



# STB6NK60Z - STB6NK60Z-1 STP6NK60ZFP - STP6NK60Z

N-channel 600 V - 1  $\Omega$  - 6 A - TO-220/TO-220FP/D<sup>2</sup>PAK/I<sup>2</sup>PAK  
Zener-Protected SuperMESH™ Power MOSFET

## Features

| Type        | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> | P <sub>W</sub> |
|-------------|------------------|---------------------|----------------|----------------|
| STB6NK60Z   | 600 V            | < 1.2 $\Omega$      | 6 A            | 110 W          |
| STB6NK60Z-1 | 600 V            | < 1.2 $\Omega$      | 6 A            | 110 W          |
| STP6NK60ZFP | 600 V            | < 1.2 $\Omega$      | 6 A            | 30 W           |
| STP6NK60Z   | 600 V            | < 1.2 $\Omega$      | 6 A            | 110 W          |

- Extremely high dv/dt capability
- 100% avalanche tested
- Gate charge minimized

## Application

- Switching applications

## Description

The SuperMESH™ series is obtained through an extreme optimization of ST's well established strip-based PowerMESH™ layout. In addition to pushing on-resistance significantly down, special care is taken to ensure a very good dv/dt capability for the most demanding applications.

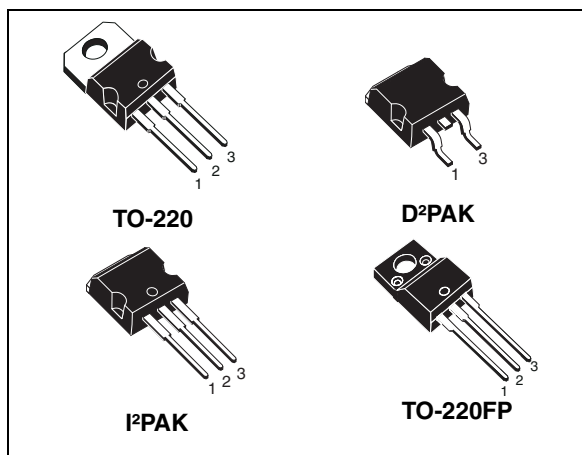


Figure 1. Internal schematic diagram

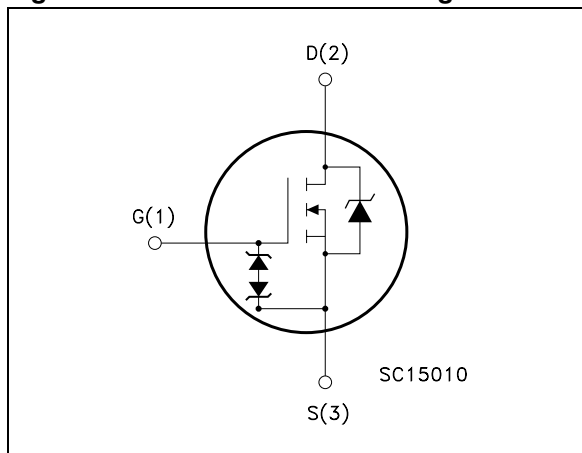


Table 1. Device summary

| Order codes | Marking   | Package            | Packaging   |
|-------------|-----------|--------------------|-------------|
| STB6NK60Z   | B6NK60Z   | D <sup>2</sup> PAK | Tape & reel |
| STB6NK60Z-1 | B6NK60Z   | I <sup>2</sup> PAK | Tube        |
| STP6NK60ZFP | P6NK60ZFP | TO-220FP           | Tube        |
| STP6NK60Z   | P6NK60Z   | TO-220             | Tube        |

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol             | Parameter                                                         | Value                                     |                    | Unit                  |
|--------------------|-------------------------------------------------------------------|-------------------------------------------|--------------------|-----------------------|
|                    |                                                                   | TO-220/D <sup>2</sup> /I <sup>2</sup> PAK | TO-220FP           |                       |
| $V_{DS}$           | Drain-source voltage ( $V_{GS} = 0$ )                             | 600                                       |                    | V                     |
| $V_{GS}$           | Gate-source voltage                                               | $\pm 30$                                  |                    | V                     |
| $I_D$              | Drain current (continuous) at $T_C = 25\text{ }^{\circ}\text{C}$  | 6                                         | 6 <sup>(1)</sup>   | A                     |
| $I_D$              | Drain current (continuous) at $T_C = 100\text{ }^{\circ}\text{C}$ | 3.8                                       | 3.8 <sup>(1)</sup> | A                     |
| $I_{DM}^{(2)}$     | Drain current (pulsed)                                            | 24                                        | 24 <sup>(1)</sup>  | A                     |
| $P_{TOT}$          | Total dissipation at $T_C = 25\text{ }^{\circ}\text{C}$           | 110                                       | 30                 | W                     |
|                    | Derating factor                                                   | 0.88                                      | 0.24               | W/ $^{\circ}\text{C}$ |
| $V_{ESD(G-S)}$     | G-S ESD (HBM $C=100\text{ pF}$ , $R=1.5\text{ k}\Omega$ )         | 3500                                      |                    | V                     |
| $dv/dt^{(3)}$      | Peak diode recovery voltage slope                                 | 4.5                                       |                    | V/ns                  |
| $V_{ISO}$          | Insulation withstand voltage (DC)                                 | --                                        | 2500               | V                     |
| $T_j$<br>$T_{stg}$ | Operating junction temperature<br>Storage temperature             | -55 to 150                                |                    | $^{\circ}\text{C}$    |

1. Limited only by maximum temperature allowed
2. Pulse width limited by safe operating area
3.  $I_{SD} \leq 6\text{ A}$ ,  $di/dt \leq 200\text{ A}/\mu\text{s}$ ,  $V_{DD} = 80\% V_{(BR)DSS}$

**Table 3. Thermal data**

| Symbol         | Parameter                                      | Value                                     |          | Unit                        |
|----------------|------------------------------------------------|-------------------------------------------|----------|-----------------------------|
|                |                                                | TO-220/D <sup>2</sup> /I <sup>2</sup> PAK | TO-220FP |                             |
| $R_{thj-case}$ | Thermal resistance junction-case max           | 1.14                                      | 4.2      | $^{\circ}\text{C}/\text{W}$ |
| $R_{thj-amb}$  | Thermal resistance junction-amb max            | 62.5                                      |          | $^{\circ}\text{C}/\text{W}$ |
| $T_l$          | Maximum lead temperature for soldering purpose | 300                                       |          | $^{\circ}\text{C}$          |

