



# STP21NM60N-F21NM60N-STW21NM60N STB21NM60N-STB21NM60N-1

N-channel 600 V - 0.17  $\Omega$  - 17 A TO-220 - TO-220FP - D<sup>2</sup>PAK - I<sup>2</sup>PAK - TO-247 second generation MDmesh™ Power MOSFET

## Features

| Type         | V <sub>DSS</sub><br>(@T <sub>jmax</sub> ) | R <sub>DS(on)</sub><br>max | I <sub>D</sub>      |
|--------------|---|----------------------------|---------------------|
| STB21NM60N   | 650 V                                     | < 0.22 $\Omega$            | 17 A                |
| STB21NM60N-1 | 650 V                                     | < 0.22 $\Omega$            | 17 A                |
| STF21NM60N   | 650 V                                     | < 0.22 $\Omega$            | 17 A <sup>(1)</sup> |
| STP21NM60N   | 650 V                                     | < 0.22 $\Omega$            | 17 A                |
| STW21NM60N   | 650 V                                     | < 0.22 $\Omega$            | 17 A                |

1. Limited by maximum temperature allowed

- 100% avalanche tested
- Low input capacitance and gate charge
- Low gate input resistance

## Application

- Switching applications

## Description

This series of devices implements the second generation of MDmesh™ technology. This revolutionary Power MOSFET associates a new vertical structure to the company's strip layout to yield one of the world's lowest on-resistance and gate charge. It is therefore suitable for the most demanding high efficiency converters.

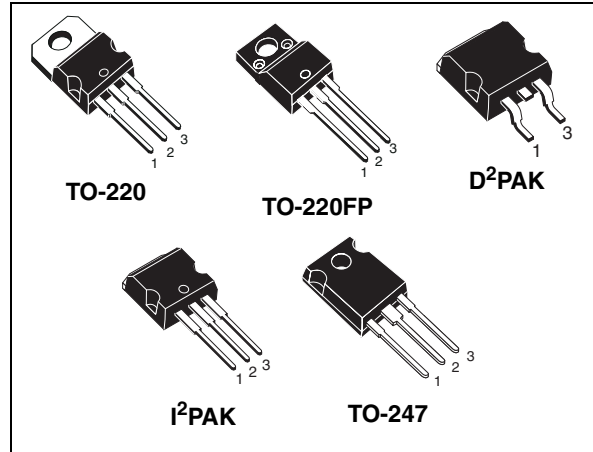


Figure 1. Internal schematic diagram

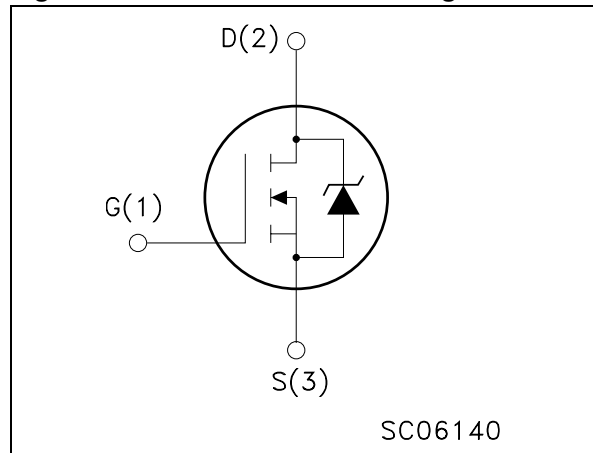


Table 1. Device summary

| Order codes  | Marking  | Package            | Packaging     |
|--------------|----------|--------------------|---------------|
| STB21NM60N   | B21NM60N | D <sup>2</sup> PAK | Tape and reel |
| STB21NM60N-1 | B21NM60N | I <sup>2</sup> PAK | Tube          |
| STF21NM60N   | F21NM60N | TO-220FP           | Tube          |
| STP21NM60N   | P21NM60N | TO-220             | Tube          |
| STW21NM60N   | W21NM60N | TO-247             | Tube          |

