

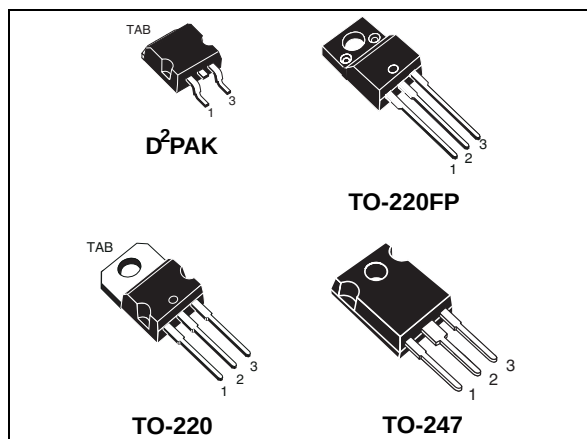
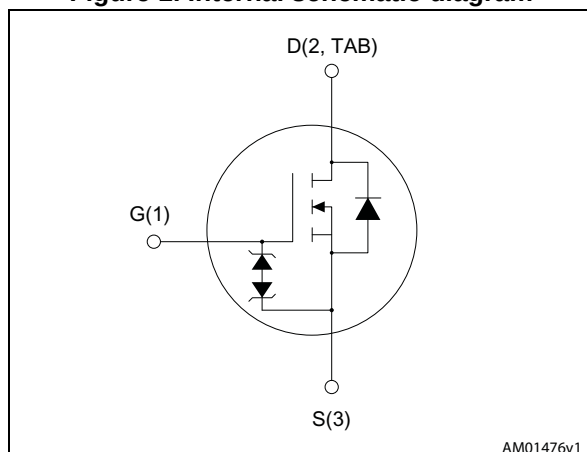


Figure 1. Internal schematic diagram



## Features

| Order codes | V <sub>DS</sub> | R <sub>DS(on)</sub> max | I <sub>D</sub> | P <sub>TOT</sub> |
|-------------|-----------------|-------------------------|----------------|------------------|
| STB10N95K5  | 950 V           | 0.8 $\Omega$            | 8 A            | 130 W            |
| STF10N95K5  |                 |                         |                | 30 W             |
| STP10N95K5  |                 |                         |                | 130 W            |
| STW10N95K5  |                 |                         |                |                  |

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

## Applications

- Switching applications

## Description

These N-channel Zener-protected Power MOSFETs are designed using ST's revolutionary avalanche-rugged very high voltage SuperMESH™ 5 technology, based on an innovative proprietary vertical structure. The result is a dramatic 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 | Package            | Packaging     |
|-------------|---------|--------------------|---------------|
| STB10N95K5  | 10N95K5 | D <sup>2</sup> PAK | Tape and reel |
| STF10N95K5  |         | TO-220FP           | Tube          |
| STP10N95K5  |         | TO-220             |               |
| STW10N95K5  |         | TO-247             |               |

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# 1 Electrical ratings

Table 2. Absolute maximum ratings

| Symbol                             | Parameter                                                                                                                 | Value            |                                       | Unit |
|------------------------------------|---------------------------------------------------------------------------------------------------------------------------|------------------|---------------------------------------|------|
|                                    |                                                                                                                           | TO-220FP         | D <sup>2</sup> PAK,<br>TO-220, TO-247 |      |
| V <sub>GS</sub>                    | Gate- source voltage                                                                                                      | ±30              |                                       | V    |
| I <sub>D</sub>                     | Drain current (continuous) at T <sub>C</sub> = 25 °C                                                                      | 8 <sup>(1)</sup> | 8                                     | A    |
| I <sub>D</sub>                     | Drain current (continuous) at T <sub>C</sub> = 100 °C                                                                     | 5 <sup>(1)</sup> | 5                                     | A    |
| I <sub>DM</sub> <sup>(2)</sup>     | Drain current (pulsed)                                                                                                    | 32               |                                       | A    |
| P <sub>TOT</sub>                   | Total dissipation at T <sub>C</sub> = 25 °C                                                                               | 30               | 130                                   | W    |
| I <sub>AR</sub>                    | Max current during repetitive or single pulse avalanche                                                                   | 2.5              |                                       | 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) | 122              |                                       | mJ   |
| 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 |
| 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    |
| T <sub>J</sub><br>T <sub>stg</sub> | Operating junction temperature<br>Storage temperature                                                                     | - 55 to 150      |                                       | °C   |

1. Limited by maximum junction temperature.
2. Pulse width limited by safe operating area.
3. I<sub>SD</sub> ≤ 8 A, di/dt ≤ 100 A/μs, V<sub>DS(peak)</sub> ≤ V<sub>(BR)DSS</sub>.
4. V<sub>SD</sub> ≤ 760 V

Table 3. Thermal data

| Symbol                              | Parameter                            | Value    |                    |                   | Unit |
|-------------------------------------|--------------------------------------|----------|--------------------|-------------------|------|
|                                     |                                      | TO-220FP | D <sup>2</sup> PAK | TO-220,<br>TO-247 |      |
| R <sub>thj-case</sub>               | Thermal resistance junction-case max | 4.2      | 0.96               |                   | °C/W |
| R <sub>thj-amb</sub>                | Thermal resistance junction-amb max  | 62.5     |                    | 62.5              | °C/W |
| R <sub>thj-pcb</sub> <sup>(1)</sup> | Thermal resistance junction-pcb max  |          | 30                 |                   | °C/W |

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

## 2 Electrical characteristics

(T<sub>case</sub> = 25 °C unless otherwise specified)

**Table 4. On /off states**

| Symbol               | Parameter                                            | Test conditions                                             | Min. | Typ. | Max. | Unit |
|----------------------|------------------------------------------------------|-------------------------------------------------------------|------|------|------|------|
| V <sub>(BR)DSS</sub> | Drain-source breakdown voltage                       | I <sub>D</sub> = 1 mA, V <sub>GS</sub> = 0                  | 950  |      |      | V    |
| I <sub>DSS</sub>     | Zero gate voltage, V <sub>GS</sub> = 0 drain current | V <sub>DS</sub> = 950 V                                     |      |      | 1    | μA   |
|                      |                                                      | V <sub>DS</sub> = 950 V, T <sub>C</sub> = 125 °C            |      |      | 50   | μA   |
| I <sub>GSS</sub>     | Gate-body leakage current                            | V <sub>GS</sub> = ± 20 V; V <sub>DS</sub> = 0               |      |      | ±10  | μA   |
| V <sub>GS(th)</sub>  | Gate threshold voltage                               | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 100 μA | 3    | 4    | 5    | V    |
| R <sub>DS(on)</sub>  | Static drain-source on-resistance                    | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 4 A                |      | 0.65 | 0.8  | Ω    |