**Table 4. Avalanche characteristics**

| Symbol   | Parameter                                                                                                              | Value | Unit |
|----------|------------------------------------------------------------------------------------------------------------------------|-------|------|
| $I_{AR}$ | Avalanche current, repetitive or not-repetitive (pulse width limited by $T_j$ max)                                     | 6     | A    |
| $E_{AS}$ | Single pulse avalanche energy (starting $T_j = 25\text{ }^{\circ}\text{C}$ , $I_D = I_{AR}$ , $V_{DD} = 50\text{ V}$ ) | 210   | mJ   |

## 2 Electrical characteristics

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

**Table 5. On/off states**

| Symbol        | Parameter                                        | Test conditions                                                                            | Min. | Typ. | Max.     | Unit                           |
|---------------|--------------------------------------------------|--------------------------------------------------------------------------------------------|------|------|----------|--------------------------------|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage                   | $I_D = 1\text{ mA}$ , $V_{GS} = 0$                                                         | 600  |      |          | V                              |
| $I_{DSS}$     | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max rating}$<br>$V_{DS} = \text{Max rating}$ , $T_C = 125^{\circ}\text{C}$ |      |      | 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    | 3.75 | 4.5      | V                              |
| $R_{DS(on)}$  | Static drain-source on resistance                | $V_{GS} = 10\text{ V}$ , $I_D = 3\text{ A}$                                                |      | 1    | 1.2      | $\Omega$                       |

**Table 6. Dynamic**

| Symbol                              | Parameter                                                               | Test conditions                                                                             | Min. | Typ.             | Max. | Unit           |
|-------------------------------------|-------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|------|------------------|------|----------------|
| $g_{fs}^{(1)}$                      | Forward transconductance                                                | $V_{DS} = 8\text{ V}$ , $I_D = 3\text{ A}$                                                  |      | 5                |      | S              |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25\text{ V}$ , $f = 1\text{ MHz}$ ,<br>$V_{GS} = 0$                               |      | 905<br>115<br>25 |      | pF<br>pF<br>pF |
| $C_{oss\text{ eq}}^{(2)}$           | Equivalent output capacitance                                           | $V_{GS} = 0$ , $V_{DS} = 0\text{ to }480\text{ V}$                                          |      | 56               |      | pF             |
| $Q_g$<br>$Q_{gs}$<br>$Q_{gd}$       | Total gate charge<br>Gate-source charge<br>Gate-drain charge            | $V_{DD} = 480\text{ V}$ , $I_D = 6\text{ A}$ ,<br>$V_{GS} = 10\text{ V}$<br>(see Figure 18) |      | 33<br>6<br>17    | 46   | nC<br>nC<br>nC |

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

2.  $C_{oss\text{ eq}}$  is defined as a constant equivalent capacitance giving the same charging time as  $C_{oss}$  when  $V_{DS}$  increases from 0 to 80%  $V_{DSS}$

**Table 7. Switching times**

| Symbol       | Parameter           | Test conditions                                                                                               | Min. | Typ. | Max. | Unit |
|--------------|---------------------|---------------------------------------------------------------------------------------------------------------|------|------|------|------|
| $t_{d(on)}$  | Turn-on delay time  | $V_{DD} = 300\text{ V}$ , $I_D = 3\text{ A}$<br>$R_G = 4.7\ \Omega$ $V_{GS} = 10\text{ V}$<br>(see Figure 17) |      | 14   |      | ns   |
| $t_r$        | Rise time           |                                                                                                               |      | 14   |      | ns   |
| $t_{d(off)}$ | Turn-off delay time |                                                                                                               |      | 47   |      | ns   |
| $t_f$        | Fall time           |                                                                                                               |      | 19   |      | ns   |

**Table 8. Source drain diode**

| Symbol          | Parameter                     | Test conditions                                                                                                                             | Min | Typ. | Max | Unit          |
|-----------------|-------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|-----|------|-----|---------------|
| $I_{SD}$        | Source-drain current          |                                                                                                                                             |     |      | 6   | A             |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |                                                                                                                                             |     |      | 24  | A             |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD} = 6\text{ A}$ , $V_{GS} = 0$                                                                                                        |     |      | 1.6 | V             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 6\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$<br>$V_{DD} = 50\text{ V}$ , $T_j = 150\text{ }^\circ\text{C}$<br>(see Figure 19) |     | 445  |     | ns            |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                             |     | 2.7  |     | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                             |     | 12   |     | A             |

1. Pulse width limited by safe operating area

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

**Table 9. Gate-source zener diode**

| Symbol           | Parameter                     | Test conditions                     | Min. | Typ. | Max. | Unit |
|------------------|-------------------------------|-------------------------------------|------|------|------|------|
| $BV_{GSO}^{(1)}$ | Gate-source breakdown voltage | Eggs $\pm 1\text{ mA}$ (open drain) | 30   |      |      | V    |

1. 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/  
I<sup>2</sup>PAK/ D<sup>2</sup>PAK

