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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol                             | Parameter                                                                                                                     | Value                                |                    | Unit |
|------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|--------------------|------|
|                                    |                                                                                                                               | D <sup>2</sup> PAK,<br>TO-220,TO-247 | TO-220FP           |      |
| V <sub>DS</sub>                    | Drain-source voltage                                                                                                          | 600                                  |                    | V    |
| V <sub>GS</sub>                    | Gate- source voltage                                                                                                          | ± 25                                 |                    |      |
| I <sub>D</sub>                     | Drain current (continuous) at T <sub>C</sub> = 25 °C                                                                          | 13                                   | 13 <sup>(1)</sup>  | A    |
| I <sub>D</sub>                     | Drain current (continuous) at T <sub>C</sub> = 100 °C                                                                         | 8.2                                  | 8.2 <sup>(1)</sup> | A    |
| I <sub>DM</sub> <sup>(2)</sup>     | Drain current (pulsed)                                                                                                        | 52                                   | 52 <sup>(1)</sup>  | A    |
| P <sub>TOT</sub>                   | Total dissipation at T <sub>C</sub> = 25 °C                                                                                   | 110                                  | 30                 | W    |
| I <sub>AR</sub>                    | Avalanche current, repetitive or not-repetitive<br>(pulse width limited by T <sub>J</sub> max)                                | 4.5                                  |                    | A    |
| E <sub>AS</sub>                    | Single pulse avalanche energy<br>(starting T <sub>J</sub> = 25 °C, I <sub>D</sub> = I <sub>AR</sub> , V <sub>DD</sub> = 50 V) | 350                                  |                    | mJ   |
| dv/dt <sup>(3)</sup>               | Peak diode recovery voltage slope                                                                                             | 15                                   |                    | V/ns |
| V <sub>ISO</sub>                   | Insulation withstand voltage (RMS) from all<br>three leads to external heat sink<br>(t=1 s;T <sub>C</sub> =25 °C)             |                                      | 2500               | V    |
| T <sub>J</sub><br>T <sub>stg</sub> | Operating junction temperature<br>Storage temperature                                                                         | -55 to 150                           |                    | °C   |

- Limited by maximum junction temperature.
- Pulse width limited by safe operating area.
- $I_{SD} \leq 13 \text{ A}$ ,  $di/dt \leq 400 \text{ A}/\mu\text{s}$ ,  $V_{DD} \leq 80 \% V_{(BR)DSS}$ ,  $V_{DS(peak)} \leq V_{(BR)DSS}$

**Table 3. Thermal data**

| Symbol                              | Parameter                            | D <sup>2</sup> PAK | TO-220 | TO-247 | TO-220FP | Unit |
|-------------------------------------|--------------------------------------|--------------------|--------|--------|----------|------|
| R <sub>thj-case</sub>               | Thermal resistance junction-case max | 1.14               |        |        | 4.17     | °C/W |
| R <sub>thj-amb</sub>                | Thermal resistance junction-amb max  |                    | 62.5   | 50     | 62.5     |      |
| R <sub>thj-pcb</sub> <sup>(1)</sup> | Thermal resistance junction-pcb max  | 30                 |        |        |          |      |

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

## 2 Electrical characteristics

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

**Table 4. 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>$V_{DS} = 600\text{ V}$ , $T_J = 125\text{ }^{\circ}\text{C}$ |      |       | 1<br>10   | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$     | Gate body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 25\text{ V}$                                                               |      |       | $\pm 100$ | 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                | $V_{GS} = 10\text{ V}$ , $I_D = 6.5\text{ A}$                                            |      | 0.260 | 0.285     | $\Omega$                       |

**Table 5. 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 | $V_{DS} = 50\text{ V}$ , $f = 1\text{ MHz}$ ,<br>$V_{GS} = 0$                                               | -    | 1000<br>60<br>3 | -    | pF<br>pF<br>pF |
| $C_{oss\text{ eq.}}^{(1)}$          | Output equivalent capacitance                                           | $V_{DS} = 0$ , to $480\text{ V}$ , $V_{GS} = 0$                                                             | -    | 225             | -    | pF             |
| $R_g$                               | Intrinsic resistance                                                    | $f = 1\text{ MHz}$ open drain                                                                               | -    | 3.5             | -    | $\Omega$       |
| $Q_g$<br>$Q_{gs}$<br>$Q_{gd}$       | Total gate charge<br>Gate-source charge<br>Gate-drain charge            | $V_{DD} = 480\text{ V}$ , $I_D = 13\text{ A}$<br>$V_{GS} = 10\text{ V}$<br>(see <a href="#">Figure 19</a> ) | -    | 35<br>6<br>20   | -    | nC<br>nC<br>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%  $V_{DS}$ .

**Table 6. Switching times**

| Symbol                                        | Parameter                                                           | Test conditions                                                                                                                            | Min. | Typ.                 | Max. | Unit                 |
|-----------------------------------------------|---------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|------|----------------------|------|----------------------|
| $t_{d(on)}$<br>$t_r$<br>$t_{d(off)}$<br>$t_f$ | Turn-on delay time<br>Rise time<br>Turn-off delay time<br>Fall time | $V_{DD} = 300\text{ V}$ , $I_D = 6.5\text{ A}$ ,<br>$R_G = 4.7\text{ }\Omega$ , $V_{GS} = 10\text{ V}$<br>(see <a href="#">Figure 18</a> ) | -    | 12<br>15<br>55<br>25 | -    | ns<br>ns<br>ns<br>ns |

**Table 7. Source drain diode**

| Symbol          | Parameter                     | Test conditions                                                                                                                             | Min. | Typ. | Max. | Unit          |
|-----------------|-------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|---------------|
| $I_{SD}$        | Source-drain current          |                                                                                                                                             | -    |      | 13   | A             |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |                                                                                                                                             | -    |      | 52   | A             |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD} = 13\text{ A}$ , $V_{GS}=0$                                                                                                         | -    |      | 1.6  | V             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD}=13\text{ A}$ , $di/dt=100\text{ A}/\mu\text{s}$ ,<br>$V_{DD}=60\text{ V}$<br>(see <a href="#">Figure 20</a> )                       | -    | 300  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                             |      | 4.0  |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                             |      | 25   |      | A             |
| $t_{rr}$        | Reverse recovery time         | $V_{DD}=60\text{ V}$<br>$di/dt=100\text{ A}/\mu\text{s}$ , $I_{SD}=13\text{ A}$<br>$T_j=150^\circ\text{C}$ (see <a href="#">Figure 20</a> ) | -    | 360  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                             |      | 4.5  |      | $\mu\text{C}$ |
| $I_{RRM}$       | 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 TO-220 and D<sup>2</sup>PAK

