



# STB20NM60-1 - STP20NM60FP STB20NM60 - STP20NM60 - STW20NM60

N-channel 600V - 0.25Ω - 20A - TO-247 - TO-220/FP - D<sup>2</sup>/I<sup>2</sup>PAK  
MDmesh™ Power MOSFET

## Features

| Type        | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|-------------|------------------|---------------------|----------------|
| STP20NM60   | 600V             | < 0.29Ω             | 20A            |
| STP20NM60FP | 600V             | < 0.29Ω             | 20A            |
| STB20NM60   | 600V             | < 0.29Ω             | 20A            |
| STB20NM60-1 | 600V             | < 0.29Ω             | 20A            |
| STW20NM60   | 600V             | < 0.29Ω             | 20A            |

- High dv/dt and avalanche capabilities
- 100% avalanche tested
- Low input capacitance and gate charge
- Low gate input resistance

## Applications

- Switching applications

## Description

The MDmesh™ is a new revolutionary Power MOSFET technology that associates the multiple drain process with the company's PowerMESH™ horizontal layout. The resulting product has an outstanding low on-resistance, impressively high dv/dt and excellent avalanche characteristics. The adoption of the company's proprietary strip technique yields overall dynamic performance that is significantly better than that of similar competition's products.

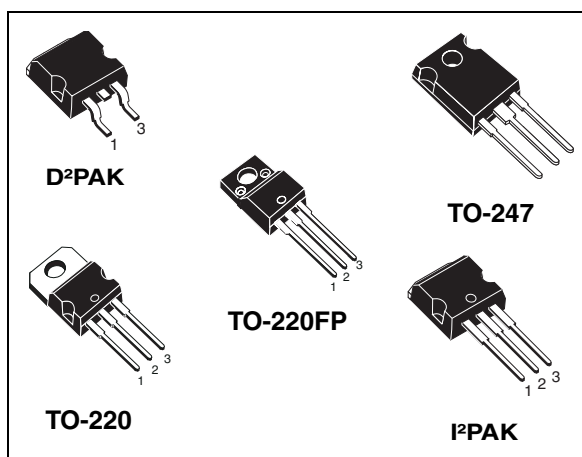


Figure 1. Internal schematic diagram

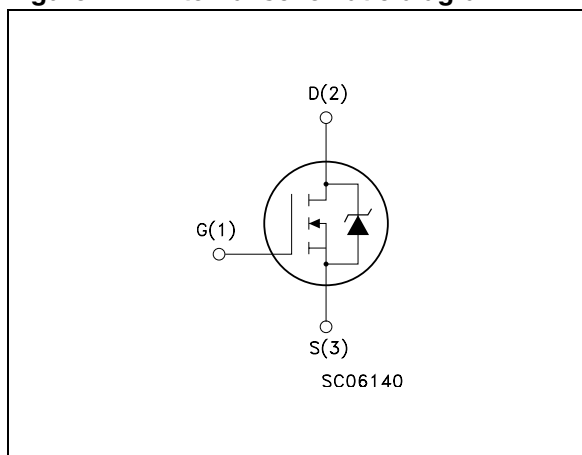


Table 1. Device summary

| Part number | Marking   | Package            | Packaging   |
|-------------|-----------|--------------------|-------------|
| STP20NM60   | P20NM60   | TO-220             | Tube        |
| STP20NM60FP | P20NM60FP | TO-220FP           | Tube        |
| STB20NM60T4 | B20NM60   | D <sup>2</sup> PAK | Tape & reel |
| STB20NM60-1 | B20NM60-1 | I <sup>2</sup> PAK | Tube        |
| STW20NM60   | W20NM60   | TO-247             | Tube        |

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol                  | Parameter                                                                                                             | Value                                                  |                     | Unit                |
|-------------------------|-----------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|---------------------|---------------------|
|                         |                                                                                                                       | TO-220/D <sup>2</sup> PAK<br>I <sup>2</sup> PAK/TO-247 | 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 $T_C = 25^\circ\text{C}$                                                                | 20                                                     | 20 <sup>(1)</sup>   | A                   |
| $I_D$                   | Drain current (continuous) at $T_C = 100^\circ\text{C}$                                                               | 12.6                                                   | 12.6 <sup>(1)</sup> | A                   |
| $I_{DM}$ <sup>(2)</sup> | Drain current (pulsed)                                                                                                | 80                                                     | 80 <sup>(1)</sup>   | A                   |
| $P_{TOT}$               | Total dissipation at $T_C = 25^\circ\text{C}$                                                                         | 192                                                    | 45                  | W                   |
|                         | Derating factor                                                                                                       | 1.5                                                    | 0.36                | W/ $^\circ\text{C}$ |
| $dv/dt$ <sup>(3)</sup>  | Peak diode recovery voltage slope                                                                                     | 15                                                     |                     | V/ns                |
| $V_{ISO}$               | Insulation withstand voltage (RMS) from all three leads to external heat sink ( $t=1\text{s}; T_C=25^\circ\text{C}$ ) | --                                                     | 2500                | V                   |
| $T_{stg}$               | Storage temperature                                                                                                   | -65 to 150                                             |                     | $^\circ\text{C}$    |
| $T_j$                   | Max. operating junction temperature                                                                                   | 150                                                    |                     | $^\circ\text{C}$    |

1. Limited only by maximum temperature allowed
2. Pulse width limited by safe operating area
3.  $I_{SD} \leq 20\text{A}$ ,  $di/dt \leq 400\text{A}/\mu\text{s}$ ,  $V_{DD} \leq V_{(BR)/DSS}$ ,  $T_j \leq T_{JMAX}$

