



# STB12NK80Z, STF12NK80Z, STP12NK80Z, STW12NK80Z

N-channel 800 V, 0.65Ω typ., 10.5 A Zener-protected SuperMESH™  
Power MOSFET in D<sup>2</sup>PAK, TO-220FP, TO-220 and TO-247

Datasheet — production data

## Features

| Type       | V <sub>DSS</sub><br>(@T <sub>jmax</sub> ) | R <sub>DS(on)</sub> | I <sub>D</sub> | P <sub>W</sub> |
|------------|---|---------------------|----------------|----------------|
| STB12NK80Z | 800V                                      | <0.75Ω              | 10.5 A         | 190W           |
| STF12NK80Z | 800V                                      | <0.75Ω              | 10.5 A         | 40W            |
| STP12NK80Z | 800V                                      | <0.75Ω              | 10.5 A         | 190W           |
| STW12NK80Z | 800V                                      | <0.75Ω              | 10.5 A         | 190W           |

- Extremely high dv/dt capability
- Improved esd capability
- 100% avalanche tested
- Gate charge minimized
- Very low intrinsic capacitances
- Very good manufacturing reliability

## Applications

- Switching applications

## Description

These devices are N-channel Zener-protected Power MOSFETs developed using STMicroelectronics' SuperMESH™ technology, achieved through optimization of ST's well established strip-based PowerMESH™ layout. In addition to a significant reduction in on-resistance, this device is designed to ensure a high level of dv/dt capability for the most demanding applications.

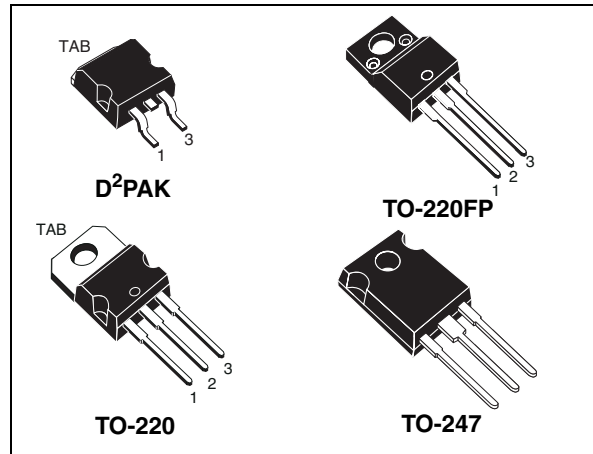


Figure 1. Internal schematic diagram

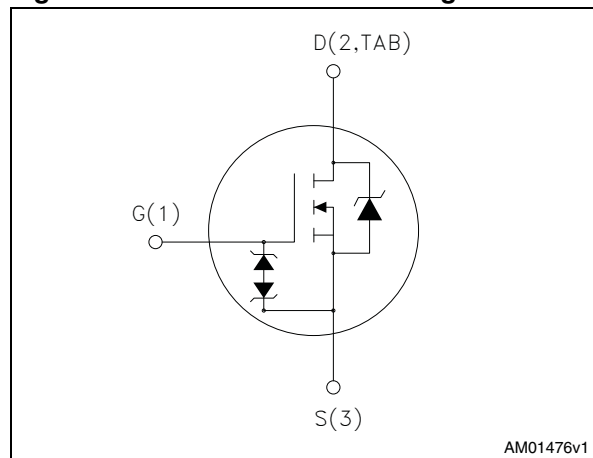


Table 1. Device summary

| Order codes | Marking | Package            | Packaging     |
|-------------|---------|--------------------|---------------|
| STB12NK80Z  | 12NK80Z | D <sup>2</sup> PAK | Tape and reel |
| STF12NK80Z  | 12NK80Z | TO-220FP           | Tube          |
| STP12NK80Z  | 12NK80Z | TO-220             | Tube          |
| STW12NK80Z  | 12NK80Z | TO-247             | Tube          |

## Contents

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol                             | Parameter   | Value                                  |                     | Unit |
|------------------------------------|---|--|---------------------|------|
|                                    |   | D <sup>2</sup> PAK<br>TO-220<br>TO-247 | TO-220FP            |      |
| V <sub>DS</sub>                    | Drain-source voltage (V <sub>GS</sub> = 0)            | 800                                    |                     | V    |
| V <sub>DGR</sub>                   | Drain-gate voltage (R <sub>GS</sub> = 20KΩ)           | 800                                    |                     | V    |
| V <sub>GS</sub>                    | Gate-source voltage                                   | ± 30                                   |                     | V    |
| I <sub>D</sub>                     | Drain current (continuous) at T <sub>C</sub> = 25°C   | 10.5                                   | 10.5 <sup>(1)</sup> | A    |
| I <sub>D</sub>                     | Drain current (continuous) at T <sub>C</sub> =100°C   | 6.6                                    | 6.6 <sup>(1)</sup>  | A    |
| I <sub>DM</sub> <sup>(2)</sup>     | Drain current (pulsed)                                | 42                                     | 42 <sup>(1)</sup>   | A    |
| P <sub>TOT</sub>                   | Total dissipation at T <sub>C</sub> = 25°C            | 190                                    | 40                  | W    |
|                                    | Derating factor                                       | 1.52                                   | 0.32                | W/°C |
| Vesd(G-S)                          | G-S ESD (HBM C= 100pF, R= 1.5kΩ)                      | 4                                      |                     | kV   |
| V <sub>ISO</sub>                   | Insulation withstand voltage (DC)                     | --                                     | 2500                | V    |
| dv/dt <sup>(3)</sup>               | Peak diode recovery voltage slope                     | 4.5                                    |                     | 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> ≤ 10.5 A, di/dt ≤ 200A/μs, V<sub>DD</sub> ≤ V<sub>(BR)DSS</sub>, T<sub>j</sub> ≤ T<sub>JMAX</sub>

**Table 3. Thermal data**

| Symbol                | Parameter                               | Value                         |          |        | Unit |
|-----------------------|---|-------------------------------|----------|--------|------|
|                       |   | TO-220/<br>D <sup>2</sup> PAK | TO-220FP | TO-247 |      |
| R <sub>thj-case</sub> | Thermal resistance junction-case max    | 0.66                          | 3.1      | 0.66   | °C/W |
| R <sub>thj-a</sub>    | Thermal resistance junction-ambient max | 62.5                          |          | 50     | °C/W |

**Table 4. Avalanche characteristics**

| Symbol   | Parameter  | Value | Unit |
|----------|--|-------|------|
| $I_{AS}$ | Avalanche current, repetitive or not-repetitive<br>(pulse width limited by Tj Max) | 10.5  | A    |
| $E_{AS}$ | Single pulse avalanche energy<br>(starting Tj=25°C, Id=Iar, Vdd=50V)               | 400   | mJ   |