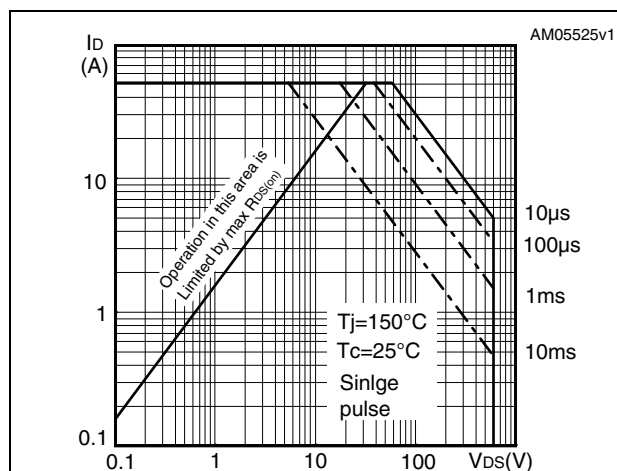


Figure 3. Thermal impedance for TO-220 and D<sup>2</sup>PAK

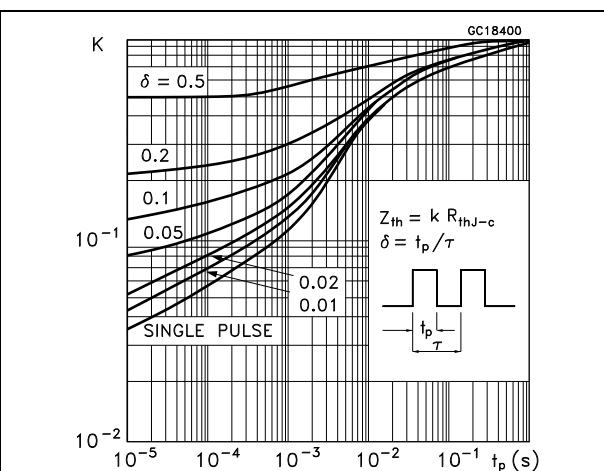


Figure 4. Safe operating area for TO-220FP

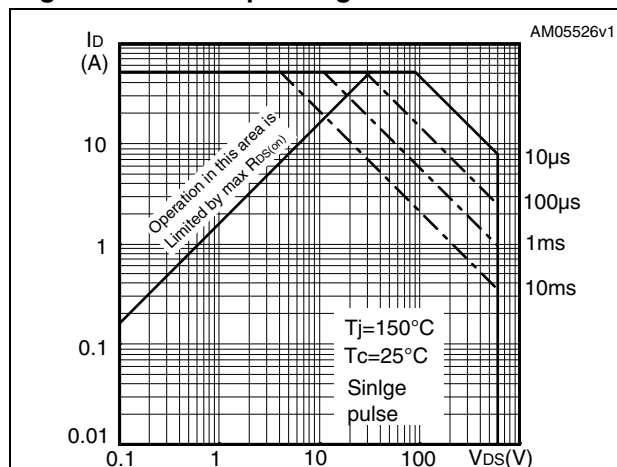


Figure 5. Thermal impedance for TO-220FP

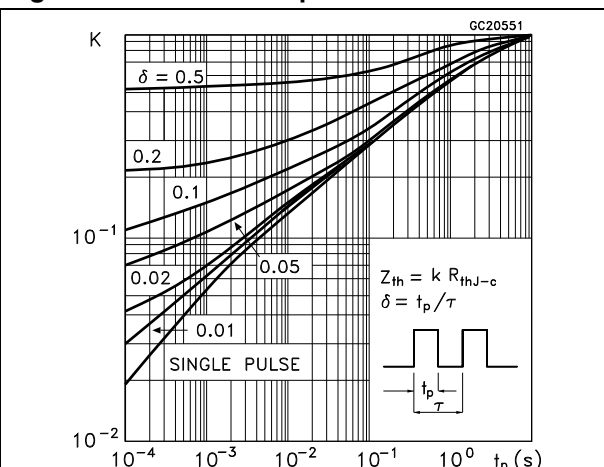


Figure 6. Safe operating area for TO-247

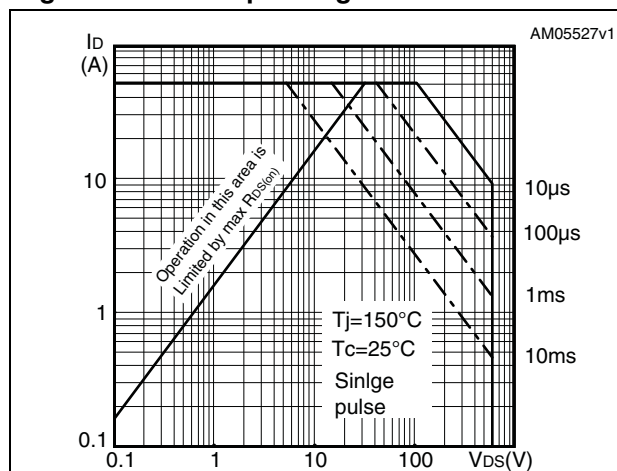


Figure 7. Thermal impedance for TO-247

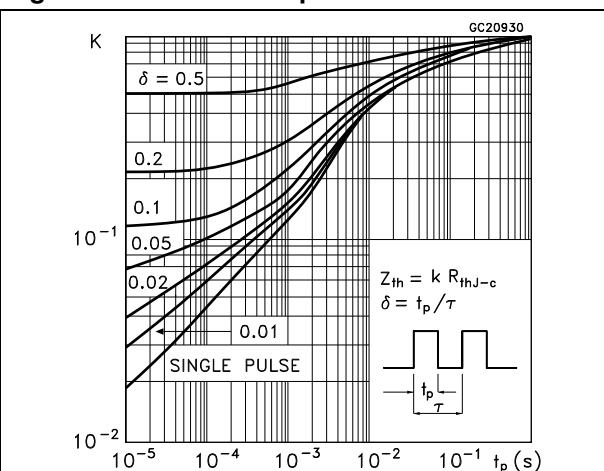


Figure 8. Output characteristics