**Table 5. Dynamic**

| Symbol                            | Parameter                             | Test conditions                                                                                             | Min. | Typ. | Max. | Unit |
|-----------------------------------|---------------------------------------|-------------------------------------------------------------------------------------------------------------|------|------|------|------|
| C <sub>iss</sub>                  | Input capacitance                     | V <sub>DS</sub> = 100 V, f = 1 MHz, V <sub>GS</sub> = 0                                                     | -    | 630  | -    | pF   |
| C <sub>oss</sub>                  | Output capacitance                    |                                                                                                             | -    | 50   | -    | pF   |
| C <sub>rss</sub>                  | Reverse transfer capacitance          |                                                                                                             | -    | 0.6  | -    | pF   |
| C <sub>o(tr)</sub> <sup>(1)</sup> | Equivalent capacitance time related   | V <sub>GS</sub> = 0, V <sub>DS</sub> = 0 to 760 V                                                           | -    | 77   | -    | pF   |
| C <sub>o(er)</sub> <sup>(2)</sup> | Equivalent capacitance energy related |                                                                                                             | -    | 28   | -    | pF   |
| R <sub>G</sub>                    | Intrinsic gate resistance             | f = 1 MHz open drain                                                                                        | -    | 6.5  | -    | Ω    |
| Q <sub>g</sub>                    | Total gate charge                     | V <sub>DD</sub> = 760 V, I <sub>D</sub> = 8 A<br>V <sub>GS</sub> = 10 V<br>(see <a href="#">Figure 20</a> ) | -    | 22   | -    | nC   |
| Q <sub>gs</sub>                   | Gate-source charge                    |                                                                                                             | -    | 5    | -    | nC   |
| Q <sub>gd</sub>                   | Gate-drain charge                     |                                                                                                             | -    | 15   | -    | nC   |

1. Time related is defined as a constant equivalent capacitance giving the same charging time as C<sub>oss</sub> when V<sub>DS</sub> increases from 0 to 80% V<sub>DSS</sub>
2. energy related is defined as a constant equivalent capacitance giving the same stored energy as C<sub>oss</sub> when V<sub>DS</sub> increases from 0 to 80% V<sub>DSS</sub>

Table 6. Switching times

| Symbol       | Parameter           | Test conditions                                                                                                   | Min. | Typ. | Max | Unit |
|--------------|---------------------|-------------------------------------------------------------------------------------------------------------------|------|------|-----|------|
| $t_{d(on)}$  | Turn-on delay time  | $V_{DD} = 475\text{ V}$ , $I_D = 4\text{ A}$ ,<br>$R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$<br>(see Figure 19) | -    | 22   | -   | ns   |
| $t_r$        | Rise time           |                                                                                                                   | -    | 14   | -   | ns   |
| $t_{d(off)}$ | Turn-off-delay time |                                                                                                                   | -    | 51   | -   | ns   |
| $t_f$        | Fall time           |                                                                                                                   | -    | 15   | -   | ns   |

Table 7. Source drain diode

| Symbol          | Parameter                     | Test conditions                                                                                                                             | Min. | Typ. | Max | Unit          |
|-----------------|-------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|------|------|-----|---------------|
| $I_{SD}$        | Source-drain current          |                                                                                                                                             | -    |      | 8   | A             |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |                                                                                                                                             | -    |      | 32  | A             |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD} = 8\text{ A}$ , $V_{GS} = 0$                                                                                                        | -    |      | 1.5 | V             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 8\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$<br>$V_{DD} = 60\text{ V}$<br>(see Figure 21)                                     | -    | 404  |     | ns            |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                             | -    | 5.2  |     | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                             | -    | 25.5 |     | A             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 8\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$<br>$V_{DD} = 60\text{ V}$ , $T_J = 150\text{ }^\circ\text{C}$<br>(see Figure 21) | -    | 596  |     | ns            |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                             | -    | 6.9  |     | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                             | -    | 23   |     | A             |

