



# STB13NK60ZT4, STP13NK60Z STP13NK60ZFP, STW13NK60Z

N-channel 600 V, 0.48  $\Omega$ , 13 A, TO-220, TO-220FP, D<sup>2</sup>PAK  
TO-247 Zener-protected SuperMESH™ Power MOSFET

## Features

| Type         | V <sub>DSS</sub> | R <sub>DS(on) max</sub> | I <sub>D</sub> | P <sub>w</sub> |
|--------------|------------------|-------------------------|----------------|----------------|
| STB13NK60ZT4 | 600 V            | <0.55 $\Omega$          | 13 A           | 150 W          |
| STP13NK60ZFP | 600 V            | <0.55 $\Omega$          | 13 A           | 35 W           |
| STP13NK60Z   | 600 V            | <0.55 $\Omega$          | 13 A           | 150 W          |
| STW13NK60Z   | 600 V            | <0.55 $\Omega$          | 13 A           | 150 W          |

- Gate charge minimized
- Very low intrinsic capacitances
- Very good manufacturing repeatability

## 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.

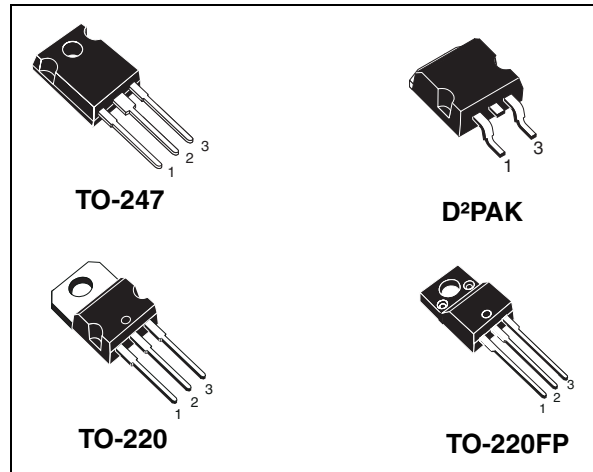


Figure 1. Internal schematic diagram

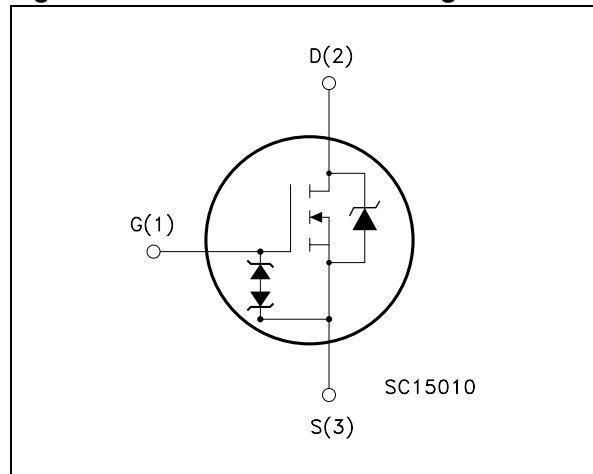


Table 1. Device summary

| Order codes  | Marking    | Package            | Packaging     |
|--------------|------------|--------------------|---------------|
| STB13NK60ZT4 | B13NK60Z   | D <sup>2</sup> PAK | Tape and reel |
| STP13NK60ZFP | P13NK60ZFP | TO-220FP           | Tube          |
| STP13NK60Z   | P13NK60Z   | TO-220             | Tube          |
| STW13NK60Z   | W13NK60Z   | TO-247             | Tube          |

# Contents

|          |   |           |
|----------|---|-----------|
| <b>1</b> | <b>Electrical ratings</b> .....               | <b>3</b>  |
| <b>2</b> | <b>Electrical characteristics</b> .....       | <b>5</b>  |
|          | 2.1 Electrical characteristics (curves) ..... | 7         |
| <b>3</b> | <b>Test circuits</b> .....                    | <b>10</b> |
| <b>4</b> | <b>Package mechanical data</b> .....          | <b>11</b> |
| <b>5</b> | <b>Packing mechanical data</b> .....          | <b>16</b> |
| <b>6</b> | <b>Revision history</b> .....                 | <b>17</b> |

# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol                             | Parameter   | Value                                 |                    | Unit |
|------------------------------------|---|---------------------------------------|--------------------|------|
|                                    |   | TO-220 / TO-247<br>D <sup>2</sup> PAK | TO-220FP           |      |
| V <sub>DS</sub>                    | Drain-source voltage (V <sub>GS</sub> = 0)            | 600                                   |                    | V    |
| V <sub>GS</sub>                    | Gate-source voltage                                   | ± 30                                  |                    | V    |
| I <sub>D</sub>                     | Drain current (continuous) at T <sub>C</sub> = 25 °C  | 13                                    | 13 <sup>(1)</sup>  | A    |
| I <sub>D</sub>                     | Drain current (continuous) at T <sub>C</sub> = 100 °C | 8.2                                   | 8.2 <sup>(1)</sup> | A    |
| I <sub>DM</sub> <sup>(2)</sup>     | Drain current (pulsed)                                | 52                                    | 52 <sup>(1)</sup>  | A    |
| P <sub>TOT</sub>                   | Total dissipation at T <sub>C</sub> = 25 °C           | 150                                   | 35                 | W    |
|                                    | Derating factor                                       | 1.20                                  | 0.27               | W/°C |
| Vesd(G-S)                          | G-S ESD (HBM C=100pF, R=1.5 kΩ)                       | 4000                                  |                    | V    |
| dv/dt <sup>(3)</sup>               | Peak diode recovery voltage slope                     | 4.5                                   |                    | V/ns |
| V <sub>ISO</sub>                   | Insulation withstand voltage (AC)                     | --                                    | 2500               | V    |
| T <sub>j</sub><br>T <sub>stg</sub> | Operating junction temperature<br>Storage temperature | -55 to 150                            |                    | °C   |

