



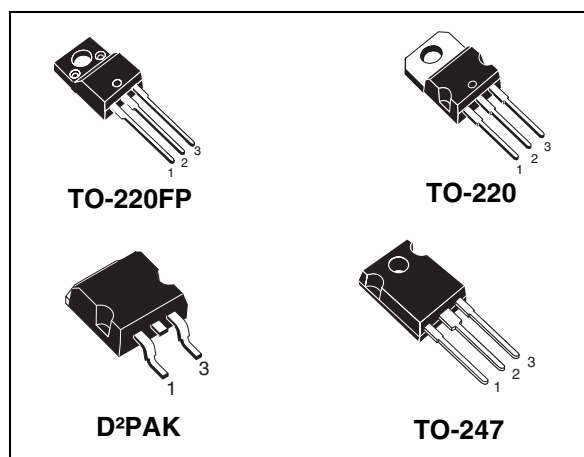
# STB28NM50N, STF28NM50N STP28NM50N, STW28NM50N

N-channel 500 V, 0.135  $\Omega$ , 21 A D<sup>2</sup>PAK, TO-220, TO-220FP, TO-247  
MDmesh™ II Power MOSFET

## Features

| Order codes | V <sub>DSS</sub><br>(@T <sub>Jmax</sub> ) | R <sub>DS(on)</sub><br>max. | I <sub>D</sub> |
|-------------|-------------------------------------------|-----------------------------|----------------|
| STB28NM50N  | 550 V                                     | < 0.158 $\Omega$            | 21 A           |
| STF28NM50N  |                                           |                             |                |
| STP28NM50N  |                                           |                             |                |
| STW28NM50N  |                                           |                             |                |

- 100% avalanche tested
- Low input capacitance and gate charge
- Low gate input resistance



## Applications

- Switching applications

## Description

These devices are N-channel Power MOSFETs developed using the second generation of MDmesh™ technology. This revolutionary Power MOSFET associates a vertical structure to the company's strip layout to yield one of the world's lowest on-resistance and gate charge. It is therefore suitable for the most demanding high efficiency converters.

Figure 1. Internal schematic diagram

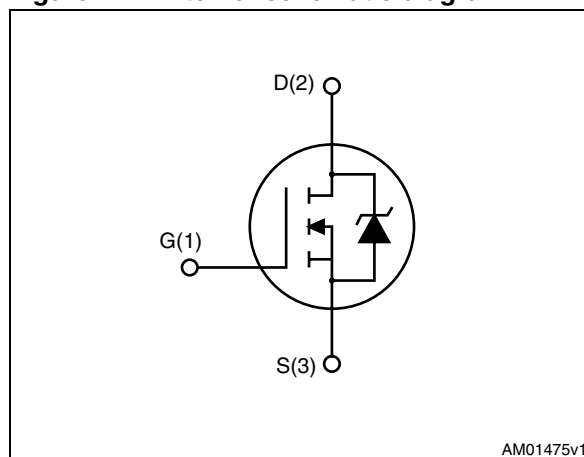


Table 1. Device summary

| Order codes | Marking | Package            | Packaging     |
|-------------|---------|--------------------|---------------|
| STB28NM50N  | 28NM50N | D <sup>2</sup> PAK | Tape and reel |
| STF28NM50N  |         | TO-220FP           | Tube          |
| STP28NM50N  |         | TO-220             |               |
| STW28NM50N  |         | TO-247             |               |

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol                         | Parameter                                                                                                   | Value       |                    |        |                   | Unit |
|--------------------------------|-------------------------------------------------------------------------------------------------------------|-------------|--------------------|--------|-------------------|------|
|                                |                                                                                                             | TO-220      | D <sup>2</sup> PAK | TO-247 | TO-220FP          |      |
| V <sub>DS</sub>                | Drain-source voltage (V <sub>GS</sub> = 0)                                                                  | 500         |                    |        |                   | V    |
| V <sub>GS</sub>                | Gate- source voltage                                                                                        | ± 25        |                    |        |                   | V    |
| I <sub>D</sub>                 | Drain current (continuous) at T <sub>C</sub> = 25 °C                                                        | 21          |                    |        | 21 <sup>(1)</sup> | A    |
| I <sub>D</sub>                 | Drain current (continuous) at T <sub>C</sub> = 100 °C                                                       | 13          |                    |        | 13 <sup>(1)</sup> | A    |
| I <sub>DM</sub> <sup>(2)</sup> | Drain current (pulsed)                                                                                      | 84          |                    |        | 84 <sup>(1)</sup> | A    |
| P <sub>TOT</sub>               | Total dissipation at T <sub>C</sub> = 25 °C                                                                 | 150         |                    |        | 35                | W    |
| 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>(3)</sup>           | Peak diode recovery voltage slope                                                                           | 15          |                    |        |                   | V/ns |
| T <sub>stg</sub>               | Storage temperature                                                                                         | - 55 to 150 |                    |        |                   | °C   |
| T <sub>j</sub>                 | Max. operating junction temperature                                                                         | 150         |                    |        |                   | °C   |

1. Limited only by maximum temperature allowed

2. Pulse width limited by safe operating area

3.  $I_{SD} \leq 21\text{ A}$ ,  $di/dt \leq 400\text{ A}/\mu\text{s}$ ,  $V_{DS\text{ peak}} \leq V_{(BR)DSS}$ ,  $V_{DD} = 80\% V_{(BR)DSS}$

**Table 3. Thermal data**

| Symbol                       | Parameter                                      | Value  |                    |        |          | Unit                        |
|------------------------------|------------------------------------------------|--------|--------------------|--------|----------|-----------------------------|
|                              |                                                | TO-220 | D <sup>2</sup> PAK | TO-247 | TO-220FP |                             |
| $R_{thj-case}$               | Thermal resistance junction-case max           | 0.83   |                    |        | 3.6      | $^{\circ}\text{C}/\text{W}$ |
| $R_{thj-amb}$                | Thermal resistance junction-ambient max        | 62.5   |                    | 50     | 62.5     | $^{\circ}\text{C}/\text{W}$ |
| $R_{thj-pcb}$ <sup>(1)</sup> | Thermal resistance junction-pcb max            |        | 30                 |        |          | $^{\circ}\text{C}/\text{W}$ |
| $T_l$                        | Maximum lead temperature for soldering purpose | 300    |                    | 300    |          | $^{\circ}\text{C}$          |

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

**Table 4. Avalanche characteristics**

| Symbol   | Parameter                                                                                                              | Value | Unit |
|----------|------------------------------------------------------------------------------------------------------------------------|-------|------|
| $I_{AR}$ | Avalanche current, repetitive or not-repetitive (pulse width limited by $T_j\text{ Max}$ )                             | 7.5   | A    |
| $E_{AS}$ | Single pulse avalanche energy (starting $T_j = 25\text{ }^{\circ}\text{C}$ , $I_D = I_{AR}$ , $V_{DD} = 50\text{ V}$ ) | 300   | mJ   |

