

N-channel 800 V, 0.37  $\Omega$ , 12 A Zener-protected SuperMESH™ 5  
Power MOSFET in D<sup>2</sup>PAK, TO-220FP and TO-220 packages

Datasheet - production data

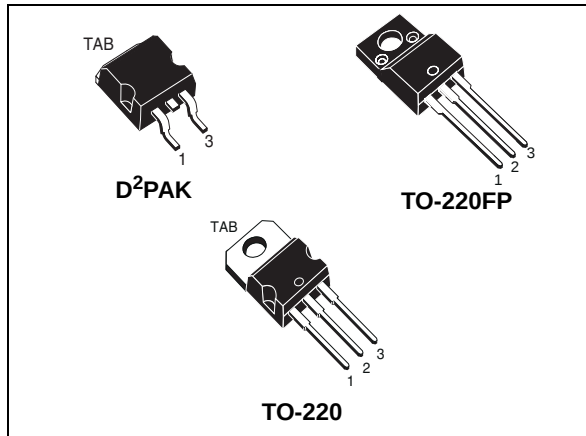
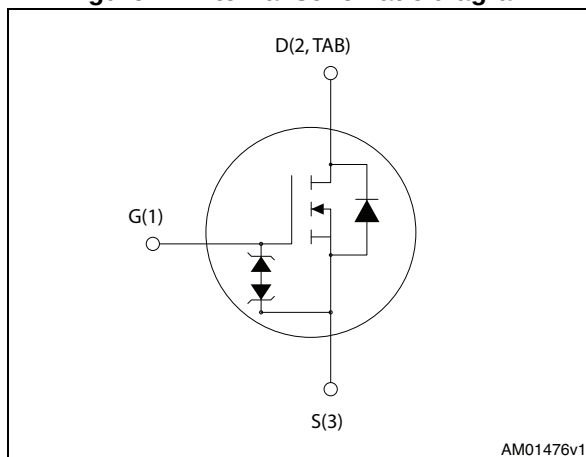


Figure 1. Internal schematic diagram



## Features

| Order codes | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> | P <sub>TOT</sub> |
|-------------|------------------|---------------------|----------------|------------------|
| STB13N80K5  | 800 V            | < 0.45 $\Omega$     | 12 A           | 190 W            |
| STF13N80K5  | 800 V            | < 0.45 $\Omega$     | 12 A           | 35 W             |
| STP13N80K5  | 800 V            | < 0.45 $\Omega$     | 12 A           | 190 W            |

- Worldwide best FOM (figure of merit)
- Ultra low gate charge
- 100% avalanche tested
- Zener-protected

## Applications

- Switching applications

## Description

These devices are N-channel Zener-protected Power MOSFETs realized in SuperMESH™ 5, a revolutionary avalanche-rugged very high voltage Power MOSFET technology based on an innovative proprietary vertical structure. The result is a drastic reduction in on-resistance and ultra low gate charge for applications which require superior power density and high efficiency.

Table 1. Device summary

| Order codes | Marking | Packages           | Packaging     |
|-------------|---------|--------------------|---------------|
| STB13N80K5  | 13N80K5 | D <sup>2</sup> PAK | Tape and reel |
| STF13N80K5  | 13N80K5 | TO-220FP           | Tube          |
| STP13N80K5  | 13N80K5 | TO-220             | Tube          |

## Contents

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# 1 Electrical ratings

Table 2. Absolute maximum ratings

| Symbol                             | Parameter                                                                                                                 | Value                      |                    | Unit |
|------------------------------------|---------------------------------------------------------------------------------------------------------------------------|----------------------------|--------------------|------|
|                                    |                                                                                                                           | D <sup>2</sup> PAK, TO-220 | TO-220FP           |      |
| V <sub>GS</sub>                    | Gate-source voltage                                                                                                       | ± 30                       |                    | V    |
| I <sub>D</sub>                     | Drain current (continuous) at T <sub>C</sub> = 25 °C                                                                      | 12                         | 12 <sup>(1)</sup>  | A    |
| I <sub>D</sub>                     | Drain current (continuous) at T <sub>C</sub> = 100 °C                                                                     | 7.6                        | 7.6 <sup>(1)</sup> | A    |
| I <sub>DM</sub> <sup>(2)</sup>     | Drain current (pulsed)                                                                                                    | 48                         | 48 <sup>(1)</sup>  | A    |
| P <sub>TOT</sub>                   | Total dissipation at T <sub>C</sub> = 25 °C                                                                               | 190                        | 35                 | W    |
| I <sub>AR</sub>                    | Max current during repetitive or single pulse avalanche (pulse width limited by T <sub>jmax</sub> )                       | 4                          |                    | A    |
| E <sub>AS</sub>                    | Single pulse avalanche energy (starting T <sub>J</sub> = 25 °C, I <sub>D</sub> =I <sub>AS</sub> , V <sub>DD</sub> = 50 V) | 148                        |                    | mJ   |
| 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                                                                                         | 4.5                        |                    | V/ns |
| dv/dt <sup>(4)</sup>               | MOSFET dv/dt ruggedness                                                                                                   | 50                         |                    | V/ns |
| T <sub>j</sub><br>T <sub>stg</sub> | Operating junction temperature<br>Storage temperature                                                                     | -55 to 150                 |                    | °C   |

1. Limited by package.
2. Pulse width limited by safe operating area.
3. I<sub>SD</sub> ≤ 12 A, di/dt ≤ 100 A/μs, V<sub>Peak</sub> ≤ V<sub>(BR)DSS</sub>
4. V<sub>DS</sub> ≤ 640 V

Table 3. Thermal data

| Symbol                              | Parameter                            | Value              |        |          | Unit |
|-------------------------------------|--------------------------------------|--------------------|--------|----------|------|
|                                     |                                      | D <sup>2</sup> PAK | TO-220 | TO-220FP |      |
| R <sub>thj-case</sub>               | Thermal resistance junction-case max | 0.66               |        | 3.57     | °C/W |
| R <sub>thj-amb</sub>                | Thermal resistance junction-amb max  |                    | 62.5   |          |      |
| R <sub>thj-pcb</sub> <sup>(1)</sup> | Thermal resistance junction-pcb max  | 30                 |        |          |      |

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

## 2 Electrical characteristics

( $T_{CASE} = 25\text{ °C}$  unless otherwise specified).