1. Limited only by maximum temperature allowed
2. Pulse width limited by safe operating area
3. I<sub>SD</sub> ≤ 13 A, di/dt ≤ 200 A/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>TO-247 | D <sup>2</sup> PAK | TO-220FP |      |
| R <sub>thj-case</sub>               | Thermal resistance junction-case max           | 0.83             |                    | 3.6      | °C/W |
| R <sub>thj-pcb</sub> <sup>(1)</sup> | Thermal resistance junction-pcb max            | --               | 60                 | --       | °C/W |
| R <sub>thj-amb</sub>                | Thermal resistance junction-amb max            | 62.5             |                    |          | °C/W |
| T <sub>l</sub>                      | Maximum lead temperature for soldering purpose | 300              |                    |          | °C   |

1. When mounted on minimum footprint

**Table 4. Avalanche characteristics**

| Symbol   | Parameter  | Max value | Unit |
|----------|--|-----------|------|
| $I_{AR}$ | Avalanche current, repetitive or not-repetitive (pulse width limited by $T_j$ max)                             | 10        | A    |
| $E_{AS}$ | Single pulse avalanche energy (starting $T_j=25\text{ }^\circ\text{C}$ , $I_D=I_{AR}$ , $V_{DD}=50\text{ V}$ ) | 400       | mJ   |

## 2 Electrical characteristics

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

**Figure 2. 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>$V_{DS} = \text{Max rating}, T_c = 125\text{ °C}$ |      |      | 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                | $V_{GS} = 10\text{ V}, I_D = 4.5\text{ A}$   |      | 0.48 | 0.55     | $\Omega$                       |

**Table 5. Dynamic**

| Symbol                              | Parameter   | Test conditions   | Min. | Typ.              | Max. | Unit           |
|-------------------------------------|---|---|------|-------------------|------|----------------|
| $g_{fs}^{(1)}$                      | Forward transconductance  | $V_{DS} = 8\text{ V}, I_D = 5\text{ A}$   | -    | 11                |      | S              |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25\text{ V}, f = 1\text{ MHz}, V_{GS} = 0$                                    | -    | 2030<br>210<br>48 |      | pF<br>pF<br>pF |
| $C_{oss\text{ eq.}}^{(2)}$          | Equivalent output capacitance   | $V_{GS} = 0, V_{DS} = 0\text{ to }480\text{ V}$   | -    | 125               |      | pF             |
| $Q_g$<br>$Q_{gs}$<br>$Q_{gd}$       | Total gate charge<br>Gate-source charge<br>Gate-drain charge            | $V_{DD} = 480\text{ V}, I_D = 10\text{ A}$<br>$V_{GS} = 10\text{ V}$<br>(see Figure 21) | -    | 66<br>11<br>33    | 92   | 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 6. Switching times**

| Symbol                          | Parameter   | Test conditions  | Min. | Typ.          | Max. | Unit           |
|---------------------------------|---|--|------|---------------|------|----------------|
| $t_{d(on)}$<br>$t_r$            | Turn-on delay time<br>Rise time                       | $V_{DD}=300\text{ V}$ , $I_D=5\text{ A}$ ,<br>$R_G=4.7\ \Omega$ , $V_{GS}=10\text{ V}$<br>(see Figure 20)  | -    | 22<br>14      | -    | ns<br>ns       |
| $t_{d(off)}$<br>$t_f$           | Turn-off delay time<br>Fall time                      | $V_{DD}=300\text{ V}$ , $I_D=5\text{ A}$ ,<br>$R_G=4.7\ \Omega$ , $V_{GS}=10\text{ V}$<br>(see Figure 20)  | -    | 61<br>12      | -    | ns<br>ns       |
| $t_{r(Voff)}$<br>$t_f$<br>$t_c$ | Off-voltage rise time<br>Fall time<br>Cross-over time | $V_{DD}=480\text{ V}$ , $I_D=10\text{ A}$ ,<br>$R_G=4.7\ \Omega$ , $V_{GS}=10\text{ V}$<br>(see Figure 20) | -    | 10<br>9<br>20 | -    | ns<br>ns<br>ns |

**Table 7. Gate-source Zener diode**

| Symbol     | Parameter                     | Test conditions                          | Min. | Typ. | Max. | Unit |
|------------|-------------------------------|--|------|------|------|------|
| $BV_{GSO}$ | Gate-source breakdown voltage | $I_{GS}=\pm 1\text{ mA}$<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.

**Table 8. Source drain diode**

| Symbol                            | Parameter  | Test conditions  | Min. | Typ.             | Max.     | Unit                     |
|-----------------------------------|--|--|------|------------------|----------|--------------------------|
| $I_{SD}$<br>$I_{SDM}^{(1)}$       | Source-drain current<br>Source-drain current<br>(pulsed)                     |  | -    |                  | 10<br>40 | A<br>A                   |
| $V_{SD}^{(2)}$                    | Forward on voltage   | $I_{SD}=10\text{ A}$ , $V_{GS}=0$  | -    |                  | 1.6      | V                        |
| $t_{rr}$<br>$Q_{rr}$<br>$I_{RRM}$ | Reverse recovery time<br>Reverse recovery charge<br>Reverse recovery current | $I_{SD}=10\text{ A}$ ,<br>$di/dt=100\text{ A}/\mu\text{s}$ ,<br>$V_{DD}=35\text{ V}$ , $T_j=150\text{ }^\circ\text{C}$ | -    | 570<br>4.5<br>16 |          | ns<br>$\mu\text{C}$<br>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 3. Safe operating area for TO-220/D<sup>2</sup>PAK