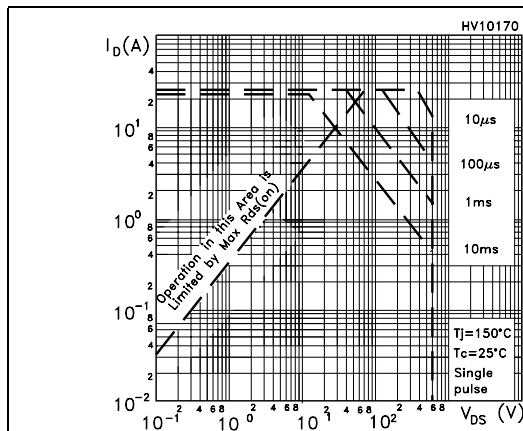


Figure 3. Thermal impedance for TO-220/  
I<sup>2</sup>PAK/ D<sup>2</sup>PAK

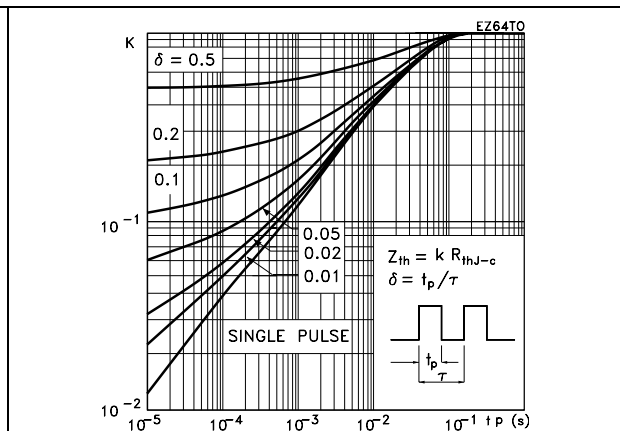


Figure 4. Safe operating area for TO-220FP

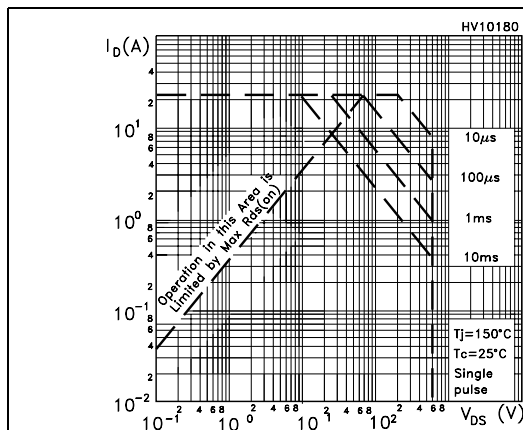


Figure 5. Thermal impedance for TO-220FP

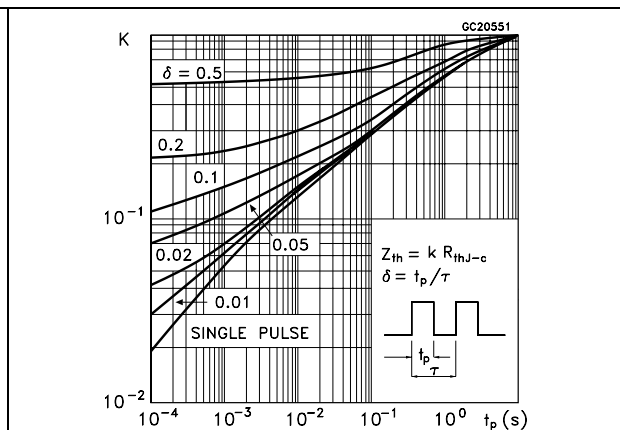


Figure 6. Output characteristics

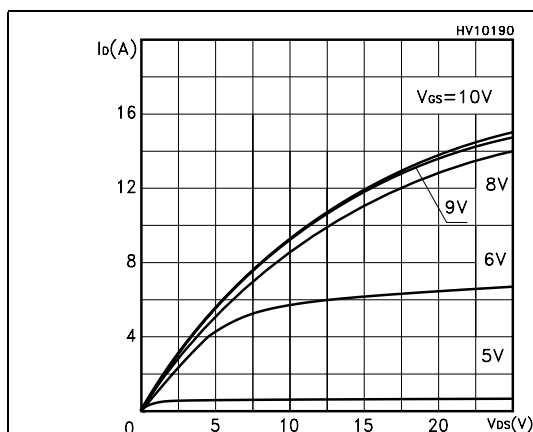


Figure 7. Transfer characteristics

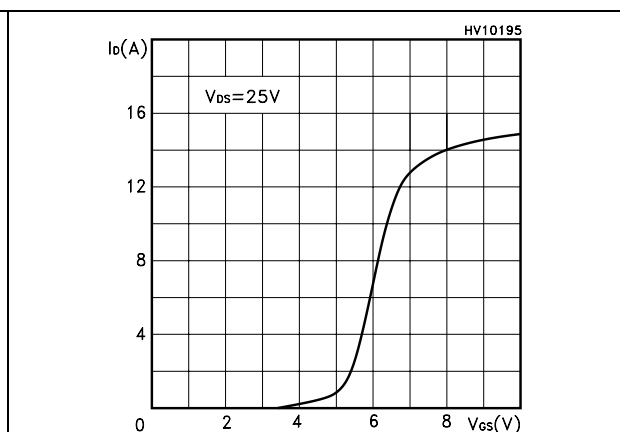


Figure 8. Transconductance

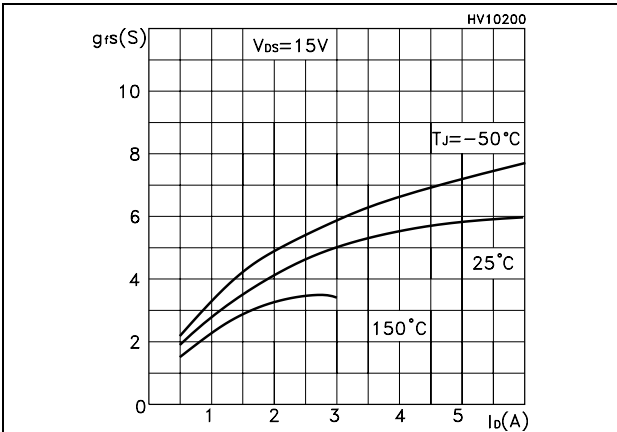


Figure 9. Static drain-source on resistance