**Table 4. On/off states**

| Symbol        | Parameter                                        | Test conditions                                                         | Min. | Typ. | Max.     | Unit                           |
|---------------|--------------------------------------------------|-------------------------------------------------------------------------|------|------|----------|--------------------------------|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage ( $V_{GS} = 0$ )  | $I_D = 1\text{ mA}$                                                     | 800  |      |          | V                              |
| $I_{DSS}$     | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = 800\text{ V}$<br>$V_{DS} = 800\text{ V}, T_c = 125\text{ °C}$ |      |      | 1<br>50  | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$     | Gate body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20\text{ V}$                                              |      |      | $\pm 10$ | $\mu\text{A}$                  |
| $V_{GS(th)}$  | Gate threshold voltage                           | $V_{DS} = V_{GS}, I_D = 100\text{ }\mu\text{A}$                         | 3    | 4    | 5        | V                              |
| $R_{DS(on)}$  | Static drain-source on-resistance                | $V_{GS} = 10\text{ V}, I_D = 6\text{ A}$                                |      | 0.37 | 0.45     | $\Omega$                       |

**Table 5. Dynamic**

| Symbol            | Parameter                             | Test conditions                                                                                          | Min. | Typ. | Max. | Unit     |
|-------------------|---------------------------------------|----------------------------------------------------------------------------------------------------------|------|------|------|----------|
| $C_{iss}$         | Input capacitance                     | $V_{DS} = 100\text{ V}, f = 1\text{ MHz}, V_{GS} = 0$                                                    | -    | 870  | -    | pF       |
| $C_{oss}$         | Output capacitance                    |                                                                                                          | -    | 50   | -    | pF       |
| $C_{rss}$         | Reverse transfer capacitance          |                                                                                                          | -    | 2    | -    | pF       |
| $C_{o(tr)}^{(1)}$ | Equivalent capacitance time related   | $V_{GS} = 0, V_{DS} = 0\text{ to }640\text{ V}$                                                          | -    | 110  | -    | pF       |
| $C_{o(er)}^{(2)}$ | Equivalent capacitance energy related |                                                                                                          | -    | 43   | -    | pF       |
| $R_G$             | Intrinsic gate resistance             | $f = 1\text{ MHz}, I_D = 0$                                                                              | -    | 5    | -    | $\Omega$ |
| $Q_g$             | Total gate charge                     | $V_{DD} = 640\text{ V}, I_D = 12\text{ A}$<br>$V_{GS} = 10\text{ V}$<br>(see <a href="#">Figure 20</a> ) | -    | 29   | -    | nC       |
| $Q_{gs}$          | Gate-source charge                    |                                                                                                          | -    | 7    |      | nC       |
| $Q_{gd}$          | Gate-drain charge                     |                                                                                                          | -    | 18   |      | nC       |

1. Time related is defined as a constant equivalent capacitance giving the same charging time as  $C_{oss}$  when  $V_{DS}$  increases from 0 to 80%  $V_{DSS}$
2. Energy related is defined as a constant equivalent capacitance giving the same stored energy as  $C_{oss}$  when  $V_{DS}$  increases from 0 to 80%  $V_{DSS}$

Table 6. Switching times

| Symbol       | Parameter           | Test conditions                                                                                                                    | Min. | Typ. | Max. | Unit |
|--------------|---------------------|------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|
| $t_{d(on)}$  | Turn-on delay time  | $V_{DD} = 400\text{ V}$ , $I_D = 6\text{ A}$ ,<br>$R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$<br>(see <a href="#">Figure 22</a> ) | -    | 16   | -    | ns   |
| $t_r$        | Rise time           |                                                                                                                                    | -    | 16   | -    | ns   |
| $t_{d(off)}$ | Turn-off delay time |                                                                                                                                    | -    | 42   | -    | ns   |
| $t_f$        | Fall time           |                                                                                                                                    | -    | 16   | -    | ns   |

Table 7. Source drain diode

| Symbol         | Parameter                     | Test conditions                                                                                                                                                  | Min. | Typ. | Max. | Unit          |
|----------------|-------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|---------------|
| $I_{SD}$       | Source-drain current          |                                                                                                                                                                  | -    |      | 14   | A             |
| $I_{SDM}$      | Source-drain current (pulsed) |                                                                                                                                                                  | -    |      | 56   | A             |
| $V_{SD}^{(1)}$ | Forward on voltage            | $I_{SD} = 12\text{ A}$ , $V_{GS} = 0$                                                                                                                            | -    |      | 1.5  | V             |
| $t_{rr}$       | Reverse recovery time         | $I_{SD} = 12\text{ A}$ , $V_{DD} = 60\text{ V}$<br>$di/dt = 100\text{ A}/\mu\text{s}$ ,<br>(see <a href="#">Figure 21</a> )                                      | -    | 406  |      | ns            |
| $Q_{rr}$       | Reverse recovery charge       |                                                                                                                                                                  | -    | 5.7  |      | $\mu\text{C}$ |
| $I_{RRM}$      | Reverse recovery current      |                                                                                                                                                                  | -    | 28   |      | A             |
| $t_{rr}$       | Reverse recovery time         | $I_{SD} = 12\text{ A}$ , $V_{DD} = 60\text{ V}$<br>$di/dt = 100\text{ A}/\mu\text{s}$ ,<br>$T_J = 150\text{ }^\circ\text{C}$<br>(see <a href="#">Figure 21</a> ) | -    | 600  |      | ns            |
| $Q_{rr}$       | Reverse recovery charge       |                                                                                                                                                                  | -    | 7.9  |      | $\mu\text{C}$ |
| $I_{RRM}$      | Reverse recovery current      |                                                                                                                                                                  | -    | 26   |      | A             |

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

Table 8. Gate-source Zener diode

| Symbol        | Parameter                     | Test conditions                        | Min. | Typ. | Max. | Unit |
|---------------|-------------------------------|----------------------------------------|------|------|------|------|
| $V_{(BR)GSO}$ | Gate-source breakdown voltage | $I_{GS} = \pm 1\text{ mA}$ , $I_D = 0$ | 30   | -    | -    | V    |

The built-in back-to-back Zener diodes have been specifically designed to enhance not only the device's ESD capability, but also to make them capable of safely absorbing any voltage transients that may occasionally be applied from gate to source. In this respect, the Zener voltage is appropriate to achieve efficient and cost-effective protection of device integrity. The integrated Zener diodes thus eliminate the need for external components.