1. Pulse width limited by safe operating area

2. 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>PAK and TO-220

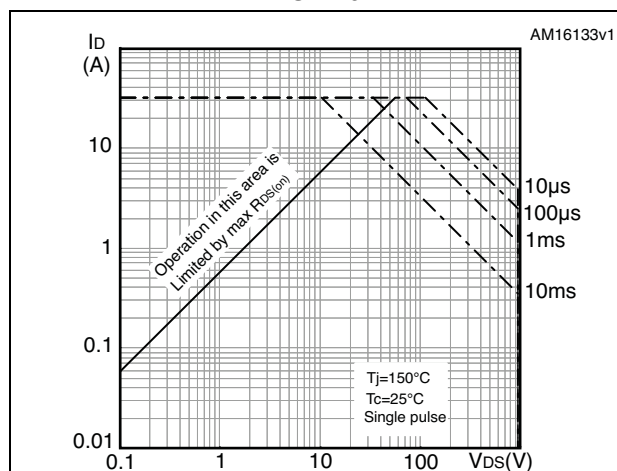


Figure 3. Thermal impedance for D<sup>2</sup>PAK and TO-220

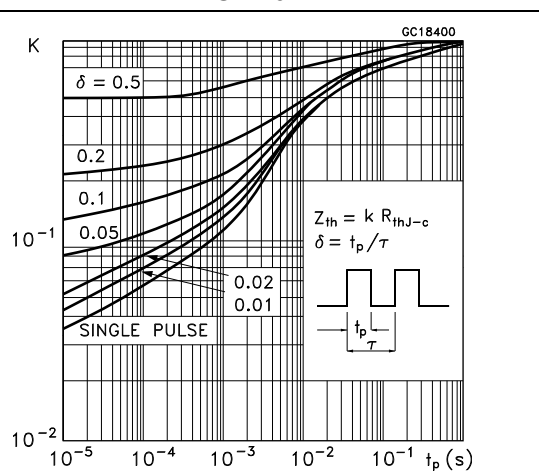


Figure 4. Safe operating area for TO-220FP

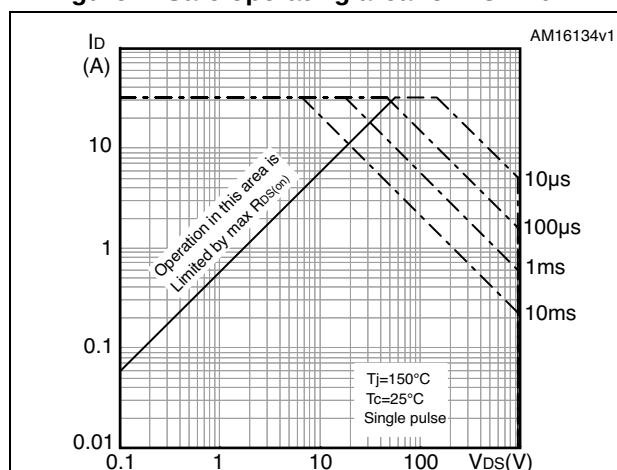


Figure 5. Thermal impedance for TO-220FP

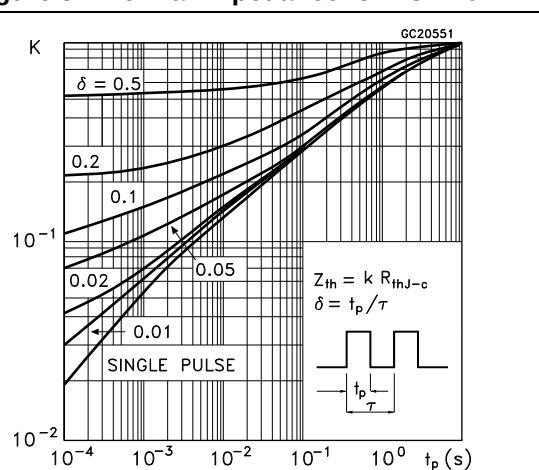


Figure 6. Safe operating area for TO-247

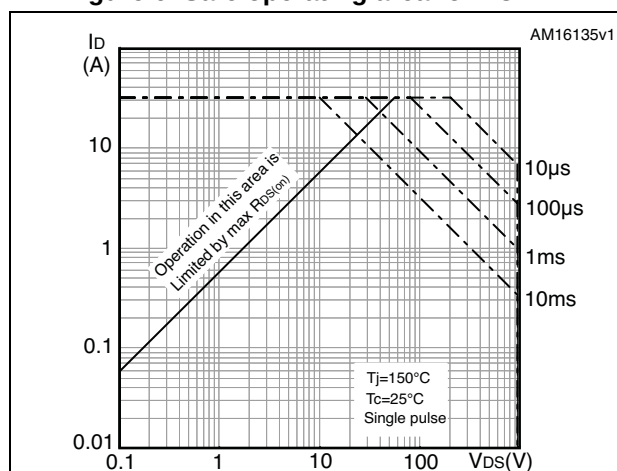


Figure 7. Thermal impedance for TO-247

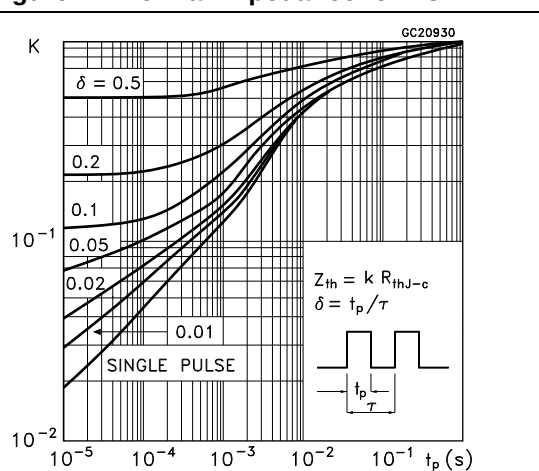


Figure 8. Output characteristics

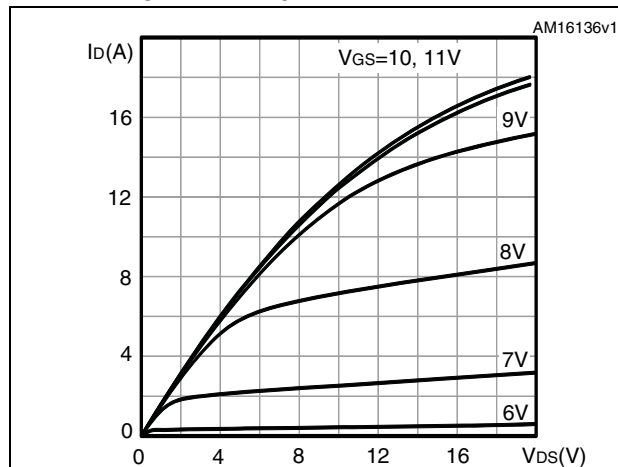