## 2 Electrical characteristics

( $T_{CASE}=25^{\circ}\text{C}$  unless otherwise specified)

**Table 5. On/off states**

| Symbol        | Parameter                                        | Test conditions                                                                        | Min. | Typ.  | Max.     | Unit                           |
|---------------|--------------------------------------------------|----------------------------------------------------------------------------------------|------|-------|----------|--------------------------------|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage                   | $I_D = 1\text{ mA}$ , $V_{GS} = 0$                                                     | 500  |       |          | V                              |
| $I_{DSS}$     | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{max rating}$<br>$V_{DS} = \text{max rating}$ , @ $125^{\circ}\text{C}$ |      |       | 1<br>100 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$     | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 25\text{ V}$                                                             |      |       | 100      | nA                             |
| $V_{GS(th)}$  | 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                | $V_{GS} = 10\text{ V}$ , $I_D = 10.5\text{ A}$                                         |      | 0.135 | 0.158    | $\Omega$                       |

**Table 6. Dynamic**

| Symbol                              | Parameter                                                               | Test conditions                                                                                                 | Min. | Typ.               | Max. | Unit           |
|-------------------------------------|-------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|------|--------------------|------|----------------|
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25\text{ V}$ , $f = 1\text{ MHz}$ ,<br>$V_{GS} = 0$                                                   | -    | 1735<br>122<br>4.3 | -    | pF<br>pF<br>pF |
| $C_{oss(eq)}^{(1)}$                 | Equivalent output capacitance time related                              | $V_{GS} = 0$ , $V_{DS} = 0\text{ to }50\text{ V}$                                                               | -    | 418                | -    | pF             |
| $Q_g$<br>$Q_{gs}$<br>$Q_{gd}$       | Total gate charge<br>Gate-source charge<br>Gate-drain charge            | $V_{DD} = 400\text{ V}$ , $I_D = 21\text{ A}$ ,<br>$V_{GS} = 10\text{ V}$ ,<br>(see <a href="#">Figure 19</a> ) | -    | 50<br>9.5<br>25    | -    | nC<br>nC<br>nC |
| $R_g$                               | Gate input resistance                                                   | $f=1\text{ MHz}$ Gate DC Bias=0<br>Test signal level=20 mV<br>open drain                                        | -    | 2.7                | -    | $\Omega$       |

1.  $C_{oss(eq)}$  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  | $V_{DD} = 250\text{ V}$ , $I_D = 10.5\text{ A}$<br>$R_G = 4.7\ \Omega$ $V_{GS} = 10\text{ V}$<br>(see <a href="#">Figure 18</a> ) | -    | 13.6 | -    | ns   |
| $t_r$        | Rise time           |                                                                                                                                   |      | 19   |      | ns   |
| $t_{d(off)}$ | Turn-off delay time |                                                                                                                                   |      | 62   |      | ns   |
| $t_f$        | Fall time           |                                                                                                                                   |      | 52   |      | ns   |

**Table 8. Source drain diode**

| Symbol          | Parameter                     | Test conditions                                                                                                                                                | Min. | Typ. | Max. | Unit          |
|-----------------|-------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|---------------|
| $I_{SD}$        | Source-drain current          |                                                                                                                                                                | -    |      | 21   | A             |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |                                                                                                                                                                |      |      | 84   | A             |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD} = 21\text{ A}$ , $V_{GS} = 0$                                                                                                                          | -    |      | 1.5  | V             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 21\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$<br>$V_{DD} = 400\text{ V}$<br>(see <a href="#">Figure 23</a> )                                     | -    | 326  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                                                |      | 5    |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                                                |      | 30   |      | A             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 21\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$<br>$V_{DD} = 400\text{ V}$ , $T_J = 150\text{ }^\circ\text{C}$<br>(see <a href="#">Figure 23</a> ) | -    | 376  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                                                |      | 6.2  |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                                                |      | 33.2 |      | 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 TO-220, D<sup>2</sup>PAK