## 2.1 Electrical characteristics (curves)

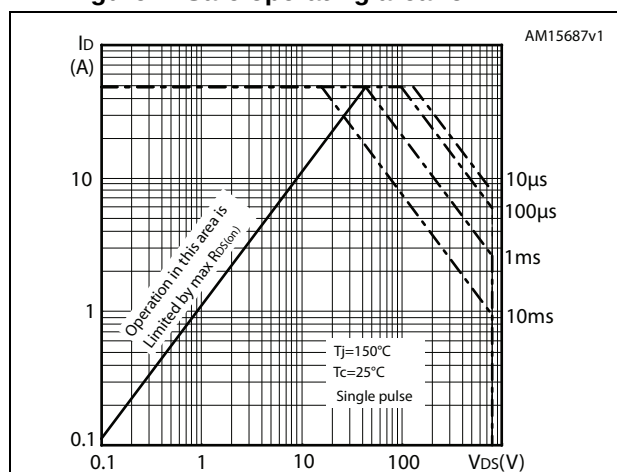
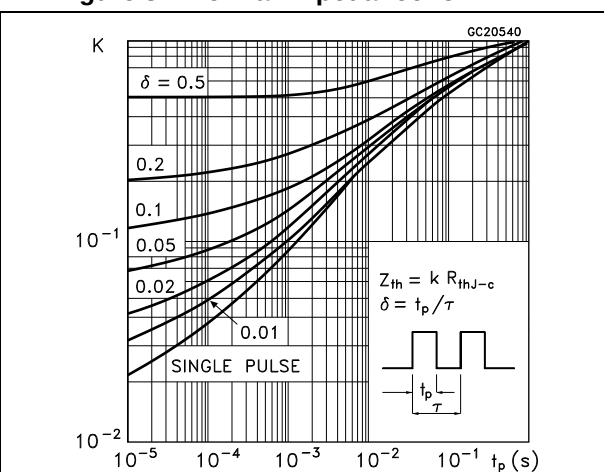
Figure 2. Safe operating area for D<sup>2</sup>PAKFigure 3. Thermal impedance for D<sup>2</sup>PAK

