# STD5NM60
# STB8NM60 - STP8NM60

## N-channel 650 V @Tjmax, 0.9 Ω, 8 A MDmesh™ Power MOSFET
## TO-220, TO-220FP, D²PAK, DPAK, IPAK

## Features

| Type | $V_{DSS}$ | $R_{DS(on)}$ | $I_D$ | Pw |
|---|---|---|---|---|
| STD5NM60 | 650 V | < 1 Ω | 5 A | 96 W |
| STD5NM60-1 | 650 V | < 1 Ω | 5 A | 96 W |
| STB8NM60 | 650 V | < 1 Ω | 5 A | 100 W |
| STP8NM60 | 650 V | < 1 Ω | 8 A | 100 W |
| STP8NM60FP | 650 V | < 1 Ω | 8 A[(1)] | 30 W |

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



DPAK  D²PAK  TO-220FP  TO-220  IPAK

## Application

- 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



SC06140

Table 1.    Device summary

| Order codes | Marking | Package | Packaging |
|---|---|---|---|
| STD5NM60-1 | D5NM60 | IPAK | Tube |
| STD5NM60T4 | D5NM60 | DPAK | Tape & reel |
| STB8NM60T4 | B8NM60 | D²PAK | Tape & reel |
| STP8NM60 | P8NM60 | TO-220 | Tube |
| STP8NM60FP | P8NM60FP | TO-220FP | Tube |

# 1    Electrical ratings

**Table 1.    Absolute maximum ratings**

| Symbol | Parameter | Value | | | Unit |
|---|---|---|---|---|---|
| | | **TO-220 D²PAK** | **TO-220FP** | **IPAK DPAK** | |
| $V_{GS}$ | Gate-source voltage | ± 30 | | | V |
| $I_D$ | Drain current (continuous) at $T_C$ = 25 °C | 8 | 8[1] | 5 | A |
| $I_D$ | Drain current (continuous) at $T_C$=100 °C | 5 | 5 [1] | 3.1 [1] | A |
| $I_{DM}$[2] | Drain current (pulsed) | 32 | 32 [1] | 20 [1] | A |
| $P_{TOT}$ | Total dissipation at $T_C$ = 25 °C | 100 | 30 | 96 | W |
| | Derating factor | 0.8 | 0.24 | 0.0.4 | W/°C |
| dv/dt[3] | Peak diode recovery voltage slope | 15 | | | V/ns |
| $V_{ISO}$ | Insulation withstand voltage (RMS) from all three leads to external heat sink (t=1 s;$T_C$=25 °C) | -- | 2500 | -- | V |
| $T_J$ $T_{stg}$ | Operating junction temperature Storage temperature | -55 to 150 | | | °C |

1.  Limited only by maximum temperature allowed

2.  Pulse width limited by safe operating area

3.  $I_{SD} \leq$ 5 A, di/dt $\leq$ 400 A/μs, $V_{DD}$ = 80%$V_{(BR)DSS}$

**Table 2.    Thermal resistance**

| Symbol | Parameter | Value | | | Unit |
|---|---|---|---|---|---|
| | | **TO-220 D²PAK** | **IPAK DPAK** | **TO-220FP** | |
| $R_{thj-case}$ | Thermal resistance junction-case max | 1.25 | 1.3 | 4.16 | °C/W |
| $R_{thj-a}$ | Thermal resistance junction-ambient max | 62.5 | | | °C/W |
| $T_l$ | Maximum lead temperature for soldering purpose | 300 | | | °C |

**Table 3.    Avalanche data**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $I_{AS}$ | Avalanche current, repetitive or not-repetitive (pulse width limited by Tj Max) | 2.5 | A |
| $E_{AS}$ | Single pulse avalanche energy (starting Tj=25 °C, $I_D$=$I_{AS}$, $V_{DD}$=50 V) | 200 | mJ |

# 2 Electrical characteristics

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

**Table 4. On/off states**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage | $I_D$ = 250 µA, $V_{GS}$= 0 | 600 | | | V |
| $I_{DSS}$ | Zero gate voltage drain current ($V_{GS}$ = 0) | $V_{DS}$ = max rating, <br> $V_{DS}$ = max rating @125 °C | | | 1 <br> 10 | µA <br> µA |
| $I_{GSS}$ | Gate body leakage current ($V_{DS}$ = 0) | $V_{GS}$ = ±20 V | | | ±100 | nA |
| $V_{GS(th)}$ | Gate threshold voltage | $V_{DS}$ = $V_{GS}$, $I_D$ = 250 µA | 3 | 4 | 5 | V |
| $R_{DS(on)}$ | Static drain-source on resistance | $V_{GS}$= 10 V, $I_D$= 2.5 A | | 0.9 | 1 | $\Omega$ |

**Table 5. Dynamic**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $g_{fs}$ | Forward transconductance | $V_{DS}$ = $I_{D(on)}$ x $R_{DS(on)max}$, <br> $I_D$ = 2.5 A | | 2.4 | | S |
| $C_{iss}$ <br> $C_{oss}$ <br> $C_{rss}$ | Input capacitance <br> Output capacitance <br> Reverse transfer capacitance | $V_{DS}$ = 25 V, f=1 MHz, <br> $V_{GS}$=0 | | 400 <br> 100 <br> 10 | | pF <br> pF <br> pF |
| $C_{oss\ eq}$[1] | Equivalent output capacitance | $V_{GS}$=0, $V_{DS}$ =0 to 480 V | | 50 | | pF |
| $Q_g$ <br> $Q_{gs}$ <br> $Q_{gd}$ | Total gate charge <br> Gate-source charge <br> Gate-drain charge | $V_{DD}$= 400 V, $I_D$ = 5 A <br> $V_{GS}$ =10 V <br> *(see Figure 12)* | | 13 <br> 5 <br> 6 | 18 | nC <br> nC <br> nC |