**Table 3. Thermal resistance**

| Symbol         | Parameter                                      | TO-220/D <sup>2</sup> PAK<br>I <sup>2</sup> PAK/TO-247 | TO-220FP | Unit                      |
|----------------|------------------------------------------------|--------------------------------------------------------|----------|---------------------------|
| $R_{thj-case}$ | Thermal resistance junction-case max           | 0.65                                                   | 2.8      | $^\circ\text{C}/\text{W}$ |
| $R_{thj-amb}$  | Thermal resistance junction-ambient max        | 62.5                                                   |          | $^\circ\text{C}/\text{W}$ |
| $T_I$          | Maximum lead temperature for soldering purpose | 300                                                    |          | $^\circ\text{C}$          |

**Table 4. Avalanche data**

| Symbol   | Parameter                                                                                                   | Max. value | Unit |
|----------|-------------------------------------------------------------------------------------------------------------|------------|------|
| $I_{AS}$ | Avalanche current, repetitive or not-repetitive (pulse width limited by $T_j$ max)                          | 10         | A    |
| $E_{AS}$ | Single pulse avalanche energy (starting $T_j = 25^\circ\text{C}$ , $I_D = I_{AS}$ , $V_{DD} = 50\text{V}$ ) | 650        | 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                   | $I_D = 250\ \mu\text{A}$ , $V_{GS} = 0$                                              | 600  |      |           | V                              |
| $I_{DSS}$     | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max rating}$<br>$V_{DS} = \text{Max rating, @ } 125^{\circ}\text{C}$ |      |      | 1<br>10   | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$     | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 30\text{V}$                                                            |      |      | $\pm 100$ | nA                             |
| $V_{GS(th)}$  | Gate threshold voltage                           | $V_{DS} = V_{GS}$ , $I_D = 250\ \mu\text{A}$                                         | 3    | 4    | 5         | V                              |
| $R_{DS(on)}$  | Static drain-source on resistance                | $V_{GS} = 10\text{V}$ , $I_D = 10\ \text{A}$                                         |      | 0.25 | 0.29      | $\Omega$                       |

**Table 6. Dynamic**

| Symbol                              | Parameter                                                               | Test conditions                                                                               | Min. | Typ.              | Max. | Unit           |
|-------------------------------------|-------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|------|-------------------|------|----------------|
| $g_{fs}^{(1)}$                      | Forward transconductance                                                | $V_{DS} > I_{D(on)} \times R_{DS(on)max}$ ,<br>$I_D = 10\ \text{A}$                           |      | 11                |      | 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>$V_{GS} = 0$                                 |      | 1500<br>350<br>35 |      | pF<br>pF<br>pF |
| $C_{oss\ eq.}^{(2)}$                | Equivalent output capacitance                                           | $V_{GS} = 0\text{V}$ , $V_{DS} = 0\text{V}$ to<br>480 V                                       |      | 215               |      | pF             |
| $Q_g$<br>$Q_{gs}$<br>$Q_{gd}$       | Total gate charge<br>Gate-source charge<br>Gate-drain charge            | $V_{DD} = 480\ \text{V}$ , $I_D = 20\ \text{A}$ ,<br>$V_{GS} = 10\text{V}$<br>(see Figure 16) |      | 39<br>10<br>20    | 54   | nC<br>nC<br>nC |
| $R_g$                               | Gate input resistance                                                   | $f = 1\ \text{MHz}$ Gate DC<br>bias=0 Test signal<br>level = 20 mV<br>open drain              |      | 1.6               |      | $\Omega$       |

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

2.  $C_{oss\ eq.}$  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  | $V_{DD} = 300\text{ V}$ , $I_D = 10\text{ A}$<br>$R_G = 4.7\Omega$ $V_{GS} = 10\text{ V}$<br>(see Figure 15) |      | 25   |      | ns   |
| $t_r$        | Rise time           |                                                                                                              |      | 20   |      | ns   |
| $t_{d(off)}$ | Turn-off delay time |                                                                                                              |      | 42   |      | ns   |
| $t_f$        | Fall time           |                                                                                                              |      | 11   |      | ns   |

**Table 8. Source drain diode**

| Symbol          | Parameter                     | Test conditions                                                                                                                        | Min | Typ. | Max | Unit          |
|-----------------|-------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|-----|------|-----|---------------|
| $I_{SD}$        | Source-drain current          |                                                                                                                                        |     |      | 20  | A             |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |                                                                                                                                        |     |      | 80  | A             |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD} = 20\text{ A}$ , $V_{GS} = 0$                                                                                                  |     |      | 1.5 | V             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 20\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ ,<br>$V_{DD} = 60\text{ V}$<br>(see Figure 20)                             |     | 390  |     | ns            |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                        |     | 5    |     | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                        |     | 25   |     | A             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 20\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ ,<br>$T_j = 150^\circ\text{C}$ , $V_{DD} = 60\text{ V}$<br>(see Figure 20) |     | 510  |     | ns            |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                        |     | 6.5  |     | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                        |     | 26   |     | A             |