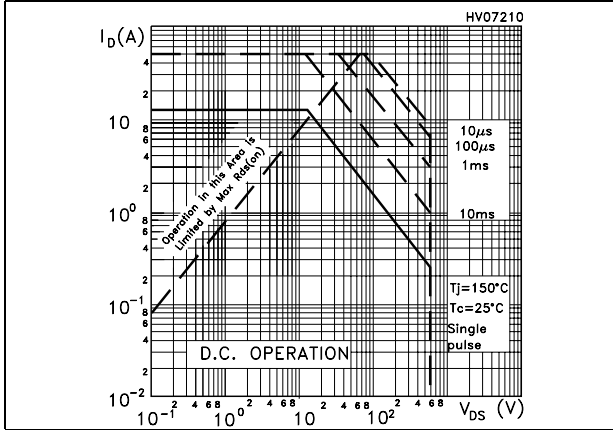


Figure 4. Thermal impedance for TO-220/D<sup>2</sup>PAK

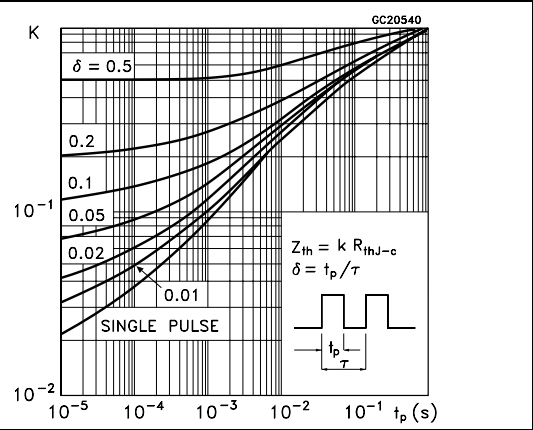


Figure 5. Safe operating area for TO-220FP

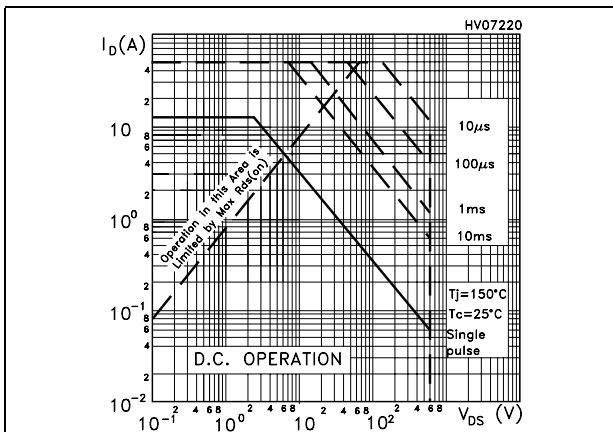


Figure 6. Thermal impedance for TO-220FP

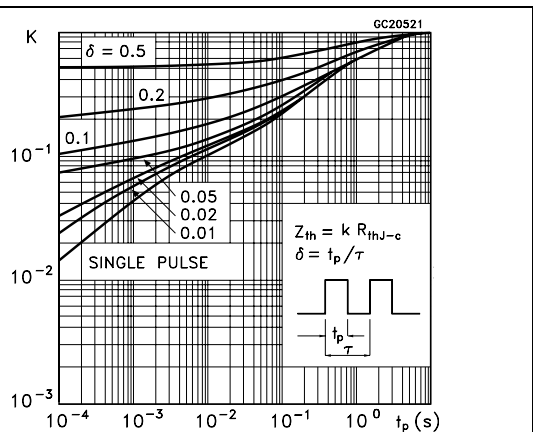


Figure 7. Safe operating area for TO-247

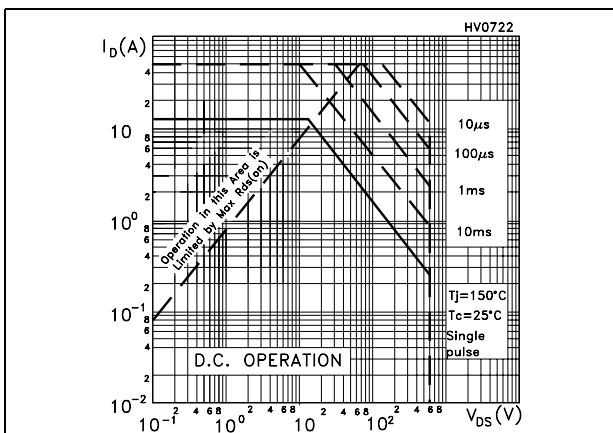


Figure 8. Thermal impedance for TO-247

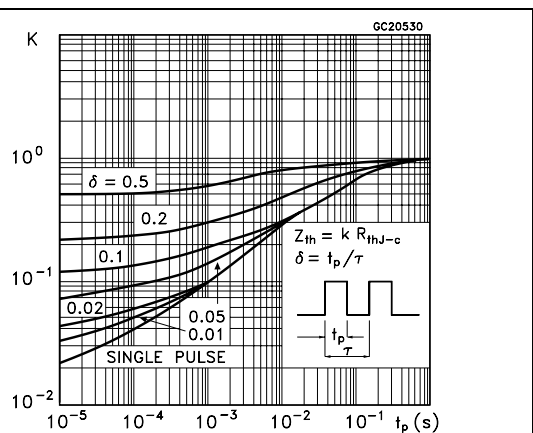