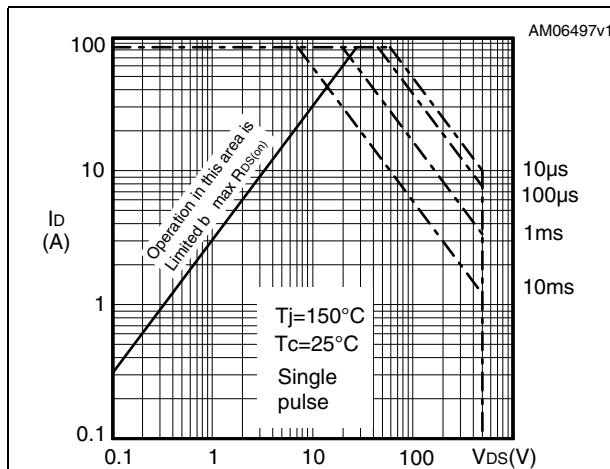


Figure 3. Thermal impedance for TO-220, D<sup>2</sup>PAK

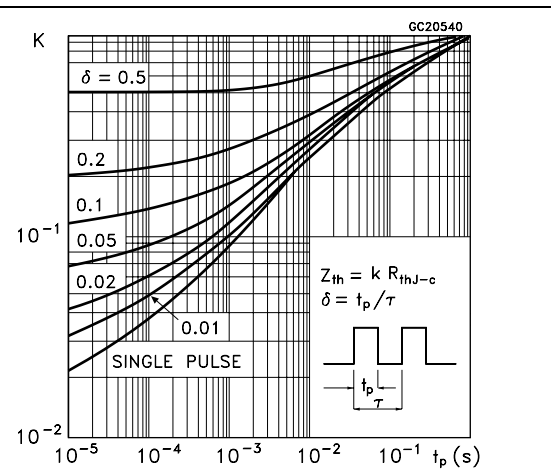


Figure 4. Safe operating area for TO-220FP

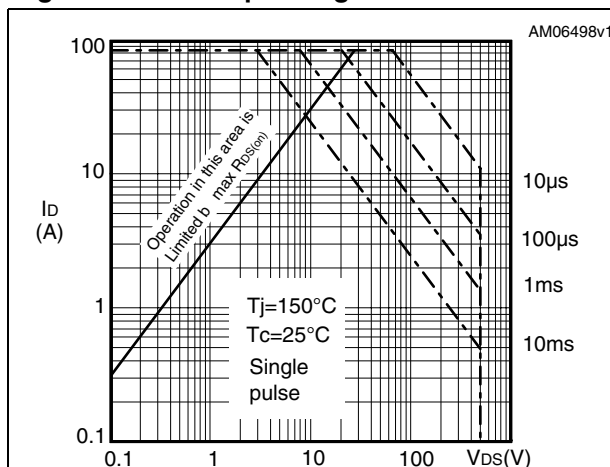


Figure 5. Thermal impedance for TO-220FP

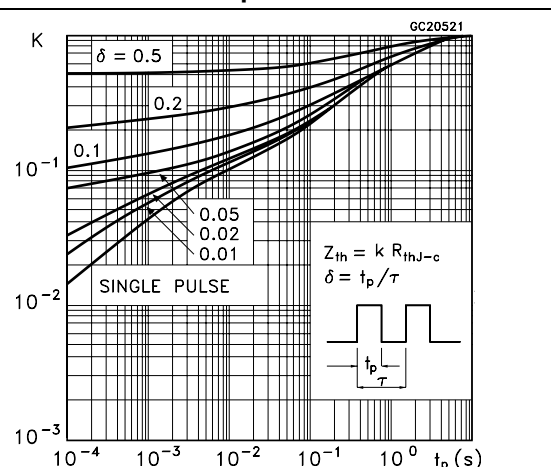


Figure 6. Safe operating area for TO-247

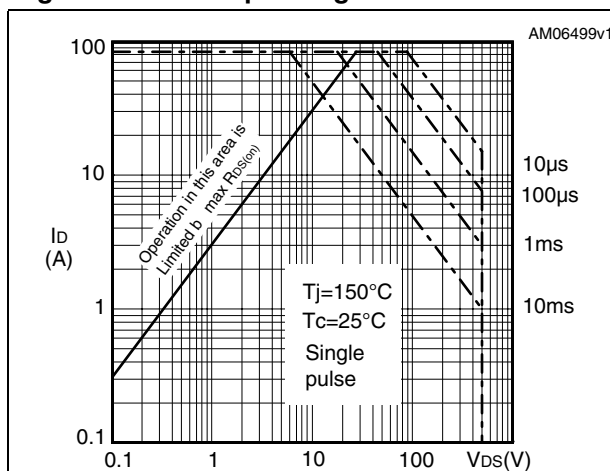


Figure 7. Thermal impedance for TO-247

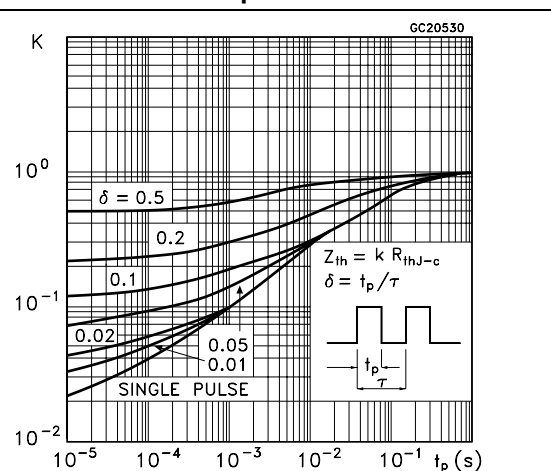


Figure 8. Output characteristics

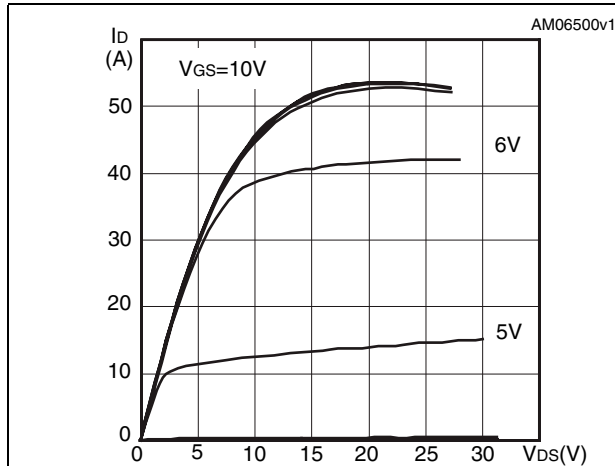


Figure 9. Transfer characteristics

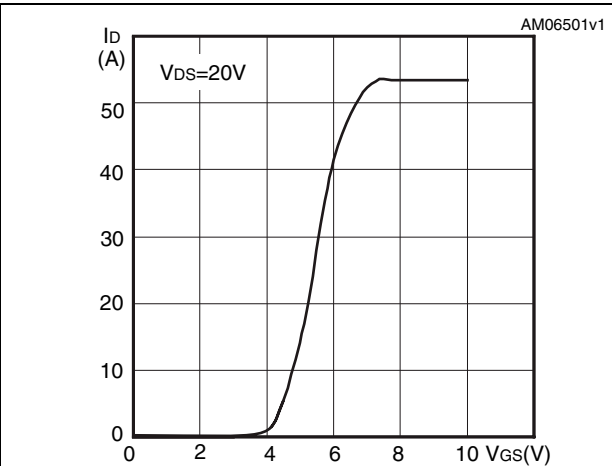


Figure 10. Gate charge vs gate-source voltage