1. Pulse width limited by safe operating area

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

## 2.1 Electrical characteristics (curves)

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

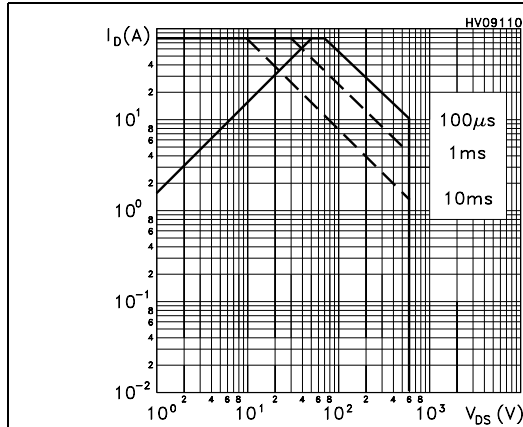


Figure 3. Thermal impedance for TO-220 / D<sup>2</sup>PAK / I<sup>2</sup>PAK

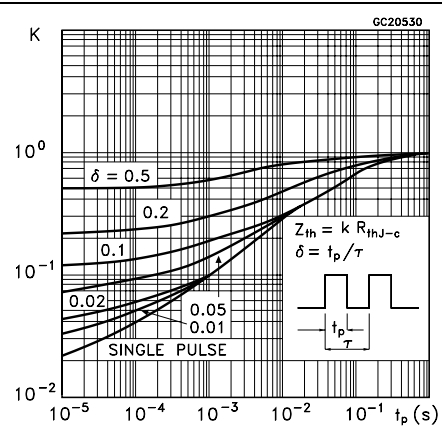


Figure 4. Safe operating area for TO-220FP

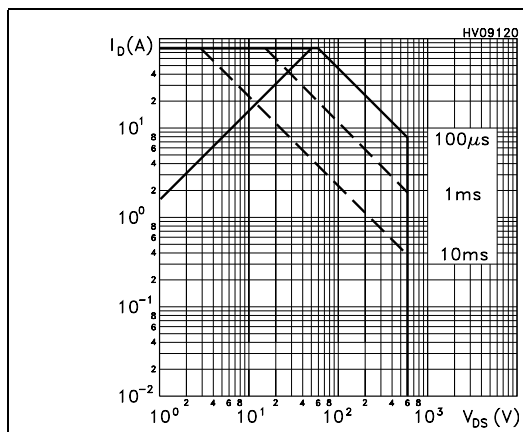


Figure 5. Thermal impedance for TO-220FP

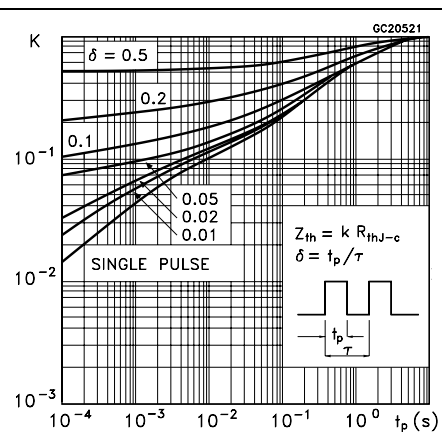


Figure 6. Output characteristics

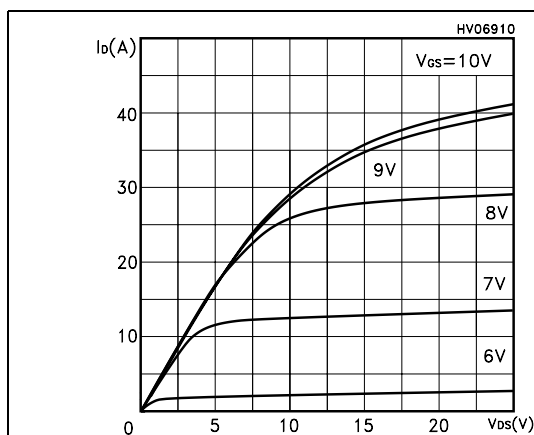


Figure 7. Transfer characteristics