Figure 9. Output characteristics

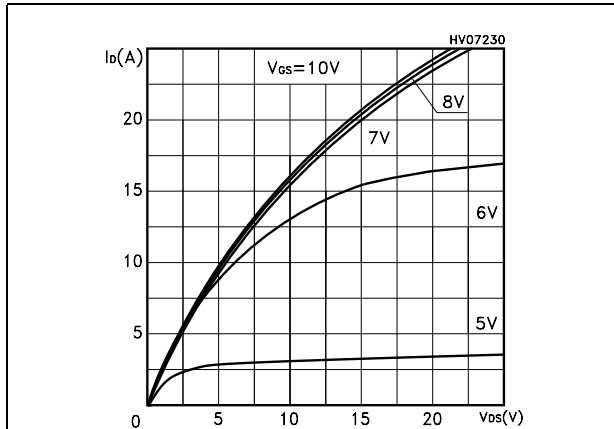


Figure 10. Transfer characteristics

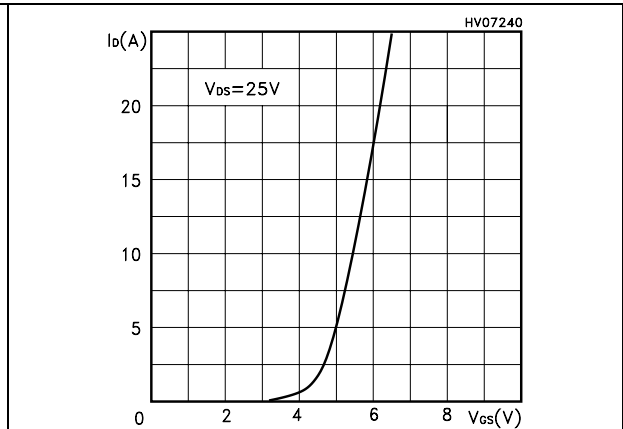


Figure 11. Transconductance

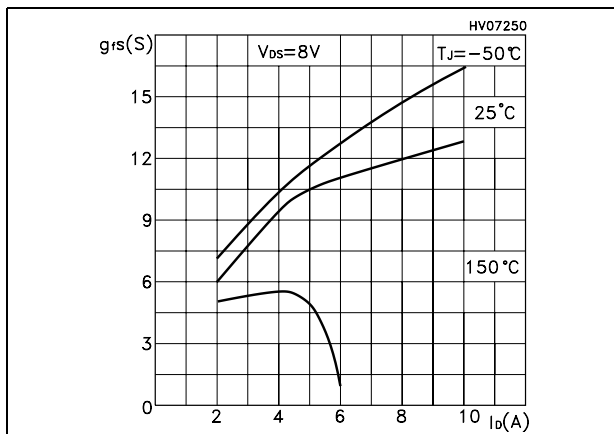


Figure 12. Static drain-source on resistance

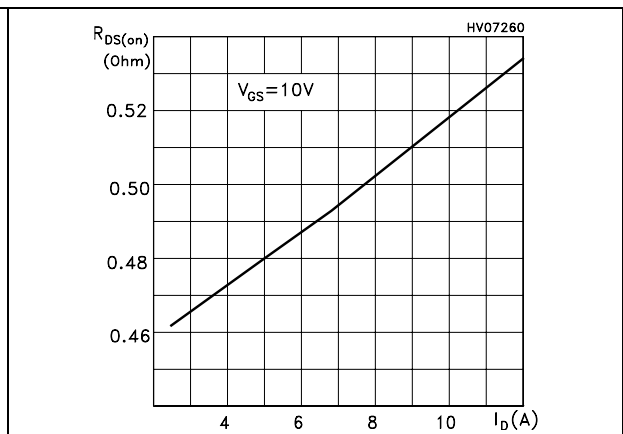


Figure 13. Gate charge vs gate-source voltage Figure 14. Capacitance variations

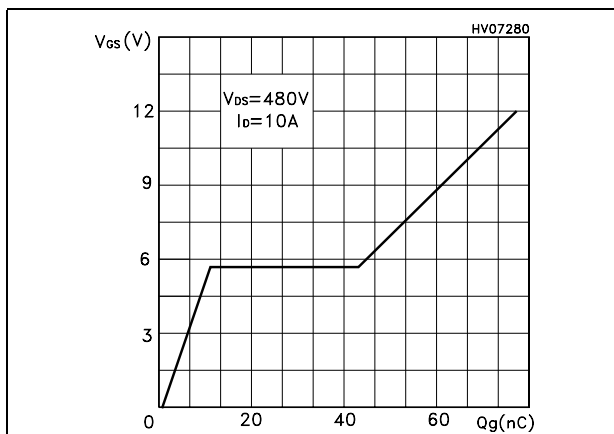


Figure 14. Capacitance variations