Figure 4. Safe operating area for TO-220FP

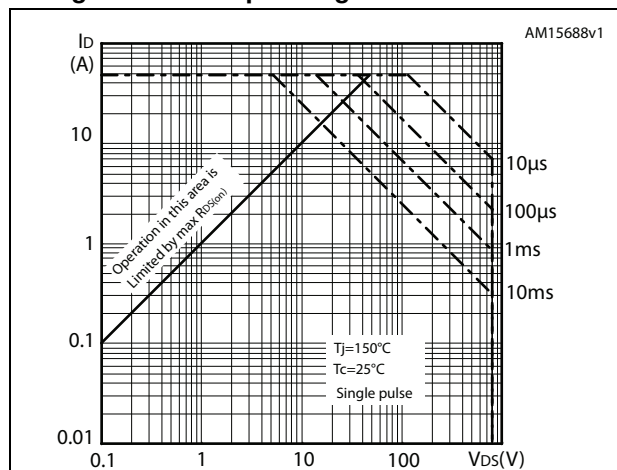


Figure 5. Thermal impedance for TO-220FP

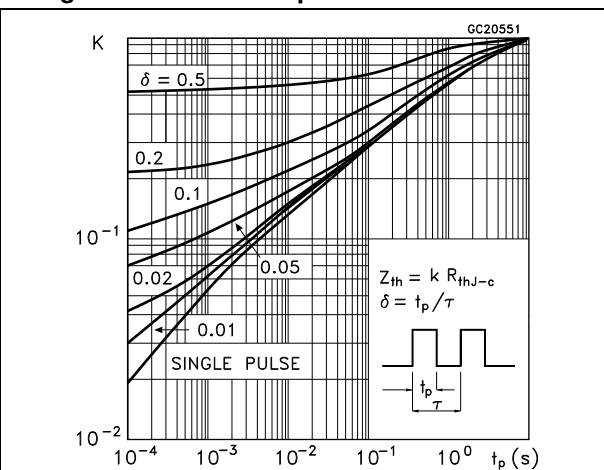


Figure 6. Safe operating area for TO-220

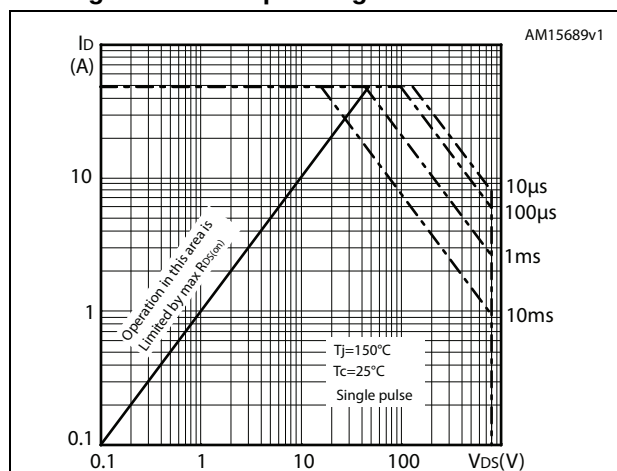


Figure 7. Thermal impedance for TO-220

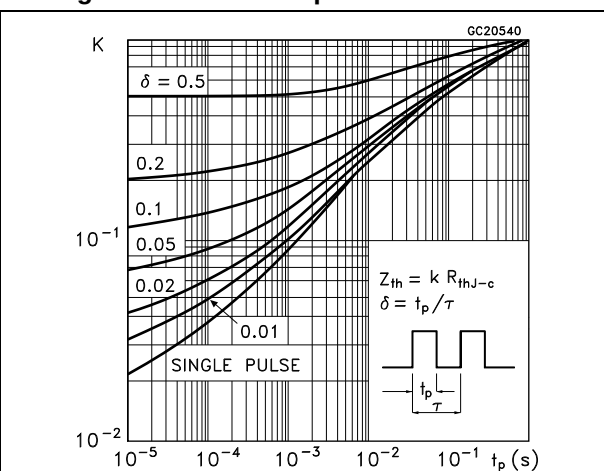


Figure 8. Output characteristics

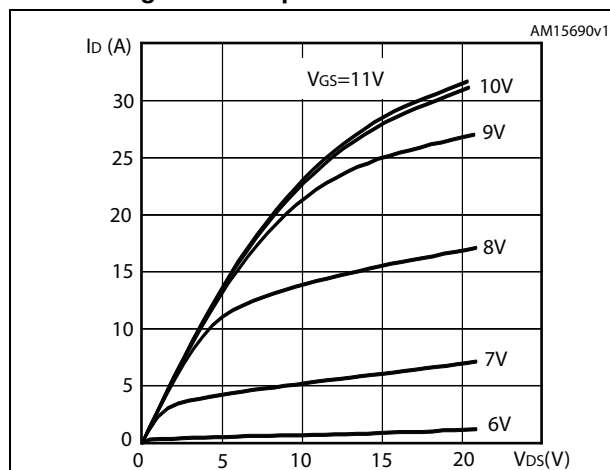


Figure 9. Transfer characteristics

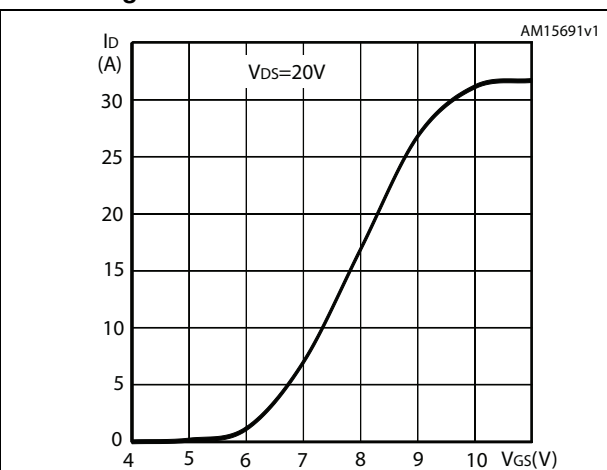
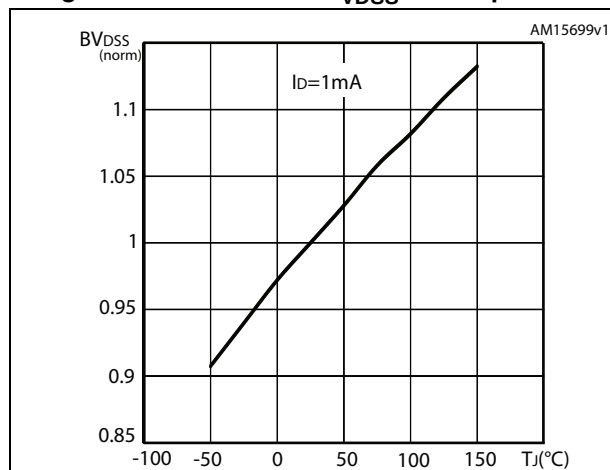
Figure 10. Normalized  $B_{V_{DS}}$  vs temperature