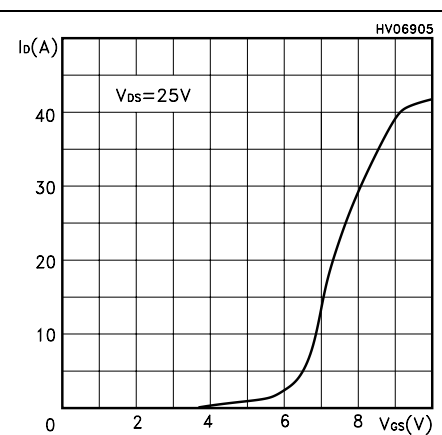


Figure 8. Transconductance

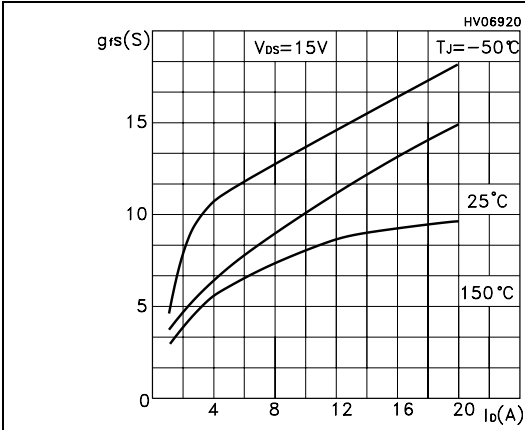


Figure 9. Static drain-source on resistance

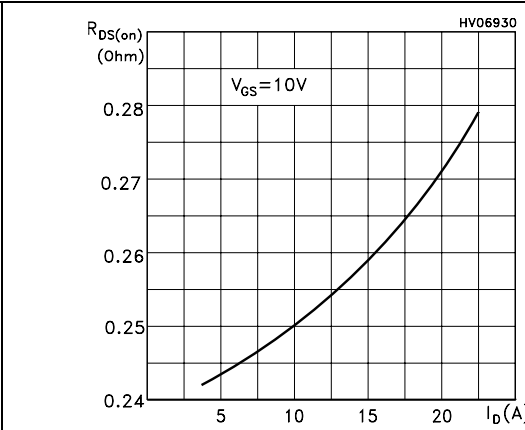


Figure 10. Gate charge vs gate-source voltage

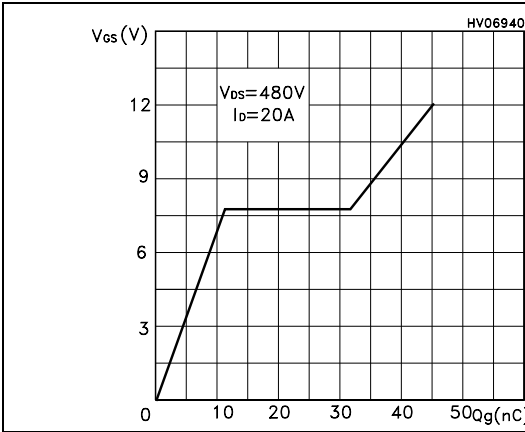


Figure 11. Capacitance variations

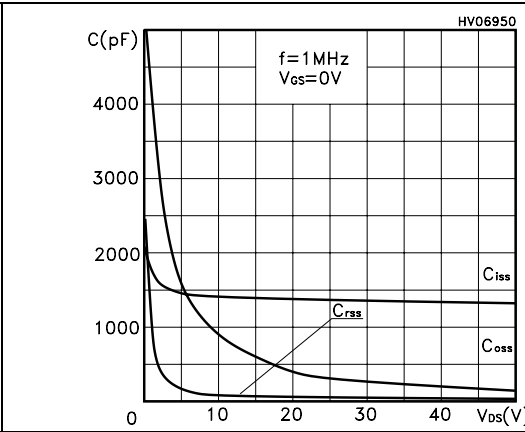


Figure 12. Normalized gate threshold voltage vs temperature

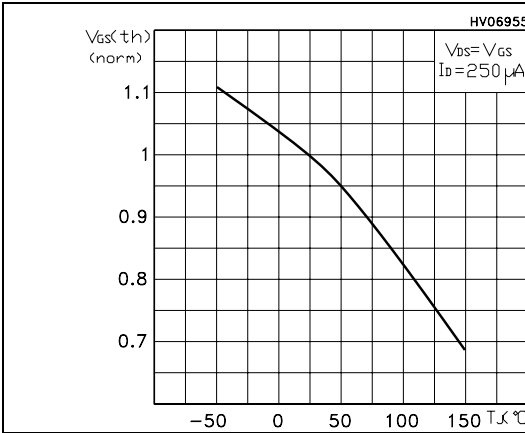


Figure 13. Normalized on resistance vs temperature

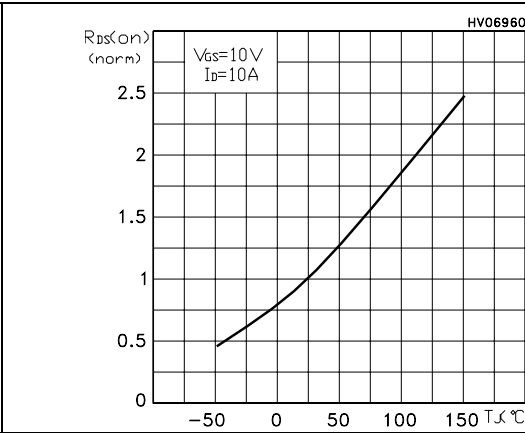
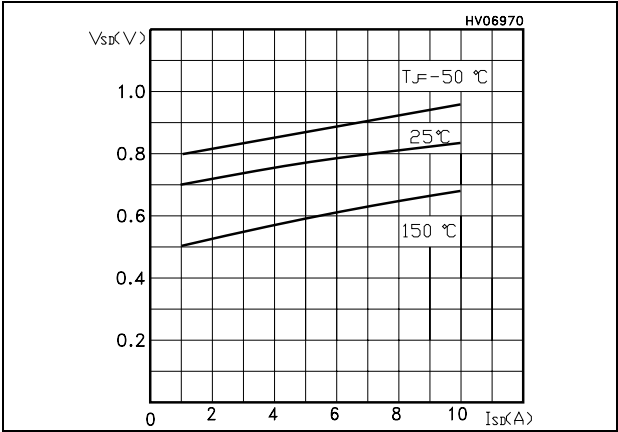
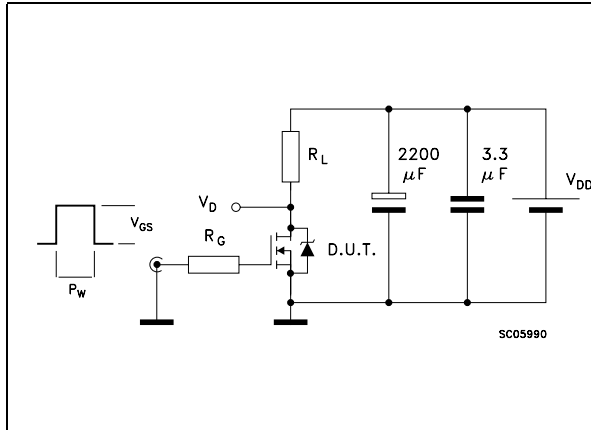