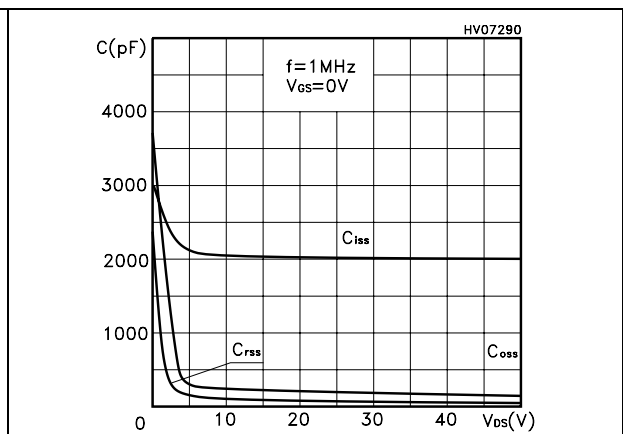




Figure 15. Normalized gate threshold voltage vs temperature

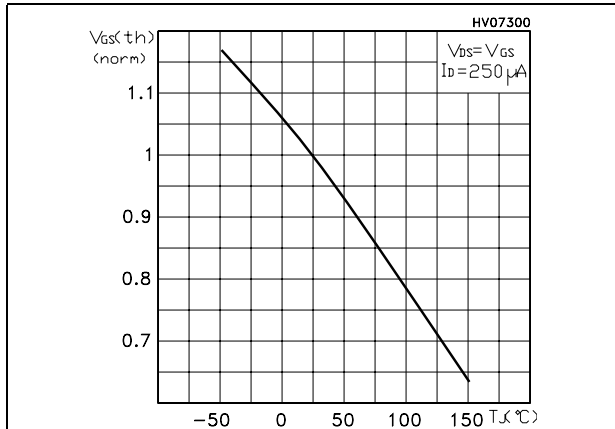


Figure 16. Normalized on resistance vs temperature

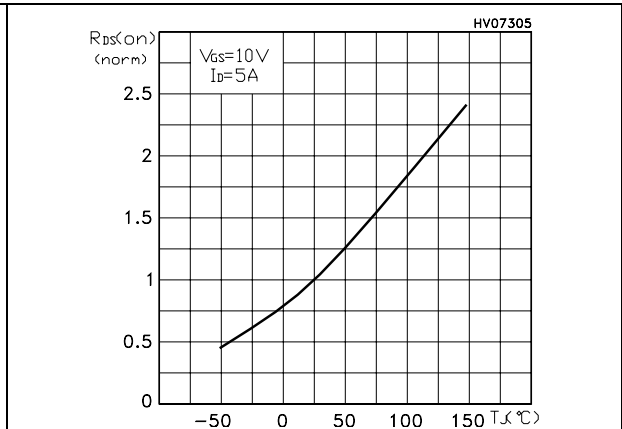


Figure 17. Source-drain diode forward characteristics

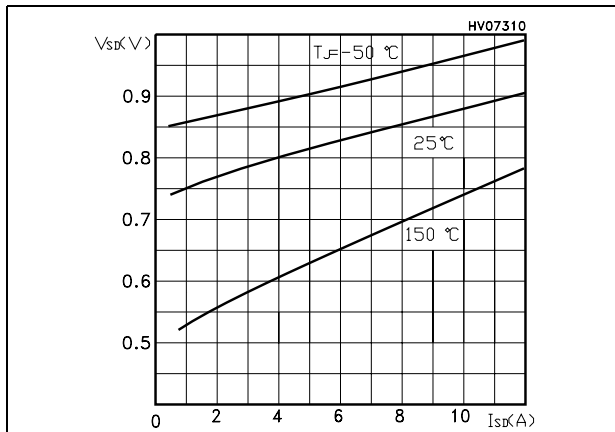


Figure 18. Normalized BV<sub>DSS</sub> vs temperature

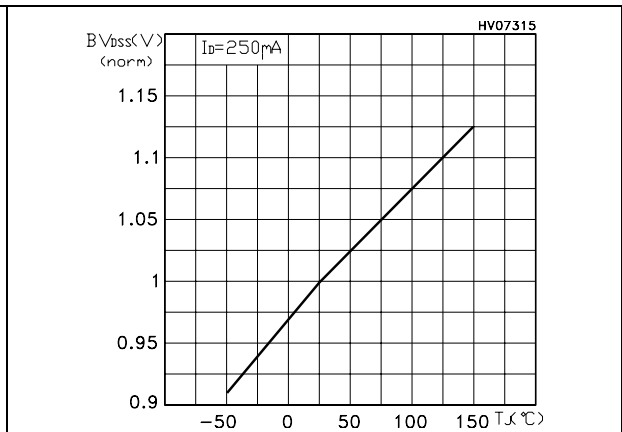
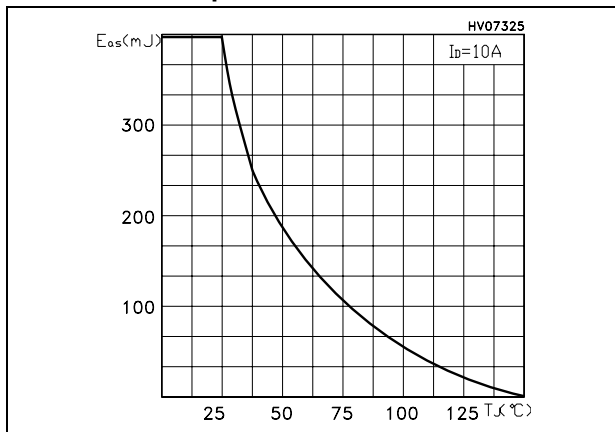