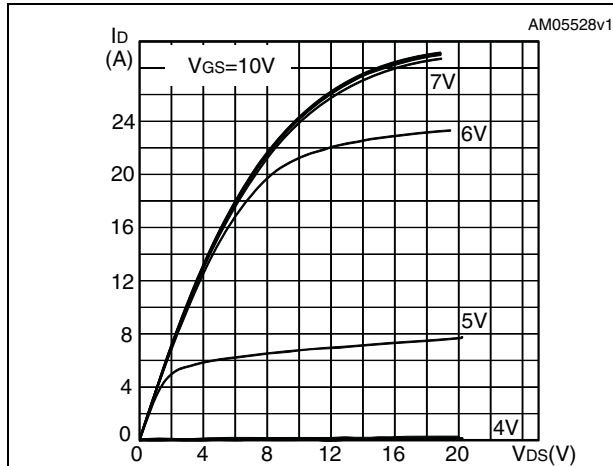


Figure 9. Transfer characteristics

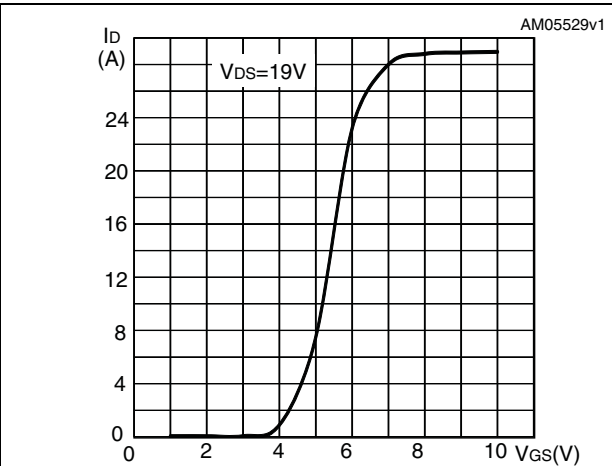


Figure 10. Static drain-source on resistance

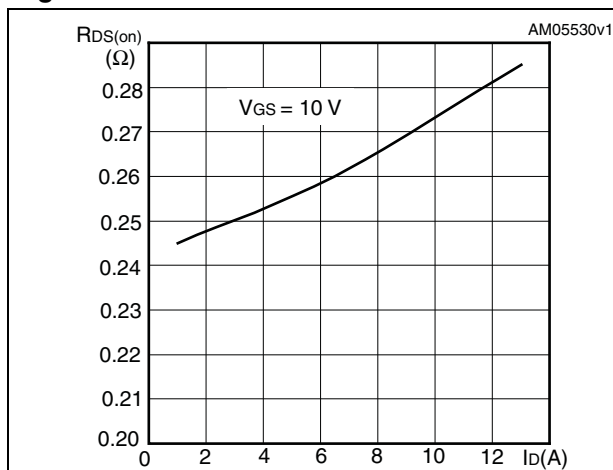


Figure 11. Gate charge vs gate-source voltage

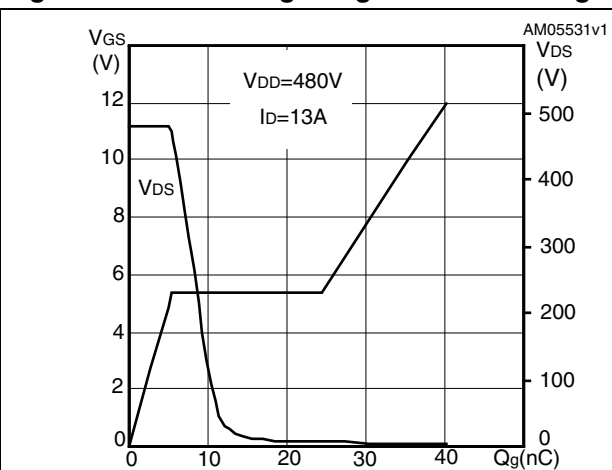


Figure 12. Capacitance variations

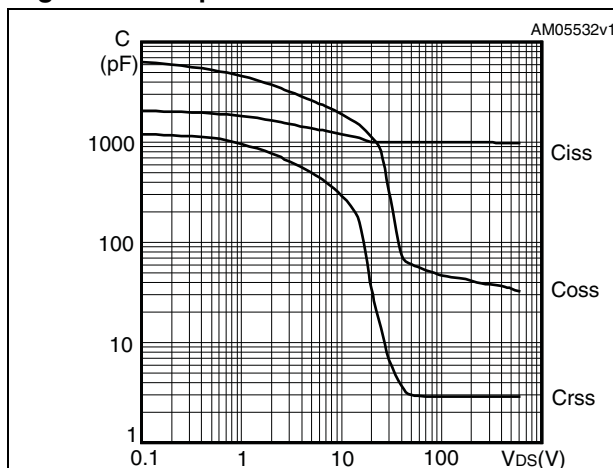


Figure 13. Output capacitance stored energy

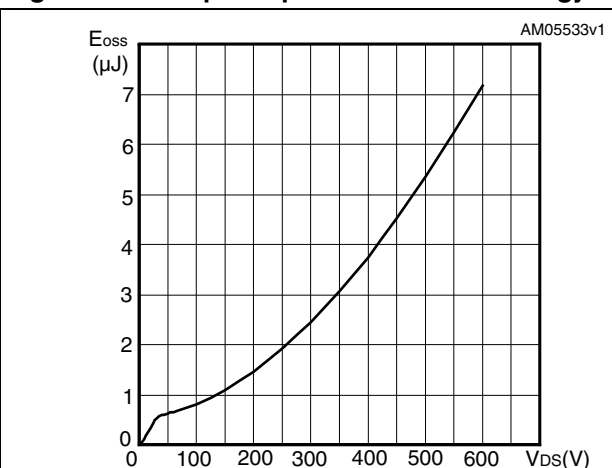


Figure 14. Normalized gate threshold voltage vs temperature