Figure 14. Source-drain diode forward characteristics

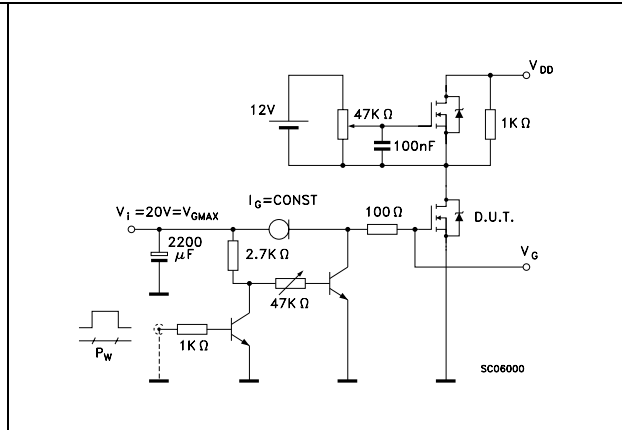


### 3 Test circuit

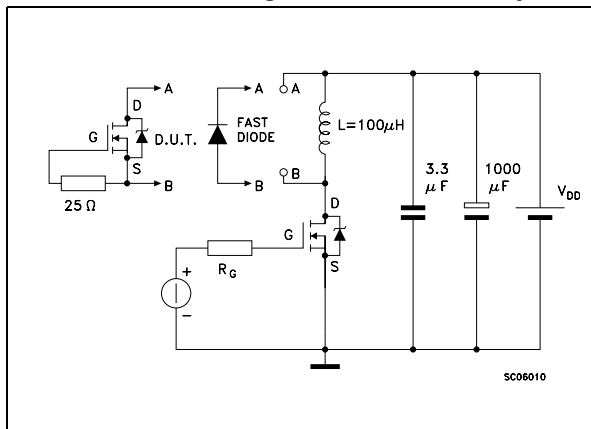
**Figure 15. Switching times test circuit for resistive load**



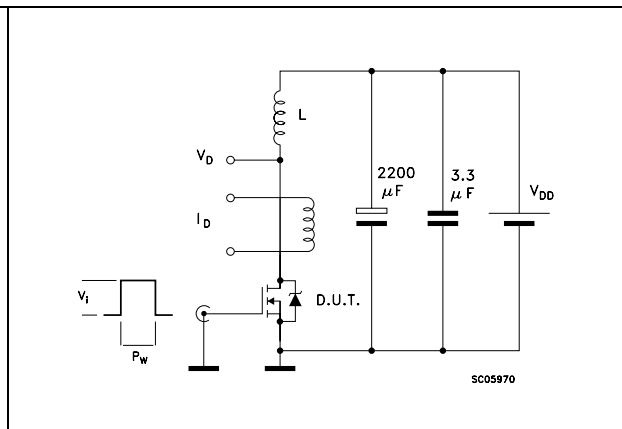
**Figure 16. Gate charge test circuit**



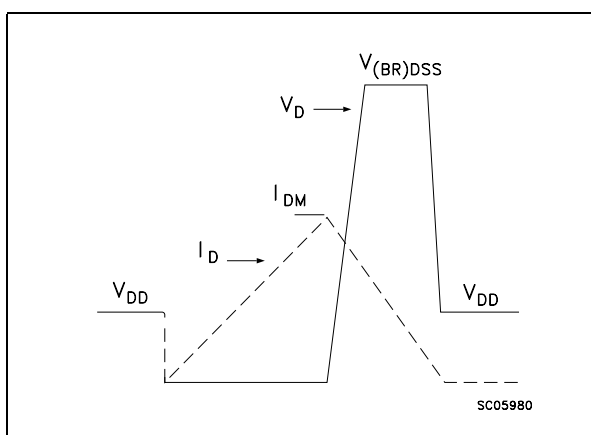
**Figure 17. Test circuit for inductive load switching and diode recovery times**



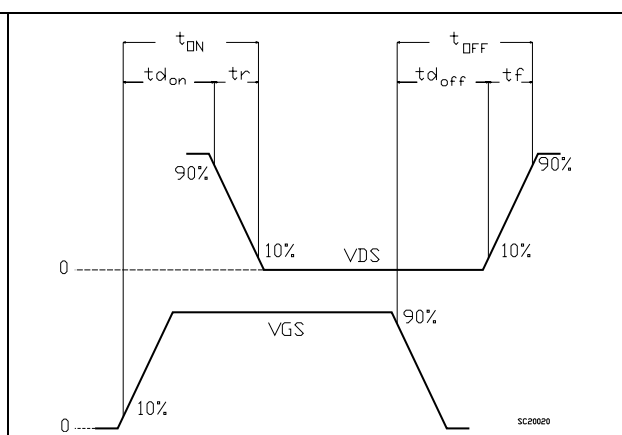
**Figure 18. Unclamped inductive load test circuit**