## Contents

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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 <sub>DS</sub>                | Drain-source voltage (V <sub>GS</sub> = 0)  | 600  |                   | V    |
| V <sub>GS</sub>                | Gate- source voltage  | ±25  |                   | V    |
| I <sub>D</sub>                 | Drain current (continuous) at T <sub>C</sub> = 25 °C  | 17   | 17 <sup>(1)</sup> | A    |
| I <sub>D</sub>                 | Drain current (continuous) at T <sub>C</sub> = 100 °C   | 10   | 10 <sup>(1)</sup> | A    |
| I <sub>DM</sub> <sup>(2)</sup> | Drain current (pulsed)  | 68   | 68 <sup>(1)</sup> | A    |
| P <sub>TOT</sub>               | Total dissipation at T <sub>C</sub> = 25 °C   | 140  | 30                | W    |
| dv/dt <sup>(3)</sup>           | Peak diode recovery voltage slope   | 15   |                   | V/ns |
| V <sub>ISO</sub>               | Insulation withstand voltage (RMS) from all three leads to external heat sink (t=1 s; T <sub>C</sub> = 25 °C) | --   | 2500              | V    |
| T <sub>stg</sub>               | Storage temperature   | -55 to 150   |                   | °C   |
| T <sub>j</sub>                 | Max. operating junction temperature   | 150  |                   | °C   |

- Limited only by maximum temperature allowed
- Pulse width limited by safe operating area
- I<sub>SD</sub> ≤ 17 A, di/dt ≤ 480 A/μs, V<sub>DD</sub> = 80% V<sub>(BR)DSS</sub>

**Table 3. Thermal data**

| Symbol                | Parameter                                      | TO-220 | D <sup>2</sup> PAK | I <sup>2</sup> PAK | TO-220FP | TO-247 | Unit |
|-----------------------|--|--------|--------------------|--------------------|----------|--------|------|
| R <sub>thj-case</sub> | Thermal resistance junction-case max           | 0.89   |                    |                    | 4.21     | 0.89   | °C/W |
| R <sub>thj-pcb</sub>  | Thermal resistance junction-pcb max            | --     | 30                 | --                 | --       | --     | °C/W |
| R <sub>thj-amb</sub>  | Thermal resistance junction-ambient max        | 62.5   | --                 | 62.5               |          | 50     | °C/W |
| T <sub>l</sub>        | Maximum lead temperature for soldering purpose | 300    |                    |                    |          |        | °C   |

**Table 4. Avalanche characteristics**

| Symbol          | Parameter  | Max value | Unit |
|-----------------|--|-----------|------|
| I <sub>AS</sub> | Avalanche current, repetitive or not-repetitive (pulse width limited by T <sub>j</sub> max)                                | 8.5       | A    |
| E <sub>AS</sub> | Single pulse avalanche energy (starting T <sub>j</sub> = 25 °C, I <sub>D</sub> = I <sub>AS</sub> , V <sub>DD</sub> = 50 V) | 610       | mJ   |

## 2 Electrical characteristics

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

**Table 5. On/off states**

| Symbol        | Parameter  | Test conditions  | Value |       |          | Unit                           |
|---------------|--|--|-------|-------|----------|--------------------------------|
|               |  |  | Min.  | Typ.  | Max.     |                                |
| $V_{(BR)DSS}$ | Drain-source breakdown voltage                   | $I_D = 1 \text{ mA}, V_{GS} = 0$   | 600   |       |          | V                              |
| $dv/dt^{(1)}$ | Drain source voltage slope                       | $V_{DD} = 480 \text{ V}, I_D = 17 \text{ A}, V_{GS} = 10 \text{ V}$          | 48    |       |          | V/ns                           |
| $I_{DSS}$     | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max rating}$<br>$V_{DS} = \text{Max rating @ } 125^{\circ}C$ |       |       | 1<br>100 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$     | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 \text{ V}$  |       |       | 100      | nA                             |
| $V_{GS(th)}$  | Gate threshold voltage                           | $V_{DS} = V_{GS}, I_D = 250 \mu\text{A}$                                     | 2     | 3     | 4        | V                              |
| $R_{DS(on)}$  | Static drain-source on resistance                | $V_{GS} = 10 \text{ V}, I_D = 8.5 \text{ A}$                                 |       | 0.170 | 0.220    | $\Omega$                       |