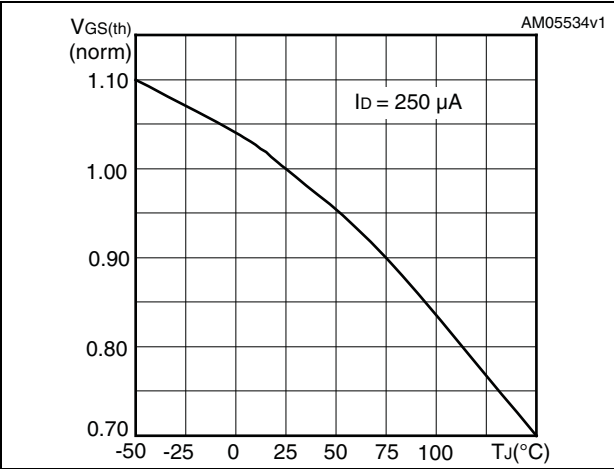


Figure 15. Normalized on resistance vs temperature

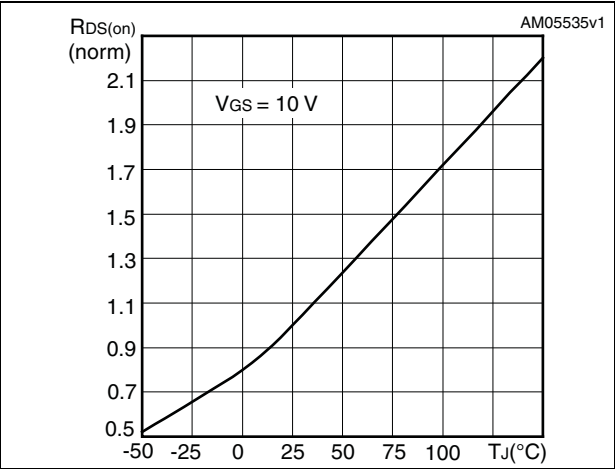


Figure 16. Normalized  $B_{V_{DS}}$  vs temperature

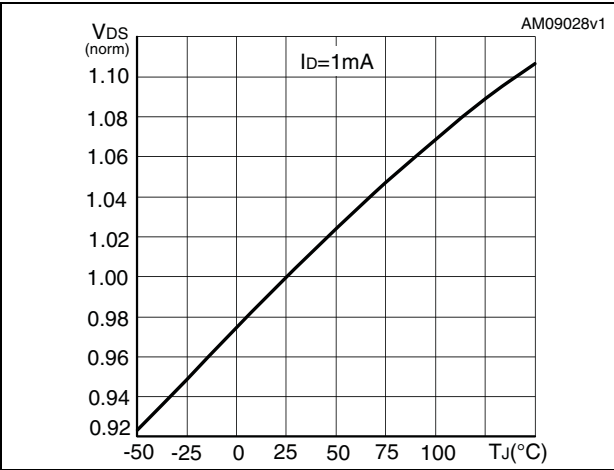
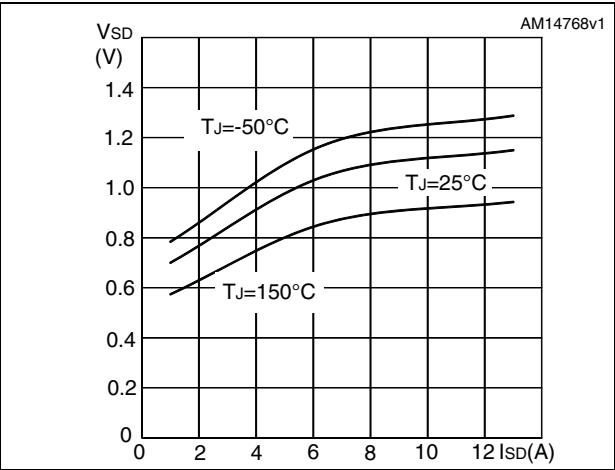
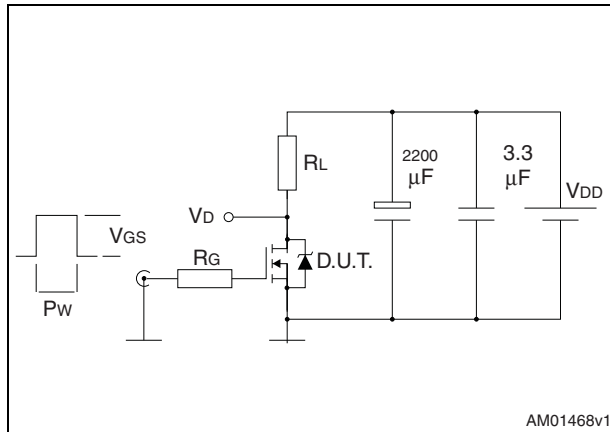


Figure 17. Source-drain diode forward vs temperature

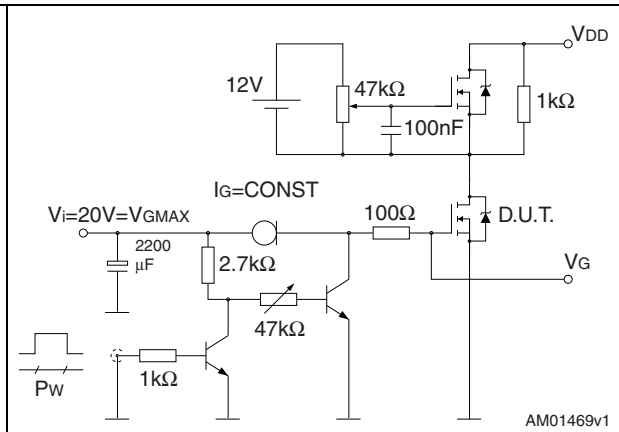


### 3 Test circuits

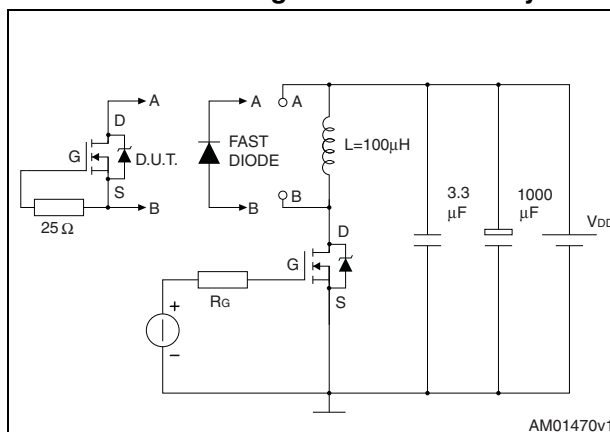
**Figure 18. Switching times test circuit for resistive load**