**Figure 19. Unclamped inductive waveform**



**Figure 20. Switching time waveform**

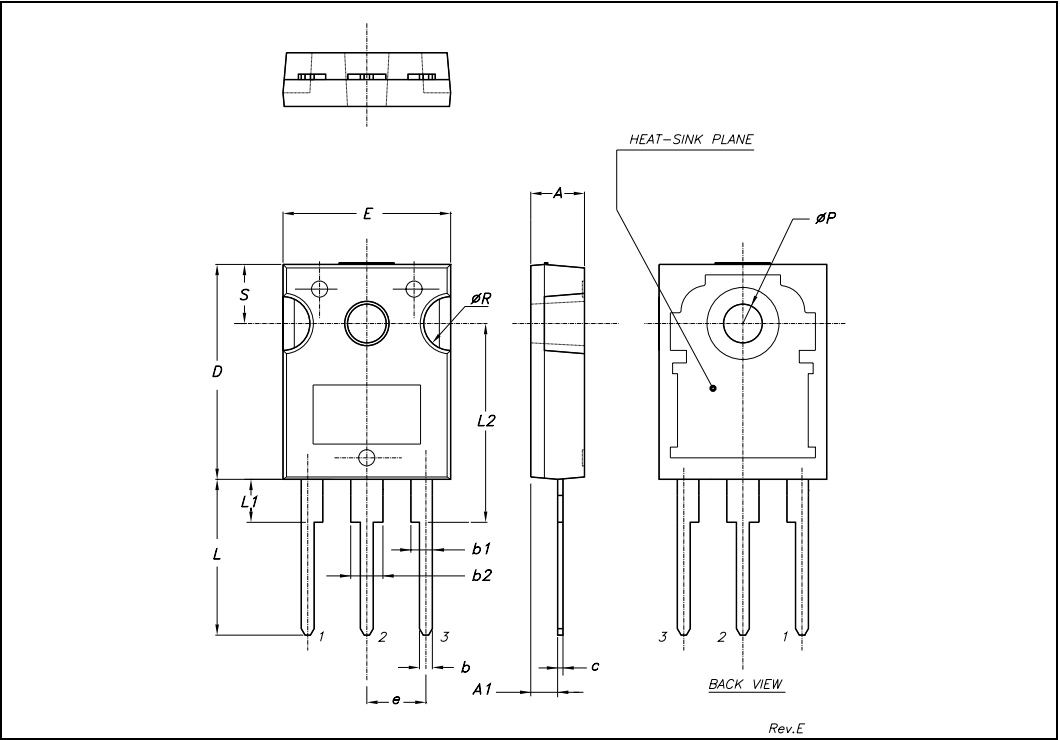


## 4 Package mechanical data

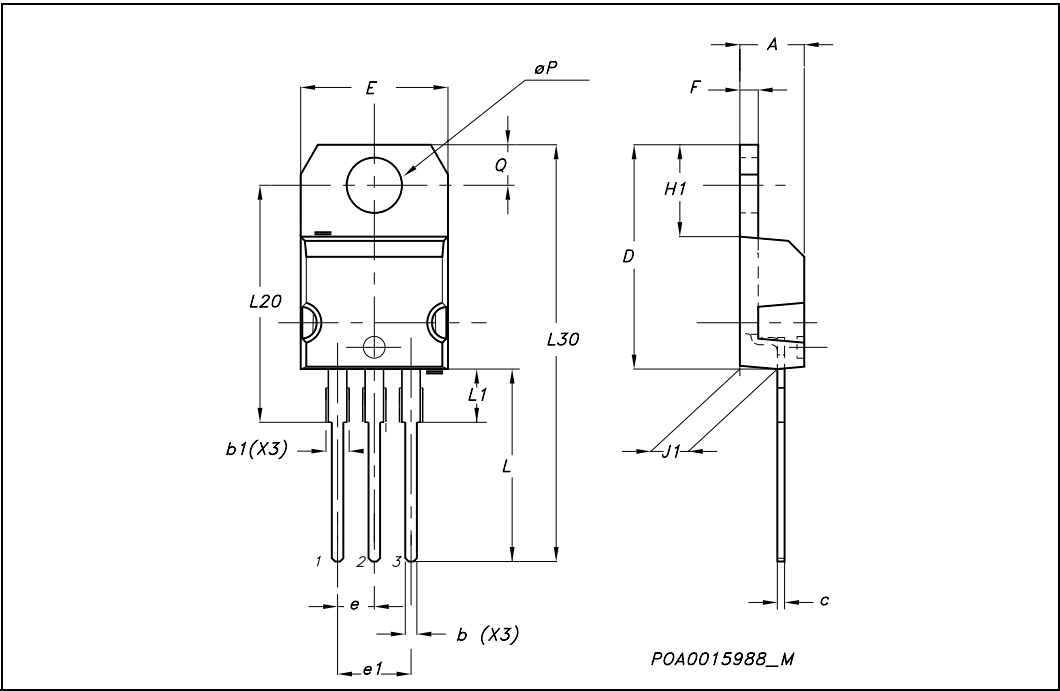
In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a Lead-free second level interconnect . The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings 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-247 MECHANICAL DATA

| DIM. | mm.   |       |       | inch  |       |       |
|------|-------|-------|-------|-------|-------|-------|
|      | MIN.  | TYP.  | MAX.  | MIN.  | TYP.  | MAX.  |
| A    | 4.85  |       | 5.15  | 0.19  |       | 0.20  |
| A1   | 2.20  |       | 2.60  | 0.086 |       | 0.102 |
| b    | 1.0   |       | 1.40  | 0.039 |       | 0.055 |
| b1   | 2.0   |       | 2.40  | 0.079 |       | 0.094 |
| b2   | 3.0   |       | 3.40  | 0.118 |       | 0.134 |
| c    | 0.40  |       | 0.80  | 0.015 |       | 0.03  |
| D    | 19.85 |       | 20.15 | 0.781 |       | 0.793 |
| E    | 15.45 |       | 15.75 | 0.608 |       | 0.620 |
| e    |       | 5.45  |       |       | 0.214 |       |
| L    | 14.20 |       | 14.80 | 0.560 |       | 0.582 |
| L1   | 3.70  |       | 4.30  | 0.14  |       | 0.17  |
| L2   |       | 18.50 |       |       | 0.728 |       |
| øP   | 3.55  |       | 3.65  | 0.140 |       | 0.143 |
| øR   | 4.50  |       | 5.50  | 0.177 |       | 0.216 |
| S    |       | 5.50  |       |       | 0.216 |       |