Figure 9. Transfer characteristics

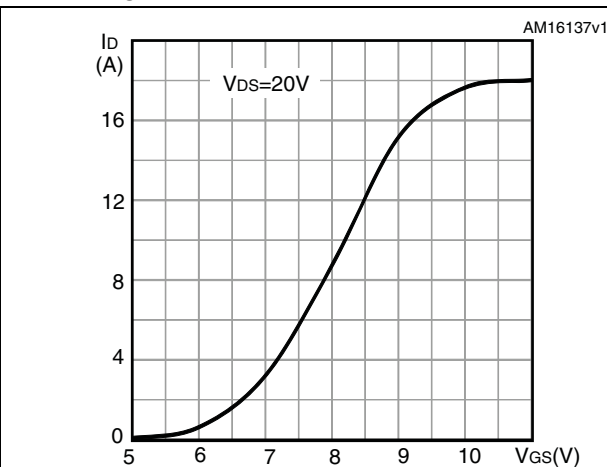


Figure 10. Gate charge vs gate-source voltage

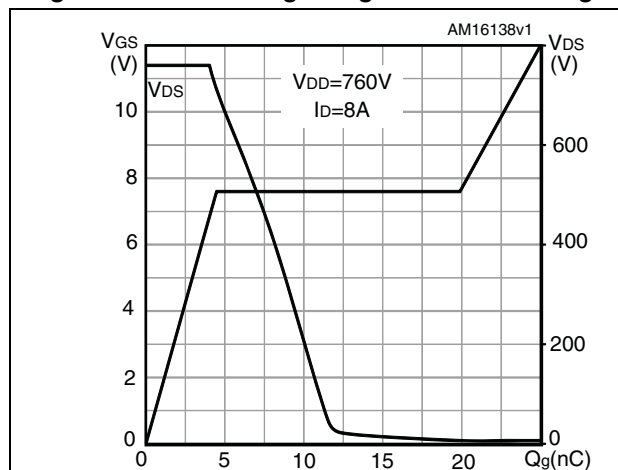


Figure 11. Static drain-source on-resistance

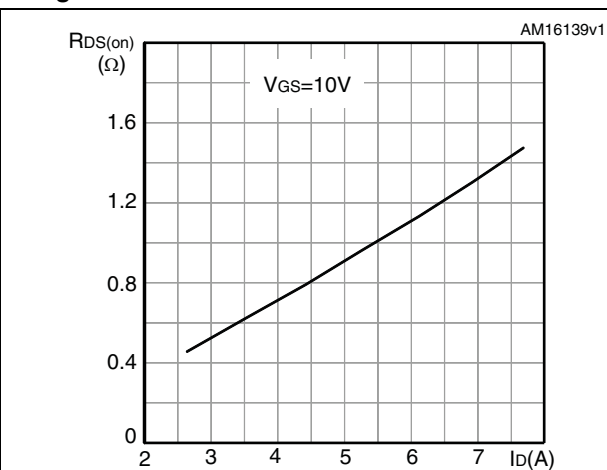


Figure 12. Capacitance variations

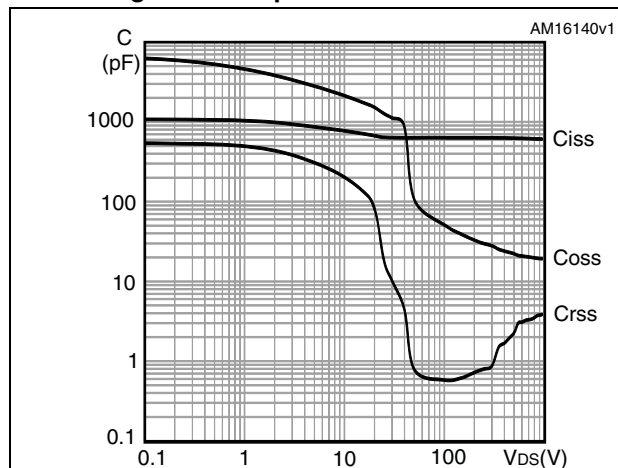


Figure 13. Output capacitance stored energy

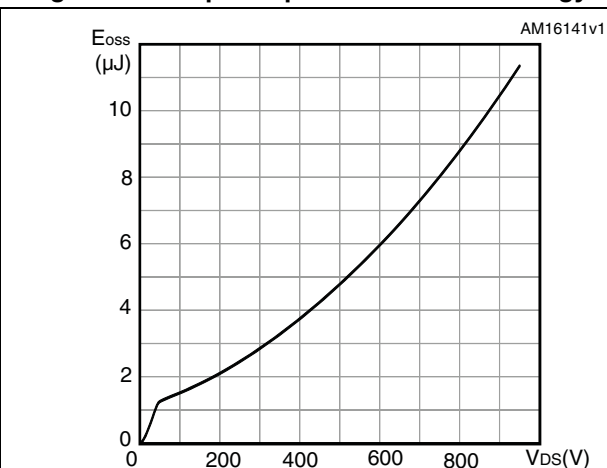


Figure 14. Normalized gate threshold voltage vs temperature

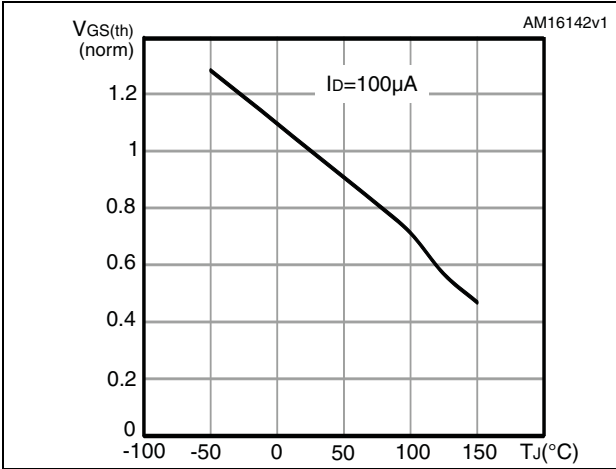


Figure 15. Normalized on-resistance vs temperature

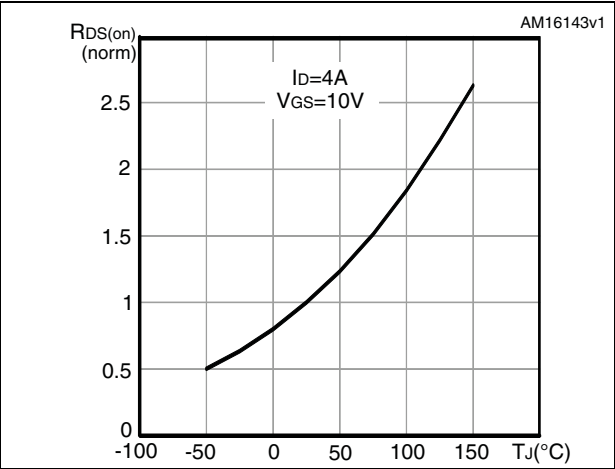


Figure 16. Normalized  $V_{DS}$  vs temperature