## 2 Electrical characteristics

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

**Table 5. On/off states**

| Symbol        | Parameter                                  | Test conditions   | Min. | Typ. | Max.     | Unit               |
|---------------|--|---|------|------|----------|--------------------|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage             | $I_D = 1mA, V_{GS} = 0$                                 | 800  |      |          | V                  |
| $I_{DSS}$     | Peak diode recovery voltage slope          | $V_{DS} = 800V,$<br>$V_{DS} = 800V, T_C = 125^{\circ}C$ |      |      | 1<br>50  | $\mu A$<br>$\mu A$ |
| $I_{GSS}$     | Gate body leakage current ( $V_{GS} = 0$ ) | $V_{GS} = \pm 20V$                                      |      |      | $\pm 10$ | $\mu A$            |
| $V_{GS(th)}$  | Gate threshold voltage                     | $V_{DS} = V_{GS}, I_D = 100\mu A$                       | 3    | 3.75 | 4.5      | V                  |
| $R_{DS(on)}$  | Static drain-source on-resistance          | $V_{GS} = 10V, I_D = 5.25A$                             |      | 0.65 | 0.75     | $\Omega$           |

**Table 6. Dynamic**

| Symbol  | Parameter   | Test conditions  | Min. | Typ.                 | Max. | Unit                 |
|---|---|--|------|----------------------|------|----------------------|
| $g_{fs}^{(1)}$                                | Forward transconductance  | $V_{DS} = 15V, I_D = 5.25A$  | -    | 12                   | -    | S                    |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$           | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25V, f = 1MHz, V_{GS} = 0$   | -    | 2620<br>250<br>53    | -    | pF<br>pF<br>pF       |
| $C_{osseq}^{(2)}$                             | Equivalent output capacitance   | $V_{GS} = 0, V_{DS} = 0V \text{ to } 640V$   | -    | 100                  | -    | pF                   |
| $Q_g$<br>$Q_{gs}$<br>$Q_{gd}$                 | Total gate charge<br>Gate-source charge<br>Gate-drain charge            | $V_{DD} = 640V, I_D = 10.5A$<br>$V_{GS} = 10V$<br>(see <a href="#">Figure 21</a> )                   | -    | 87<br>14<br>44       | -    | nC<br>nC<br>nC       |
| $t_{d(on)}$<br>$t_r$<br>$t_{d(off)}$<br>$t_f$ | Turn-on delay time<br>Rise time<br>Off-voltage rise time<br>Fall time   | $V_{DD} = 400V, I_D = 5.25A,$<br>$R_G = 4.7\Omega, V_{GS} = 10V$<br>(see <a href="#">Figure 22</a> ) | -    | 30<br>18<br>70<br>20 | -    | ns<br>ns<br>ns<br>ns |
| $t_{r(Voff)}$<br>$t_f$<br>$t_c$               | Off voltage rise time<br>Fall time<br>Cross-over time                   | $V_{DD} = 640V, I_D = 10.5A,$<br>$R_G = 4.7\Omega, V_{GS} = 10V$<br>(see <a href="#">Figure 22</a> ) | -    | 16<br>15<br>28       | -    | ns<br>ns<br>ns       |

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

2.  $C_{osseq}$  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. Source drain diode**

| Symbol          | Parameter                     | Test conditions  | Min. | Typ. | Max. | Unit    |
|-----------------|-------------------------------|--|------|------|------|---------|
| $I_{SD}$        | Source-drain current          |  | -    |      | 10.5 | A       |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |  | -    |      | 42   | A       |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD}=10.5A, V_{GS}=0$   | -    |      | 1.6  | V       |
| $t_{rr}$        | Reverse recovery time         | $I_{SD}=10.5A,$<br>$di/dt = 100A/\mu s,$<br>$V_{DD}=100V, T_j=150^\circ C$ | -    | 635  |      | ns      |
| $Q_{rr}$        | Reverse recovery charge       |  |      | 5.9  |      | $\mu C$ |
| $I_{RRM}$       | Reverse recovery current      |  |      | 18.5 |      | A       |

1. Pulse width limited by safe operating area.

2. Pulsed: pulse duration=300 $\mu s$ , duty cycle 1.5%

**Table 8. Gate-source zener diode**

| Symbol     | Parameter                     | Test conditions                  | Min | Typ. | Max. | Unit |
|------------|-------------------------------|----------------------------------|-----|------|------|------|
| $BV_{GSO}$ | Gate-Source breakdown voltage | $I_{gs}=\pm 1mA$<br>(Open drain) | 30  | -    | -    | V    |

The built-in back-to-back Zener diodes have specifically been designed to enhance not only the device's ESD capability, but also to make them safely absorb possible voltage transients that may occasionally be applied from gate to source. In this respect the Zener voltage is appropriate to achieve an efficient and cost-effective intervention to protect the device's integrity. These integrated Zener diodes thus avoid the usage of external components.