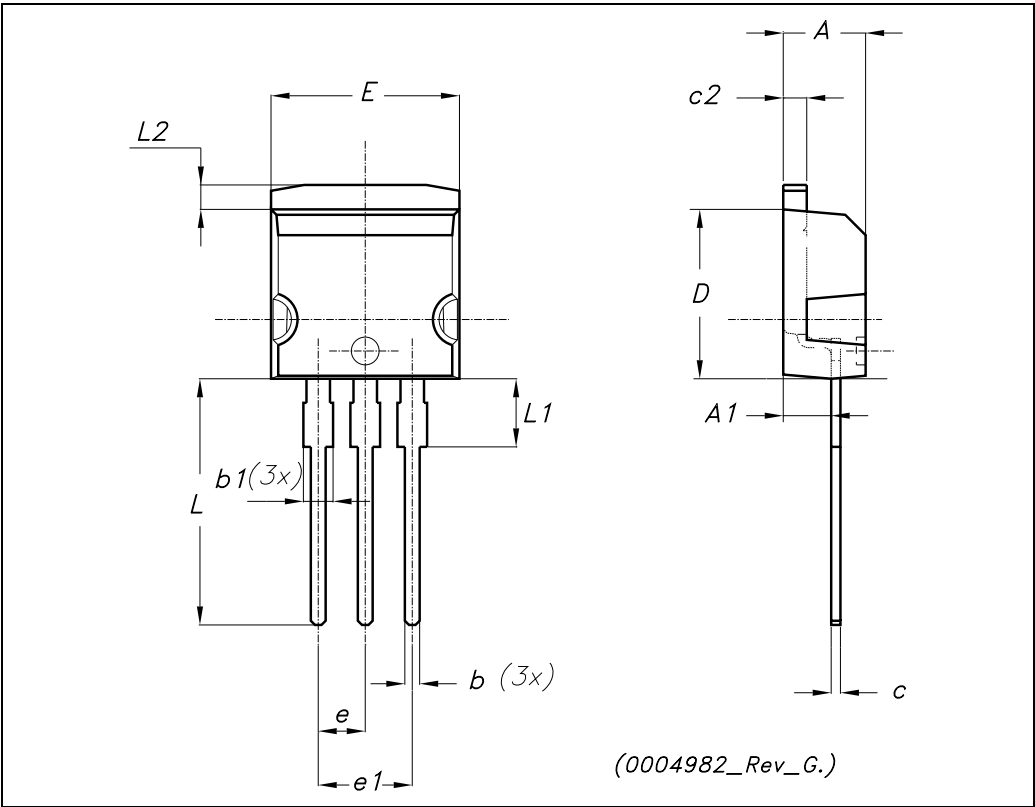


| TO-220 MECHANICAL DATA |       |       |       |       |       |       |
|------------------------|-------|-------|-------|-------|-------|-------|
| DIM.                   | mm.   |       |       | inch  |       |       |
|                        | MIN.  | TYP   | MAX.  | MIN.  | TYP.  | MAX.  |
| A                      | 4.40  |       | 4.60  | 0.173 |       | 0.181 |
| b                      | 0.61  |       | 0.88  | 0.024 |       | 0.034 |
| b1                     | 1.15  |       | 1.70  | 0.045 |       | 0.066 |
| c                      | 0.49  |       | 0.70  | 0.019 |       | 0.027 |
| D                      | 15.25 |       | 15.75 | 0.60  |       | 0.620 |
| 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 |       | 0.052 |
| 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 |



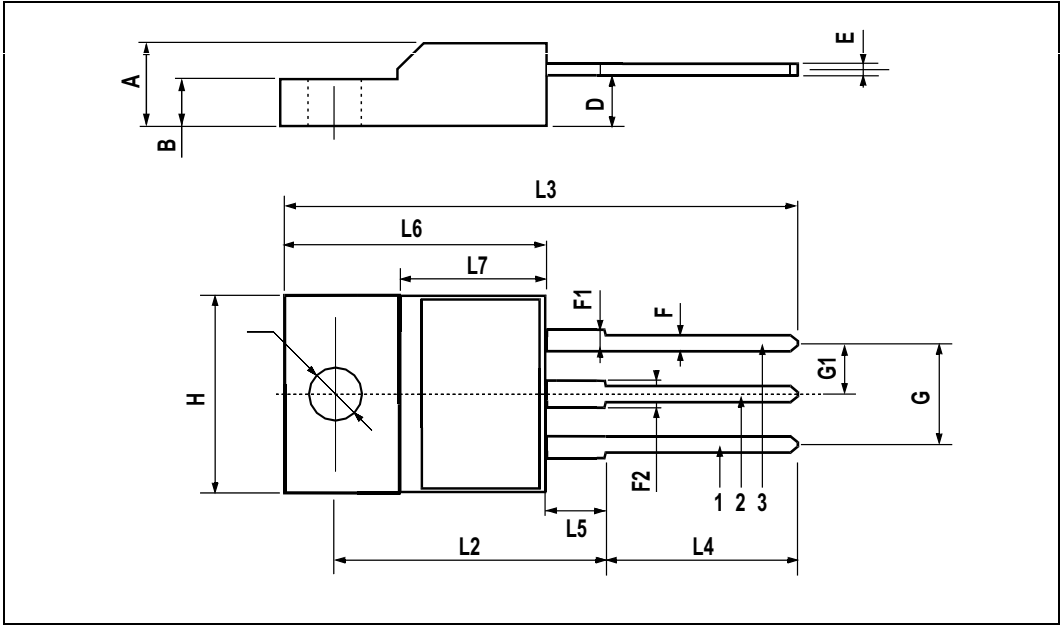
TO-262 (I<sup>2</sup>PAK) MECHANICAL DATA