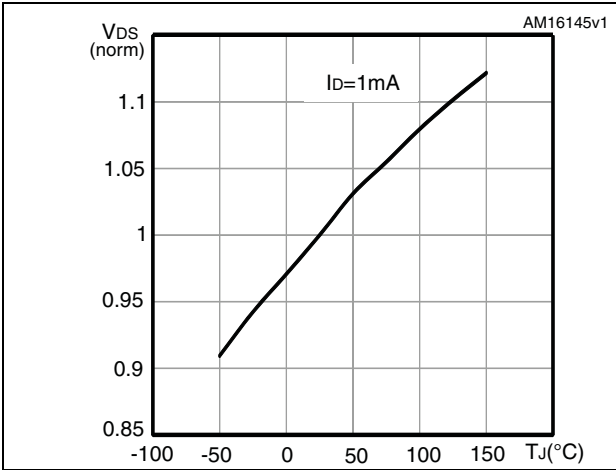


Figure 17. Source-drain diode forward characteristics

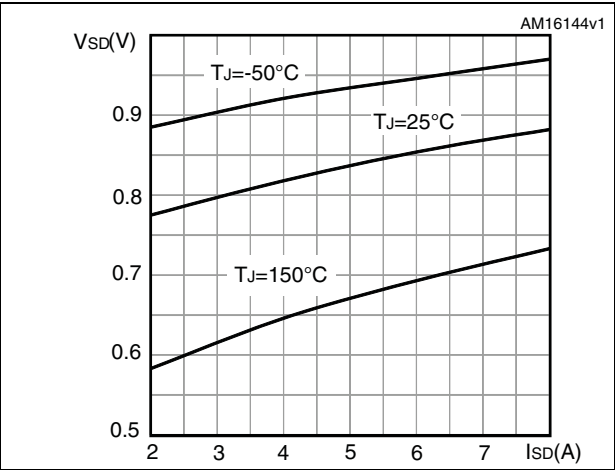
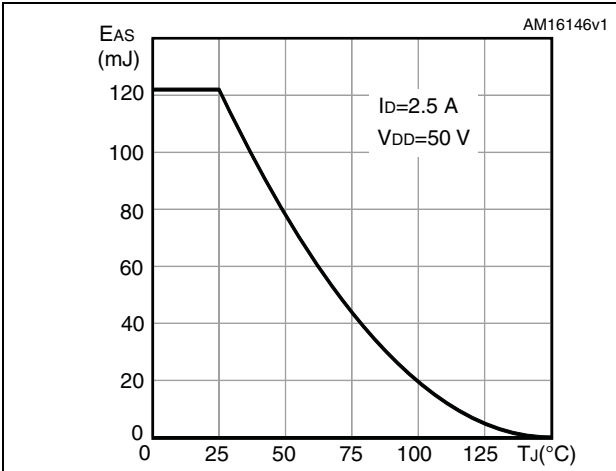


Figure 18. Maximum avalanche energy vs starting  $T_J$



### 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

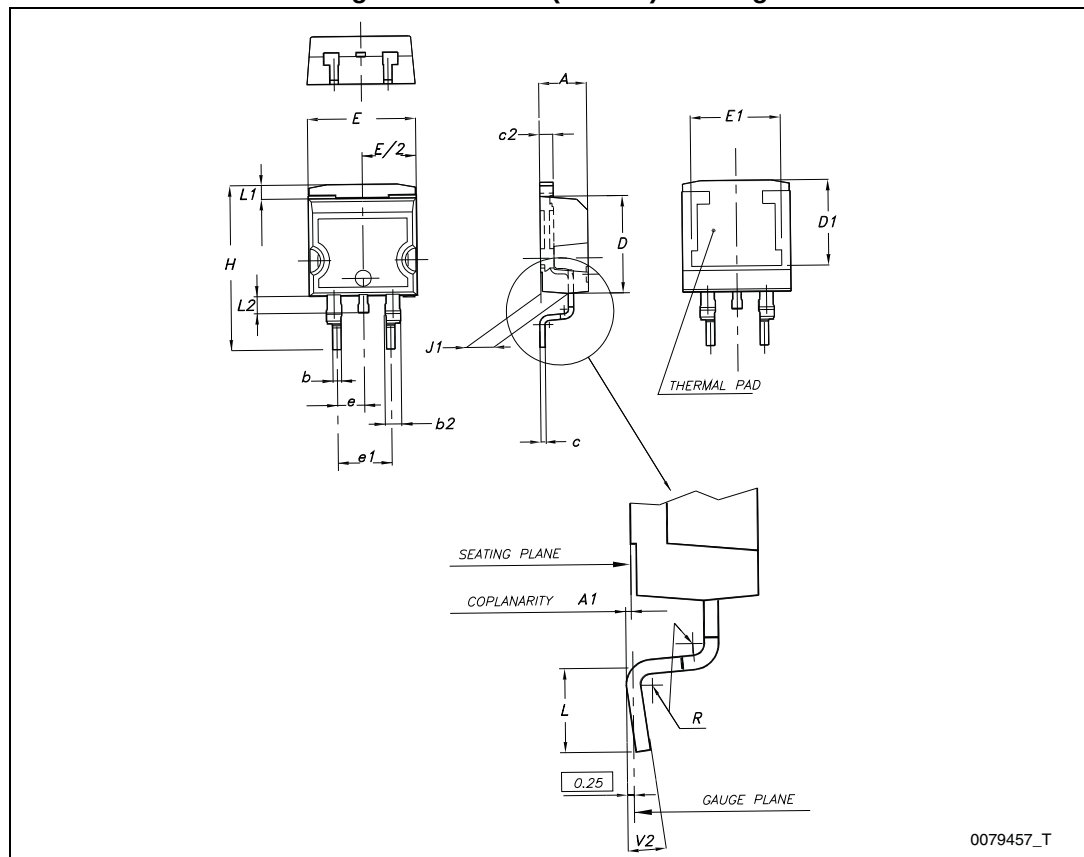


Figure 24. Switching time waveform



## 4 Package mechanical data

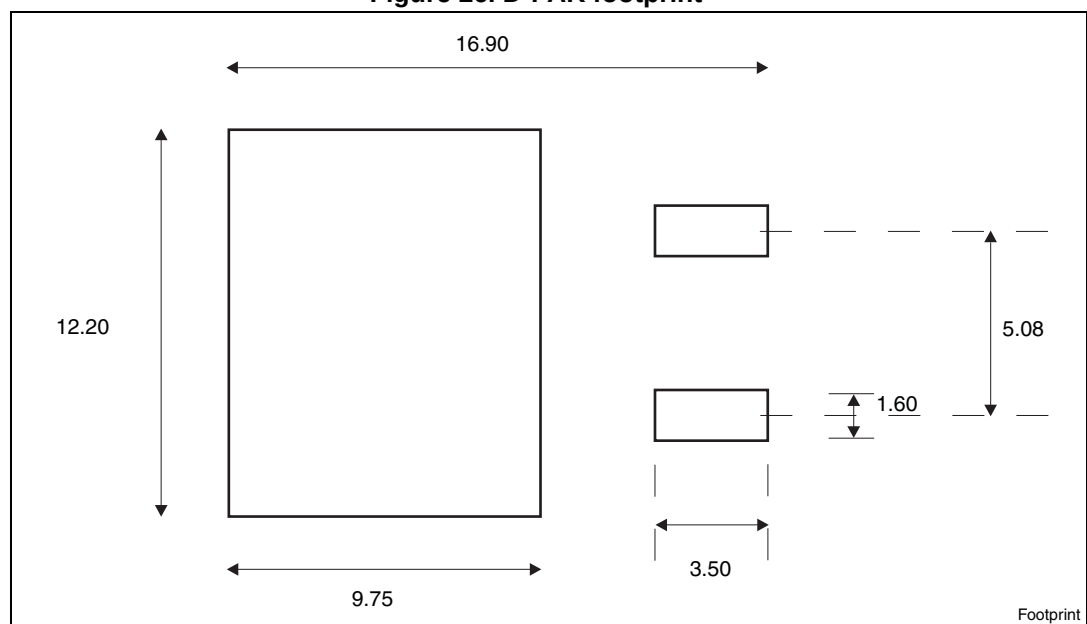
In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK<sup>®</sup> packages, depending on their level of environmental compliance. ECOPACK<sup>®</sup> specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK<sup>®</sup> is an ST trademark.