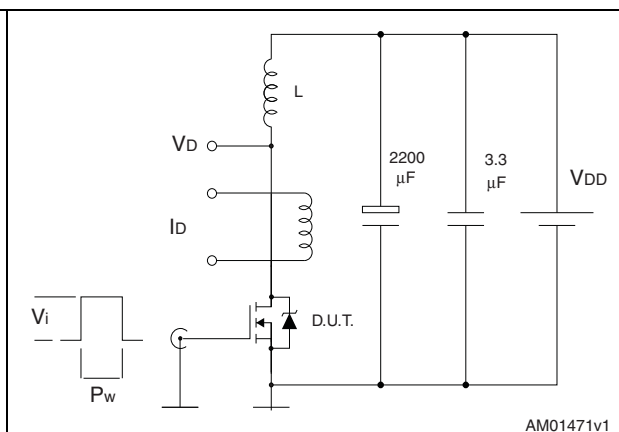
**Figure 19. Gate charge test circuit**



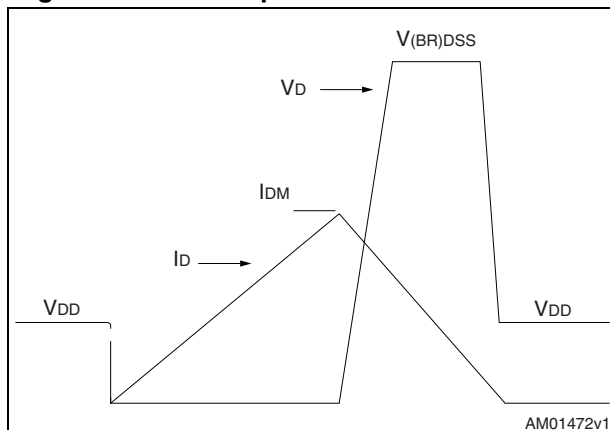
**Figure 20. Test circuit for inductive load switching and diode recovery times**



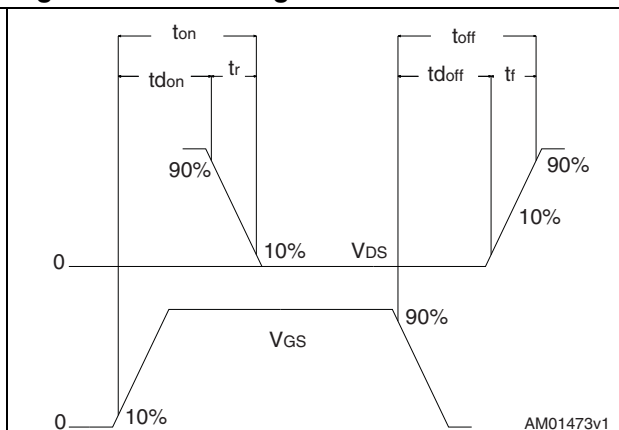
**Figure 21. Unclamped inductive load test circuit**



**Figure 22. Unclamped inductive waveform**



**Figure 23. Switching time waveform**

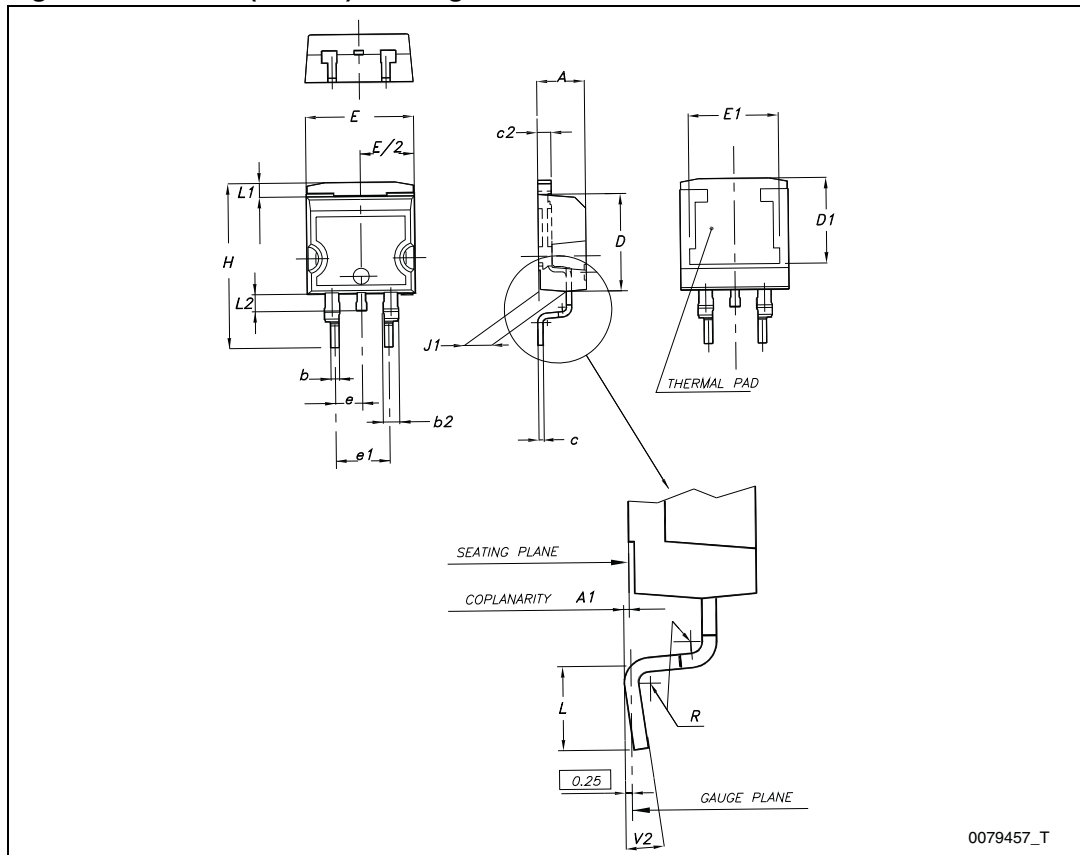
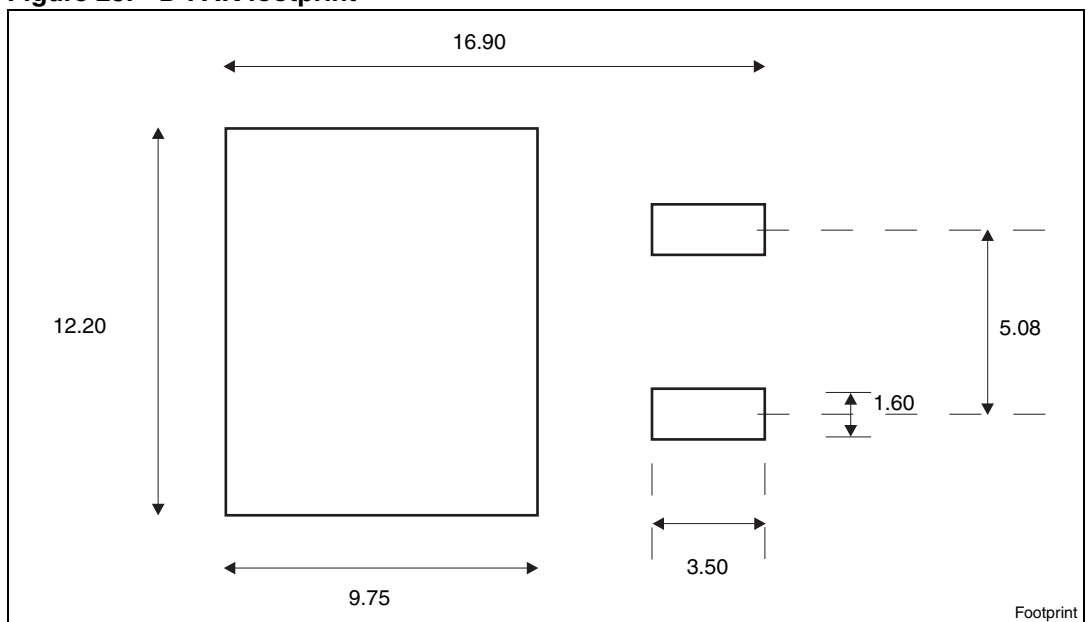