| 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 |



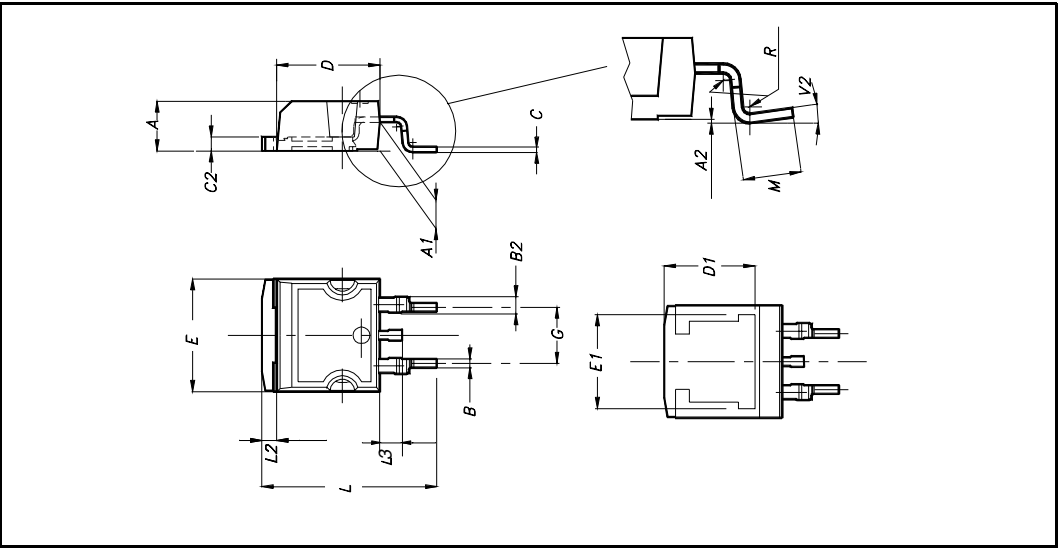
TO-220FP MECHANICAL DATA

| 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 |



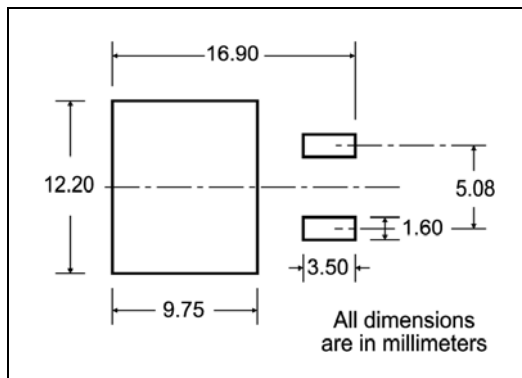
D<sup>2</sup>PAK MECHANICAL DATA

| 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°    |       |       |       |

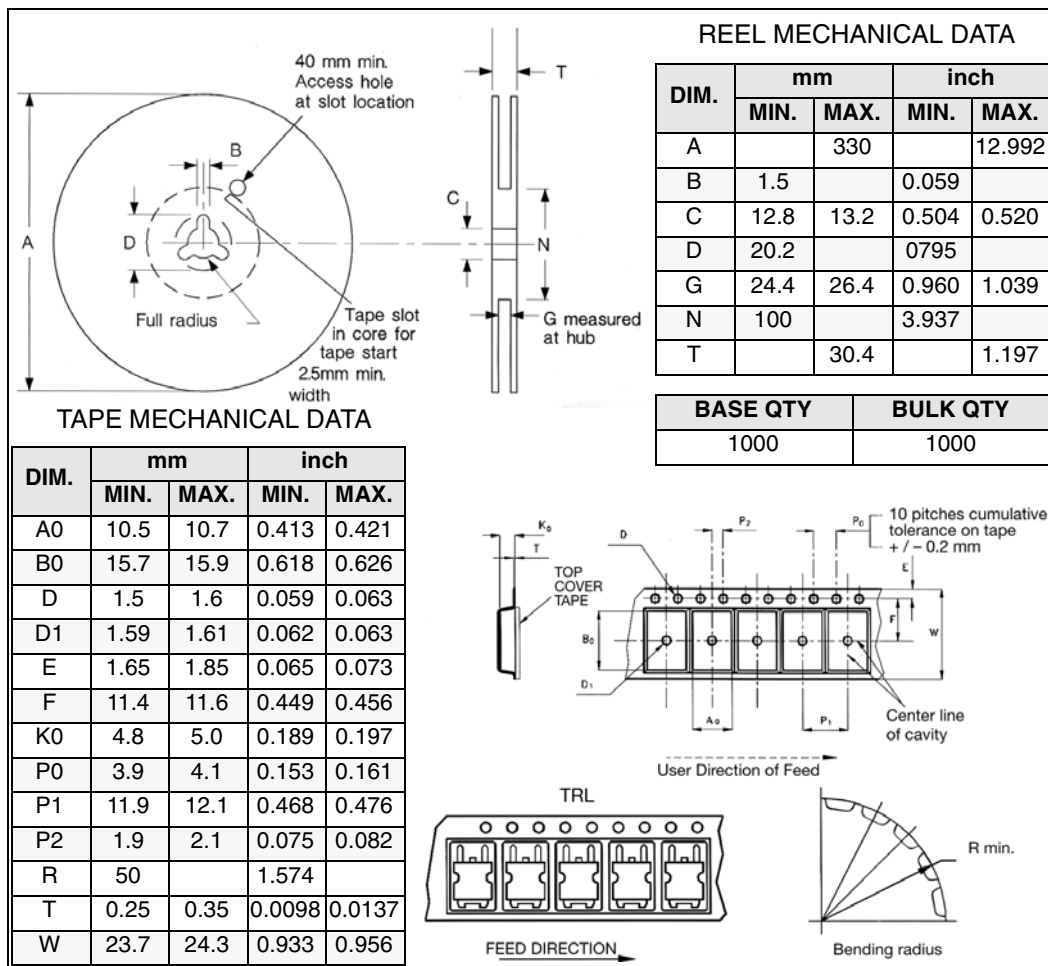


## 5 Packaging mechanical data

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



### TAPE AND REEL SHIPMENT



\* on sales type

## 6 Revision history

**Table 9. Document revision history**

| Date        | Revision | Changes                                                       |
|-------------|----------|---------------------------------------------------------------|
| 26-Jul-2004 | 8        | First Release                                                 |
| 17-Feb-2005 | 9        | Insert the TO-247 package                                     |
| 25-Oct-2006 | 10       | The document has been reformatted                             |
| 18-Dec-2006 | 11       | Text updates on <a href="#">Table 5</a> .                     |
| 27-Aug-2007 | 12       | Updated <a href="#">Figure 2</a> and <a href="#">Figure 4</a> |

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