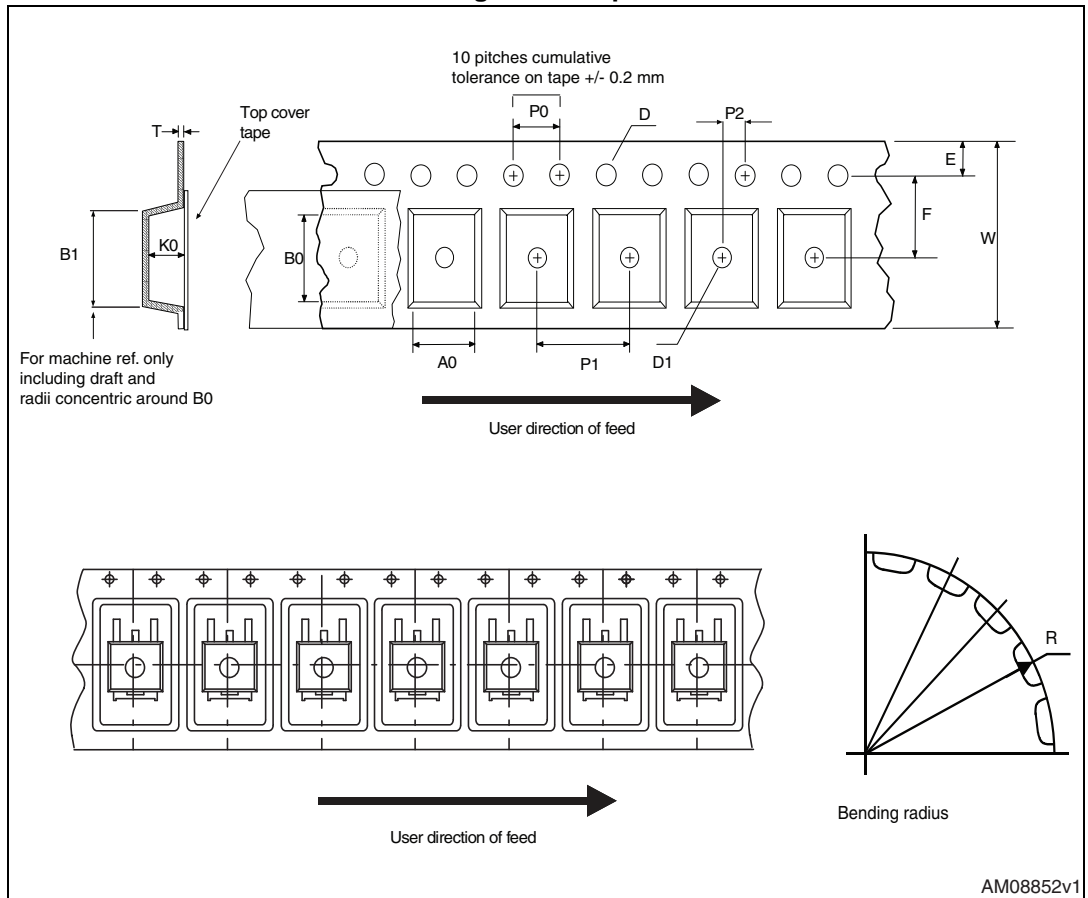
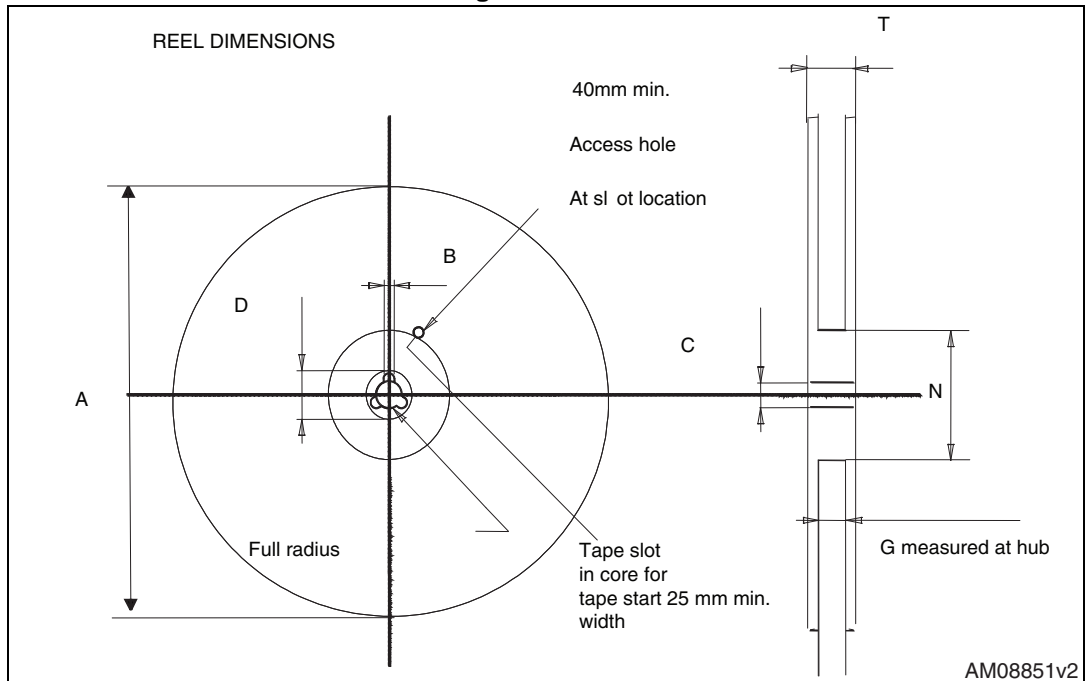


Figure 28. Reel



## 6 Revision history

Table 14. Document revision history

| Date        | Revision | Changes   |
|-------------|----------|---|
| 10-Dec-2012 | 1        | First release.  |
| 20-Dec-2012 | 2        | Added MOSFET dv/dt ruggedness in <a href="#">Table 2: Absolute maximum ratings</a> .  |
| 14-Jan-2013 | 3        | Modified: <a href="#">Figure 16</a> , <a href="#">17</a> , <a href="#">18</a> and <a href="#">17</a>  |
| 28-May-2013 | 4        | <ul style="list-style-type: none"><li>– Minor text changes</li><li>– Updated: <a href="#">Table 7</a></li><li>– Updated: <a href="#">Table 11</a> and <a href="#">Figure 25</a></li></ul> |

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