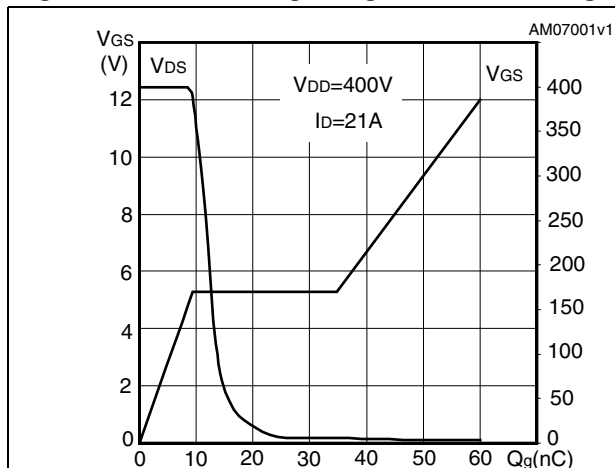


Figure 11. Static drain-source on resistance

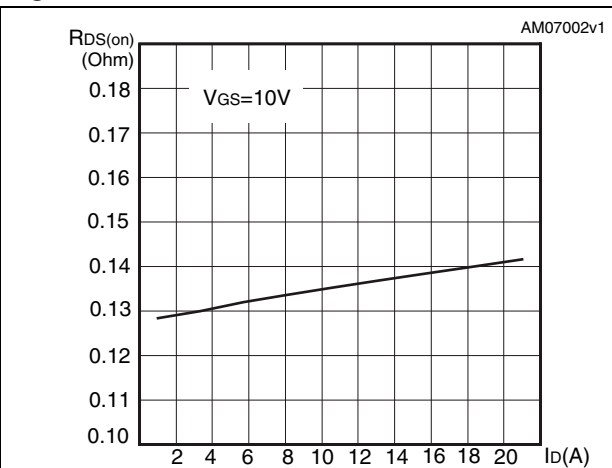


Figure 12. Capacitance variations

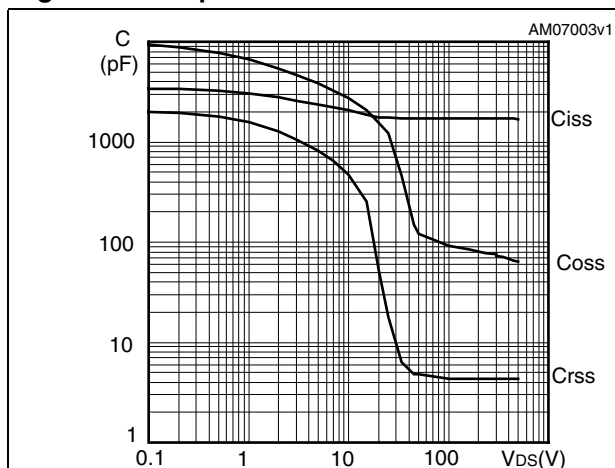


Figure 13. Output capacitance stored energy

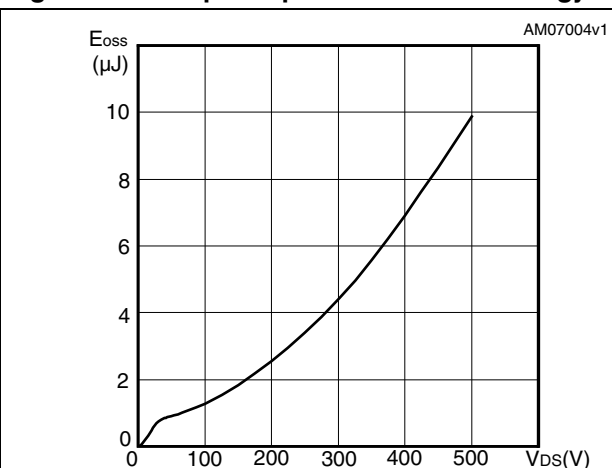


Figure 14. Normalized gate threshold voltage vs temperature

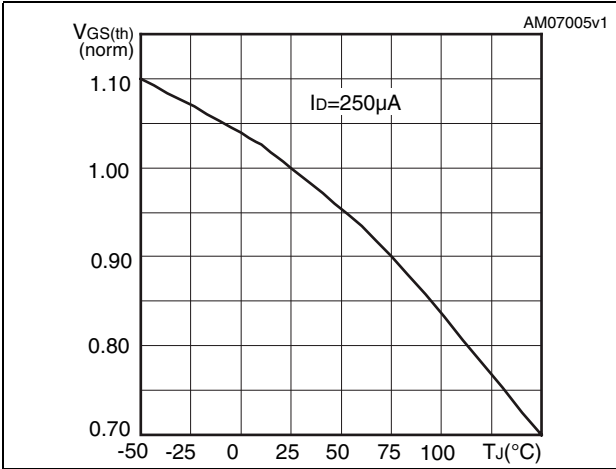


Figure 15. Normalized on resistance vs temperature

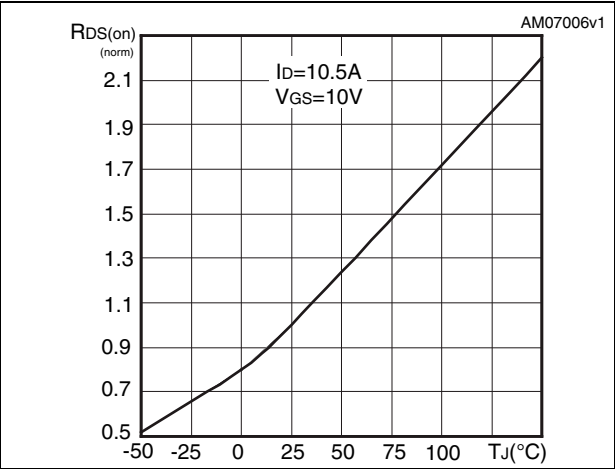


Figure 16. Normalized  $B_{VDSS}$  vs temperature

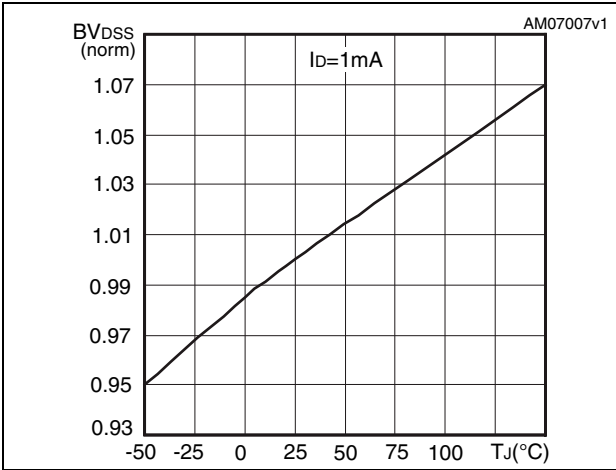
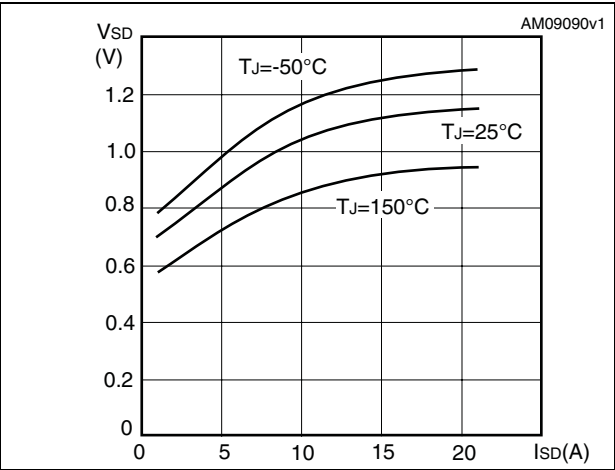


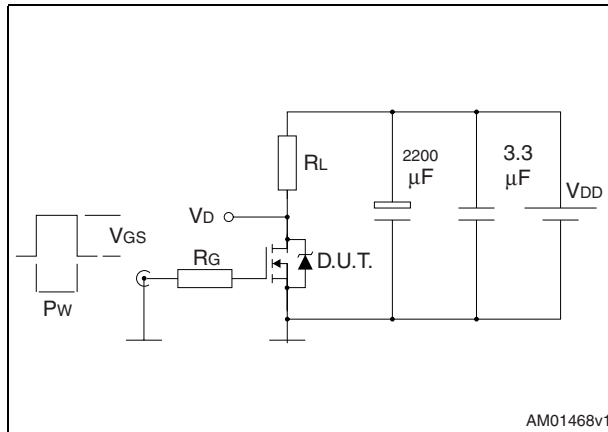
Figure 17. Source-drain diode forward characteristics