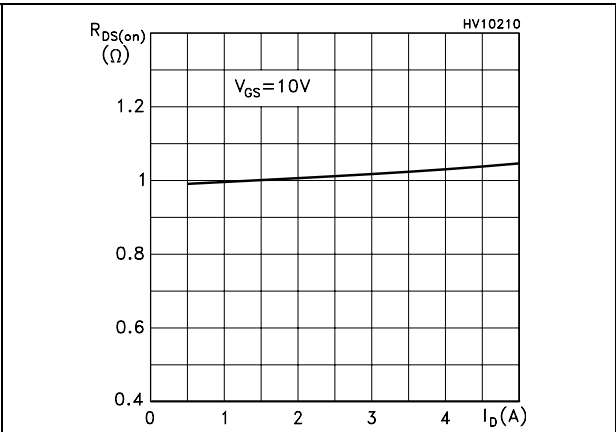


Figure 10. Gate charge vs gate-source voltage

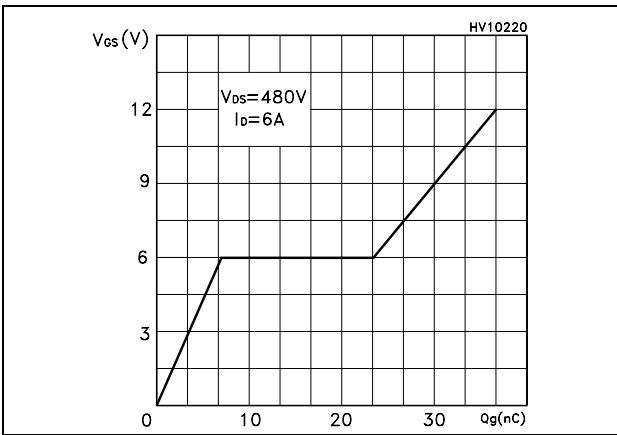


Figure 11. Capacitance variations

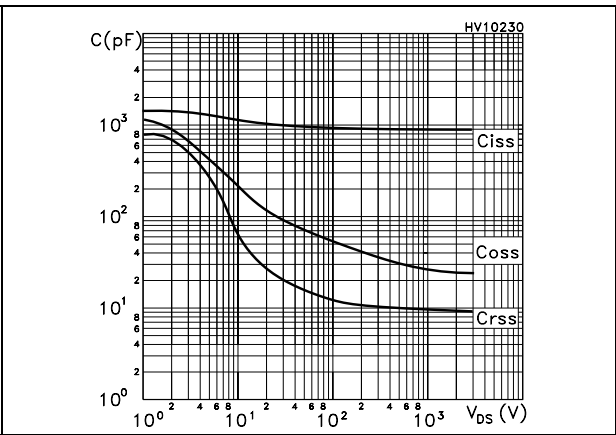


Figure 12. Normalized gate threshold voltage vs temperature

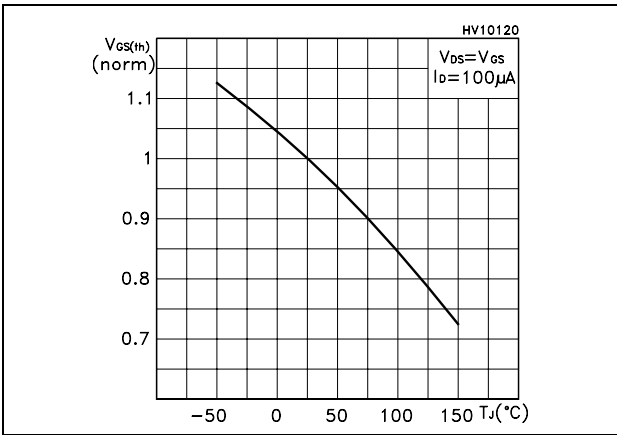


Figure 13. Normalized on resistance vs temperature

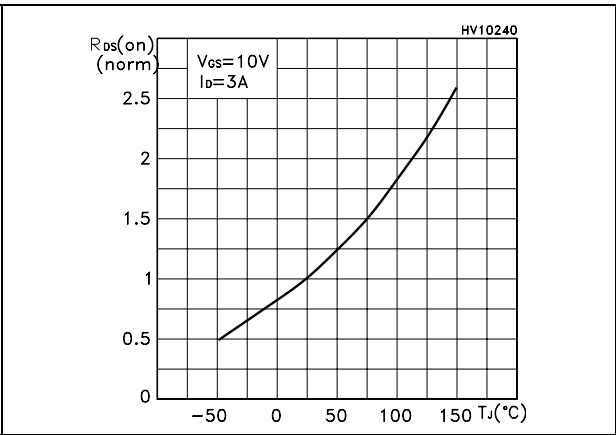


Figure 14. Source-drain diode forward characteristics

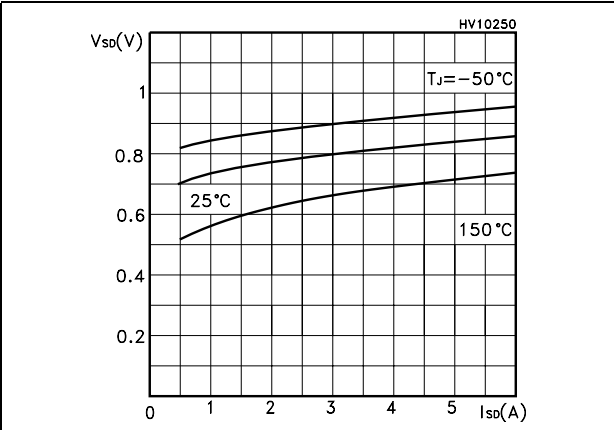


Figure 15. Normalized  $B_{VDSS}$  vs temperature

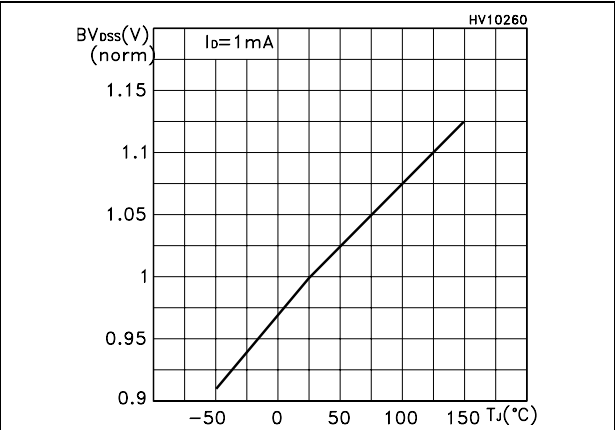
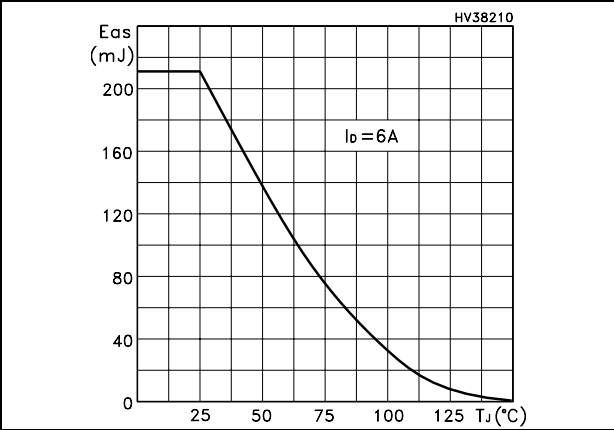