Figure 11. Static drain-source on-resistance

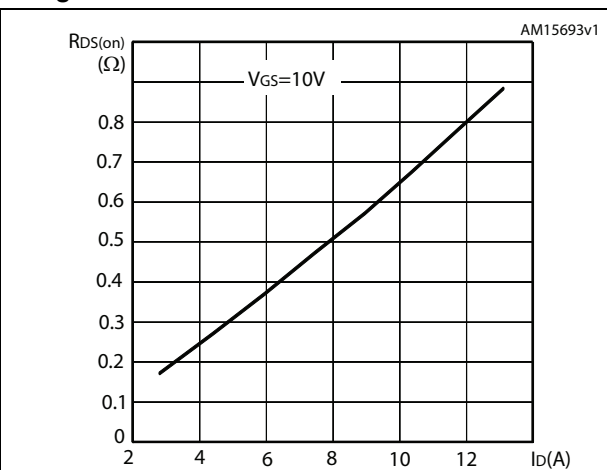


Figure 12. Gate charge vs gate-source voltage

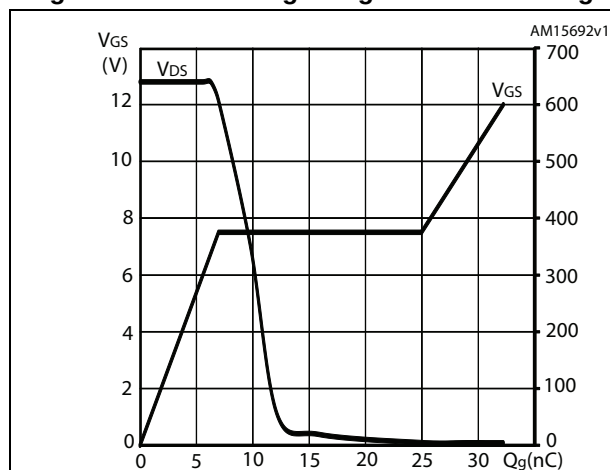


Figure 13. Capacitance variations

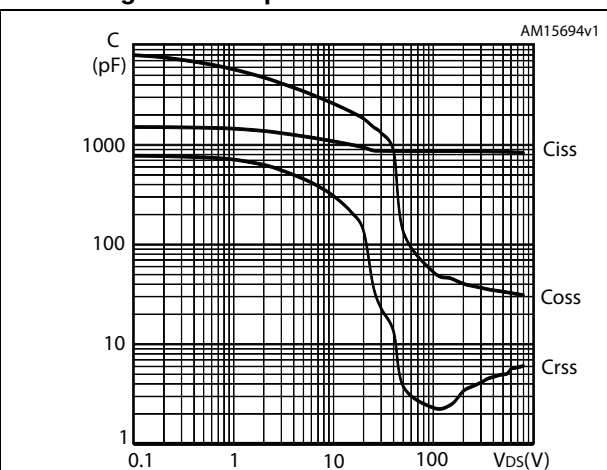


Figure 14. Normalized gate threshold voltage vs temperature

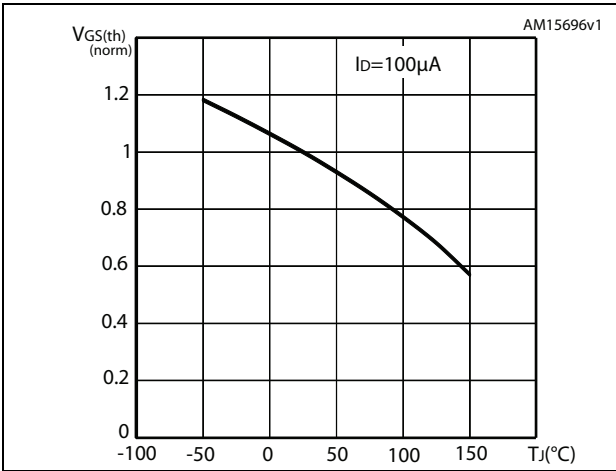


Figure 15. Normalized on-resistance vs temperature

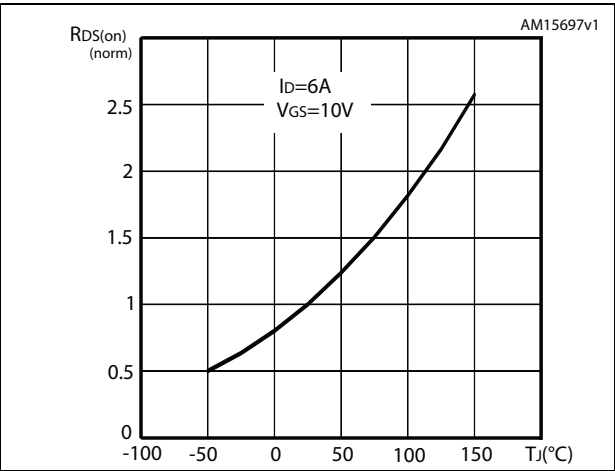


Figure 16. Source-drain diode forward characteristics

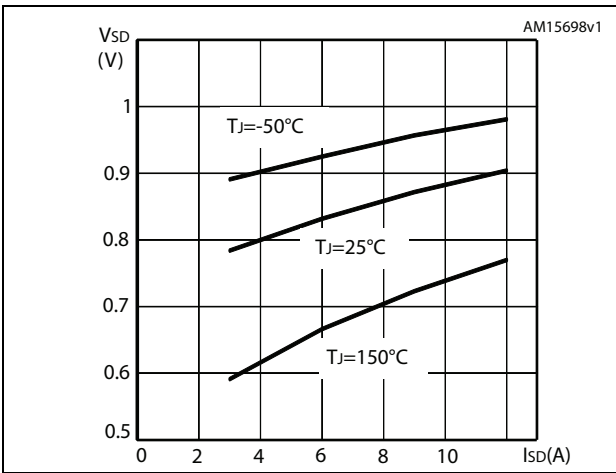


Figure 17. Output capacitance stored energy

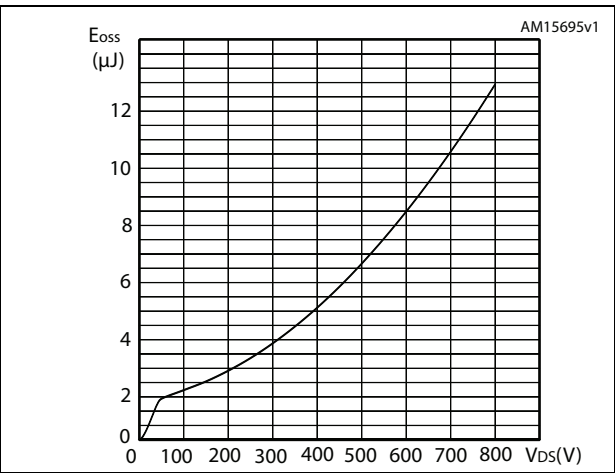
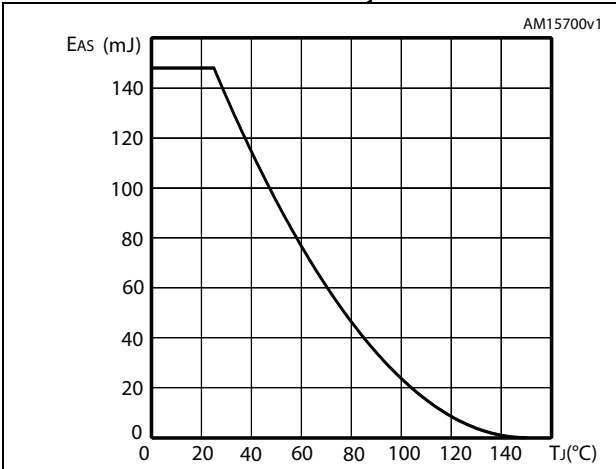