1. $C_{oss\ eq.}$ 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 6.    Switching times**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $t_{d(on)}$<br>$t_r$<br>$t_{d(off)}$<br>$t_f$ | Turn-on delay time<br>Rise time<br>Turn-off delay time<br>Fall time | $V_{DD}$= 300 V, $I_D$= 2.5 A,<br>$R_G$= 4.7 $\Omega$, $V_{GS}$=10 V<br>*(see Figure 17)* |  | 14<br>10<br>23<br>10 |  | 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 | $V_{DD}$= 480 V, $I_D$= 5 A,<br>$R_G$= 4.7 $\Omega$, $V_{GS}$=10 V |  | 7<br>10<br>17 |  | ns<br>ns<br>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 | $I_{SD}$ = 5A, $V_{GS}$=0 |  |  | 1.5 | V |
| $t_{rr}$<br>$Q_{rr}$<br>$I_{RRM}$ | Reverse recovery time<br>Reverse recovery charge<br>Reverse recovery current | $I_{SD}$ = 5 A, $V_{DD}$=100 V<br>di/dt = 100 A/µs,<br>*(see Figure 22)* |  | 300<br>1.95<br>13 |  | ns<br>µC<br>A |
| $t_{rr}$<br>$Q_{rr}$<br>$I_{RRM}$ | Reverse recovery time<br>Reverse recovery charge<br>Reverse recovery current | $I_{SD}$ = 5 A, $V_{DD}$ = 100 V<br>di/dt = 100 A/µs,<br>Tj=150 °C *(see Figure 22)* |  | 445<br>3.00<br>13.5 |  | ns<br>µC<br>A |

1.    Pulse width limited by safe operating area

2.    Pulsed: pulse duration=300µs, duty cycle 1.5%

## 2.1 Electrical characteristics (curves)

Figure 2. Safe operating area for TO-220/D²PAK
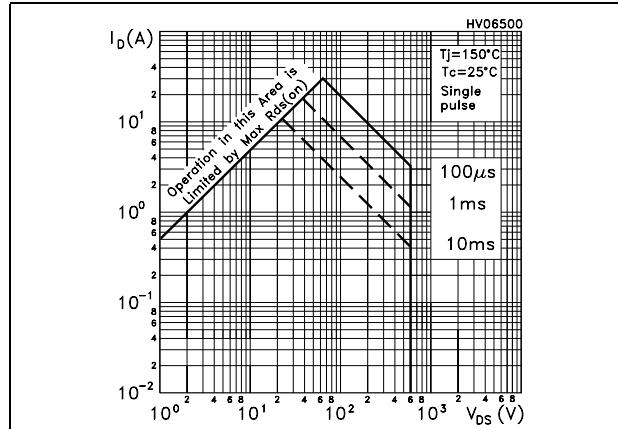
Figure 3. Thermal impedance for TO-220/D²PAK
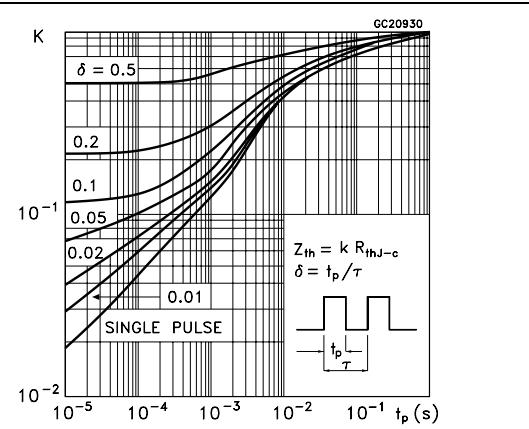




Figure 4. Safe operating area for TO-220FP
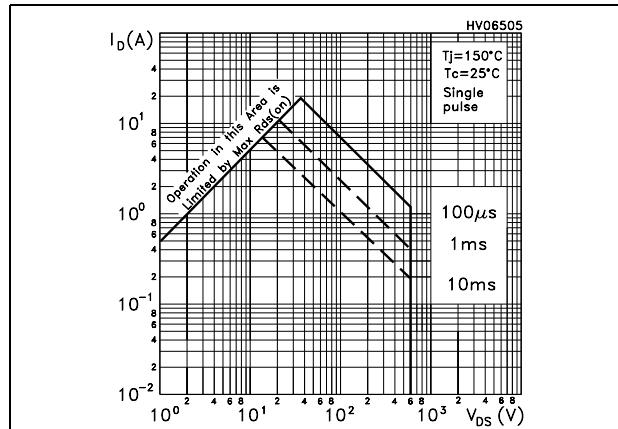
Figure 5. Thermal impedance for TO-220FP
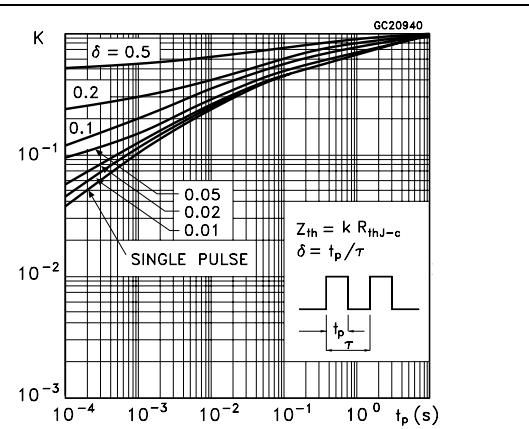