Figure 16. Maximum avalanche energy vs temperature



### 3 Test circuit

Figure 17. Switching times test circuit for resistive load

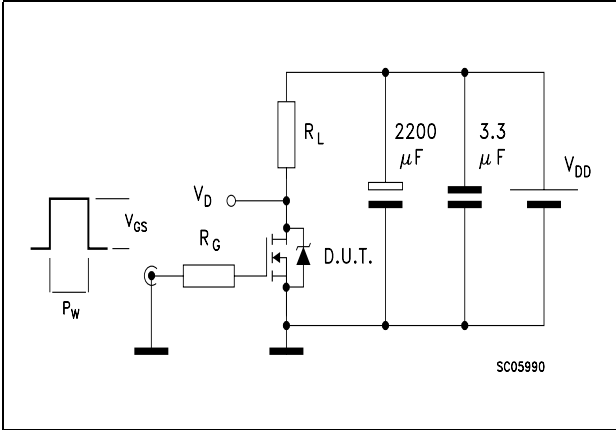


Figure 18. Gate charge test circuit

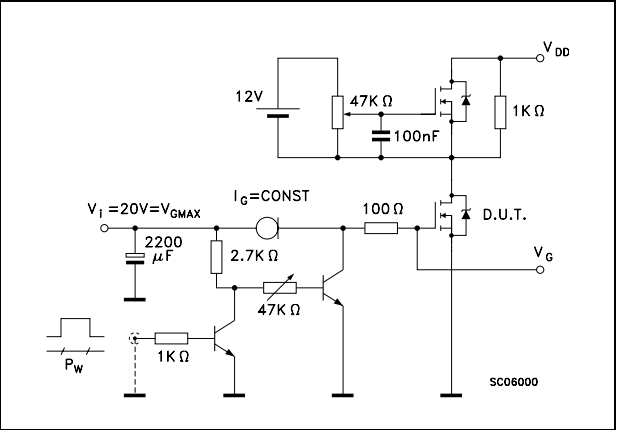


Figure 19. Test circuit for inductive load switching and diode recovery times

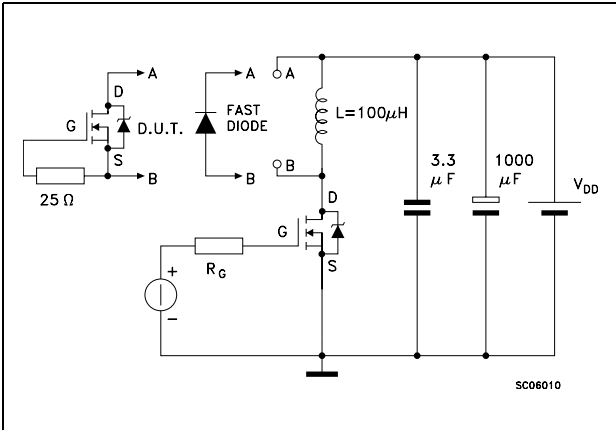


Figure 20. Unclamped Inductive load test circuit

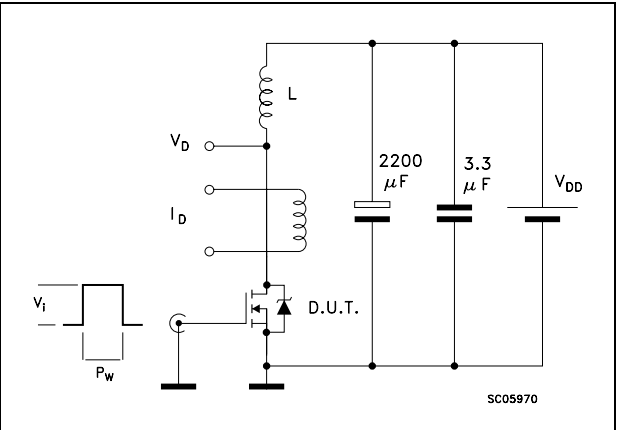


Figure 21. Unclamped inductive waveform

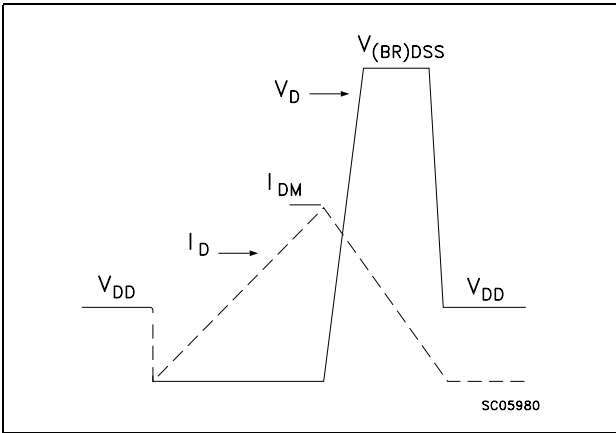
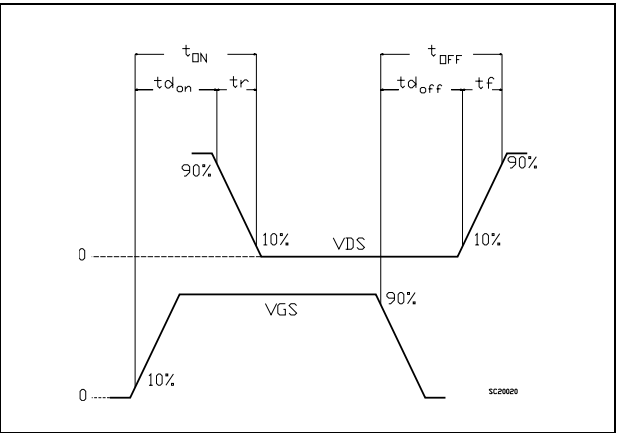