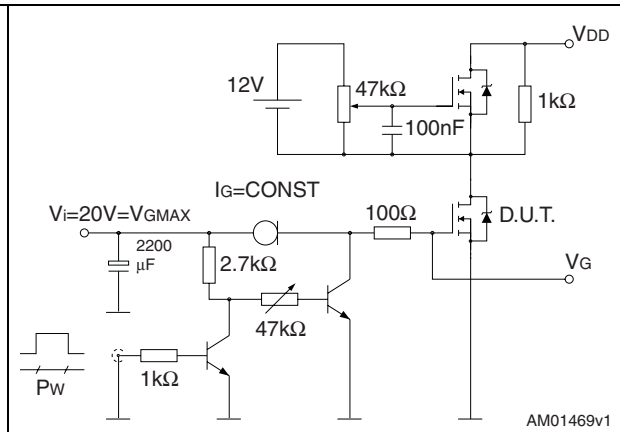


### 3 Test circuits

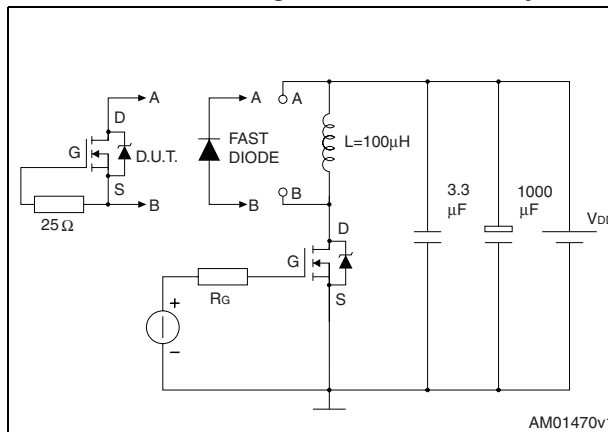
**Figure 18. Switching times test circuit for resistive load**



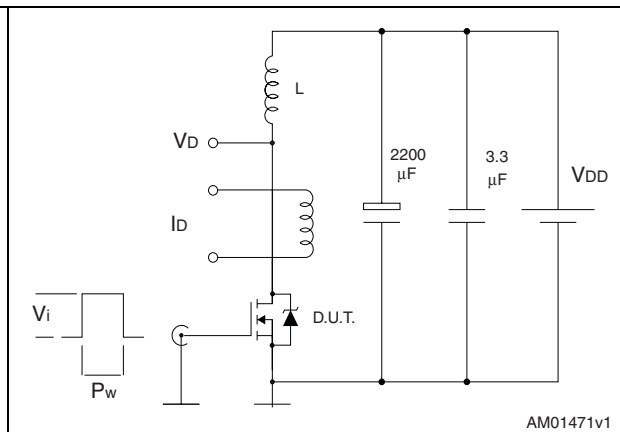
**Figure 19. Gate charge test circuit**



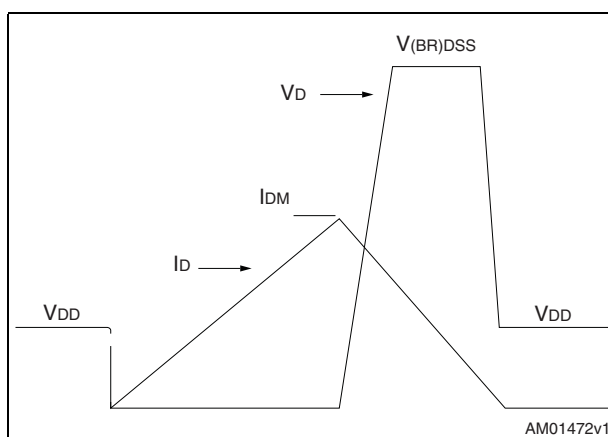
**Figure 20. Test circuit for inductive load switching and diode recovery times**



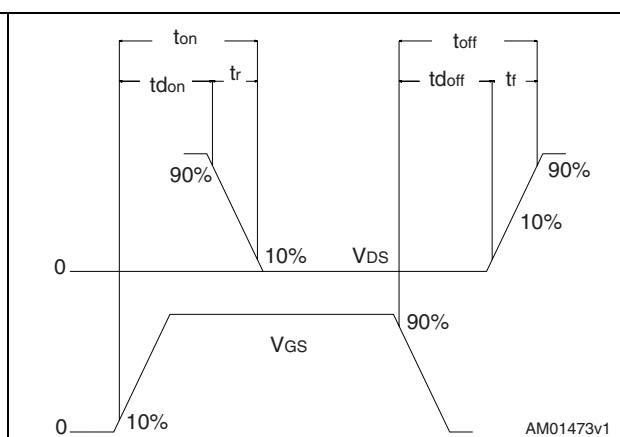
**Figure 21. Unclamped inductive load test circuit**



**Figure 22. Unclamped inductive waveform**



**Figure 23. 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 is an ST trademark.

Table 9. TO-220FP mechanical data

| Dim. | mm   |      |      |
|------|------|------|------|
|      | Min. | Typ. | Max. |
| A    | 4.4  |      | 4.6  |
| B    | 2.5  |      | 2.7  |
| D    | 2.5  |      | 2.75 |
| E    | 0.45 |      | 0.7  |
| F    | 0.75 |      | 1    |
| F1   | 1.15 |      | 1.70 |
| F2   | 1.15 |      | 1.70 |
| G    | 4.95 |      | 5.2  |
| G1   | 2.4  |      | 2.7  |
| H    | 10   |      | 10.4 |
| L2   |      | 16   |      |
| L3   | 28.6 |      | 30.6 |
| L4   | 9.8  |      | 10.6 |
| L5   | 2.9  |      | 3.6  |
| L6   | 15.9 |      | 16.4 |
| L7   | 9    |      | 9.3  |
| Dia  | 3    |      | 3.2  |