Figure 25. D<sup>2</sup>PAK (TO-263) drawingTable 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 |

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

| Dim. | mm   |      |      |
|------|------|------|------|
|      | Min. | Typ. | Max. |
| 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 26. D<sup>2</sup>PAK footprint<sup>(a)</sup>

a. All dimension are in millimeters

Figure 27. TO-220FP drawing

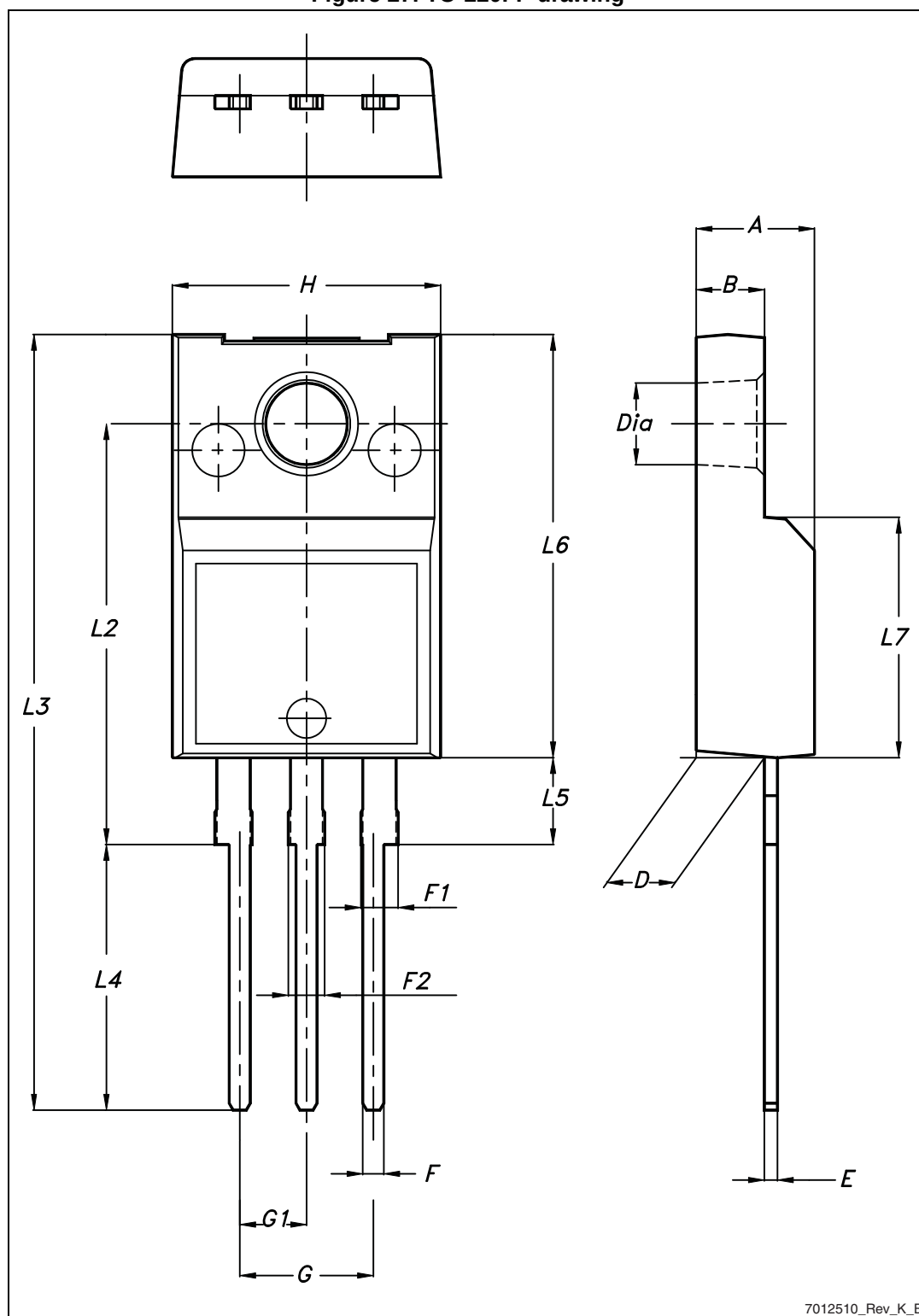


Table 10. TO-220FP mechanical data

| 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 28. TO-220 type A drawing