## 2.1 Electrical characteristics (curves)

Figure 2. Safe operating area for TO-220 and D<sup>2</sup>PAK

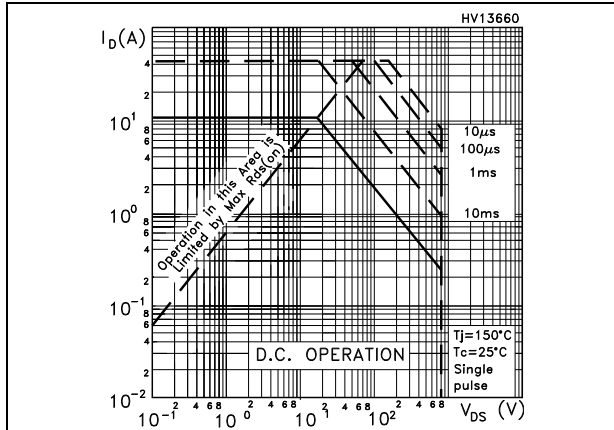


Figure 3. Thermal impedance for TO-220 and D<sup>2</sup>PAK

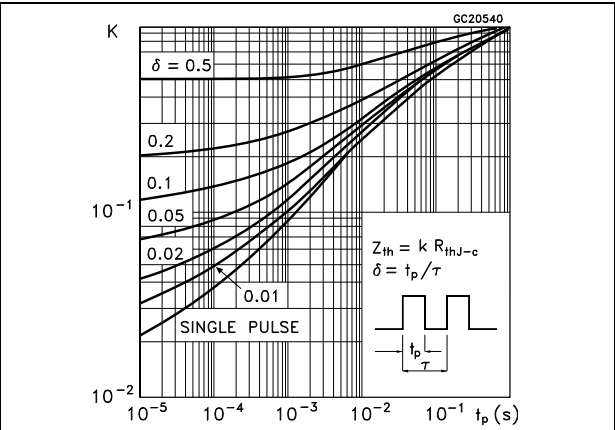


Figure 4. Safe operating area for TO-220FP

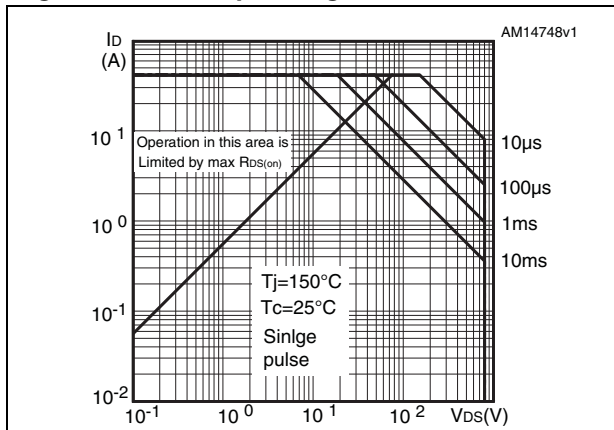


Figure 5. Thermal impedance for TO-220FP

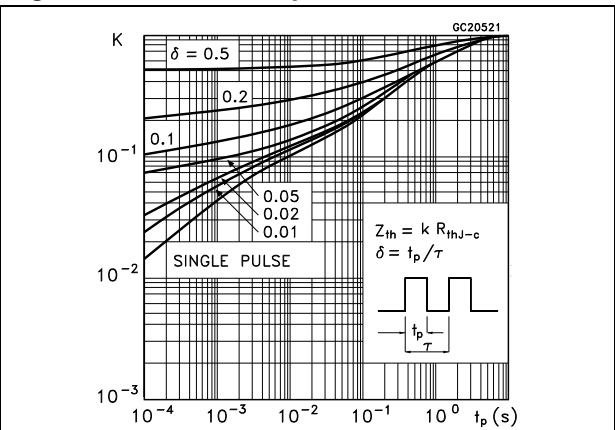


Figure 6. Safe operating area for TO-247

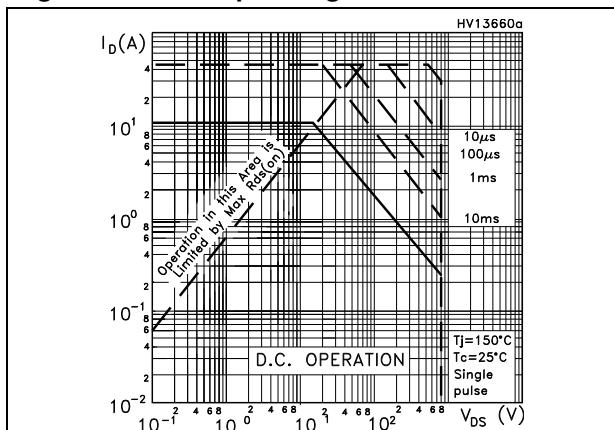


Figure 7. Thermal impedance for TO-247

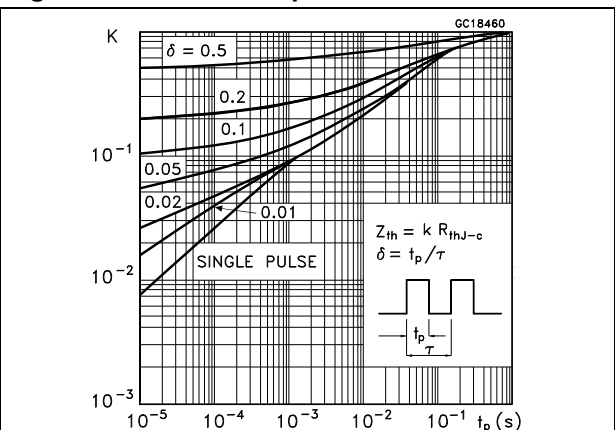


Figure 8. Output characteristics

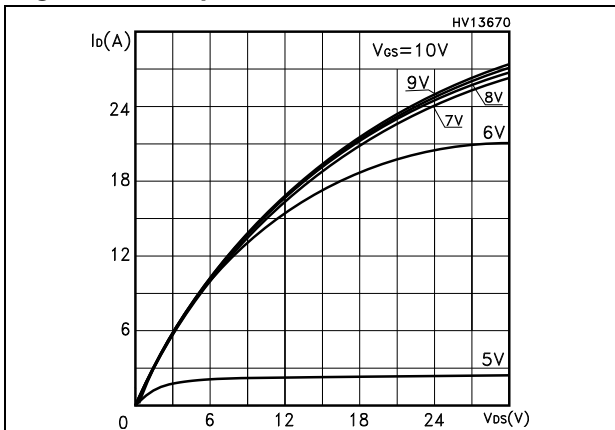


Figure 9. Transfer characteristics

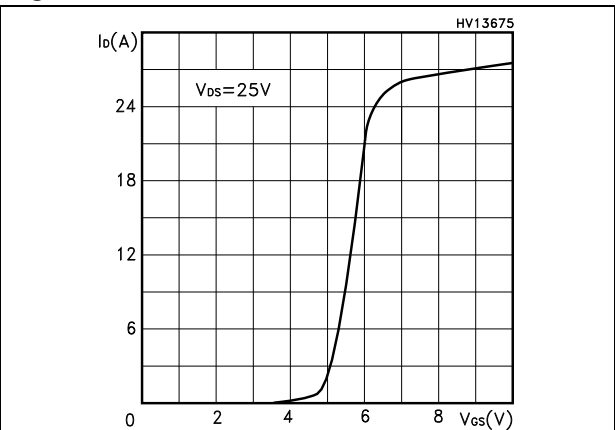