Figure 6. Safe operating area for DPAK/IPAK
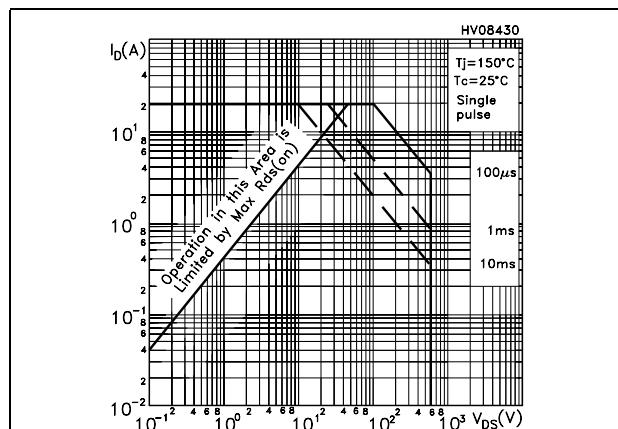
Figure 7. Thermal impedance for DPAK/IPAK
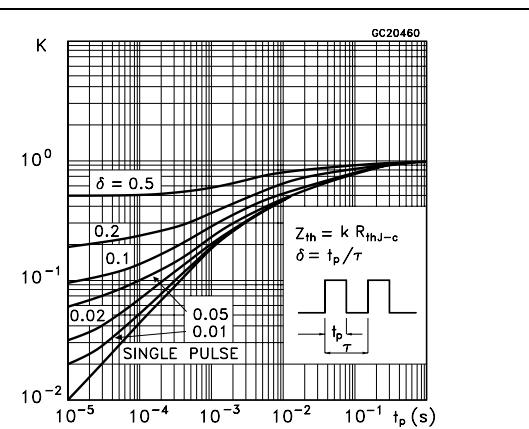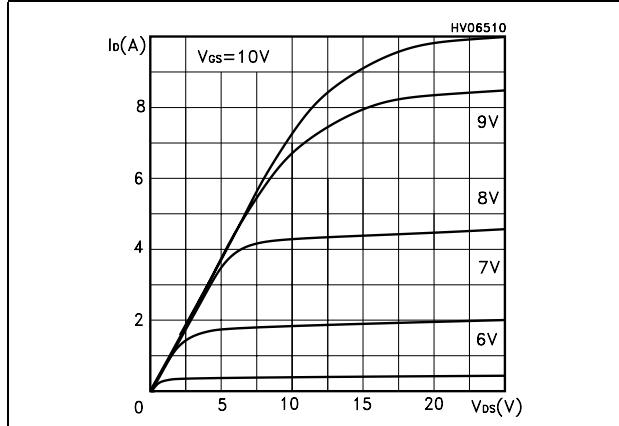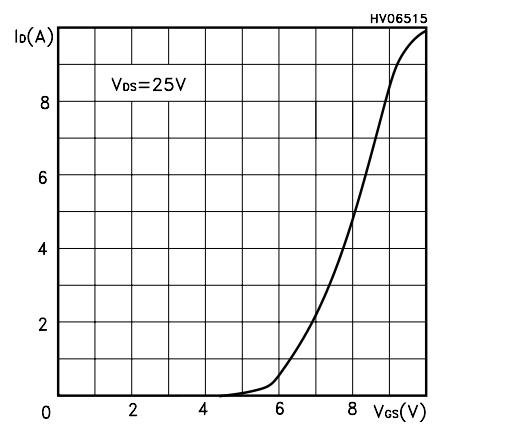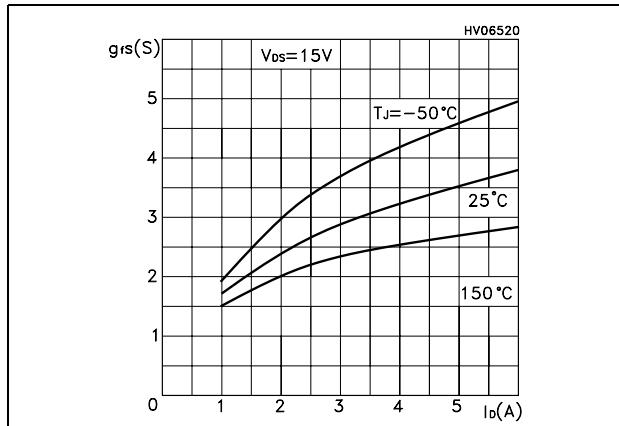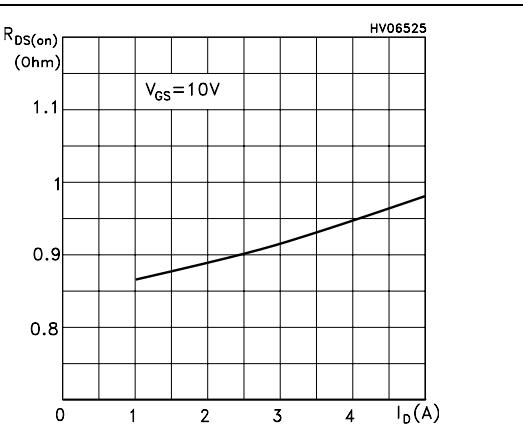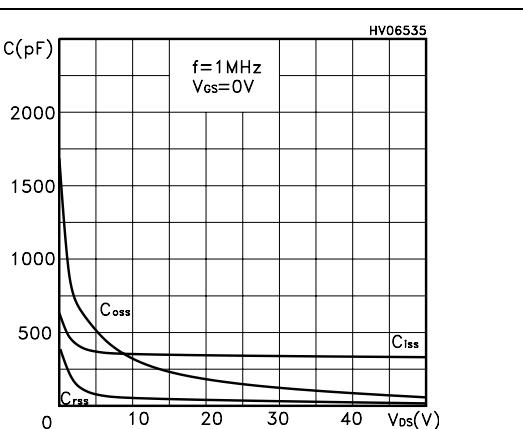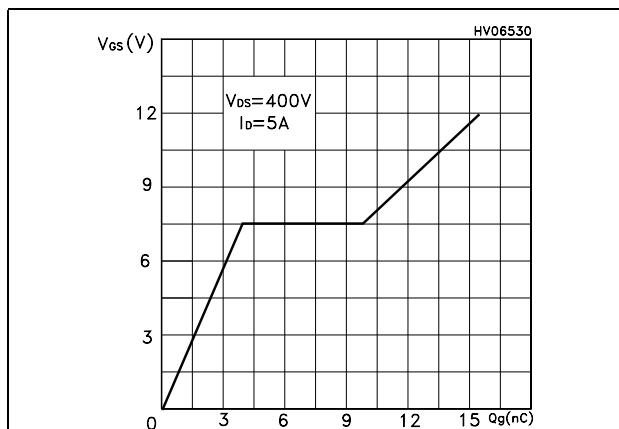
**Figure 8.    Output characteristics**