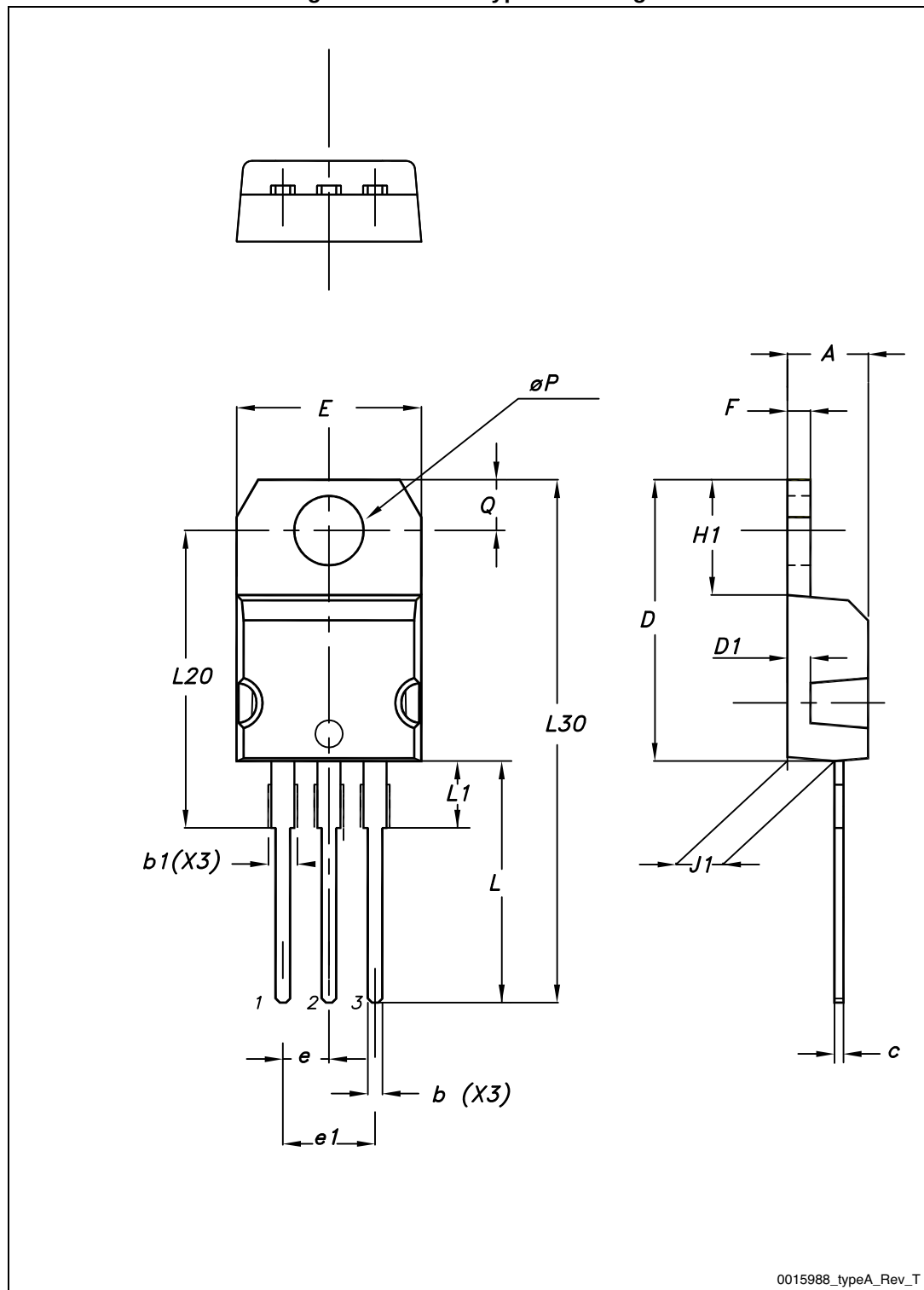


Table 11. TO-220 type A mechanical data

| 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 29. TO-247 drawing

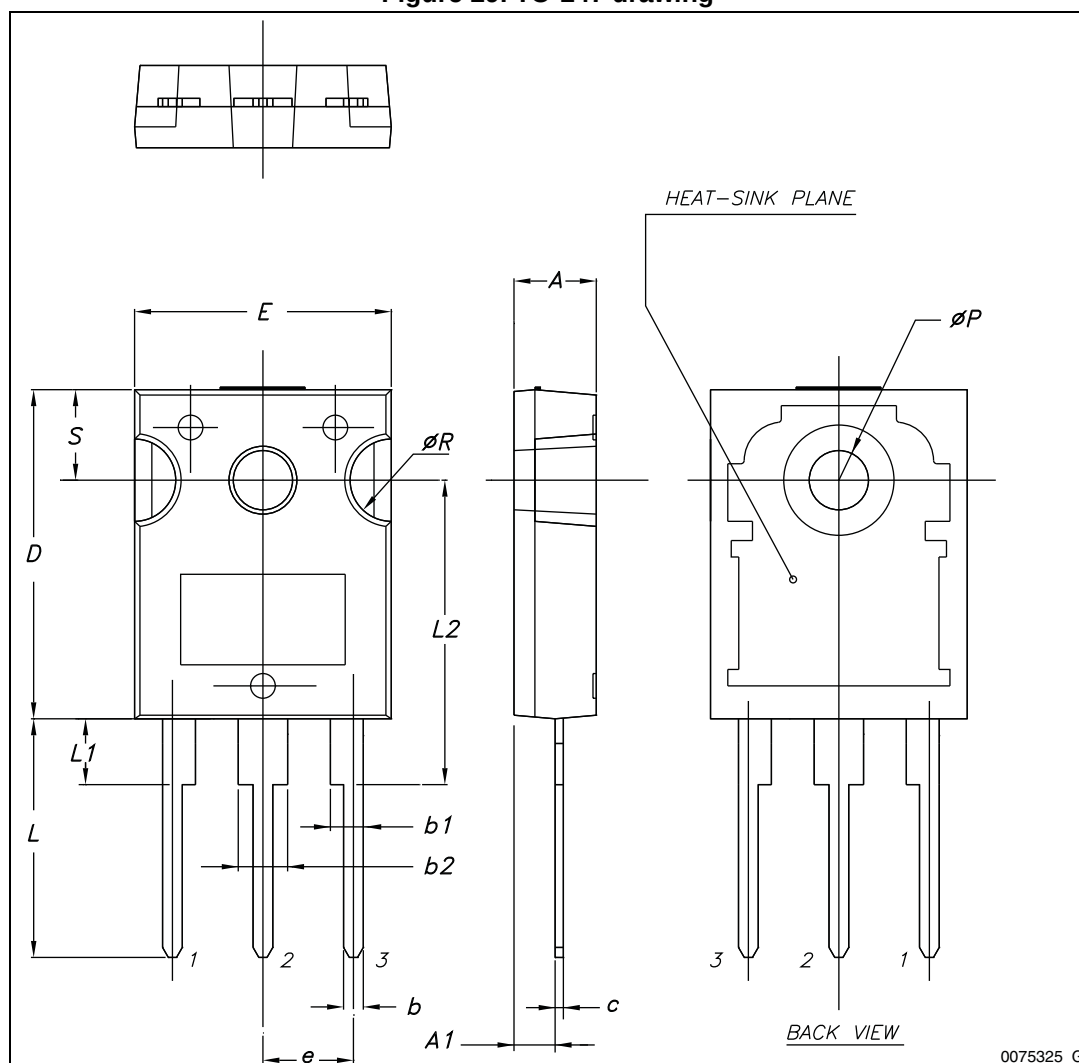


Table 12. TO-247 mechanical data

| 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 |

Table 12. TO-247 mechanical data (continued)

| Dim. | mm.   |       |       |
|------|-------|-------|-------|
|      | Min.  | Typ.  | Max.  |
| e    | 5.30  | 5.45  | 5.60  |
| L    | 14.20 |       | 14.80 |
| L1   | 3.70  |       | 4.30  |
| L2   |       | 18.50 |       |
| ØP   | 3.55  |       | 3.65  |
| ØR   | 4.50  |       | 5.50  |
| S    | 5.30  | 5.50  | 5.70  |