## 4 Package mechanical data

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® 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.

**Table 8. 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 24. D<sup>2</sup>PAK (TO-263) drawingFigure 25. D<sup>2</sup>PAK footprint<sup>(a)</sup>

a. All dimension are in millimeters

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 26. TO-220FP drawing

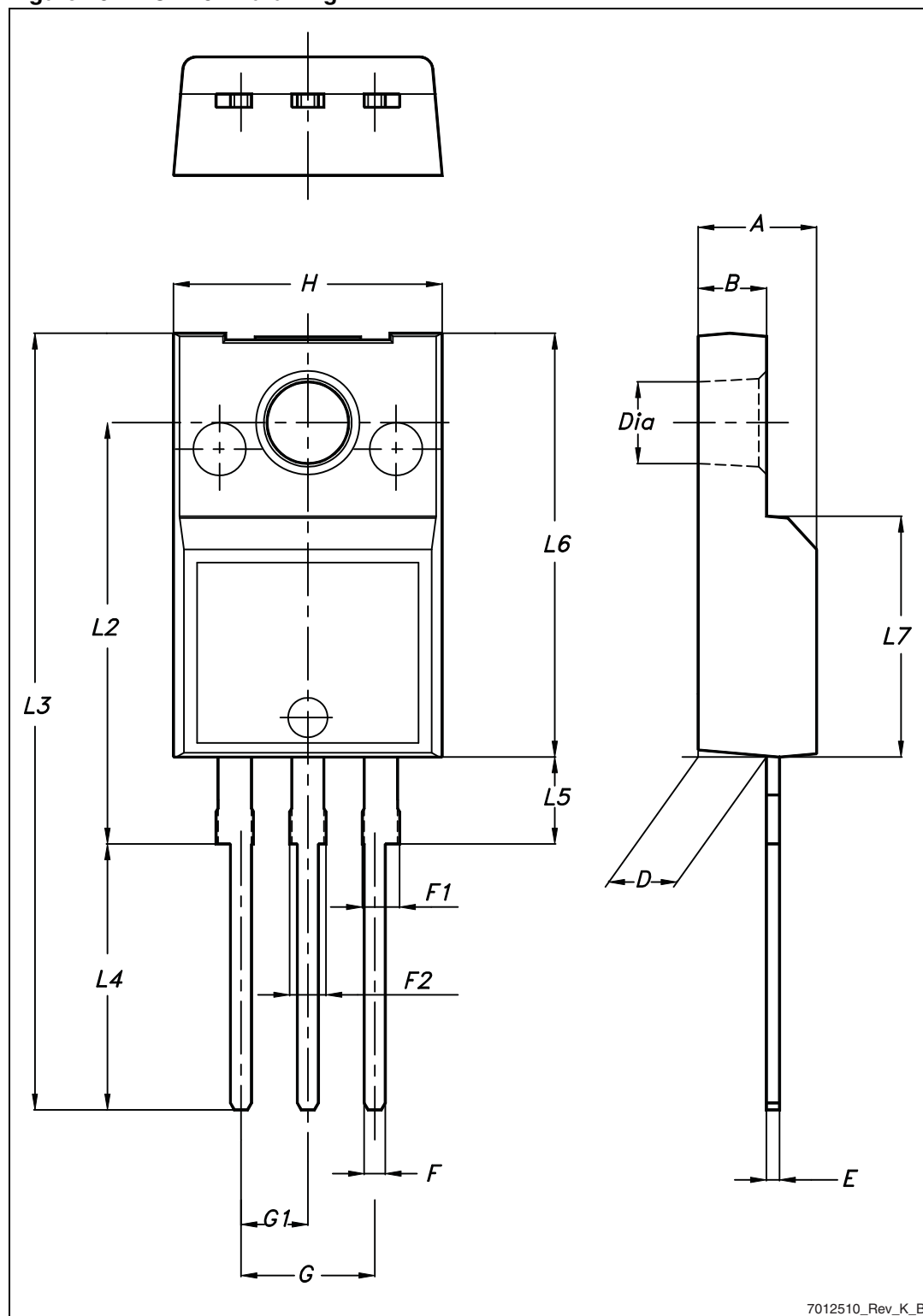


Table 10. TO-220 type A mechanical data

| 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  |

Figure 27. TO-220 type A drawing

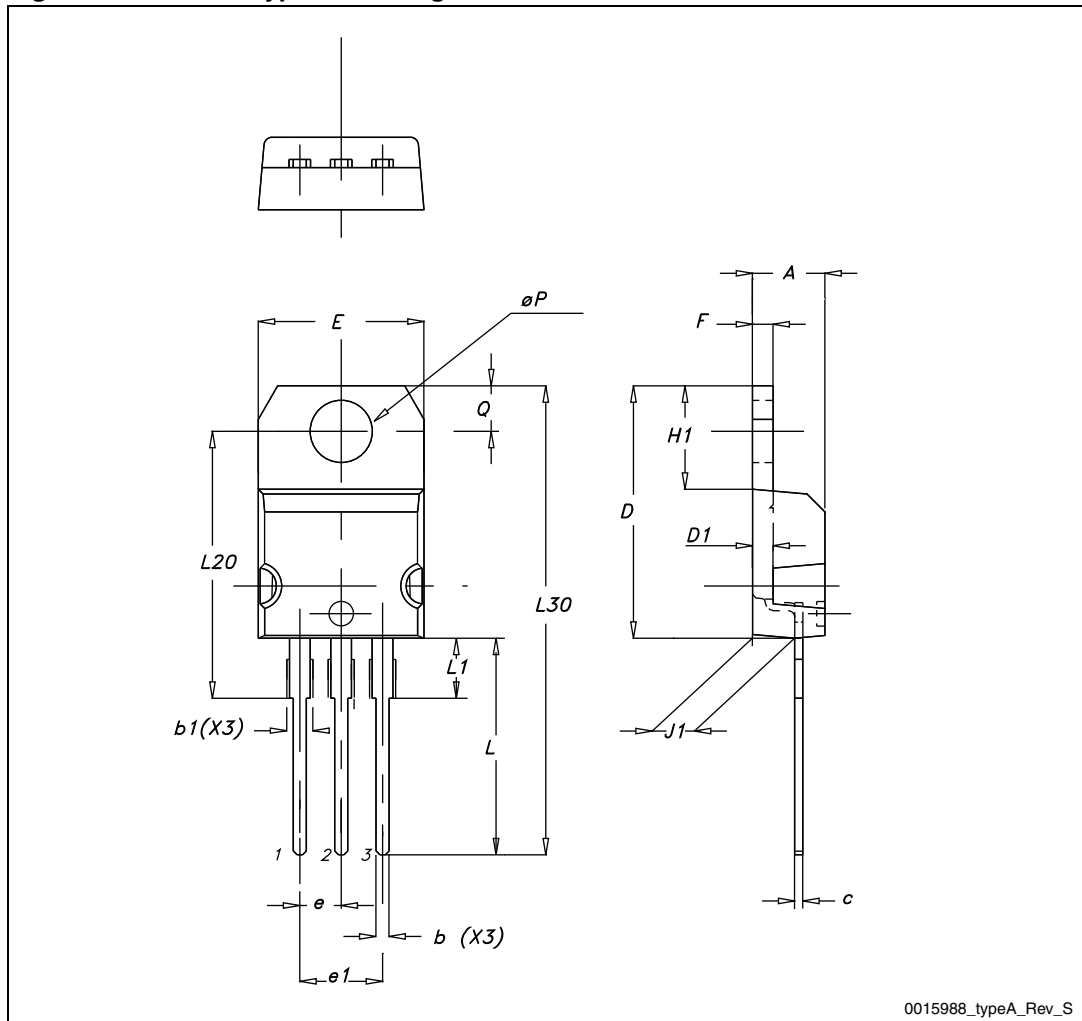
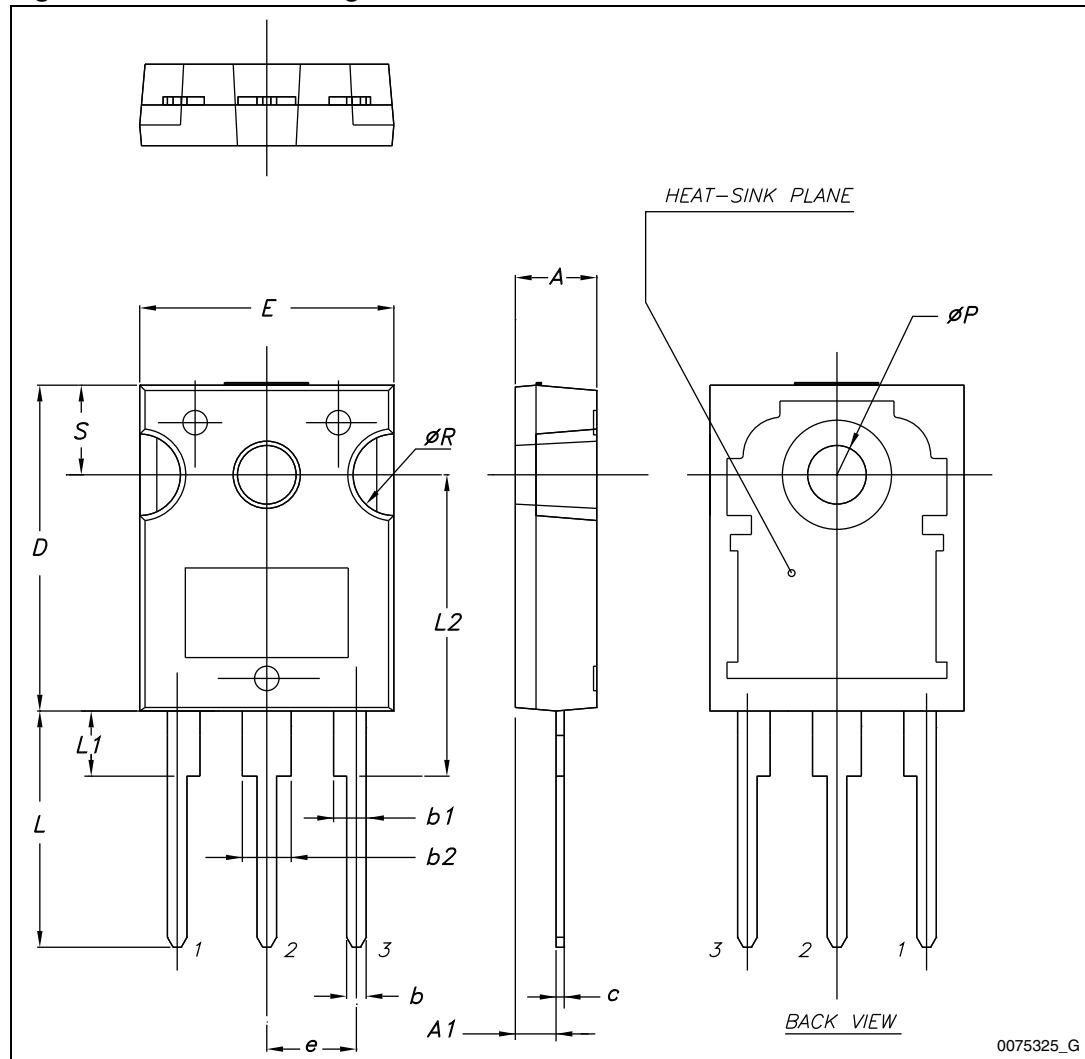