Figure 19. Maximum avalanche energy vs temperature



### 3 Test circuits

Figure 20. Switching times test circuit for resistive load

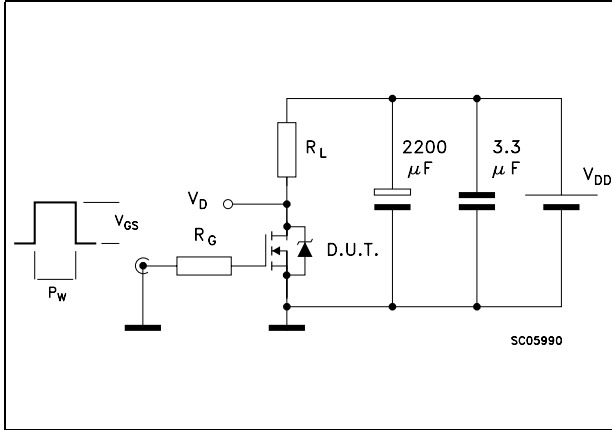


Figure 21. Gate charge test circuit

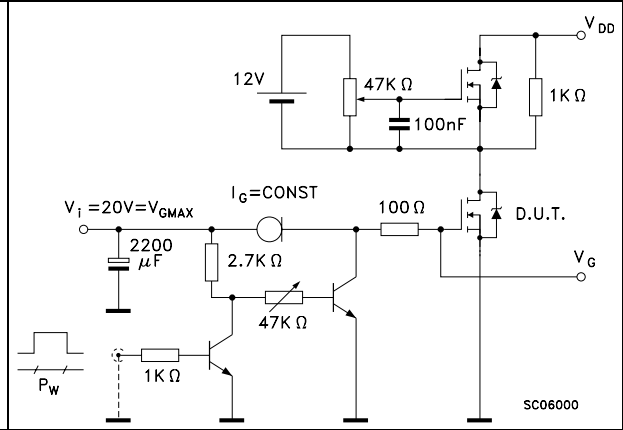


Figure 22. Test circuit for inductive load switching and diode recovery times

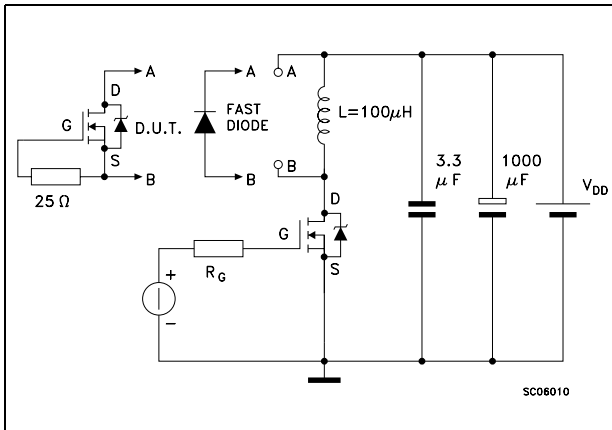


Figure 23. Unclamped inductive load test circuit

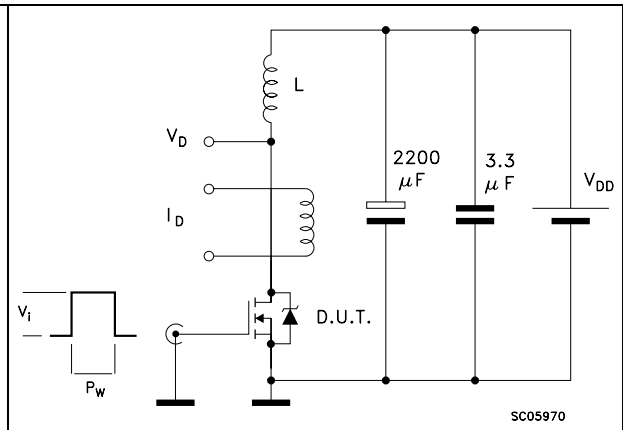


Figure 24. Unclamped inductive waveform

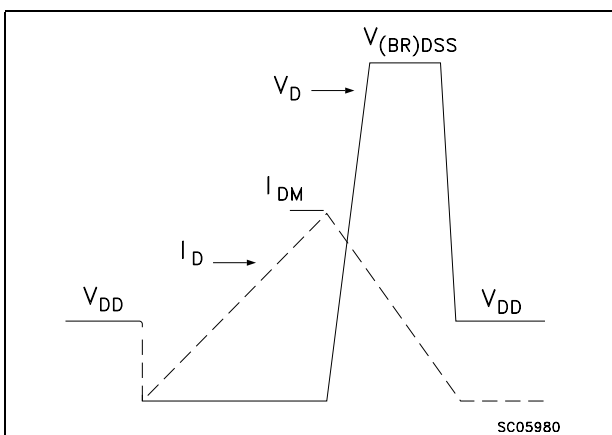
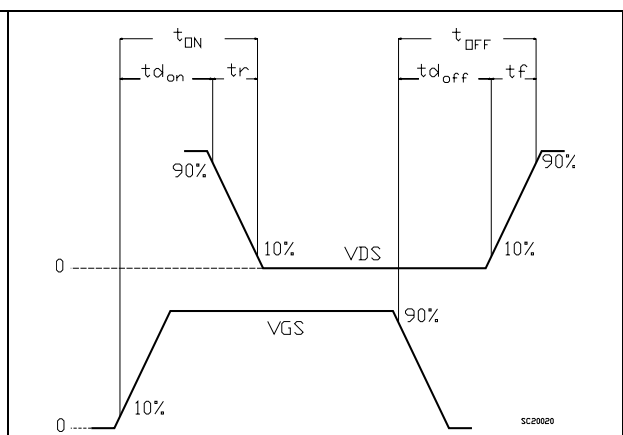