Figure 10. Transconductance

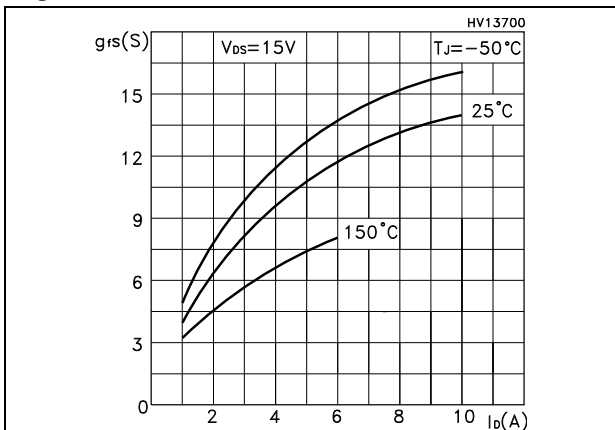


Figure 11. Static drain-source on-resistance

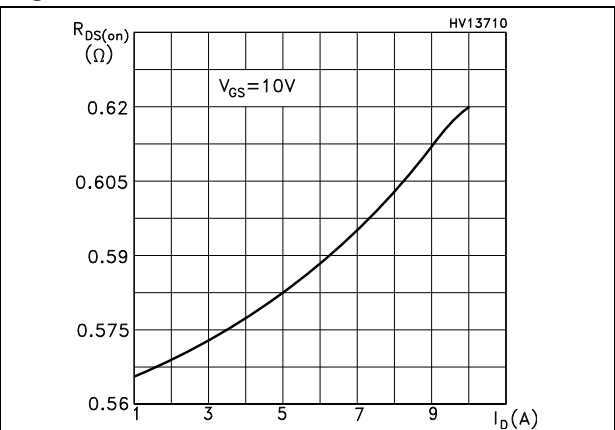


Figure 12. Gate charge vs gate-source voltage

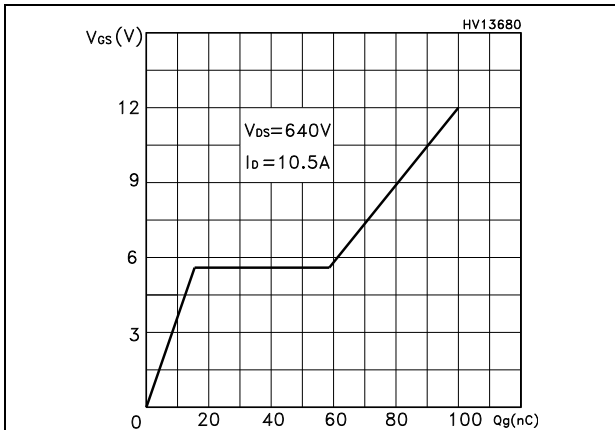


Figure 13. Capacitance variations

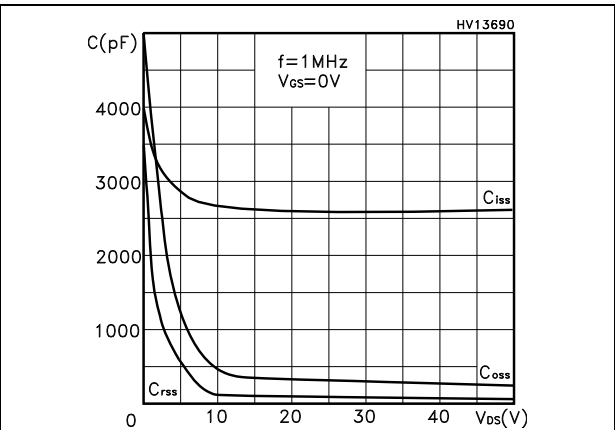




Figure 14. Normalized gate threshold voltage vs temperature

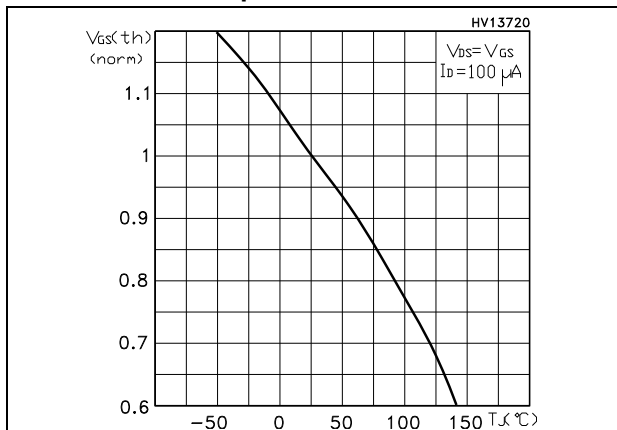


Figure 15. Normalized on-resistance vs temperature

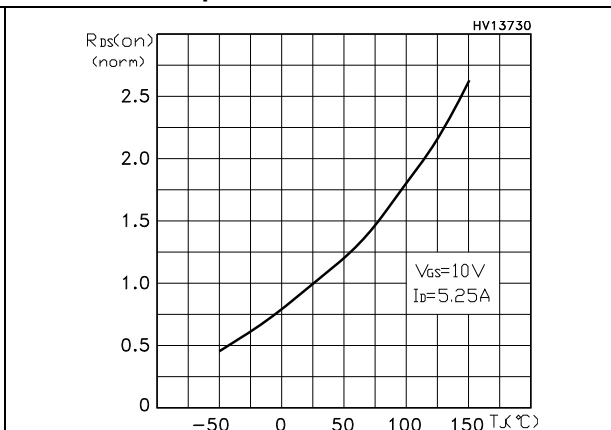


Figure 16. Source-drain diode forward characteristics

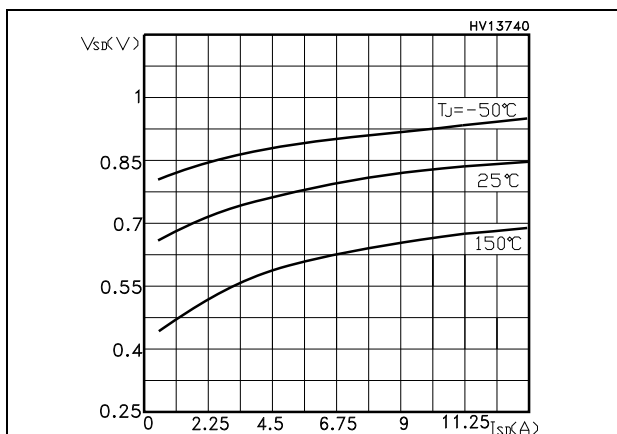


Figure 17. Normalized B<sub>V</sub>DSS vs temperature

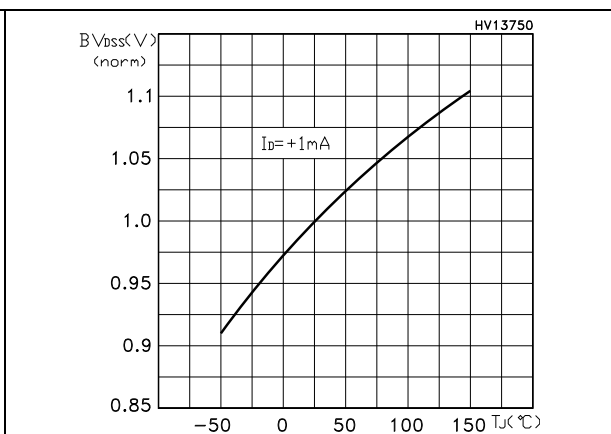
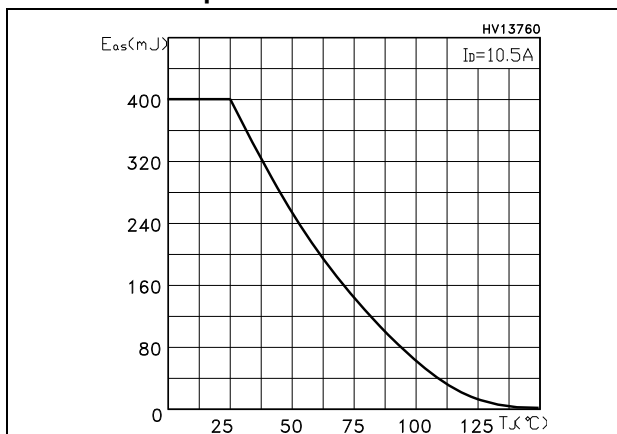