Figure 22. Switching time waveform

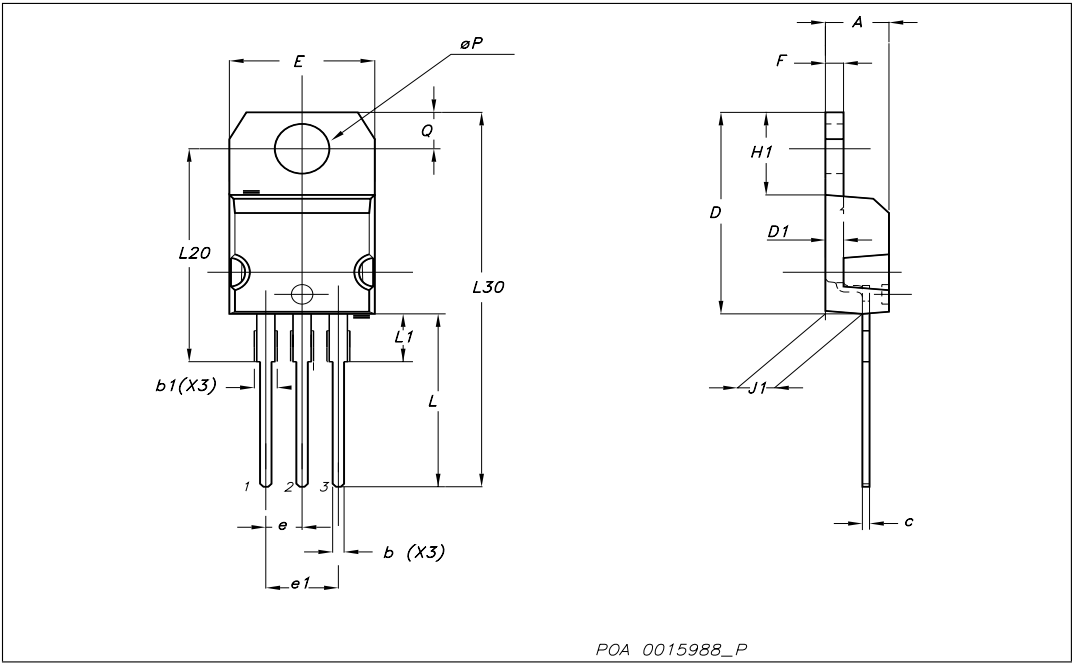


## 4 Package mechanical data

In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a Lead-free second level interconnect. The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at: [www.st.com](http://www.st.com)

TO-220 mechanical data

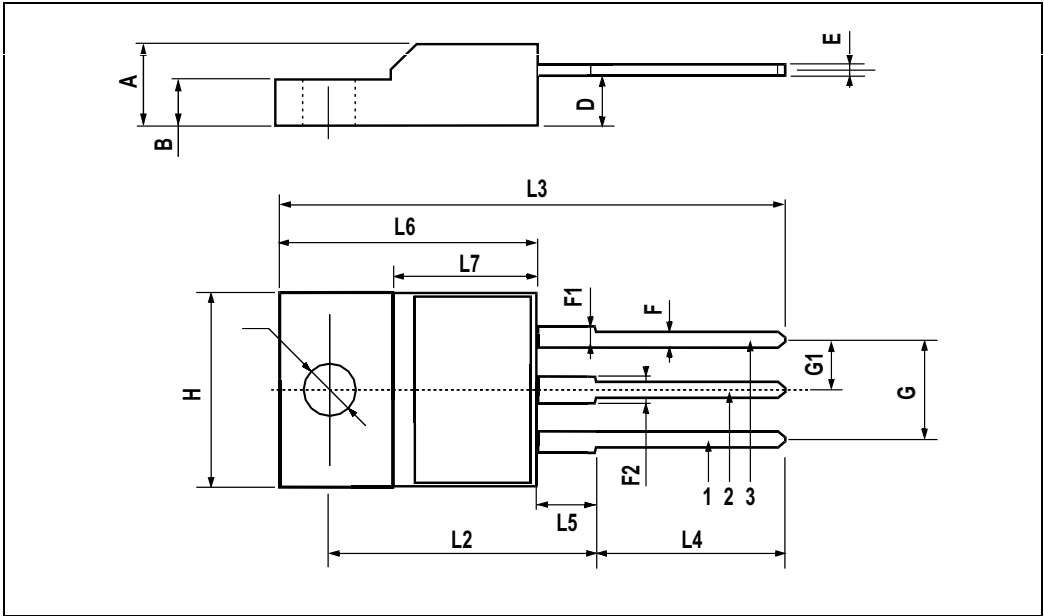
| Dim | mm    |       |       | inch  |       |       |
|-----|-------|-------|-------|-------|-------|-------|
|     | Min   | Typ   | Max   | Min   | Typ   | Max   |
| A   | 4.40  |       | 4.60  | 0.173 |       | 0.181 |
| b   | 0.61  |       | 0.88  | 0.024 |       | 0.034 |
| b1  | 1.14  |       | 1.70  | 0.044 |       | 0.066 |
| c   | 0.49  |       | 0.70  | 0.019 |       | 0.027 |
| D   | 15.25 |       | 15.75 | 0.6   |       | 0.62  |
| D1  |       | 1.27  |       |       | 0.050 |       |
| E   | 10    |       | 10.40 | 0.393 |       | 0.409 |
| e   | 2.40  |       | 2.70  | 0.094 |       | 0.106 |
| e1  | 4.95  |       | 5.15  | 0.194 |       | 0.202 |
| F   | 1.23  |       | 1.32  | 0.048 |       | 0.051 |
| H1  | 6.20  |       | 6.60  | 0.244 |       | 0.256 |
| J1  | 2.40  |       | 2.72  | 0.094 |       | 0.107 |
| L   | 13    |       | 14    | 0.511 |       | 0.551 |
| L1  | 3.50  |       | 3.93  | 0.137 |       | 0.154 |
| L20 |       | 16.40 |       |       | 0.645 |       |
| L30 |       | 28.90 |       |       | 1.137 |       |
| ØP  | 3.75  |       | 3.85  | 0.147 |       | 0.151 |
| Q   | 2.65  |       | 2.95  | 0.104 |       | 0.116 |