**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**
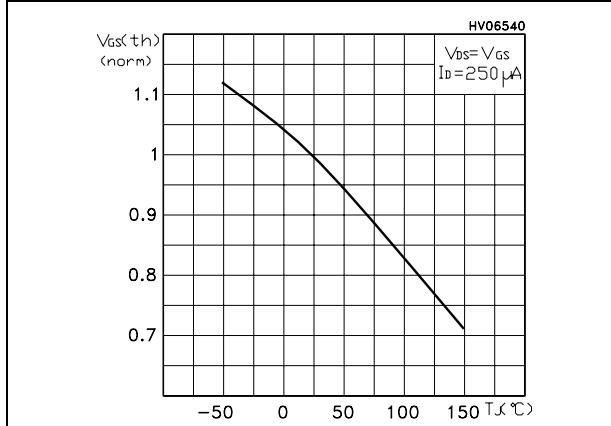


**Figure 15. Normalized on resistance vs temperature**
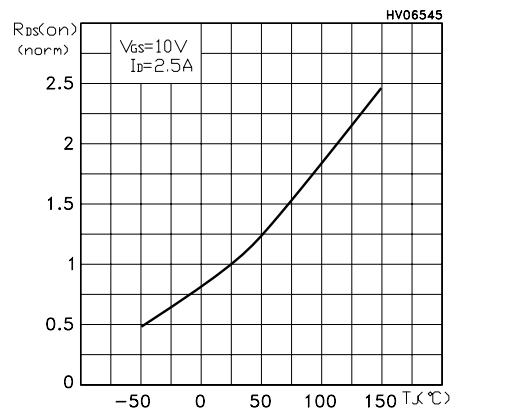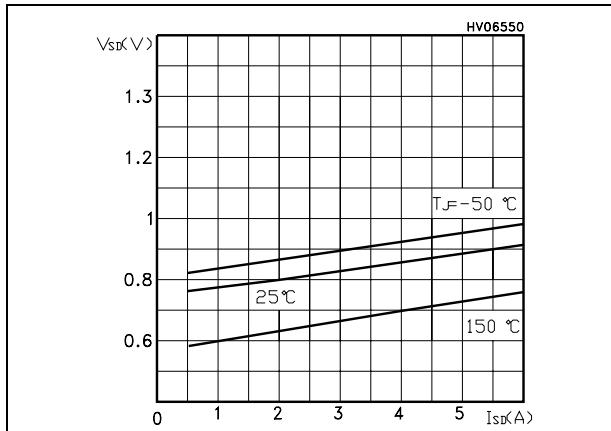


**Figure 16. Source-drain diode forward characteristics**

# 3      Test circuit

Figure 17.   Switching times test circuit for resistive load
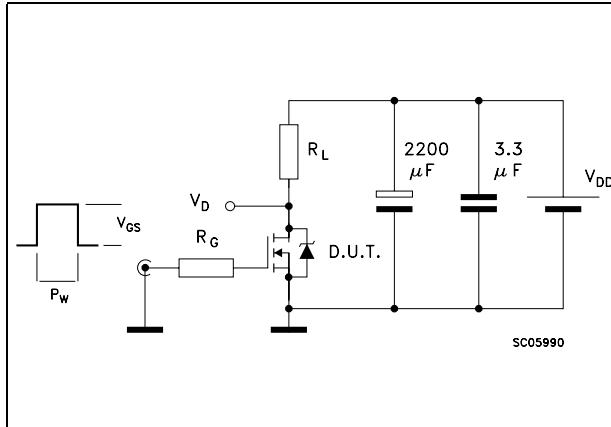


Figure 18.   Gate charge test circuit
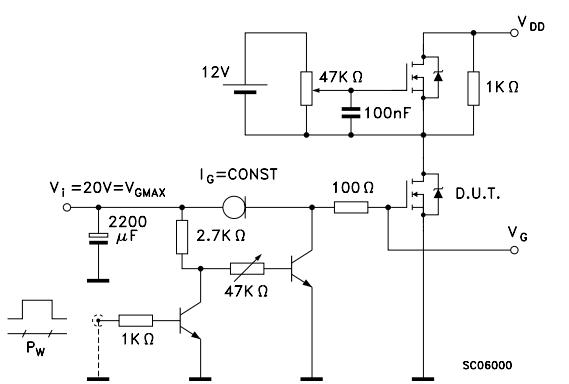


Figure 19.   Test circuit for inductive load switching and diode recovery times
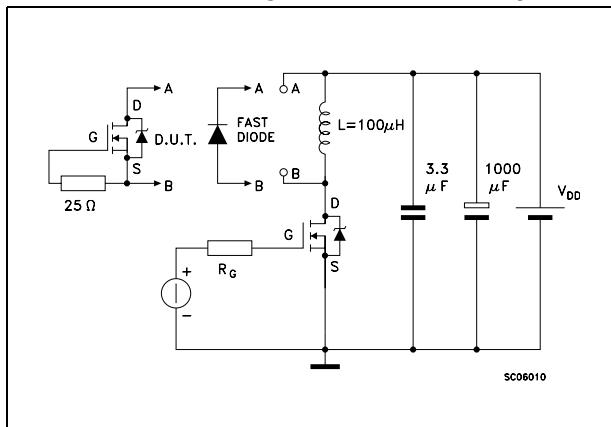


Figure 20.   Unclamped inductive load test circuit
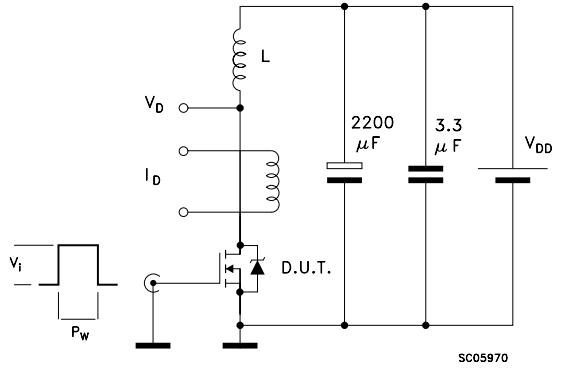


Figure 21.   Unclamped inductive waveform
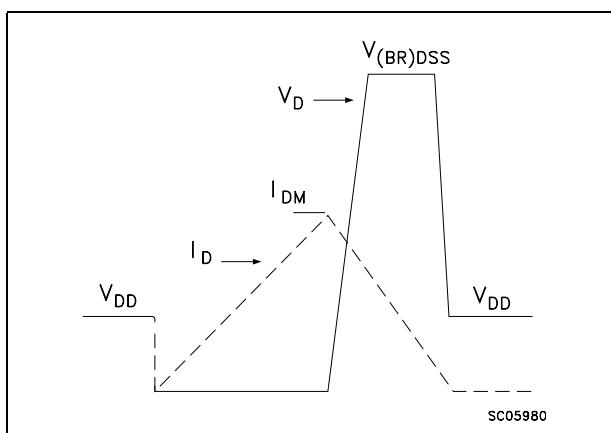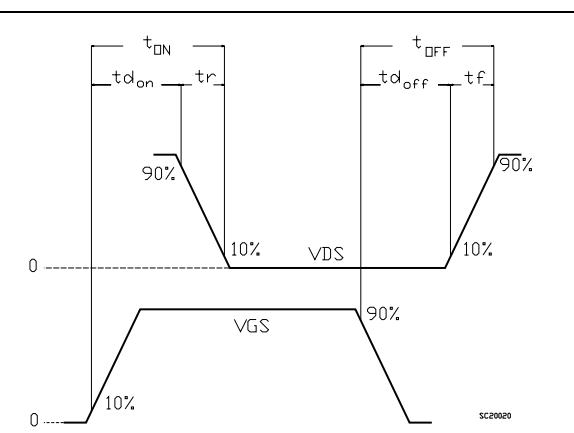