1. Characteristic value at turn off on inductive load

**Table 6. Dynamic**

| Symbol  | Parameter   | Test conditions   | Min. | Typ.                 | Max. | Unit                 |
|---|---|---|------|----------------------|------|----------------------|
| $g_{fs}^{(1)}$                                | Forward transconductance  | $V_{DS} = 15 \text{ V}, I_D = 8.5 \text{ A}$  |      | 12                   |      | S                    |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$           | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 50 \text{ V}, f = 1 \text{ MHz}, V_{GS} = 0$  |      | 1900<br>110<br>15    |      | pF<br>pF<br>pF       |
| $C_{oss \text{ eq.}}^{(2)}$                   | Equivalent output capacitance   | $V_{GS} = 0, V_{DS} = 0 \text{ to } 480 \text{ V}$  |      | 282                  |      | pF                   |
| $t_{d(on)}$<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     | $V_{DD} = 300 \text{ V}, I_D = 8.5 \text{ A}$<br>$R_G = 4.7 \Omega, V_{GS} = 10 \text{ V}$<br>(see Figure 23),<br>(see Figure 18) |      | 22<br>15<br>84<br>31 |      | ns<br>ns<br>ns<br>ns |
| $Q_g$<br>$Q_{gs}$<br>$Q_{gd}$                 | Total gate charge<br>Gate-source charge<br>Gate-drain charge            | $V_{DD} = 480 \text{ V}, I_D = 17 \text{ A}, V_{GS} = 10 \text{ V},$<br>(see Figure 19)   |      | 66<br>10<br>33       |      | nC<br>nC<br>nC       |
| $R_g$   | Gate input resistance   | $f=1 \text{ MHz}$ Gate DC Bias = 0<br>test signal level = 20 mV<br>open drain   |      | 2                    |      | $\Omega$             |

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. Source drain diode**

| Symbol          | Parameter                     | Test conditions  | Min. | Typ. | Max. | Unit          |
|-----------------|-------------------------------|--|------|------|------|---------------|
| $I_{SD}$        | Source-drain current          |  |      |      | 17   | A             |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |  |      |      | 68   | A             |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD} = 17\text{ A}, V_{GS} = 0$   |      |      | 1.5  | V             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 17\text{ A}, V_{DD} = 100\text{ V}$<br>$di/dt = 100\text{ A}/\mu\text{s}$<br><i>(see Figure 20)</i>  |      | 372  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |  |      | 4.6  |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |  |      | 25   |      | A             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 17\text{ A}, V_{DD} = 100\text{ V}$<br>$di/dt = 100\text{ A}/\mu\text{s}$ ,<br>$T_j = 150\text{ }^\circ\text{C}$<br><i>(see Figure 20)</i> |      | 486  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |  |      | 6.3  |      | $\mu\text{C}$ |
| $I_{RRM}$       | 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