Figure 24. TO-220FP drawing

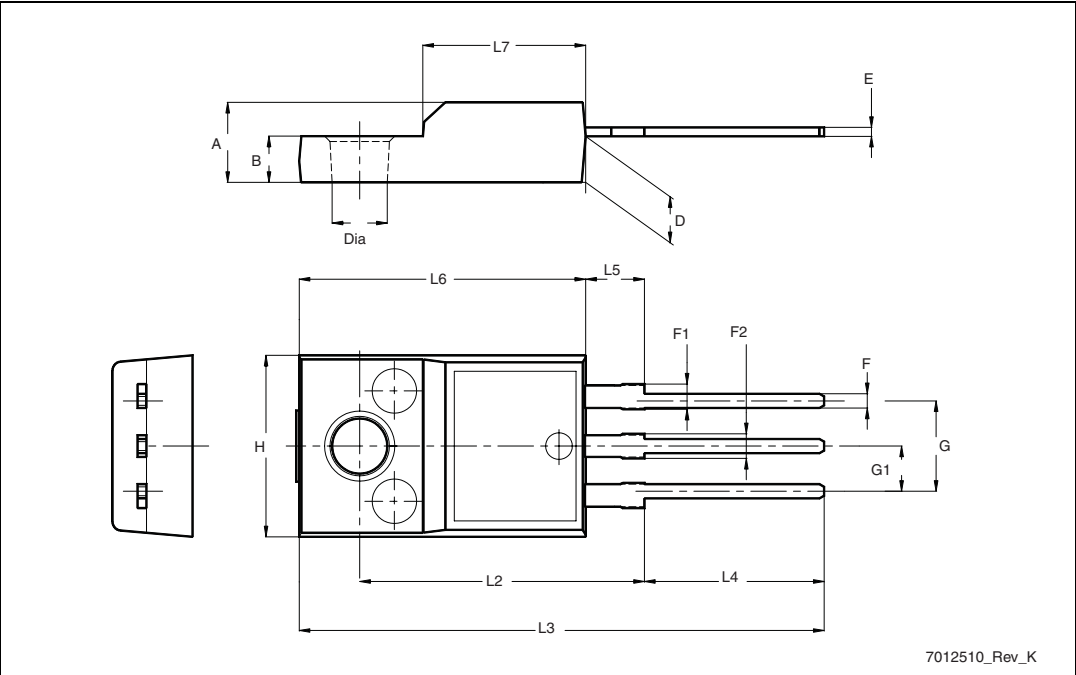
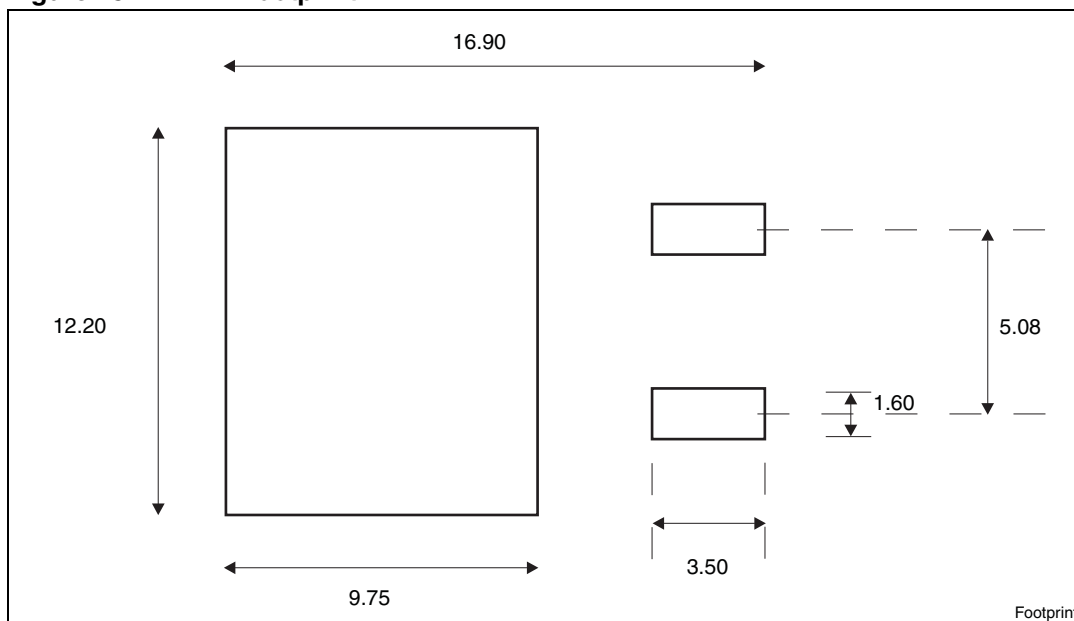
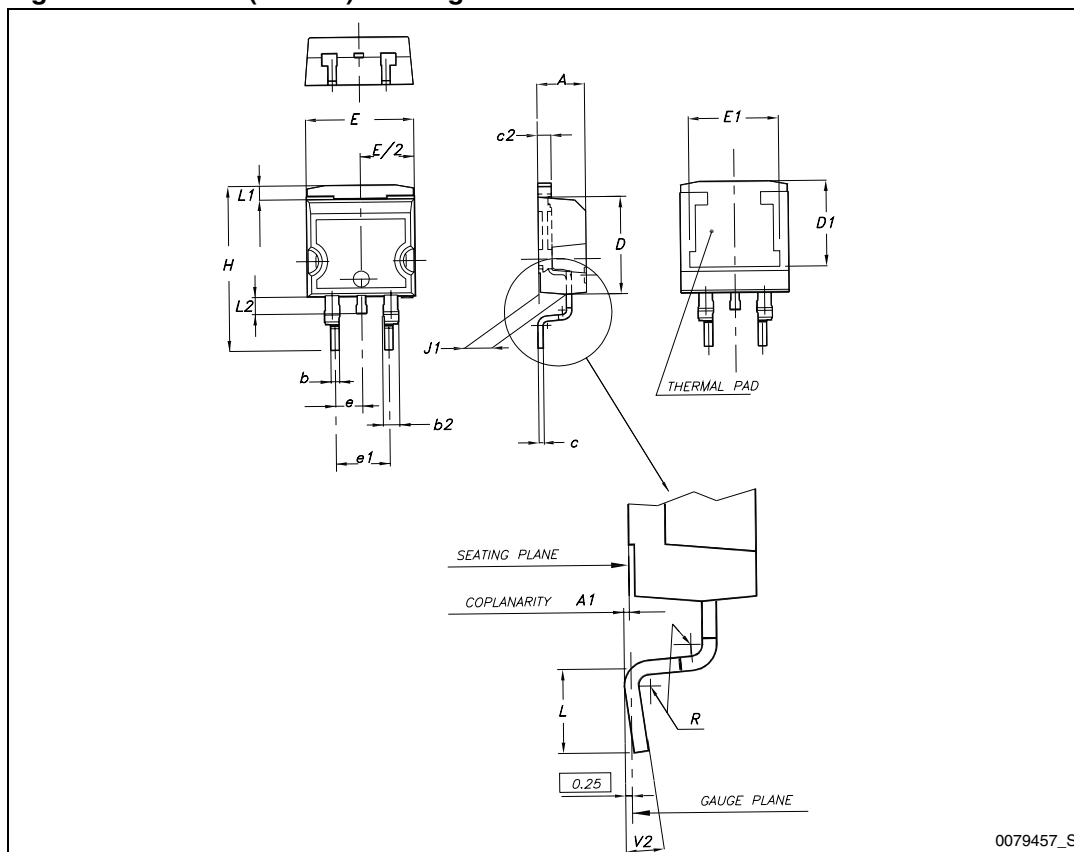