Figure 18. Maximum avalanche energy vs. starting  $T_J$



### 3 Test circuits

Figure 19. Switching times test circuit for resistive load



Figure 20. Gate charge test circuit

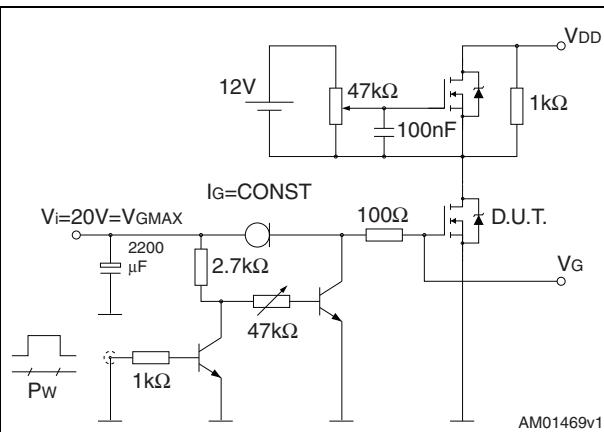


Figure 21. Test circuit for inductive load switching and diode recovery times

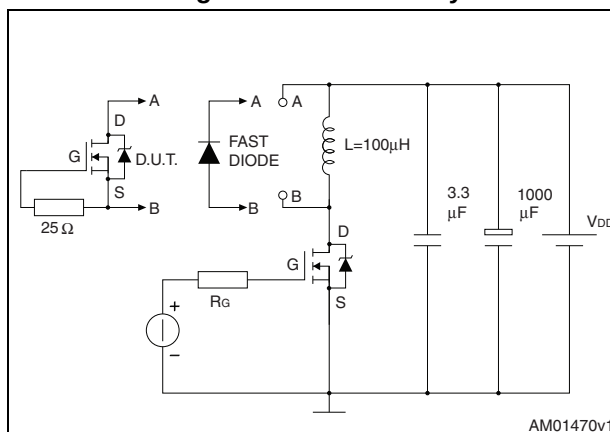


Figure 22. Unclamped inductive load test circuit

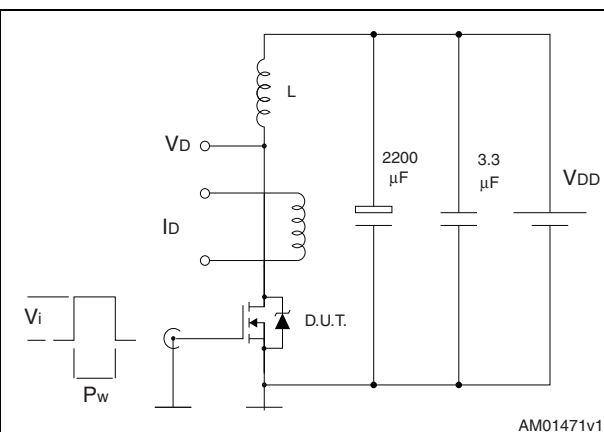


Figure 23. Unclamped inductive waveform

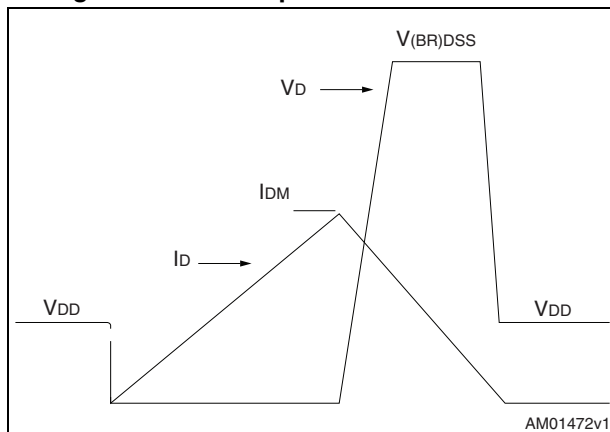


Figure 24. Switching time waveform

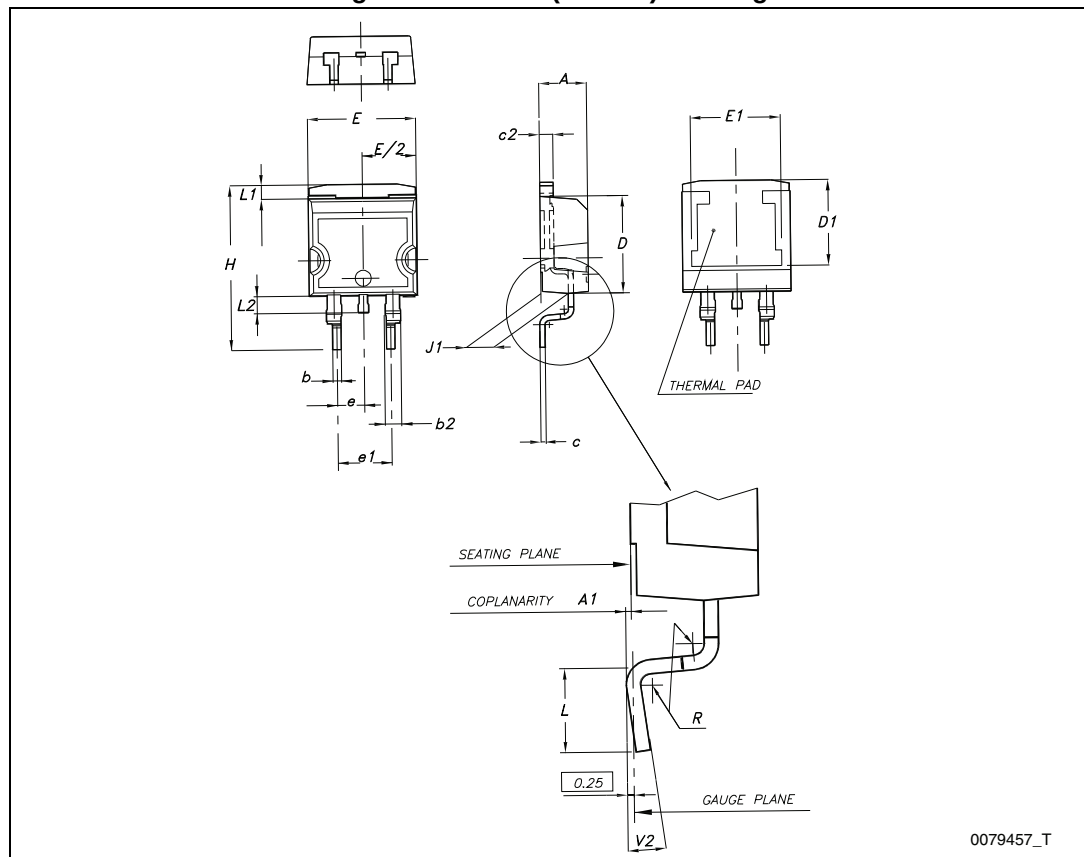
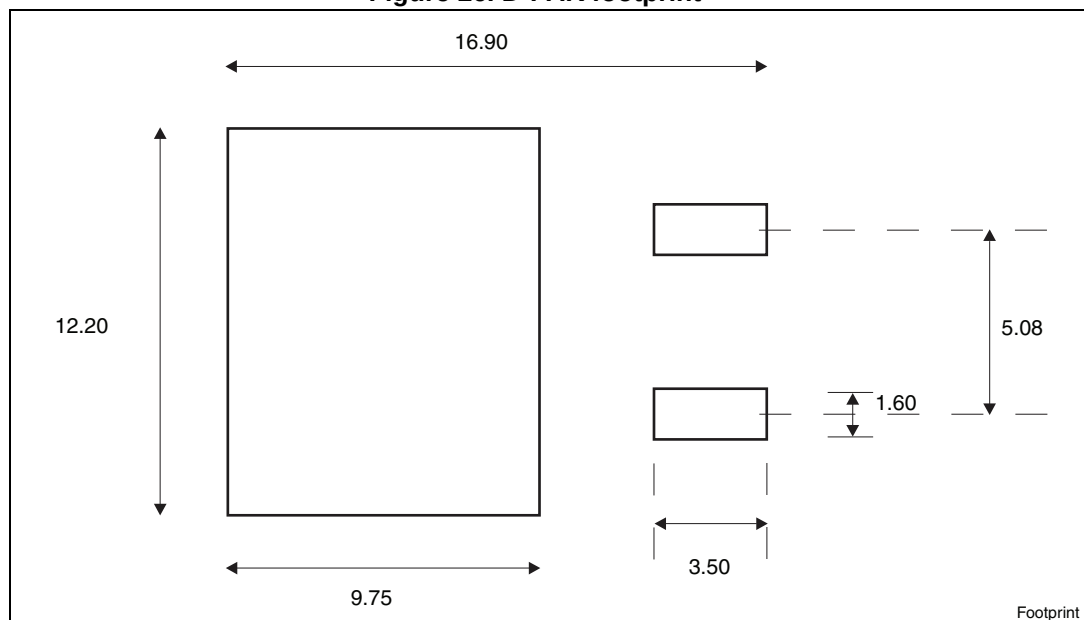


## 4 Package mechanical data

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 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°    |