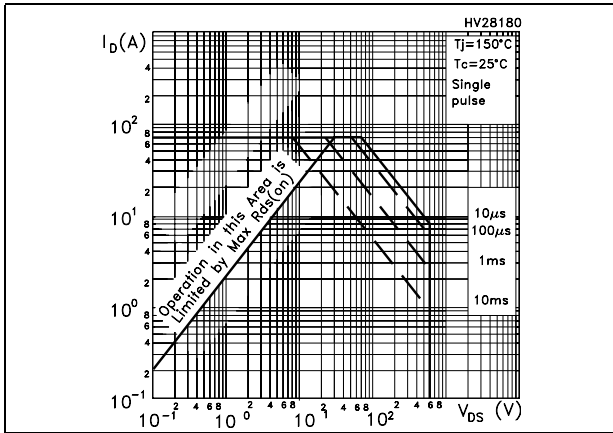


Figure 3. Thermal impedance for TO-220 / D<sup>2</sup>PAK / I<sup>2</sup>PAK

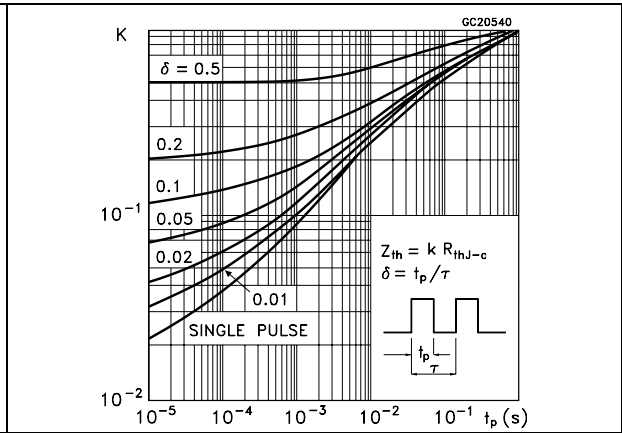


Figure 4. Safe operating area for TO-220FP

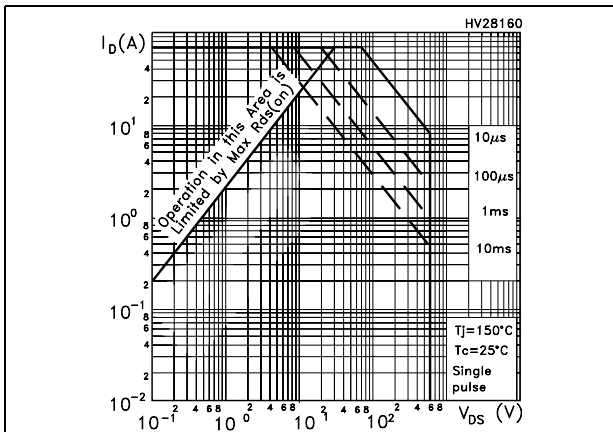


Figure 5. Thermal impedance for TO-220FP

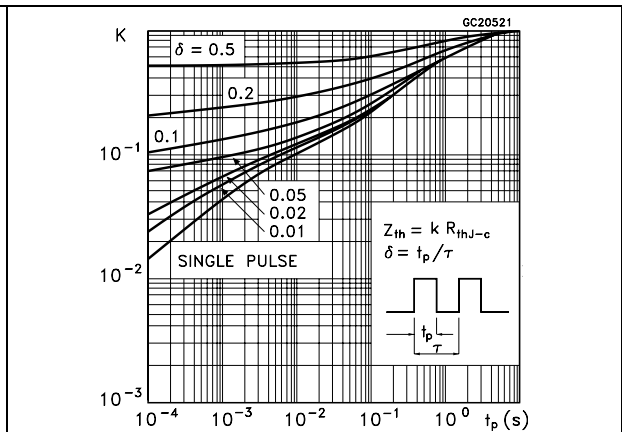