Figure 25. Switching time waveform

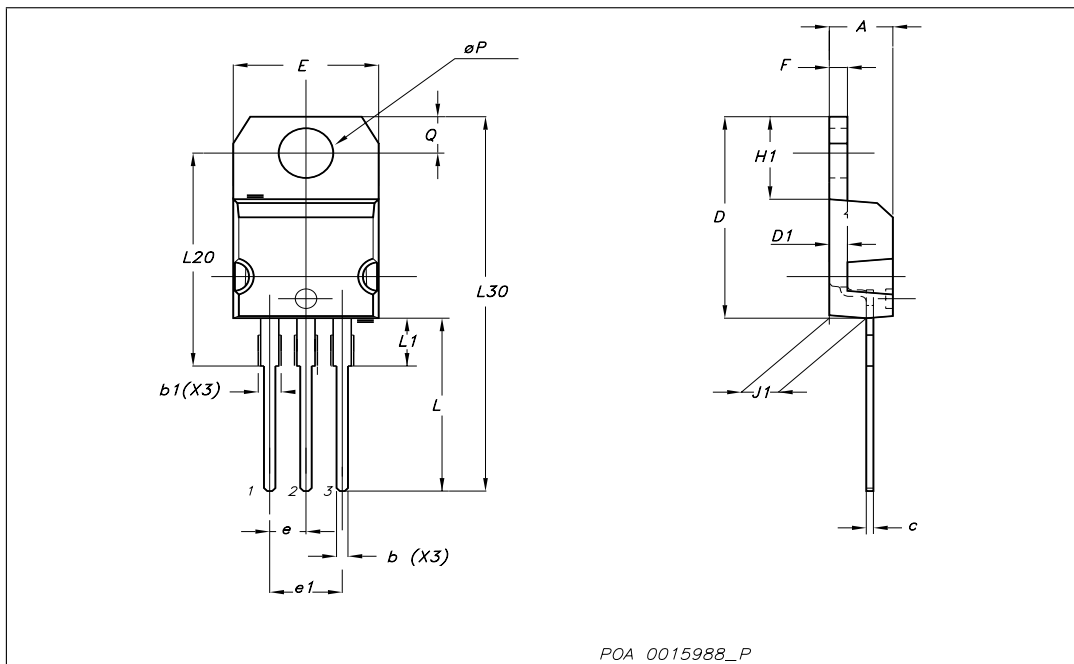


## 4 Package mechanical data

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

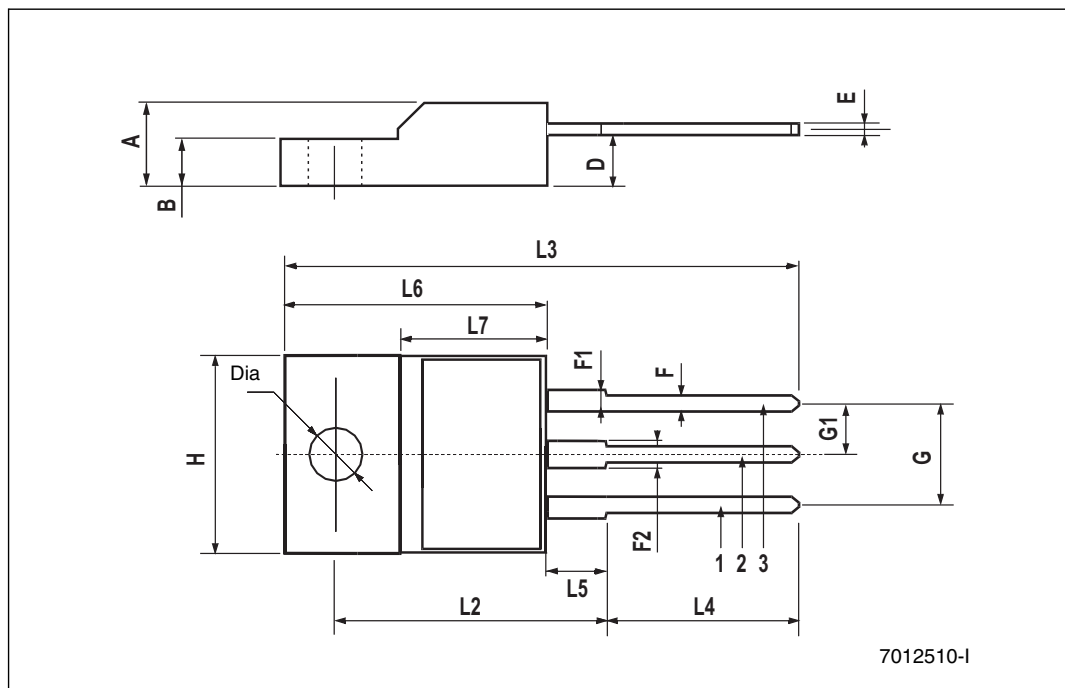
TO-220 mechanical data

| 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 |       |
| ∅P  | 3.75  |       | 3.85  | 0.147 |       | 0.151 |
| Q   | 2.65  |       | 2.95  | 0.104 |       | 0.116 |



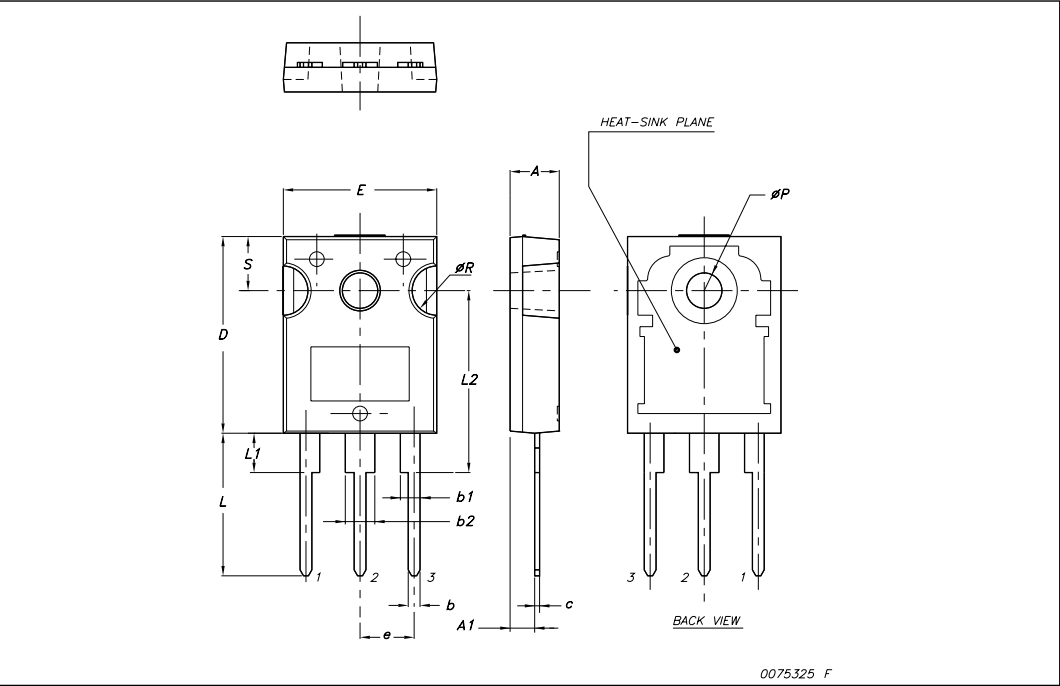
## TO-220FP mechanical data

| Dim. | mm.   |     |       | inch  |       |       |
|------|-------|-----|-------|-------|-------|-------|
|      | Min.  | Typ | Max.  | Min.  | Typ.  | Max.  |
| A    | 4.40  |     | 4.60  | 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  |     | 0.70  | 0.017 |       | 0.027 |
| F    | 0.75  |     | 1.00  | 0.030 |       | 0.039 |
| F1   | 1.15  |     | 1.50  | 0.045 |       | 0.067 |
| F2   | 1.15  |     | 1.50  | 0.045 |       | 0.067 |
| G    | 4.95  |     | 5.20  | 0.195 |       | 0.204 |
| G1   | 2.40  |     | 2.70  | 0.094 |       | 0.106 |
| H    | 10    |     | 10.40 | 0.393 |       | 0.409 |
| L2   |       | 16  |       |       | 0.630 |       |
| L3   | 28.6  |     | 30.6  | 1.126 |       | 1.204 |
| L4   | 9.80  |     | 10.60 | 0.385 |       | 0.417 |
| L5   | 2.9   |     | 3.6   | 0.114 |       | 0.141 |
| L6   | 15.90 |     | 16.40 | 0.626 |       | 0.645 |
| L7   | 9     |     | 9.30  | 0.354 |       | 0.366 |
| Dia  | 3     |     | 3.2   | 0.118 |       | 0.126 |