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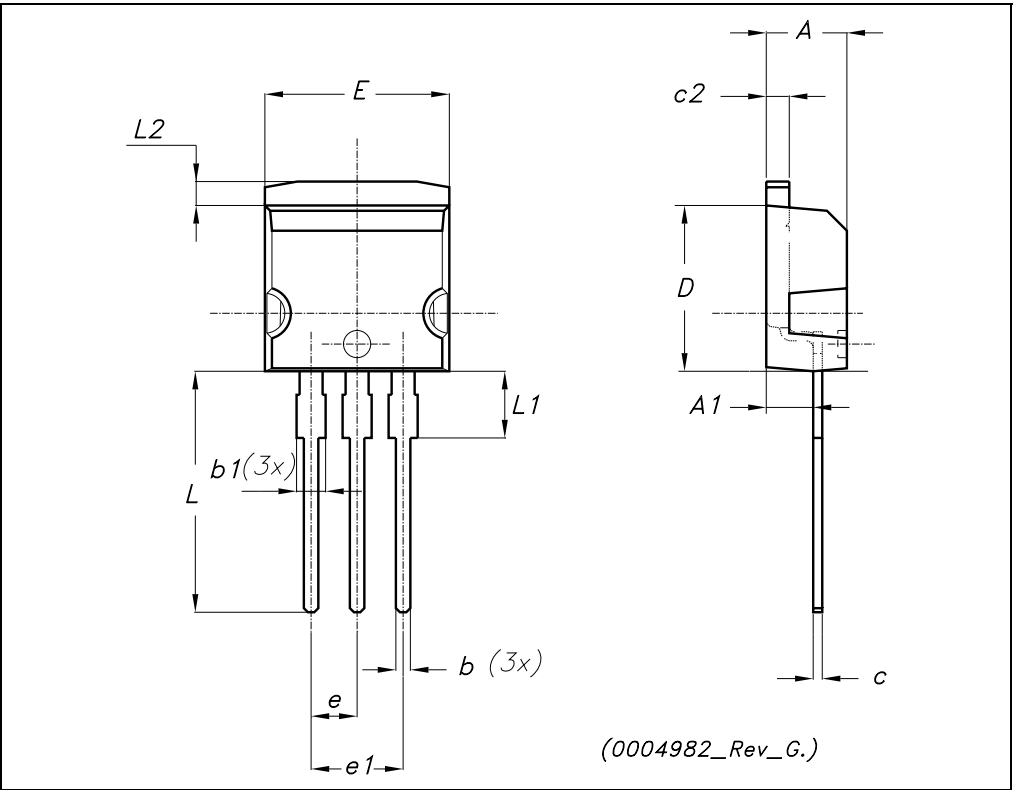
TO-220FP MECHANICAL DATA

| DIM. | mm.  |     |      | inch  |       |       |
|------|------|-----|------|-------|-------|-------|
|      | MIN. | TYP | MAX. | MIN.  | TYP.  | MAX.  |
| A    | 4.4  |     | 4.6  | 0.173 |       | 0.181 |
| B    | 2.5  |     | 2.7  | 0.098 |       | 0.106 |
| D    | 2.5  |     | 2.75 | 0.098 |       | 0.108 |
| E    | 0.45 |     | 0.7  | 0.017 |       | 0.027 |
| F    | 0.75 |     | 1    | 0.030 |       | 0.039 |
| F1   | 1.15 |     | 1.7  | 0.045 |       | 0.067 |
| F2   | 1.15 |     | 1.7  | 0.045 |       | 0.067 |
| G    | 4.95 |     | 5.2  | 0.195 |       | 0.204 |
| G1   | 2.4  |     | 2.7  | 0.094 |       | 0.106 |
| H    | 10   |     | 10.4 | 0.393 |       | 0.409 |
| L2   |      | 16  |      |       | 0.630 |       |
| L3   | 28.6 |     | 30.6 | 1.126 |       | 1.204 |
| L4   | 9.8  |     | 10.6 | .0385 |       | 0.417 |
| L5   | 2.9  |     | 3.6  | 0.114 |       | 0.141 |
| L6   | 15.9 |     | 16.4 | 0.626 |       | 0.645 |
| L7   | 9    |     | 9.3  | 0.354 |       | 0.366 |
| Ø    | 3    |     | 3.2  | 0.118 |       | 0.126 |



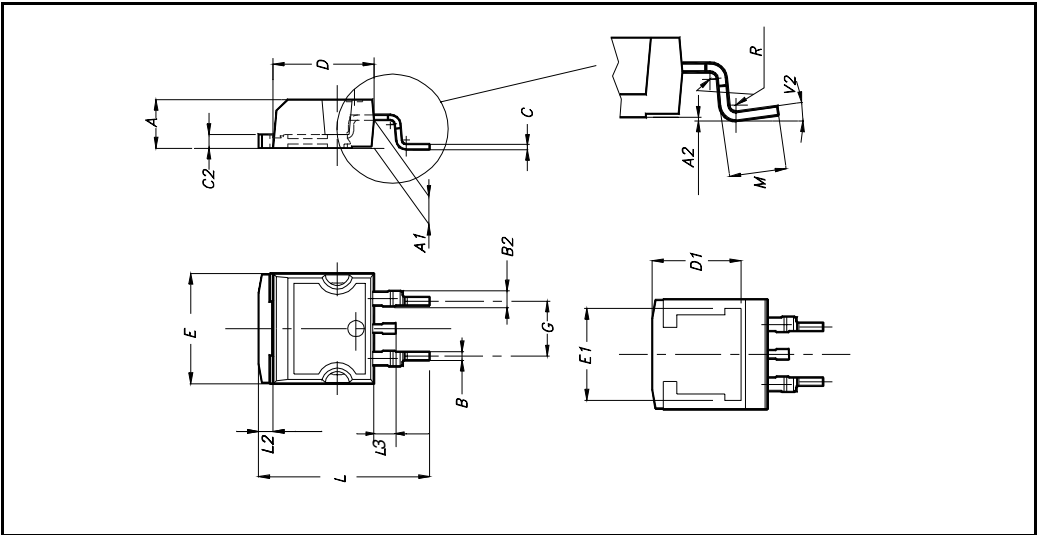
TO-262 (I<sup>2</sup>PAK) MECHANICAL DATA

| DIM. | mm.  |      |       | inch  |      |       |
|------|------|------|-------|-------|------|-------|
|      | MIN. | TYP. | MAX.  | MIN.  | TYP. | MAX.  |
| A    | 4.40 |      | 4.60  | 0.173 |      | 0.181 |
| A1   | 2.40 |      | 2.72  | 0.094 |      | 0.107 |
| b    | 0.61 |      | 0.88  | 0.024 |      | 0.034 |
| b1   | 1.14 |      | 1.70  | 0.044 |      | 0.066 |
| c    | 0.49 |      | 0.70  | 0.019 |      | 0.027 |
| c2   | 1.23 |      | 1.32  | 0.048 |      | 0.052 |
| D    | 8.95 |      | 9.35  | 0.352 |      | 0.368 |
| e    | 2.40 |      | 2.70  | 0.094 |      | 0.106 |
| e1   | 4.95 |      | 5.15  | 0.194 |      | 0.202 |
| E    | 10   |      | 10.40 | 0.393 |      | 0.410 |
| L    | 13   |      | 14    | 0.511 |      | 0.551 |
| L1   | 3.50 |      | 3.93  | 0.137 |      | 0.154 |
| L2   | 1.27 |      | 1.40  | 0.050 |      | 0.055 |