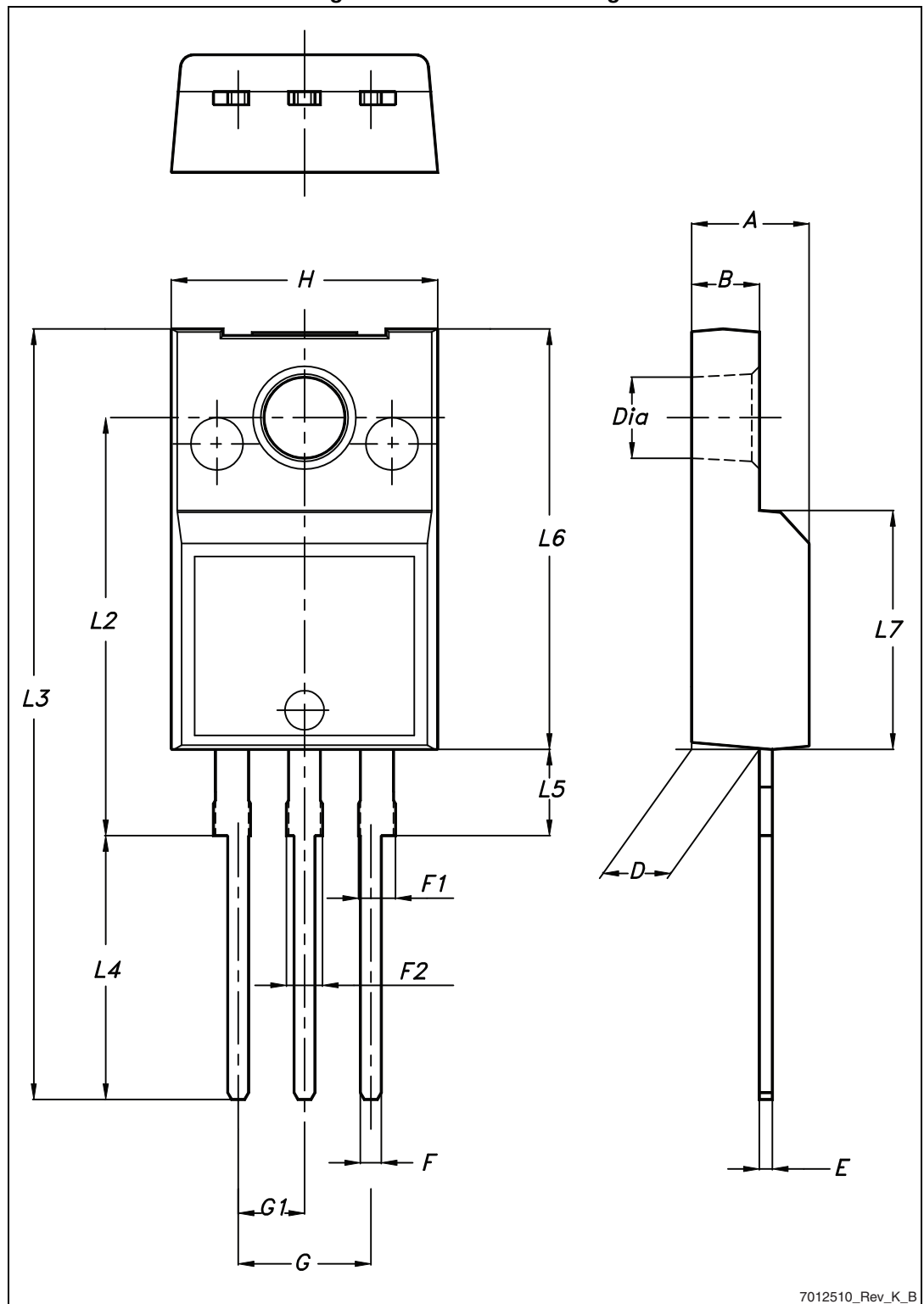
Figure 25. D<sup>2</sup>PAK (TO-263) drawingFigure 26. D<sup>2</sup>PAK footprint<sup>(a)</sup>

a. All dimension are in millimeters

Table 10. 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 27. TO-220FP drawing