Figure 22.   Switching time waveform
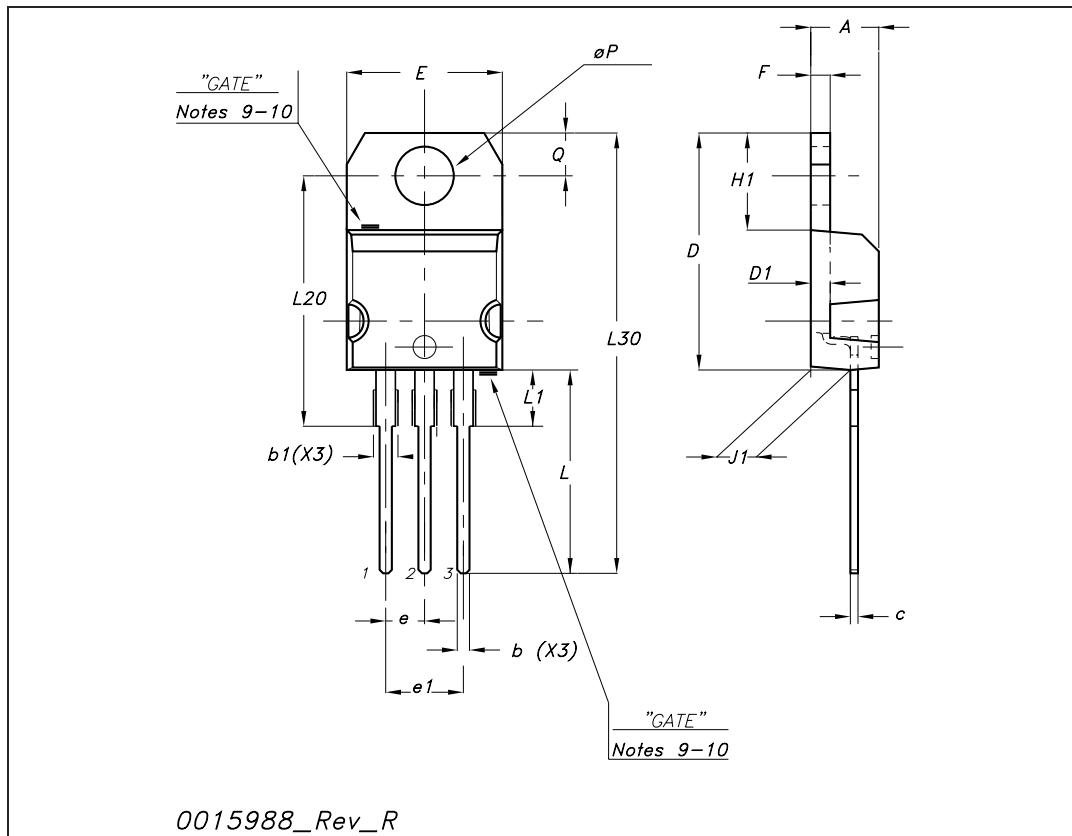
# 4        Package mechanical data

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*

## TO-220 mechanical data
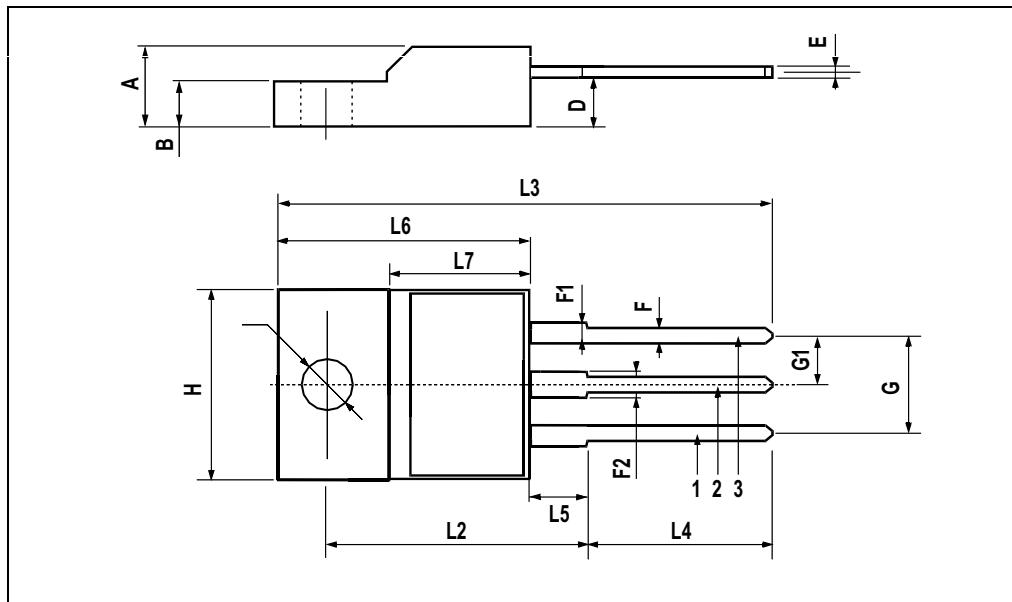
| Dim | mm | | | inch | | |
|---|---|---|---|---|---|---|
| | Min | Typ | Max | Min | Typ | Max |
| A | 4.40 | | 4.60 | 0.173 | | 0.181 |
| b | 0.61 | | 0.88 | 0.024 | | 0.034 |
| b1 | 1.14 | | 1.70 | 0.044 | | 0.066 |
| c | 0.48 | | 0.70 | 0.019 | | 0.027 |
| D | 15.25 | | 15.75 | 0.6 | | 0.62 |
| D1 | | 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 | |
| ∅P | 3.75 | | 3.85 | 0.147 | | 0.151 |
| Q | 2.65 | | 2.95 | 0.104 | | 0.116 |