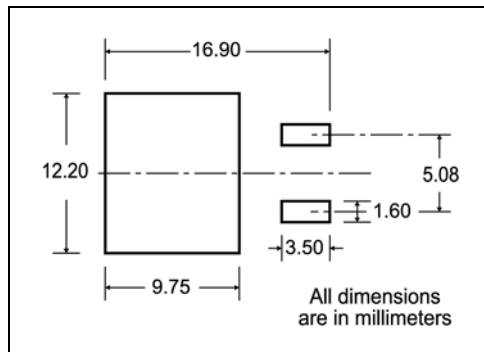
D<sup>2</sup>PAK MECHANICAL DATA

| DIM. | mm.  |      |       | inch  |       |       |
|------|------|------|-------|-------|-------|-------|
|      | MIN. | TYP. | MAX.  | MIN.  | TYP.  | MAX.  |
| A    | 4.4  |      | 4.6   | 0.173 |       | 0.181 |
| A1   | 2.49 |      | 2.69  | 0.098 |       | 0.106 |
| A2   | 0.03 |      | 0.23  | 0.001 |       | 0.009 |
| B    | 0.7  |      | 0.93  | 0.027 |       | 0.036 |
| B2   | 1.14 |      | 1.7   | 0.044 |       | 0.067 |
| C    | 0.45 |      | 0.6   | 0.017 |       | 0.023 |
| C2   | 1.23 |      | 1.36  | 0.048 |       | 0.053 |
| D    | 8.95 |      | 9.35  | 0.352 |       | 0.368 |
| D1   |      | 8    |       |       | 0.315 |       |
| E    | 10   |      | 10.4  | 0.393 |       |       |
| E1   |      | 8.5  |       |       | 0.334 |       |
| G    | 4.88 |      | 5.28  | 0.192 |       | 0.208 |
| L    | 15   |      | 15.85 | 0.590 |       | 0.625 |
| L2   | 1.27 |      | 1.4   | 0.050 |       | 0.055 |
| L3   | 1.4  |      | 1.75  | 0.055 |       | 0.068 |
| M    | 2.4  |      | 3.2   | 0.094 |       | 0.126 |
| R    |      | 0.4  |       |       | 0.015 |       |
| V2   | 0°   |      | 4°    |       |       |       |

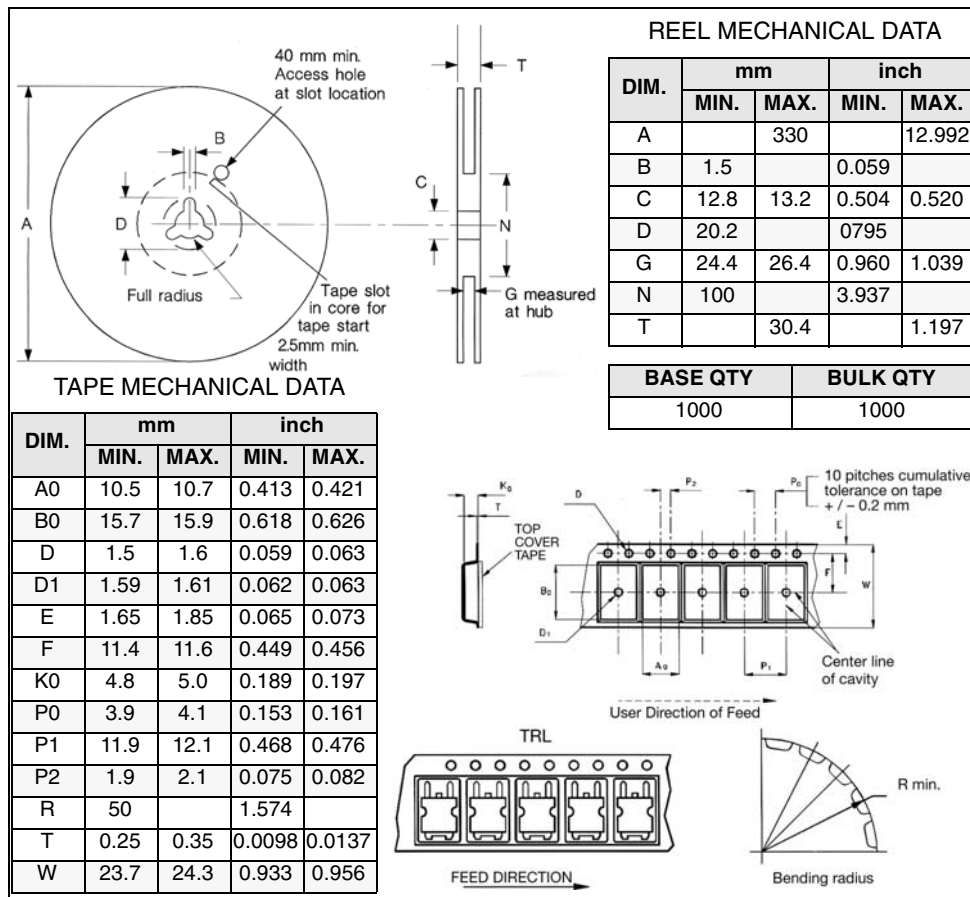


## 5 Packing mechanical data

### D<sup>2</sup>PAK FOOTPRINT



### TAPE AND REEL SHIPMENT



\* on sales type

## 6 Revision history

**Table 10. Document revision history**

| Date        | Revision | Changes                                                         |
|-------------|----------|-----------------------------------------------------------------|
| 14-Jan-2004 | 4        | Initial electronic version                                      |
| 23-Aug-2005 | 5        | Inserted ecopack label                                          |
| 04-Oct-2005 | 6        | Modified header                                                 |
| 23-May-2007 | 7        | Added <i>Figure 16: Maximum avalanche energy vs temperature</i> |
| 22-Nov-2007 | 8        | <i>Figure 11: Capacitance variations</i> has been updated       |

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