Table 10. D<sup>2</sup>PAK (TO-263) mechanical data

| 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 25. D<sup>2</sup>PAK footprint<sup>(a)</sup>Figure 26. D<sup>2</sup>PAK (TO-263) drawing

a. All dimension are in millimeters

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 27. TO-220 type A drawing

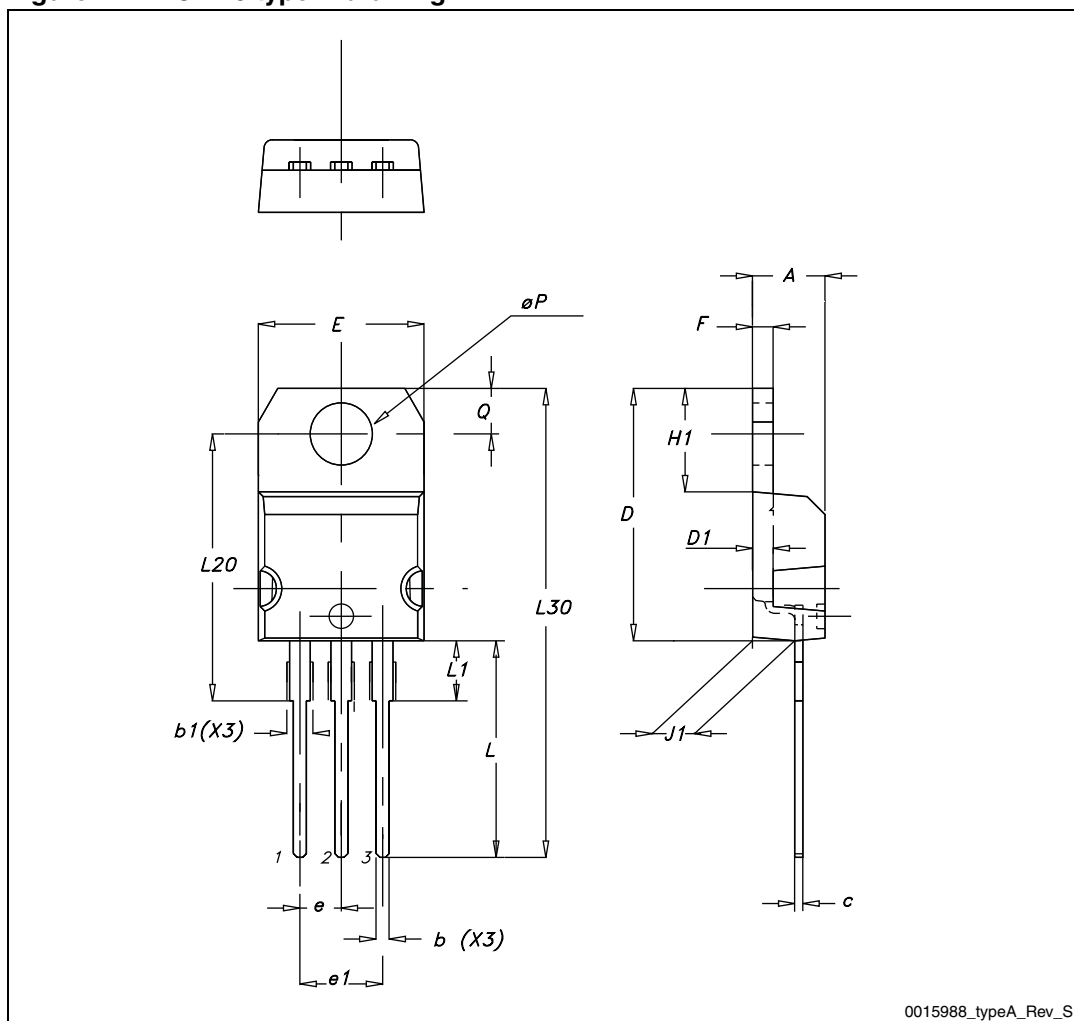
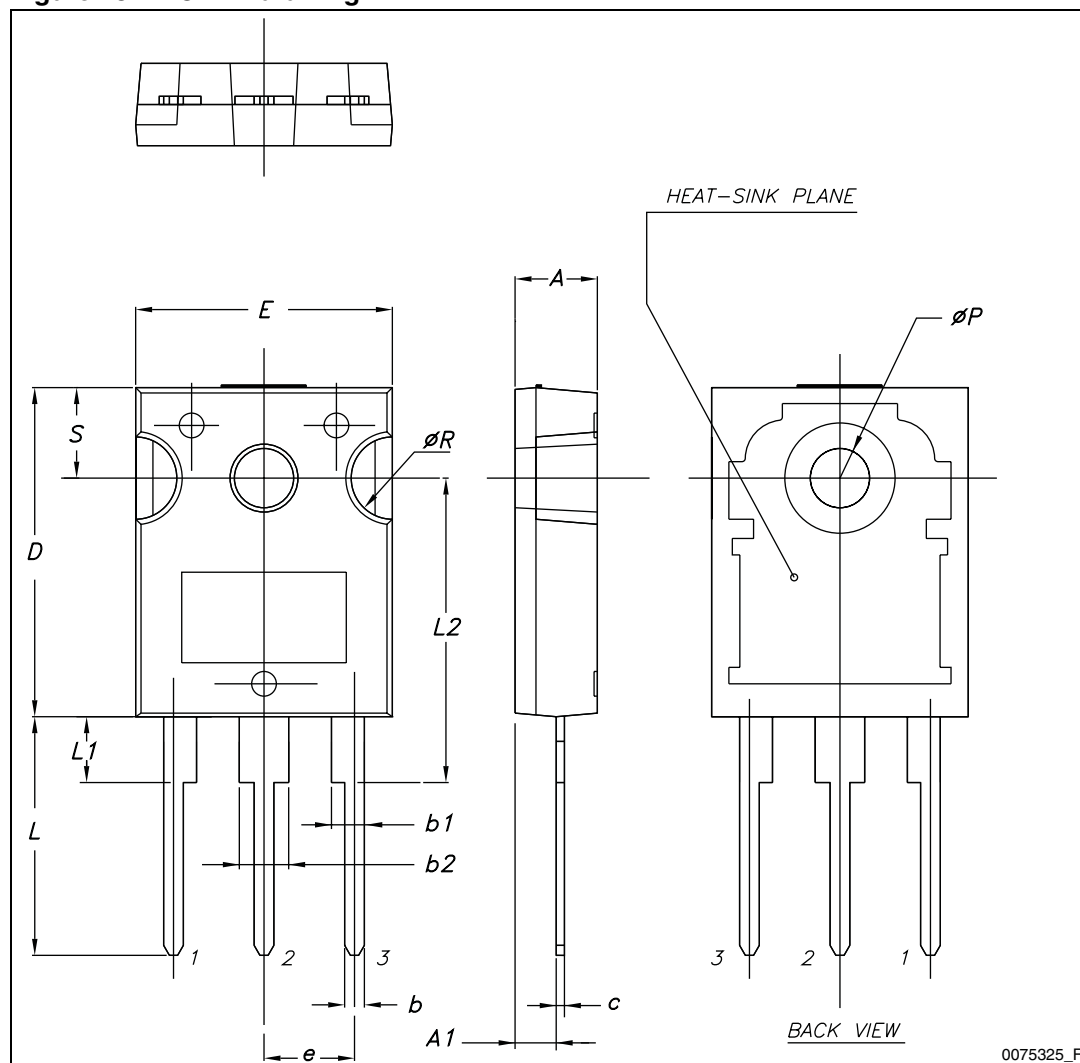