Figure 6. Safe operating area for TO-247

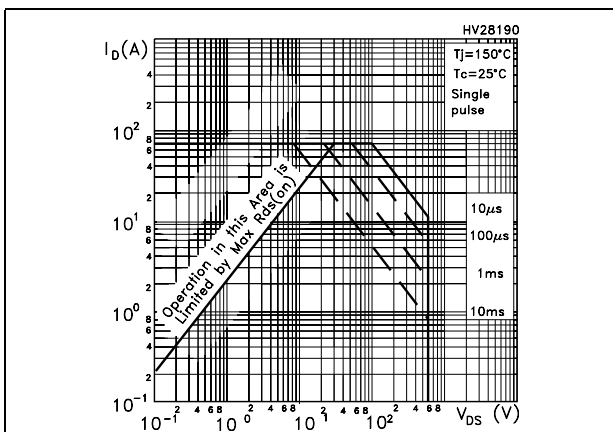


Figure 7. Thermal impedance for TO-247

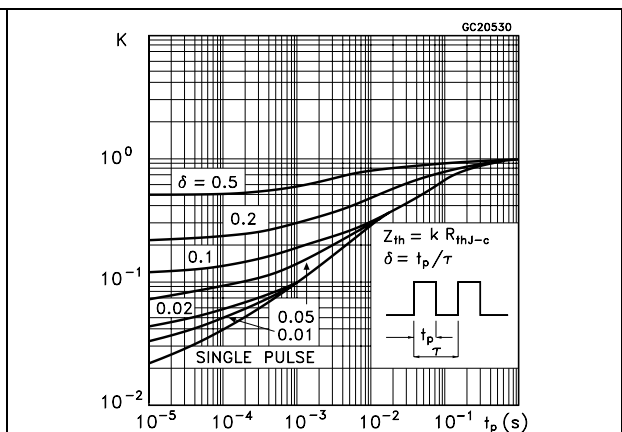


Figure 8. Output characteristics

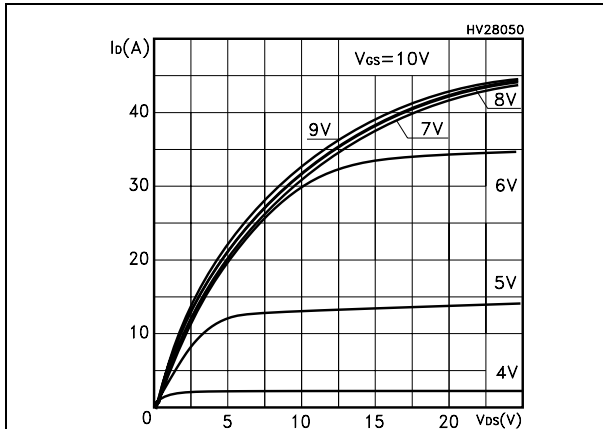


Figure 9. Transfer characteristics

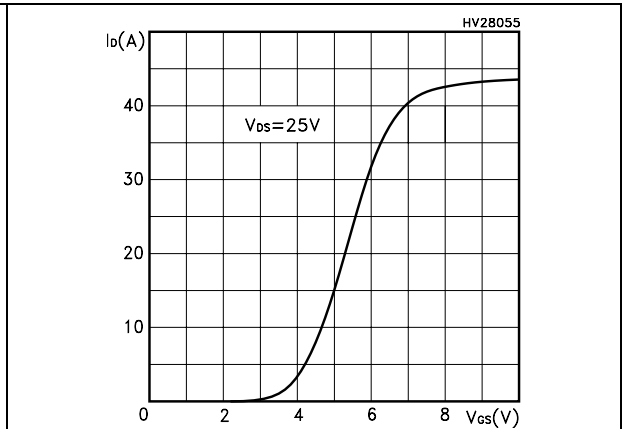