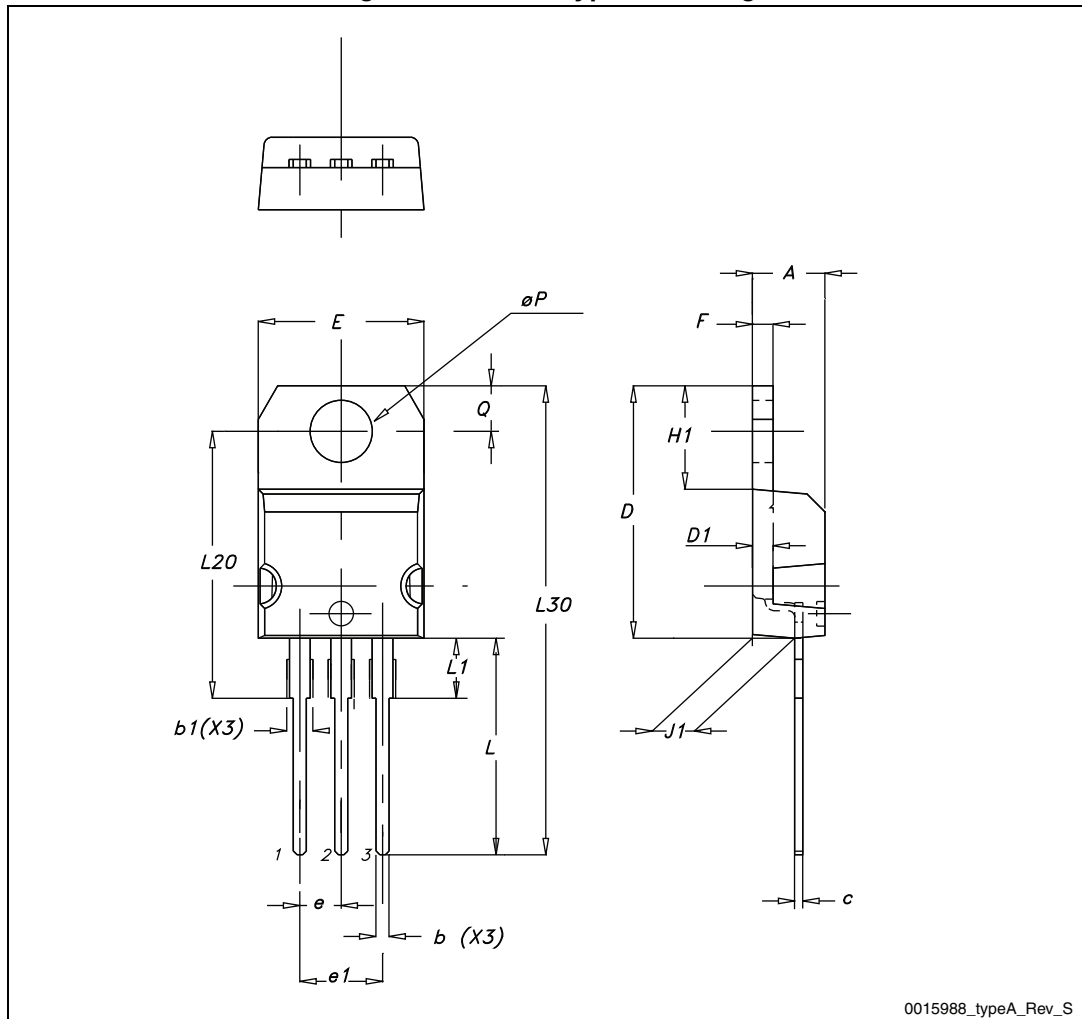


7012510\_Rev\_K\_B

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 28. TO-220 type A drawing



## 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

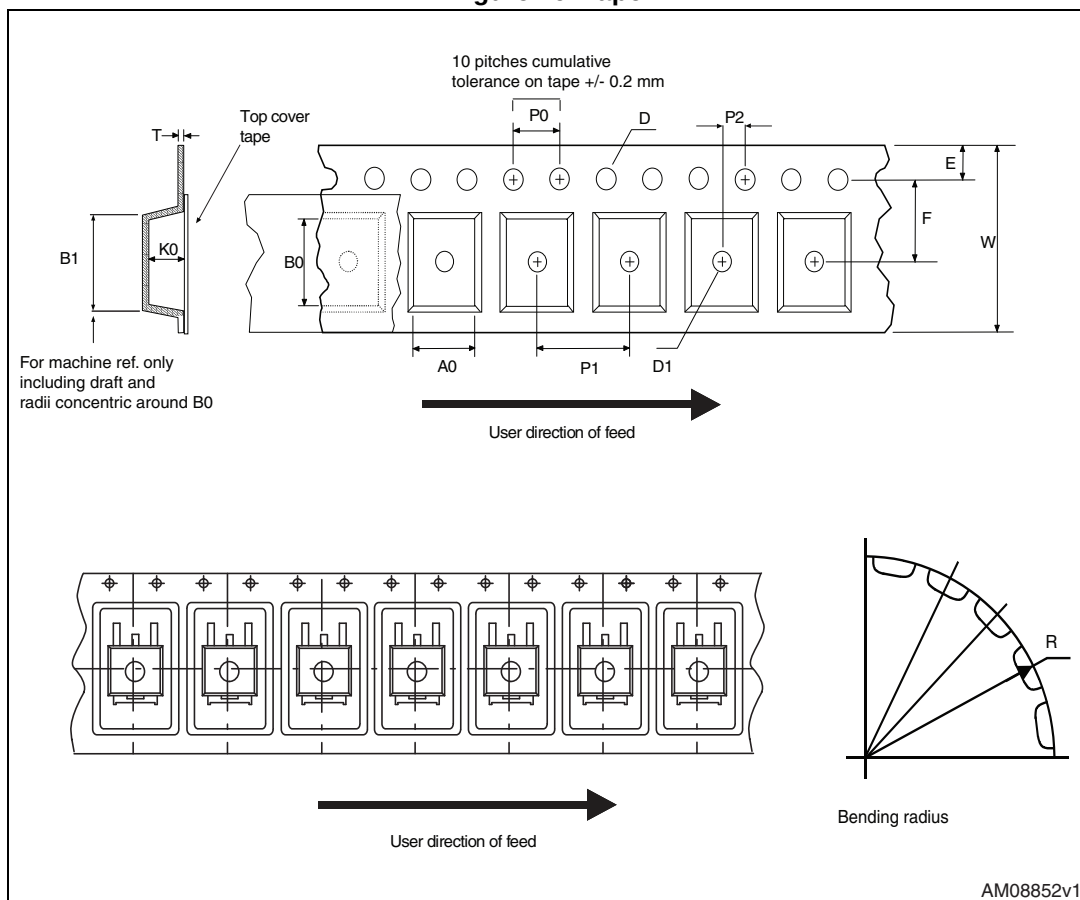
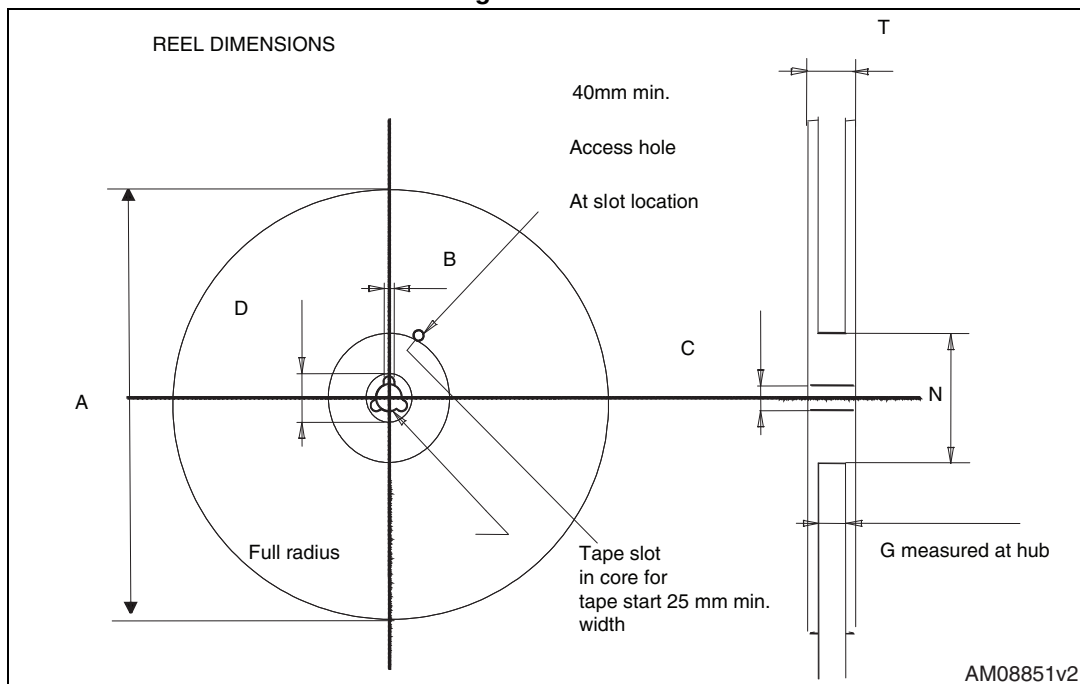


Figure 30. Reel



## 6 Revision history

**Table 13. Document revision history**

| Date        | Revision | Changes                                                                                                                                                                                                                            |
|-------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 07-Mar-2013 | 1        | Initial release.                                                                                                                                                                                                                   |
| 27-Mar-2013 | 2        | Updated <a href="#">Figure 1: Internal schematic diagram</a> .<br>Minor text changes.<br>Document status promoted from preliminary data to production data.                                                                        |
| 15-Apr-2013 | 3        | – Modified: $E_{AS}$ value, the entire typical values on <a href="#">Table 5</a> , <a href="#">6</a> and <a href="#">7</a><br>– Inserted: <a href="#">Section 2.1: Electrical characteristics (curves)</a><br>– Minor text changes |

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