0015988_Rev_R
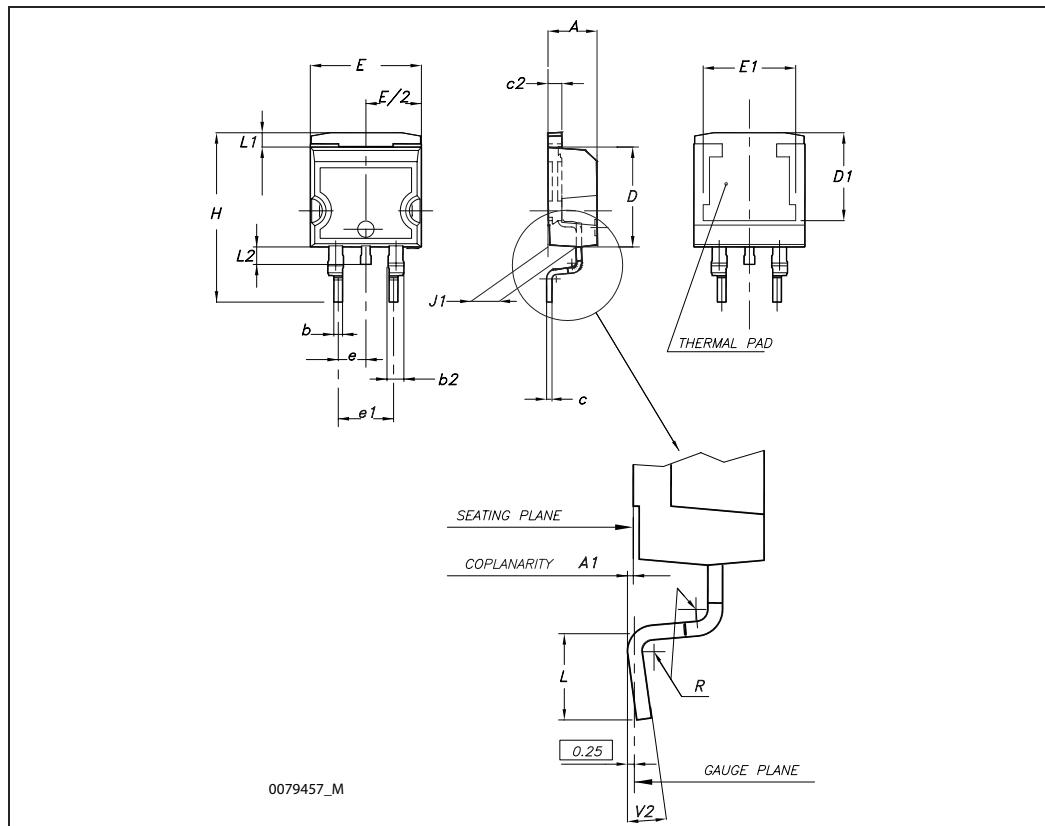
## TO-220FP MECHANICAL DATA

| 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 |
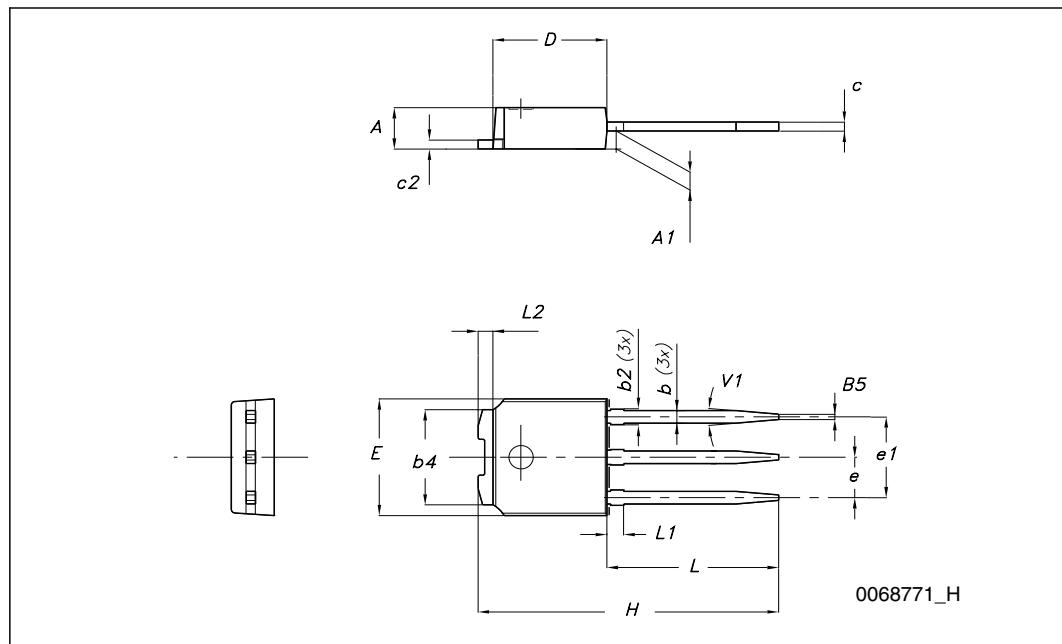
## D²PAK (TO-263) mechanical data

| Dim | mm | | | inch | | |
|-----|-----|-----|-----|-----|-----|-----|
|     | Min | Typ | Max | Min | Typ | Max |
| A | 4.40 | | 4.60 | 0.173 | | 0.181 |
| A1 | 0.03 | | 0.23 | 0.001 | | 0.009 |
| b | 0.70 | | 0.93 | 0.027 | | 0.037 |
| b2 | 1.14 | | 1.70 | 0.045 | | 0.067 |
| c | 0.45 | | 0.60 | 0.017 | | 0.024 |
| c2 | 1.23 | | 1.36 | 0.048 | | 0.053 |
| D | 8.95 | | 9.35 | 0.352 | | 0.368 |
| D1 | 7.50 | | | 0.295 | | |
| E | 10 | | 10.40 | 0.394 | | 0.409 |
| E1 | 8.50 | | | 0.334 | | |
| e | | 2.54 | | | 0.1 | |
| e1 | 4.88 | | 5.28 | 0.192 | | 0.208 |
| H | 15 | | 15.85 | 0.590 | | 0.624 |
| J1 | 2.49 | | 2.69 | 0.099 | | 0.106 |
| L | 2.29 | | 2.79 | 0.090 | | 0.110 |
| L1 | 1.27 | | 1.40 | 0.05 | | 0.055 |
| L2 | 1.30 | | 1.75 | 0.051 | | 0.069 |
| R | | 0.4 | | | 0.016 | |
| V2 | 0° | | 8° | 0° | | 8° |