Figure 10. Transconductance

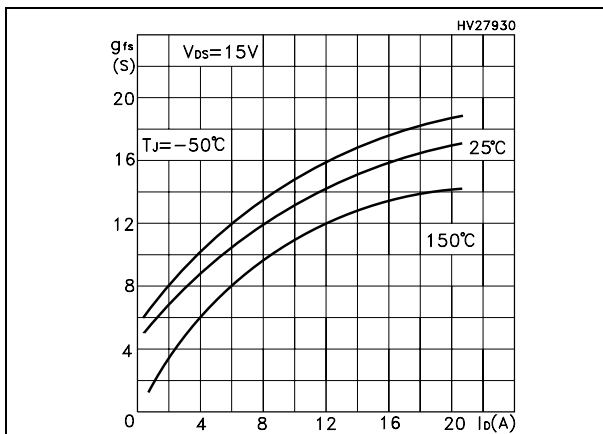


Figure 11. Static drain-source on resistance

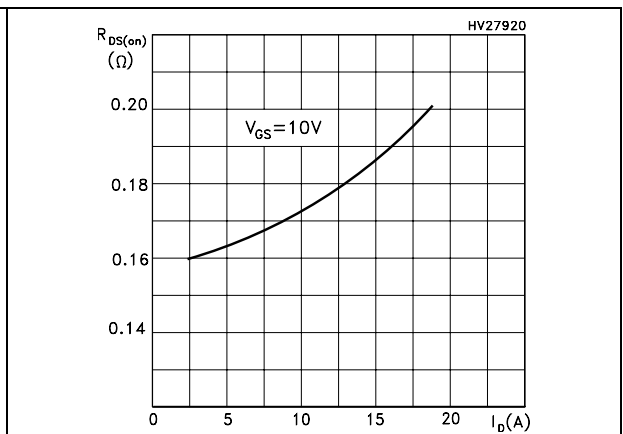


Figure 12. Gate charge vs gate-source voltage

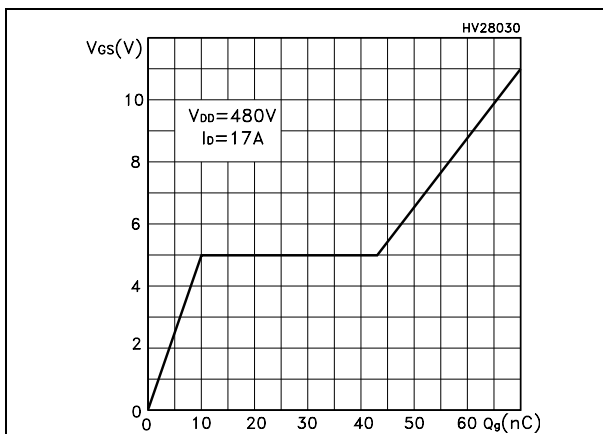


Figure 13. Capacitance variations

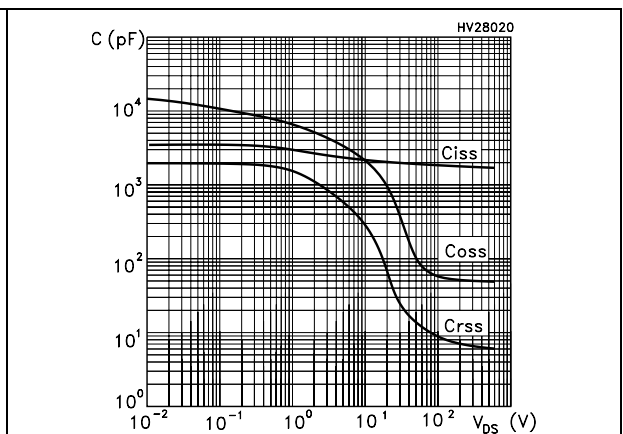