Figure 18. Maximum avalanche energy vs temperature



### 3 Test circuits

Figure 19. Switching times test circuit for resistive load

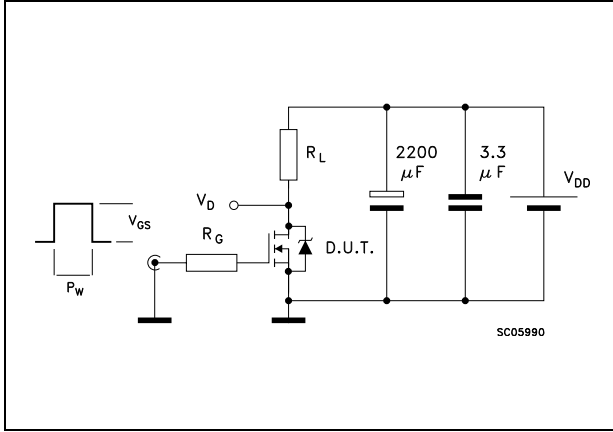


Figure 20. Gate charge test circuit

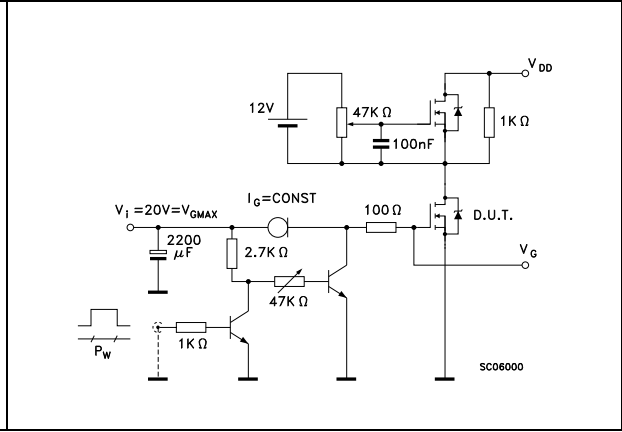


Figure 21. Test circuit for inductive load switching and diode recovery times

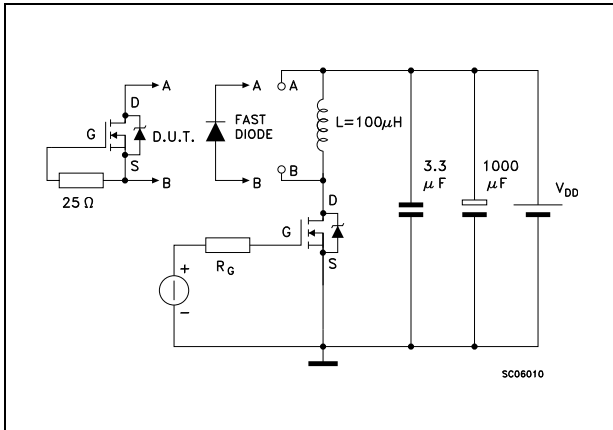


Figure 22. Unclamped Inductive load test circuit

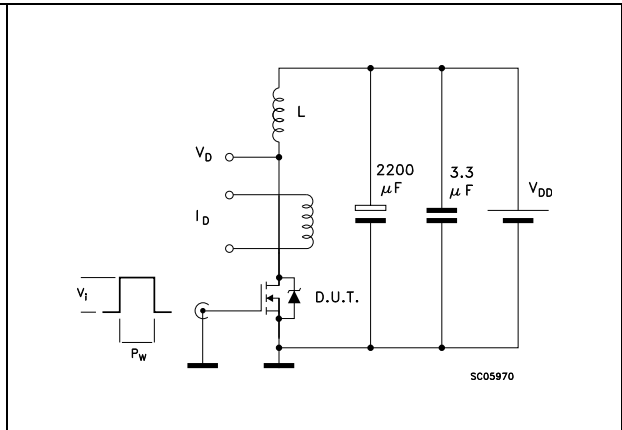
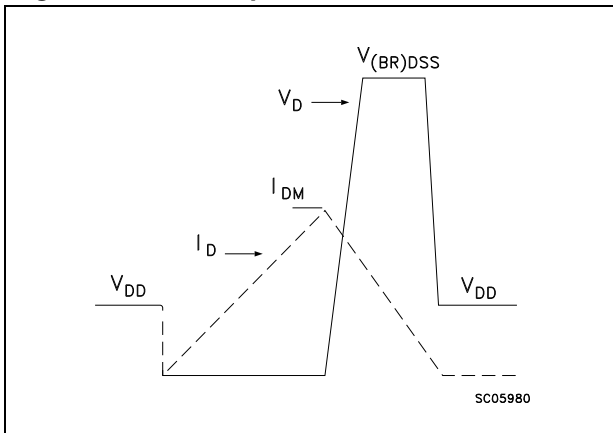


Figure 23. Unclamped inductive waveform



## 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. 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) drawing

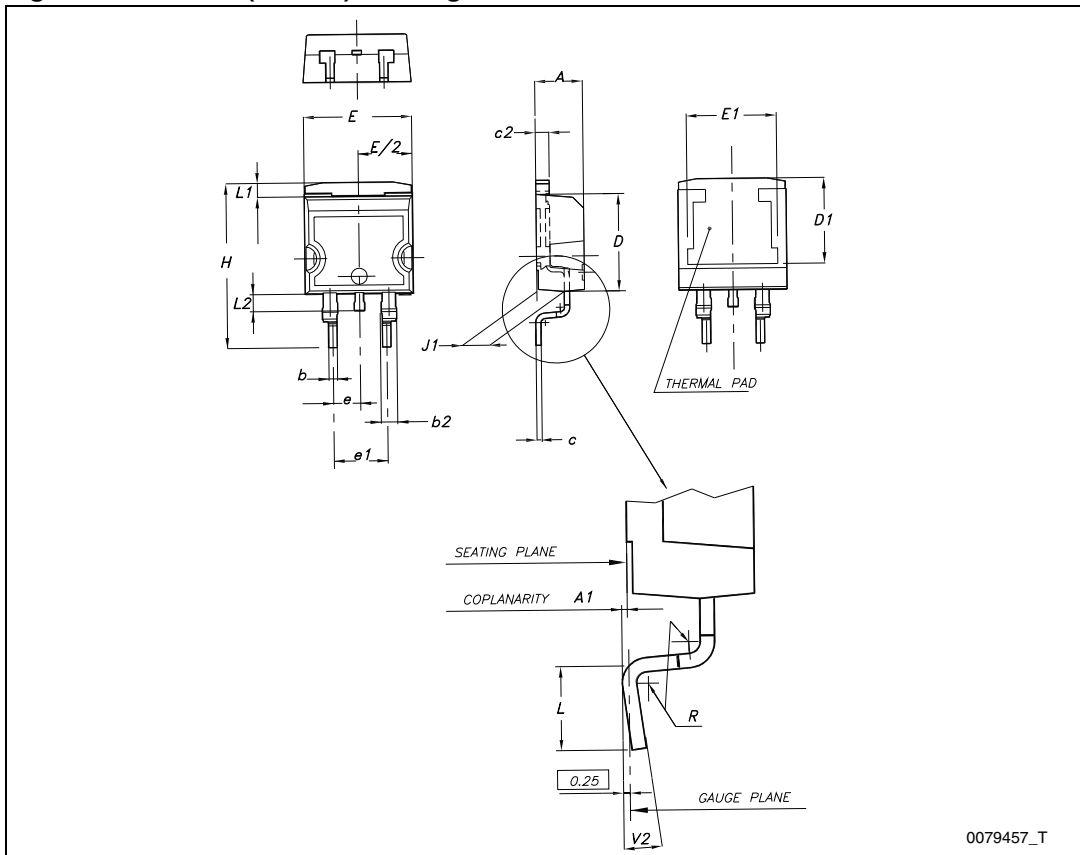
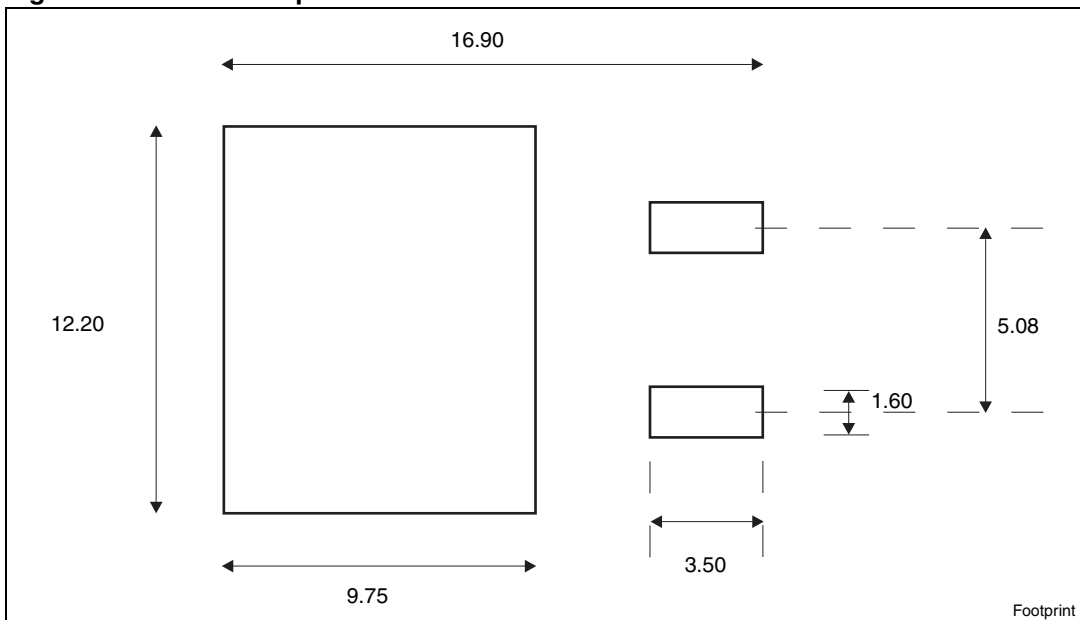