0079457_M
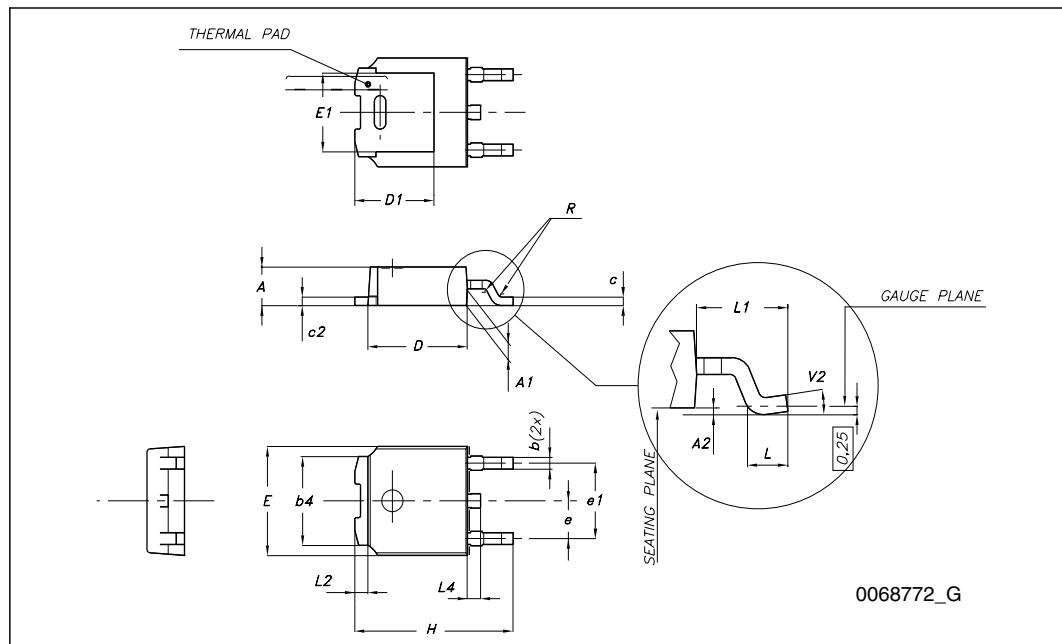
## TO-251 (IPAK) mechanical data

| DIM. | mm. | | |
|------|-----|-----|-----|
|      | min. | typ | max. |
| A | 2.20 | | 2.40 |
| A1 | 0.90 | | 1.10 |
| b | 0.64 | | 0.90 |
| b2 | | | 0.95 |
| b4 | 5.20 | | 5.40 |
| c | 0.45 | | 0.60 |
| c2 | 0.48 | | 0.60 |
| D | 6.00 | | 6.20 |
| E | 6.40 | | 6.60 |
| e | | 2.28 | |
| e1 | 4.40 | | 4.60 |
| H | | 16.10 | |
| L | 9.00 | | 9.40 |
| (L1) | 0.80 | | 1.20 |
| L2 | | 0.80 | |
| V1 | | 10 ° | |



0068771_H
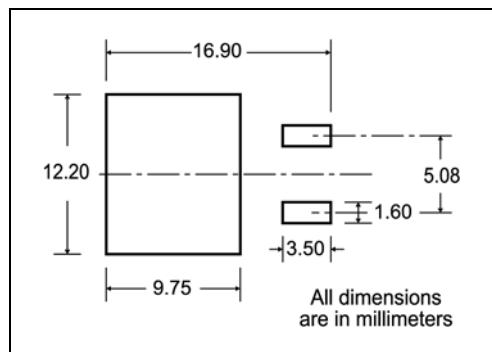
## TO-252 (DPAK) mechanical data

| DIM. | mm. | | |
|------|-----|-----|-----|
| | min. | typ | max. |
| A | 2.20 | | 2.40 |
| A1 | 0.90 | | 1.10 |
| A2 | 0.03 | | 0.23 |
| b | 0.64 | | 0.90 |
| b4 | 5.20 | | 5.40 |
| c | 0.45 | | 0.60 |
| c2 | 0.48 | | 0.60 |
| D | 6.00 | | 6.20 |
| D1 | | 5.10 | |
| E | 6.40 | | 6.60 |
| E1 | | 4.70 | |
| e | | 2.28 | |
| e1 | 4.40 | | 4.60 |
| H | 9.35 | | 10.10 |
| L | 1 | | |
| L1 | | 2.80 | |
| L2 | | 0.80 | |
| L4 | 0.60 | | 1 |
| R | | 0.20 | |
| V2 | 0 ° | | 8 ° |



0068772_G

# 5        Packaging mechanical data

### D²PAK FOOTPRINT



### TAPE AND REEL SHIPMENT



REEL MECHANICAL DATA

| DIM. | mm | | inch | |
|------|------|------|------|------|
|      | MIN. | MAX. | MIN. | MAX. |
| A    |      | 330  |      | 12.992 |
| B    | 1.5  |      | 0.059 |      |
| C    | 12.8 | 13.2 | 0.504 | 0.520 |
| D    | 20.2 |      | 0795 |      |
| G    | 24.4 | 26.4 | 0.960 | 1.039 |
| N    | 100  |      | 3.937 |      |
| T    |      | 30.4 |      | 1.197 |