Figure 14. Normalized gate threshold voltage vs temperature

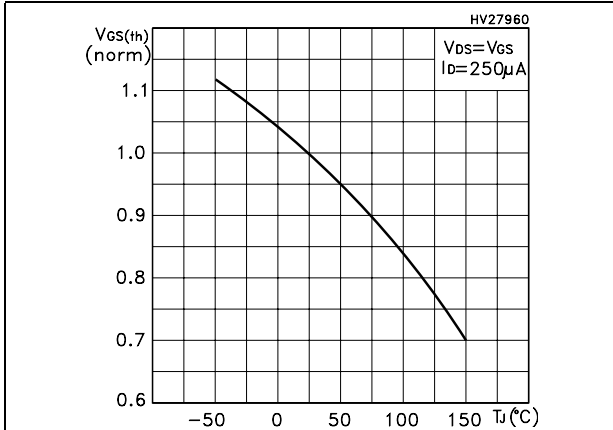


Figure 15. Normalized on resistance vs temperature

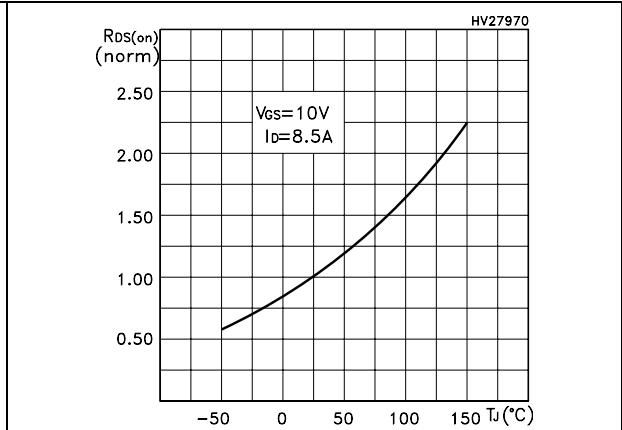


Figure 16. Source-drain diode forward characteristics

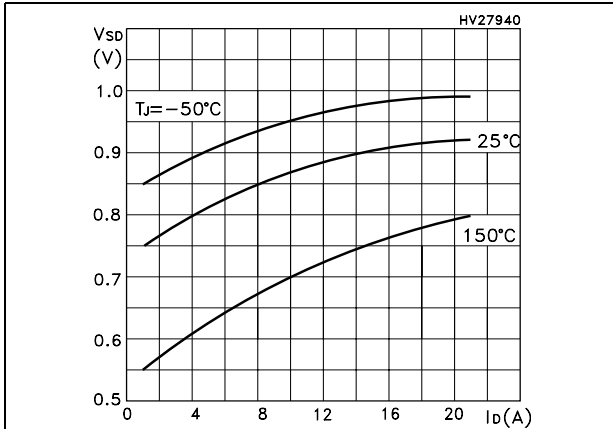
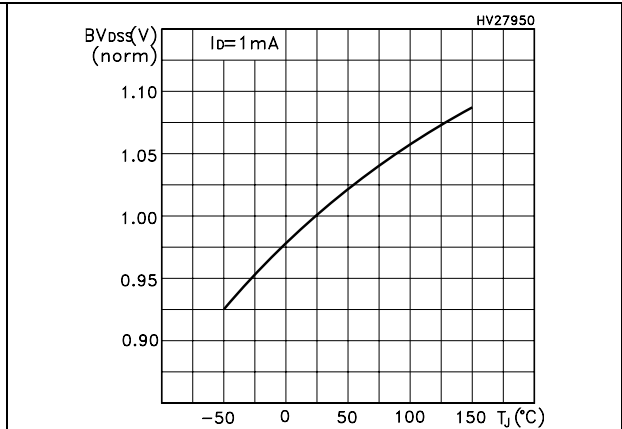