# 5 Packaging mechanical data

Figure 30. Tape

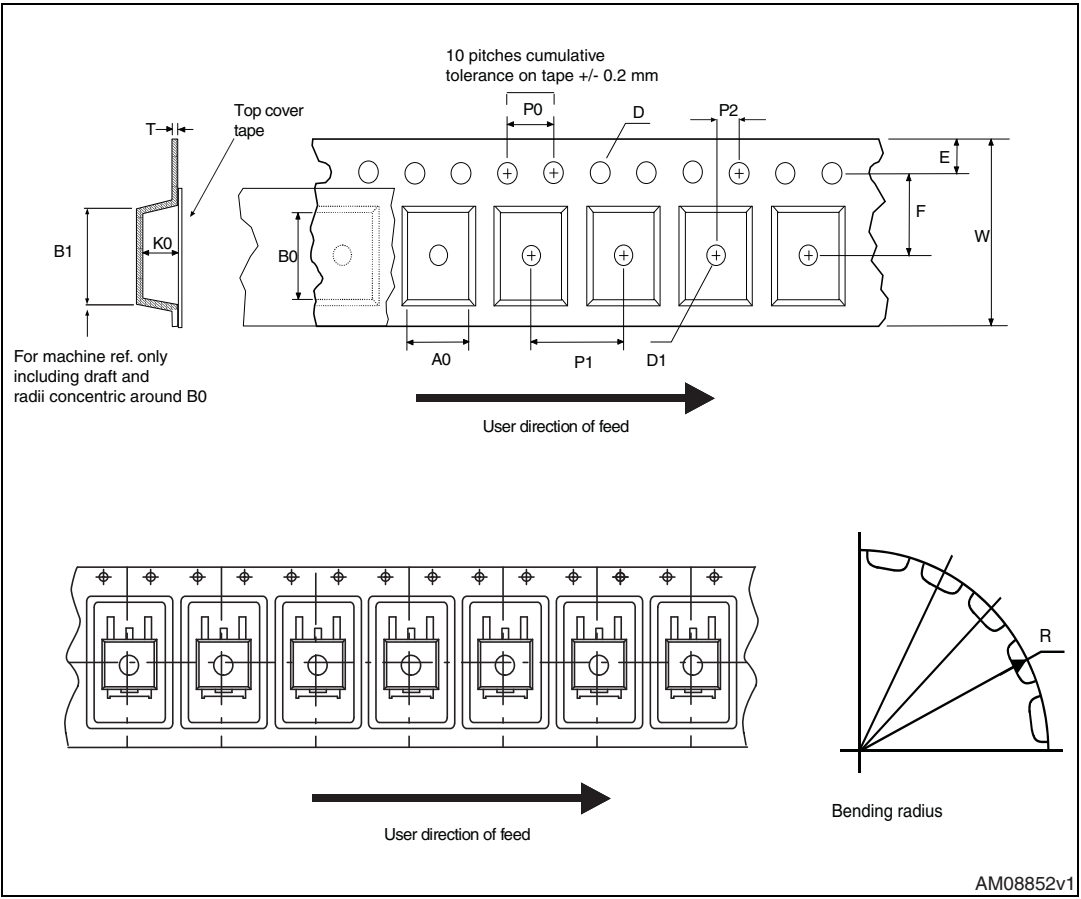
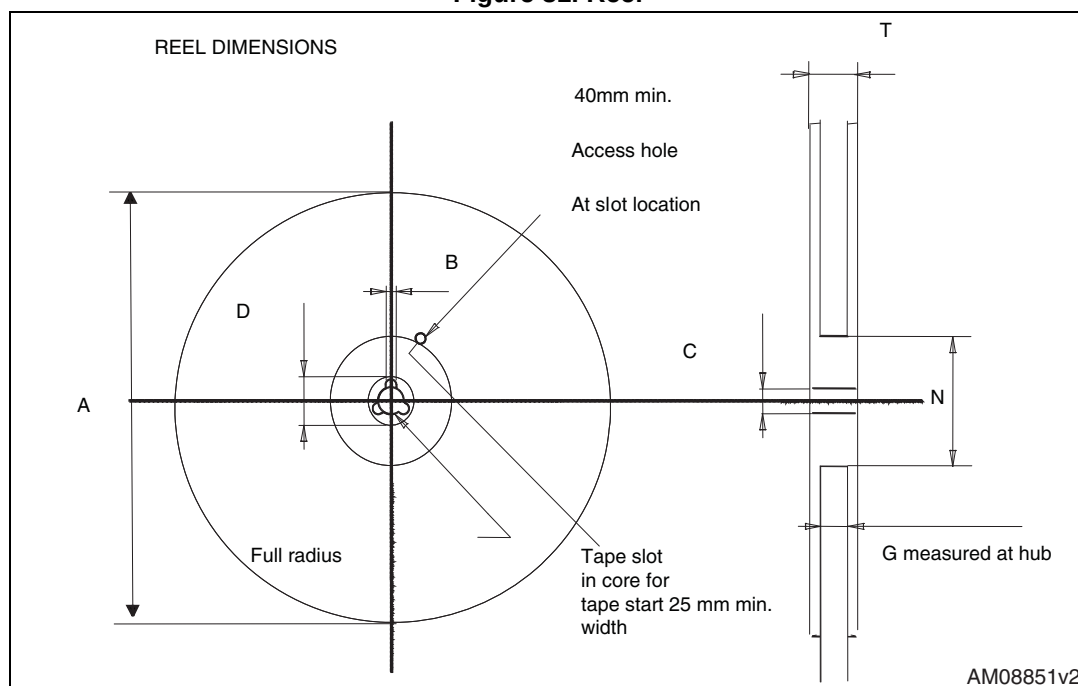


Figure 31. Reel

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 |          |      |      |

## 6 Revision history

**Table 14. Document revision history**

| Date        | Revision | Changes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|-------------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 24-Jun-2013 | 1        | First release.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 07-Oct-2013 | 2        | <ul style="list-style-type: none"><li>– Added: D<sup>2</sup>PAK package</li><li>– Modified: <a href="#">note 4</a> in <a href="#">Table 2</a></li><li>– Added: Thermal resistance junction-pcb max parameter</li><li>– Modified: typical values in <a href="#">Table 5</a>, <a href="#">6</a> and <a href="#">7</a></li><li>– Added: <a href="#">Section 2.1: Electrical characteristics (curves)</a></li><li>– Updated: <a href="#">Section 4: Package mechanical data</a></li><li>– Minor text changes</li></ul> |
| 29-Jan-2014 | 3        | <ul style="list-style-type: none"><li>– Datasheet status promoted from preliminary data to production data</li><li>– Minor text changes</li></ul>                                                                                                                                                                                                                                                                                                                                                                  |

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