Figure 25. D<sup>2</sup>PAK footprint<sup>(a)</sup>

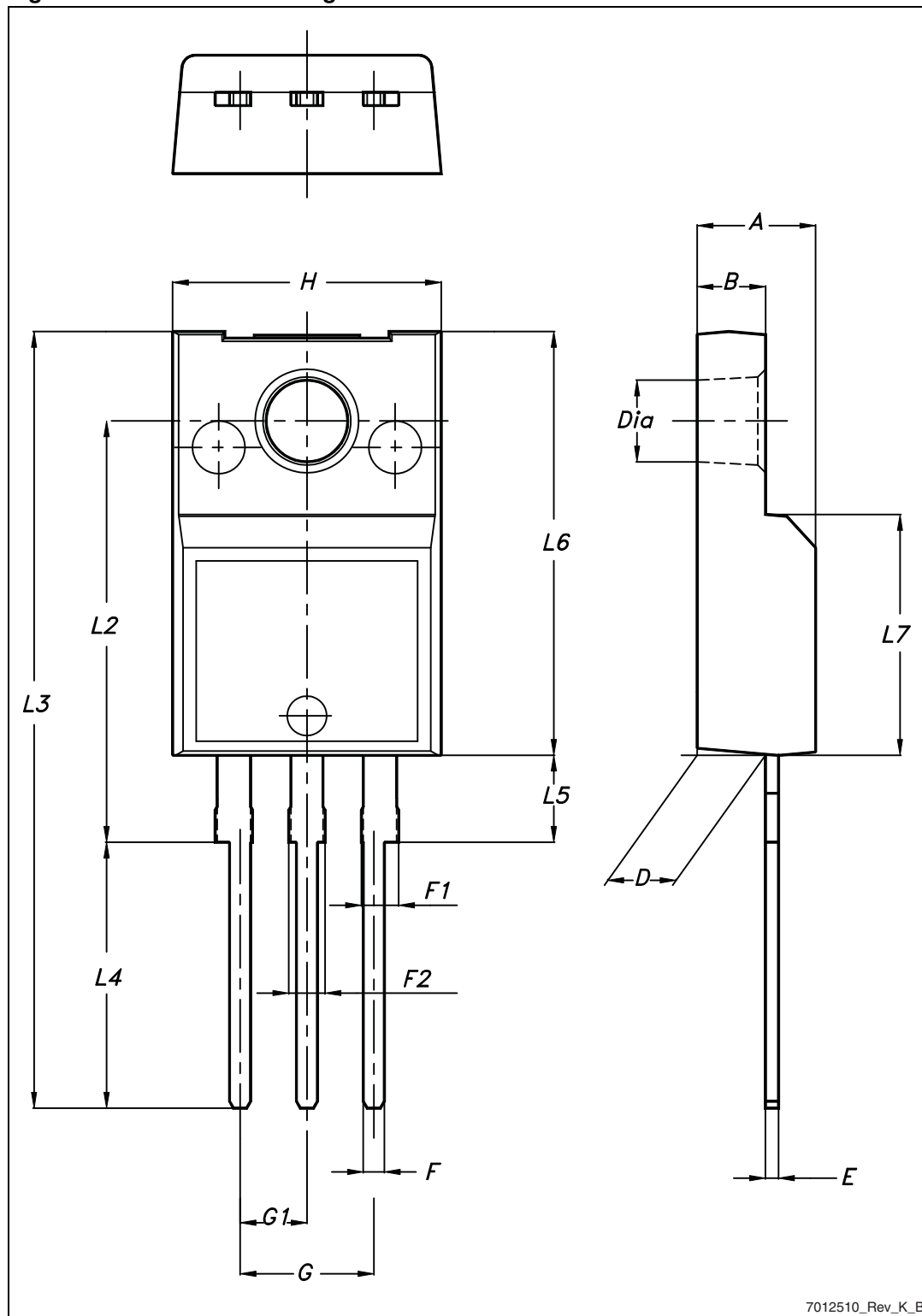


a. All dimension are in millimeters

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 26. TO-220FP drawing

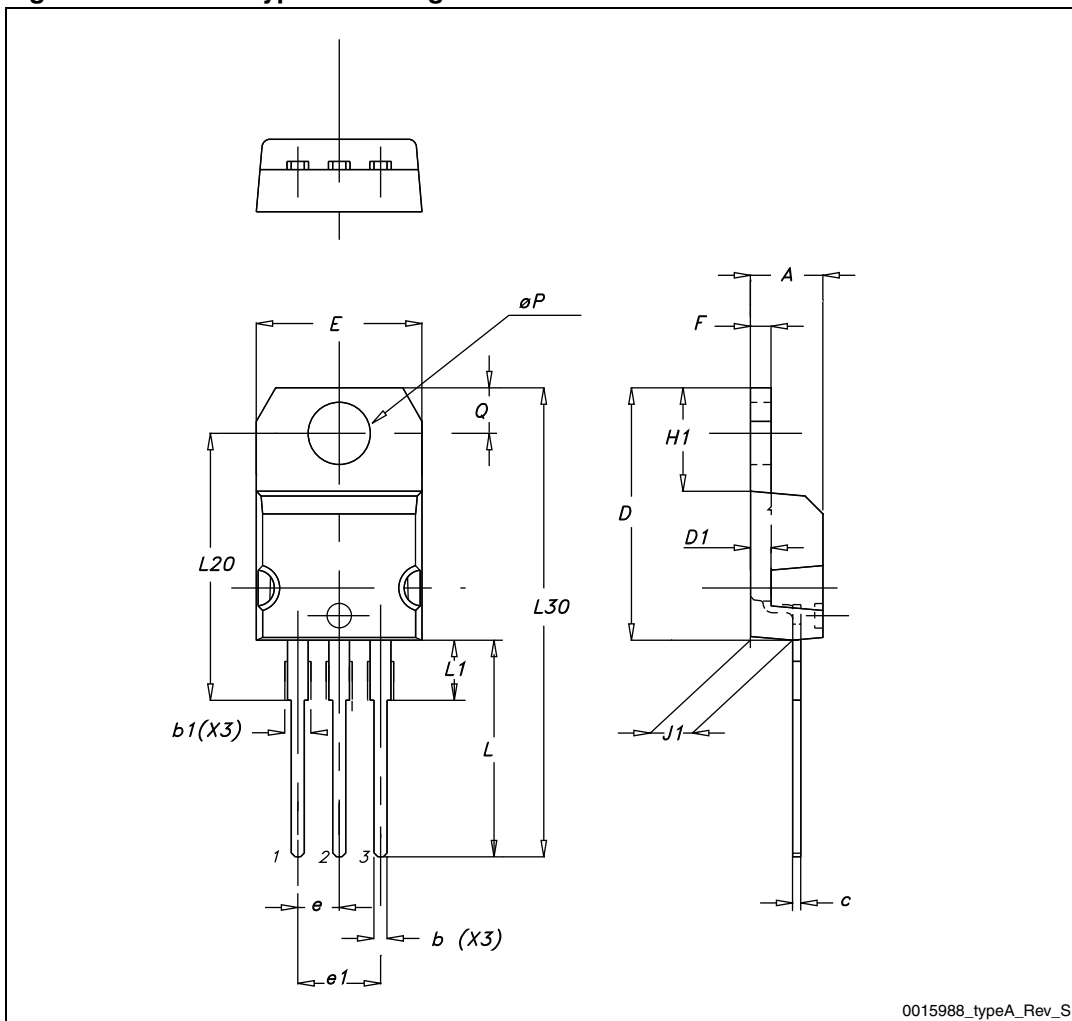


7012510\_Rev\_K\_B

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 27. TO-220 type A drawing



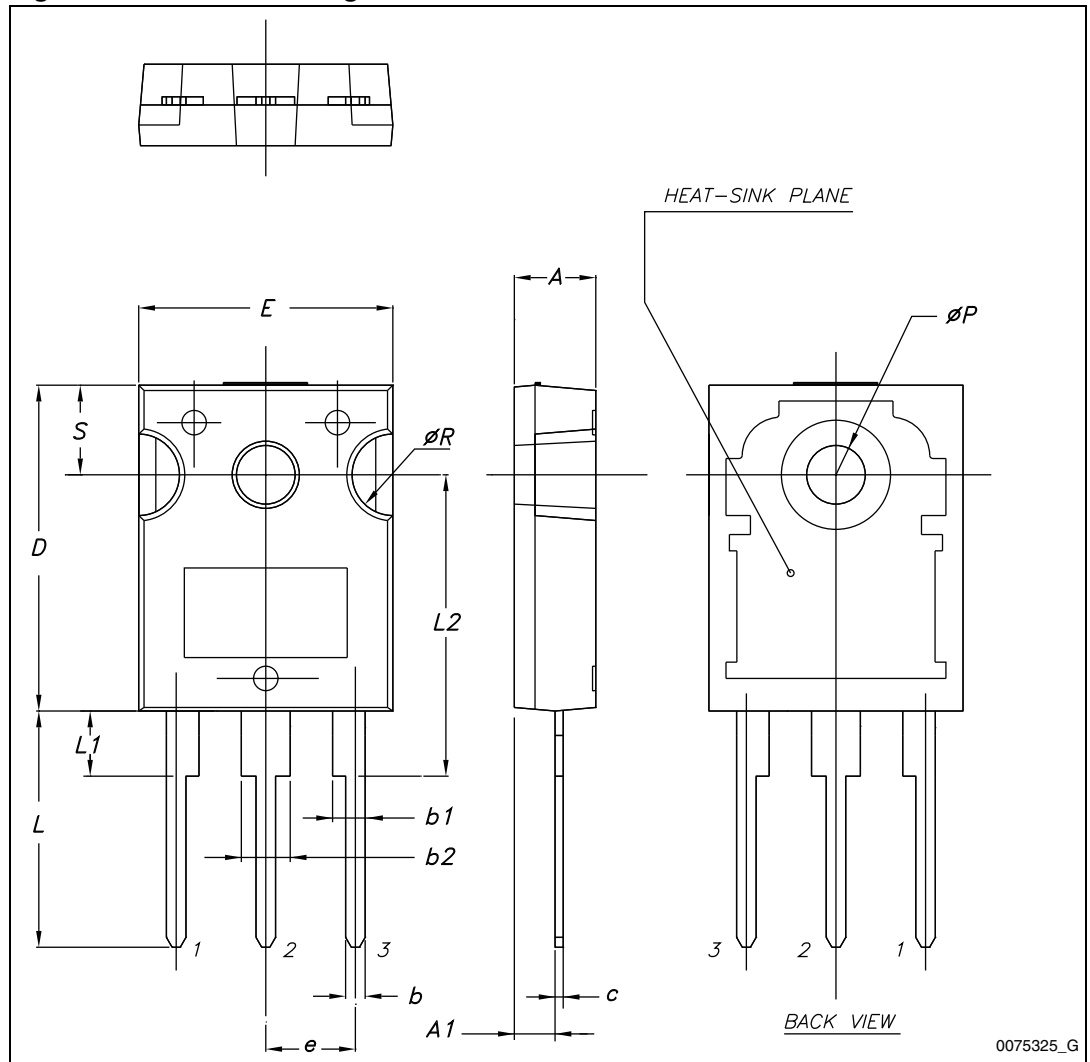
0015988\_typeA\_Rev\_S



Table 12. TO-247 mechanical data

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

Figure 28. TO-247 drawing

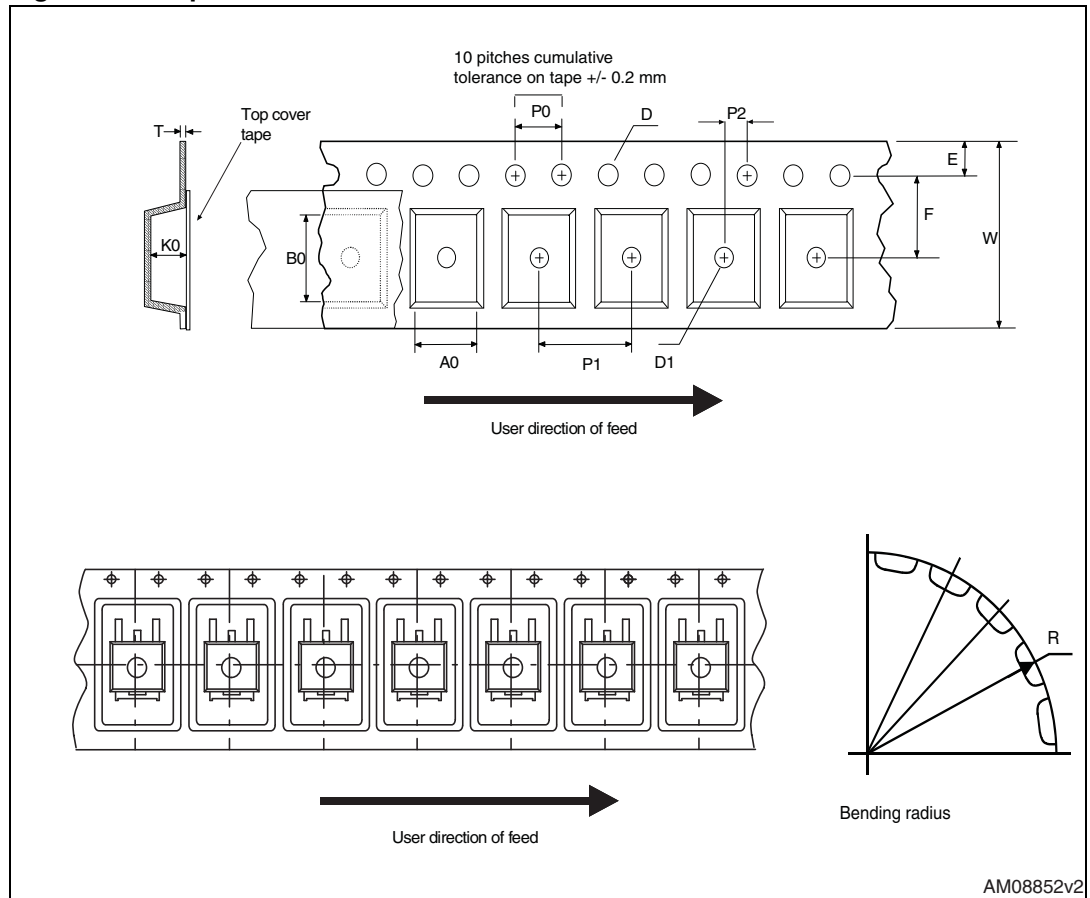


## 5 Packaging mechanical data

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