| BASE QTY | BULK QTY |
|----------|----------|
| 1000     | 1000     |
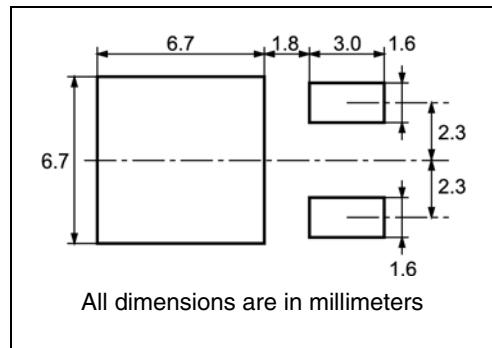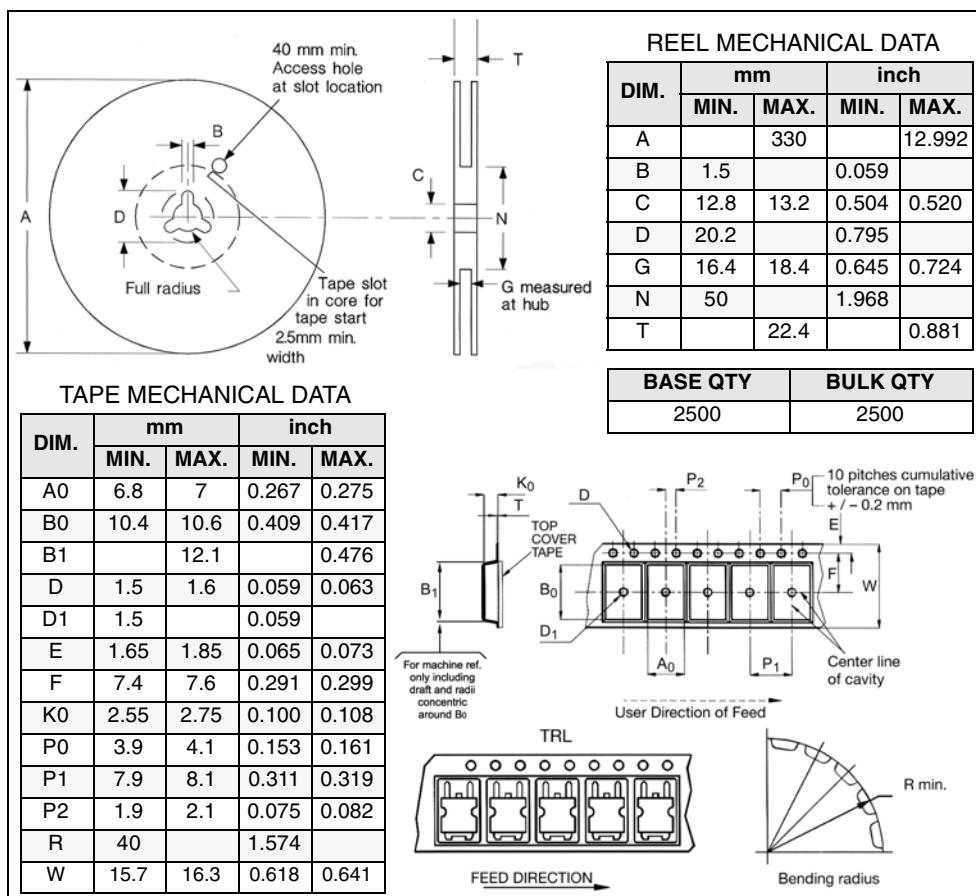
TAPE MECHANICAL DATA

| DIM. | mm | | inch | |
|------|------|------|------|------|
|      | MIN. | MAX. | MIN. | MAX. |
| A0   | 10.5 | 10.7 | 0.413 | 0.421 |
| B0   | 15.7 | 15.9 | 0.618 | 0.626 |
| D    | 1.5  | 1.6  | 0.059 | 0.063 |
| D1   | 1.59 | 1.61 | 0.062 | 0.063 |
| E    | 1.65 | 1.85 | 0.065 | 0.073 |
| F    | 11.4 | 11.6 | 0.449 | 0.456 |
| K0   | 4.8  | 5.0  | 0.189 | 0.197 |
| P0   | 3.9  | 4.1  | 0.153 | 0.161 |
| P1   | 11.9 | 12.1 | 0.468 | 0.476 |
| P2   | 1.9  | 2.1  | 0.075 | 0.082 |
| R    | 50   |      | 1.574 |      |
| T    | 0.25 | 0.35 | 0.0098 | 0.0137 |
| W    | 23.7 | 24.3 | 0.933 | 0.956 |

* on sales type

## DPAK FOOTPRINT



All dimensions are in millimeters

## TAPE AND REEL SHIPMENT



### REEL MECHANICAL DATA

| DIM. | mm | | inch | |
|------|------|------|-------|--------|
| | MIN. | MAX. | MIN. | MAX. |
| A | | 330 | | 12.992 |
| B | 1.5 | | 0.059 | |
| C | 12.8 | 13.2 | 0.504 | 0.520 |
| D | 20.2 | | 0.795 | |
| G | 16.4 | 18.4 | 0.645 | 0.724 |
| N | 50 | | 1.968 | |
| T | | 22.4 | | 0.881 |

| BASE QTY | BULK QTY |
|----------|----------|
| 2500 | 2500 |

### TAPE MECHANICAL DATA

| DIM. | mm | | inch | |
|------|------|------|-------|--------|
| | MIN. | MAX. | MIN. | MAX. |
| A0 | 6.8 | 7 | 0.267 | 0.275 |
| B0 | 10.4 | 10.6 | 0.409 | 0.417 |
| B1 | | 12.1 | | 0.476 |
| D | 1.5 | 1.6 | 0.059 | 0.063 |
| D1 | 1.5 | | 0.059 | |
| E | 1.65 | 1.85 | 0.065 | 0.073 |
| F | 7.4 | 7.6 | 0.291 | 0.299 |
| K0 | 2.55 | 2.75 | 0.100 | 0.108 |
| P0 | 3.9 | 4.1 | 0.153 | 0.161 |
| P1 | 7.9 | 8.1 | 0.311 | 0.319 |
| P2 | 1.9 | 2.1 | 0.075 | 0.082 |
| R | 40 | | 1.574 | |
| W | 15.7 | 16.3 | 0.618 | 0.641 |

# 6 Revision history

**Table 8.    Document revision history**

| Date | Revision | Changes |
|------|----------|---------|
| 14-Apr-2004 | 11 | Title changed |
| 11-Apr-2005 | 12 | Inserted D²PAK |
| 21-Feb-2006 | 13 | New template |
| 08-Sep-2006 | 14 | Modified order codes |
| 14-Sep-2006 | 15 | Corrected *Figure 6.: Safe operating area for DPAK/IPAK* |
| 09-Jul-2007 | 16 | Qrr value in *Table 7.: Source drain diode* has been updated |
| 01-Oct-2008 | 17 | *4: Package mechanical data* updated |

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