Table 12. TO-247 mechanical data

| 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    |       | 5.45  |       |
| L    | 14.20 |       | 14.80 |
| L1   | 3.70  |       | 4.30  |
| L2   |       | 18.50 |       |
| ØP   | 3.55  |       | 3.65  |
| ØR   | 4.50  |       | 5.50  |
| S    |       | 5.50  |       |



Figure 28. 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 29. Tape

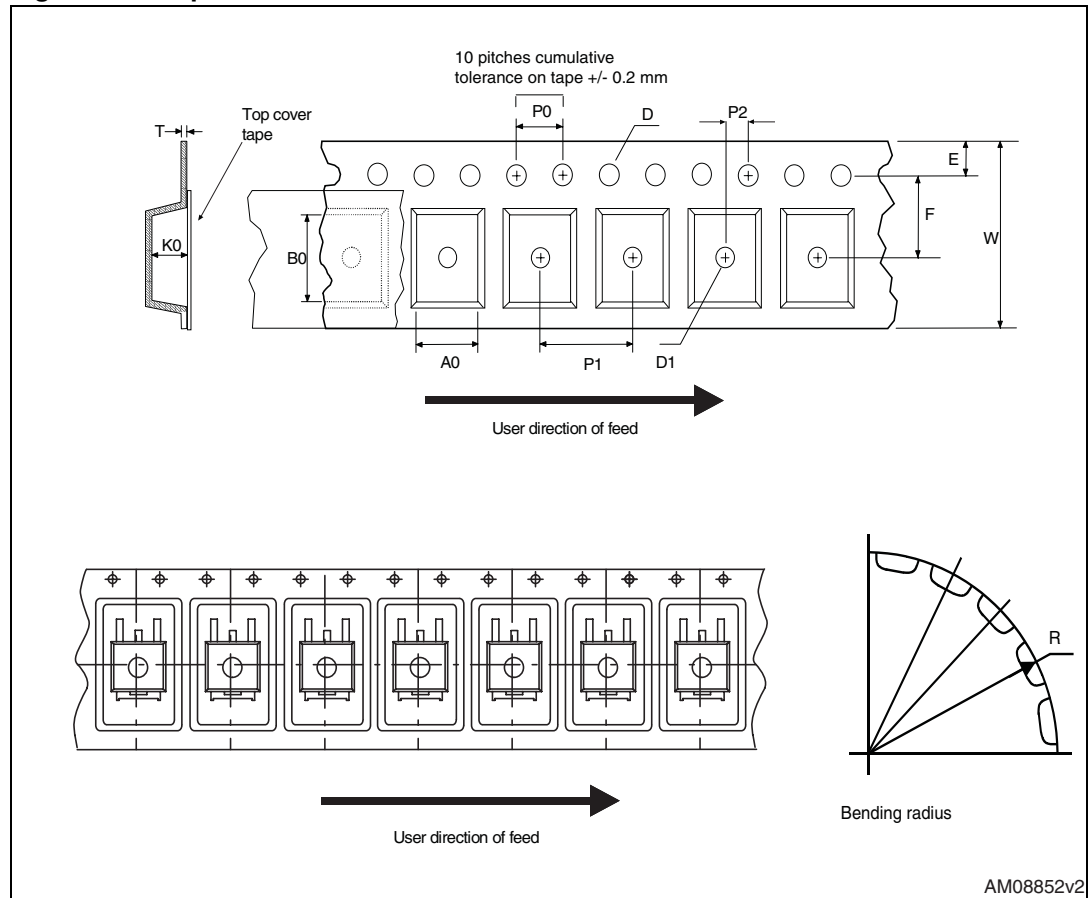
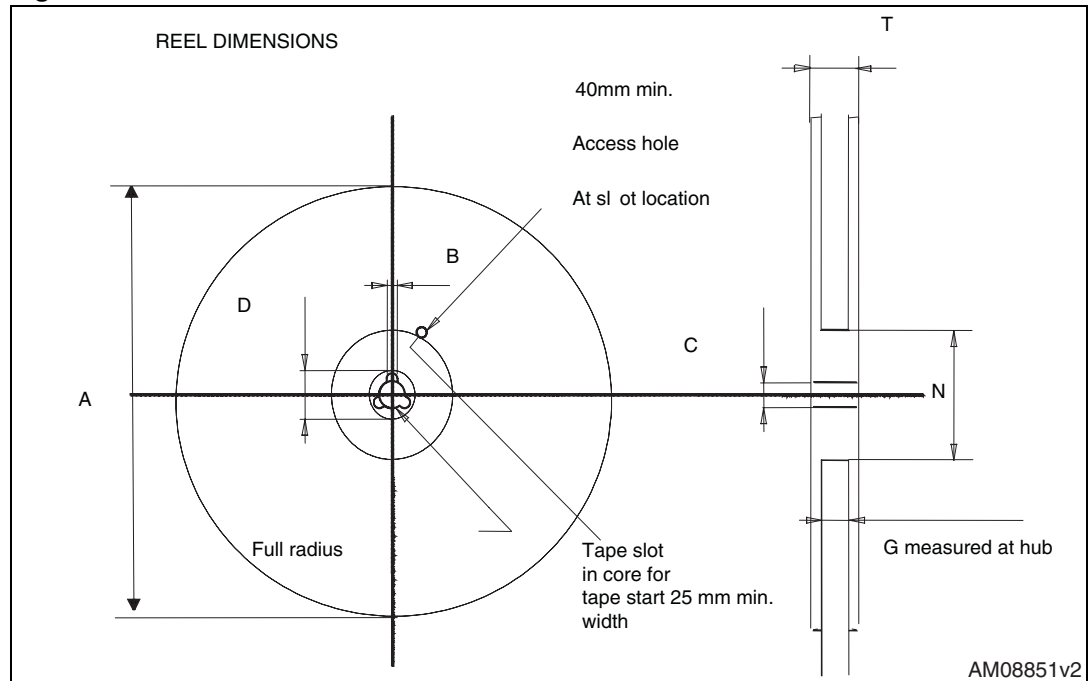


Figure 30. Reel



## 6 Revision history

**Table 14. Document revision history**

| Date        | Revision | Changes                                                                                                                                                                         |
|-------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 19-Jul-2010 | 1        | First release.                                                                                                                                                                  |
| 27-Jun-2011 | 2        | <ul style="list-style-type: none"><li>– Updated <a href="#">Table 6: Dynamic</a>.</li><li>– Updated <a href="#">Section 2.1: Electrical characteristics (curves)</a>.</li></ul> |

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