Table 11. TO-247 mechanical data

| 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 28. TO-247 drawing



0075325\_G

## 5 Packaging mechanical data

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 |          |      |      |

Figure 29. Tape

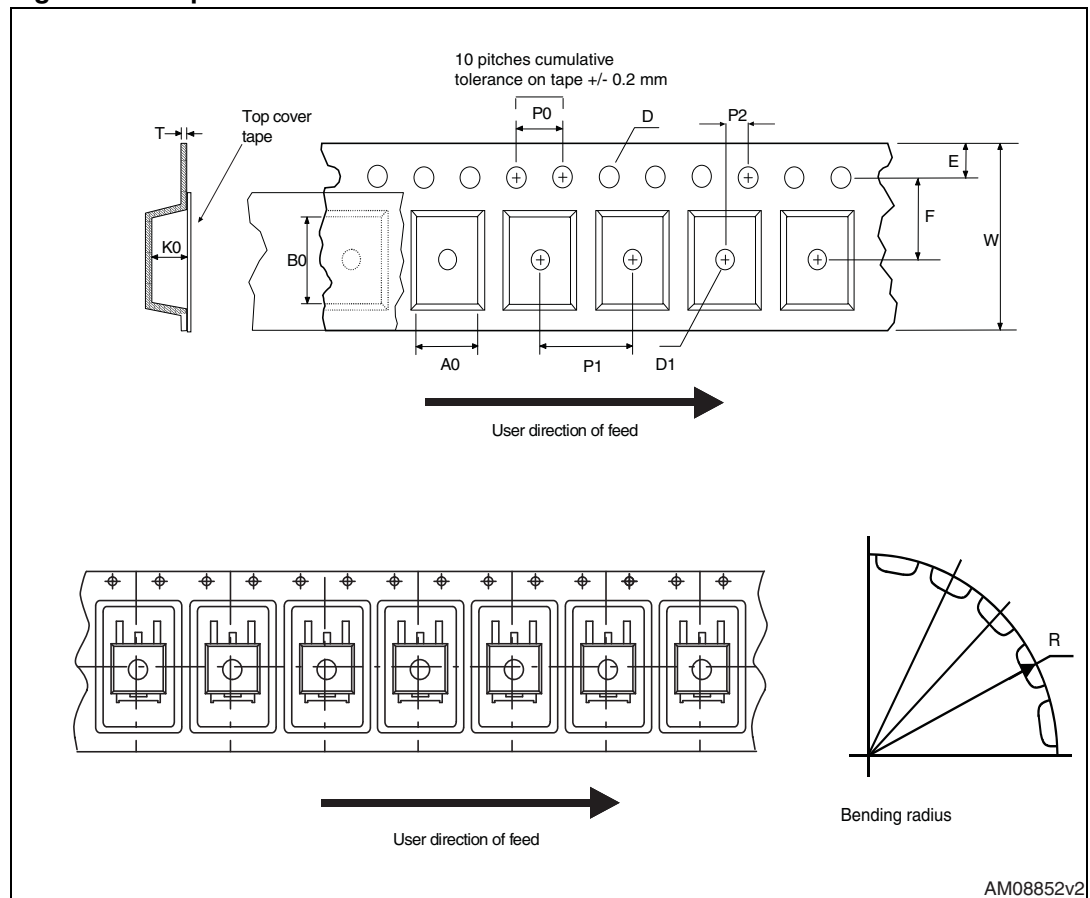
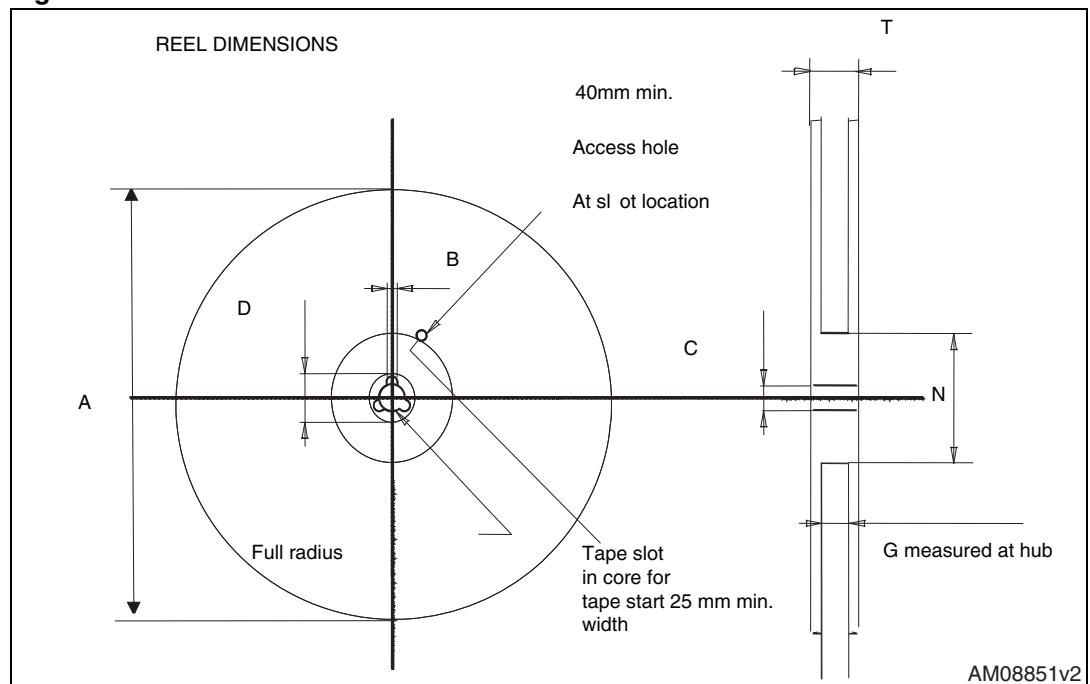


Figure 30. Reel



## 6 Revision history

**Table 13. Document revision history**

| Date        | Revision | Changes                                                                                                                                                                                                                                                                                                 |
|-------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 15-Jun-2009 | 1        | First release                                                                                                                                                                                                                                                                                           |
| 11-Nov-2009 | 2        | <ul style="list-style-type: none"><li>– Added <math>R_{DS(on)}</math> typical value</li><li>– Added new package, mechanical data: I<sup>2</sup>PAK</li><li>– Document status promoted from preliminary data to datasheet</li></ul>                                                                      |
| 06-Oct-2010 | 3        | Inserted new value in <a href="#">Table 5</a> .                                                                                                                                                                                                                                                         |
| 01-Oct-2012 | 4        | Updated title and description on the cover page.<br>Updated figures <a href="#">10</a> , <a href="#">11</a> , <a href="#">14</a> , <a href="#">15</a> and <a href="#">16</a> .<br>Updated <a href="#">Section 4: Package mechanical data</a> and <a href="#">Section 5: Packaging mechanical data</a> . |

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