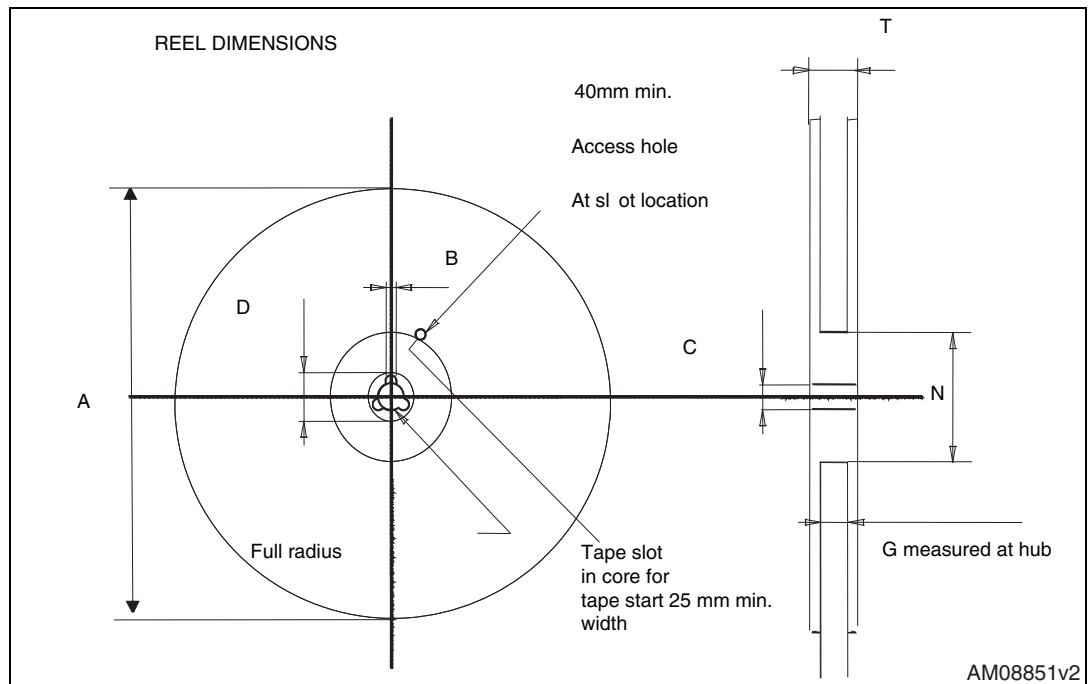
| Tape |      |      | Reel     |      |      |
|------|------|------|----------|------|------|
| Dim. | mm   |      | Dim.     | mm   |      |
|      | Min. | Max. |          | Min. | Max. |
| A0   | 10.5 | 10.7 | A        |      | 330  |
| B0   | 15.7 | 15.9 | B        | 1.5  |      |
| D    | 1.5  | 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



AM08852v2

Reel



AM08851v2

## 6 Revision history

**Table 14. Document revision history**

| Date        | Revision | Changes   |
|-------------|----------|---|
| 22-Jun-2004 | 2        | Preliminary version.  |
| 28-Jan-2005 | 3        | Complete version.   |
| 08-Sep-2005 | 4        | <a href="#">Figure 2</a> and <a href="#">Figure 6</a> changed.  |
| 31-Jul-2006 | 5        | The document has been reformatted.  |
| 27-Apr-2007 | 6        | Modified $R_{DS(on)}$ value on <a href="#">Table 5</a> .  |
| 28-Aug-2012 | 7        | <p>Inserted new device in TO-220FP.</p> <p>Updated <a href="#">Table 1: Device summary</a>, <a href="#">Table 2: Absolute maximum ratings</a> and <a href="#">Table 3: Thermal data</a>.</p> <p>Updated <a href="#">Section 4: Package mechanical data</a> and <a href="#">Section 5: Packaging mechanical data</a>.</p> <p>Minor text changes in the cover page.</p> |

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