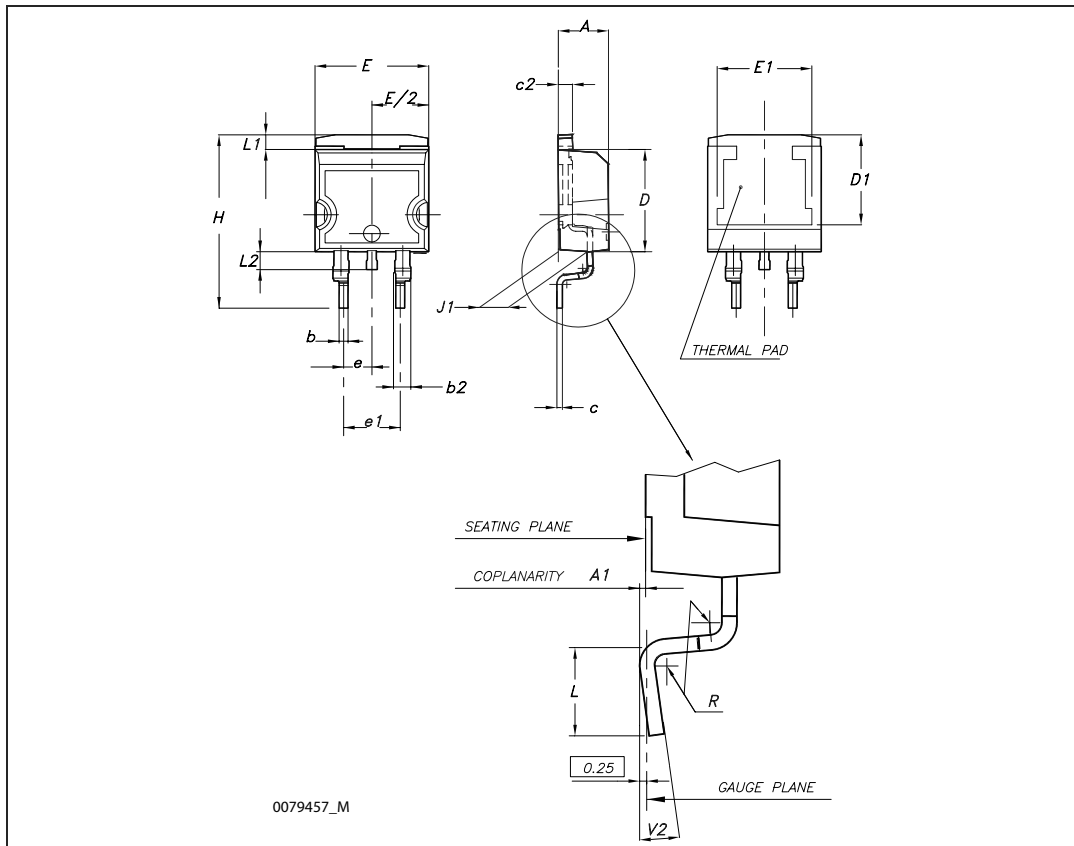
**TO-247 Mechanical data**

| 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    |       | 5.45  |       |
| L    | 14.20 |       | 14.80 |
| L1   | 3.70  |       | 4.30  |
| L2   |       | 18.50 |       |
| øP   | 3.55  |       | 3.65  |
| øR   | 4.50  |       | 5.50  |
| S    |       | 5.50  |       |



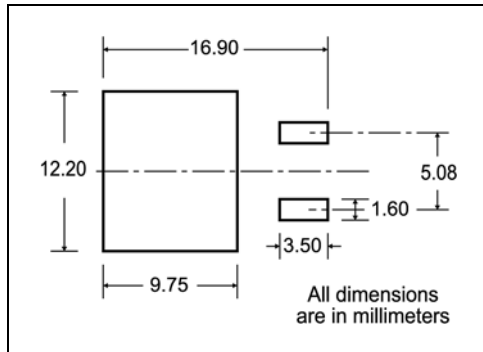
**D<sup>2</sup>PAK (TO-263) mechanical data**

| 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°    |



# 5 Packing mechanical data

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



## TAPE AND REEL SHIPMENT

**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  |

**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    | 24.4 | 26.4 | 0.960 | 1.039  |
| N    | 100  |      | 3.937 |        |
| T    |      | 30.4 |       | 1.197  |

| BASE QTY | BULK QTY |
|----------|----------|
| 1000     | 1000     |

40 mm min. Access hole at slot location

Full radius

Tape slot in core for tape start  
2.5mm min. width

10 pitches cumulative tolerance on tape +/- 0.2 mm

Center line of cavity

User Direction of Feed

TOP COVER TAPE

FEED DIRECTION

TRL

Bending radius

R min.

\* on sales type



## 6 Revision history

**Table 9. Document revision history**

| Date        | Revision | Changes   |
|-------------|----------|---|
| 20-Sep-2005 | 4        |   |
| 05-Oct-2005 | 5        | Inserted ECOPACK® indication  |
| 29-Feb-2008 | 6        | V <sub>ISO</sub> parameter on <a href="#">Table</a> has been updated    |
| 15-Apr-2009 | 7        | Order codes in <a href="#">Table 1: Device summary</a> has been changed |

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