Figure 17. Normalized BV<sub>DSS</sub> vs temperature





### 3 Test circuit

Figure 18. Switching times test circuit for resistive load

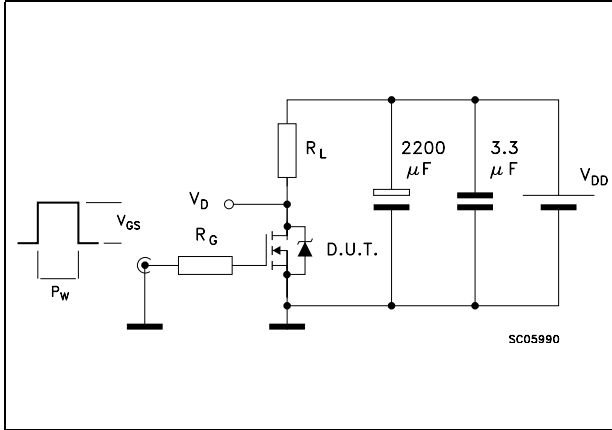


Figure 19. Gate charge test circuit

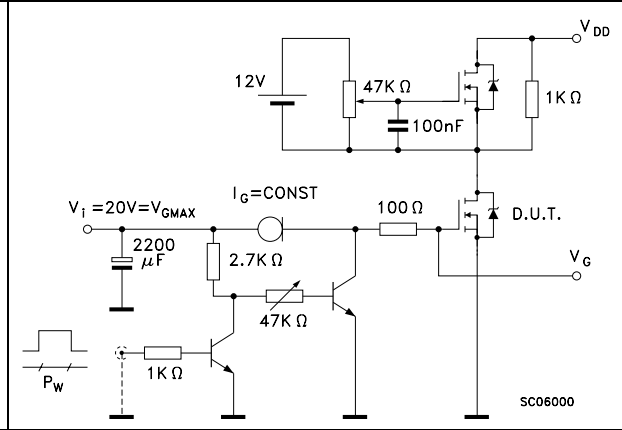


Figure 20. Test circuit for inductive load switching and diode recovery times

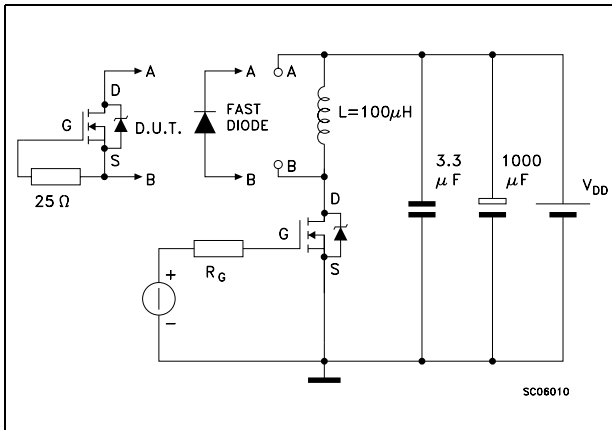


Figure 21. Unclamped Inductive load test circuit

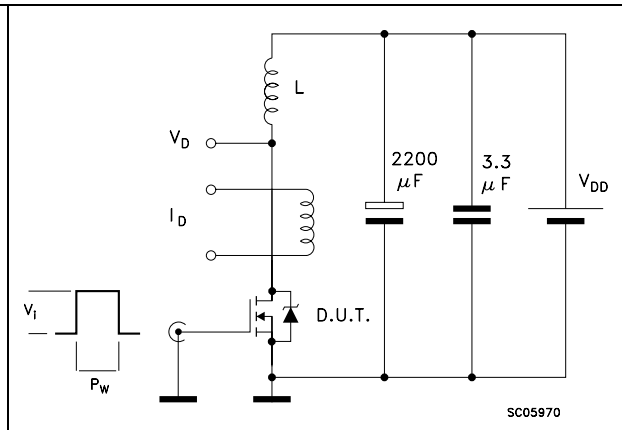


Figure 22. Unclamped inductive waveform

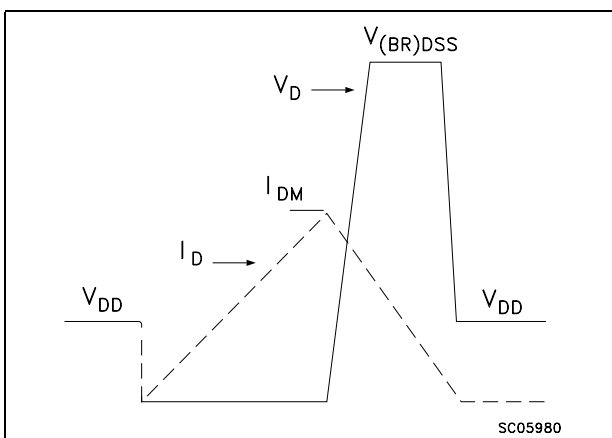
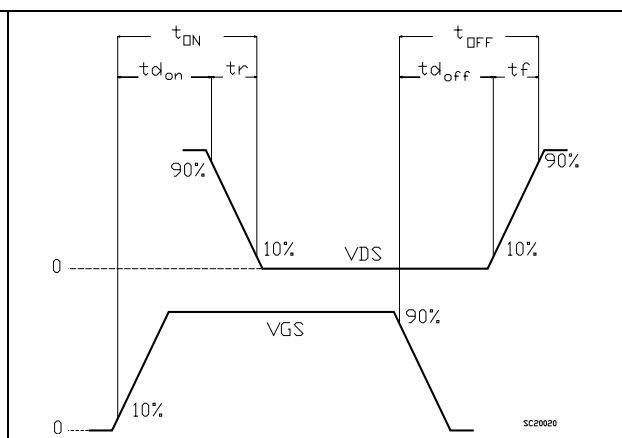


Figure 23. Switching time waveform

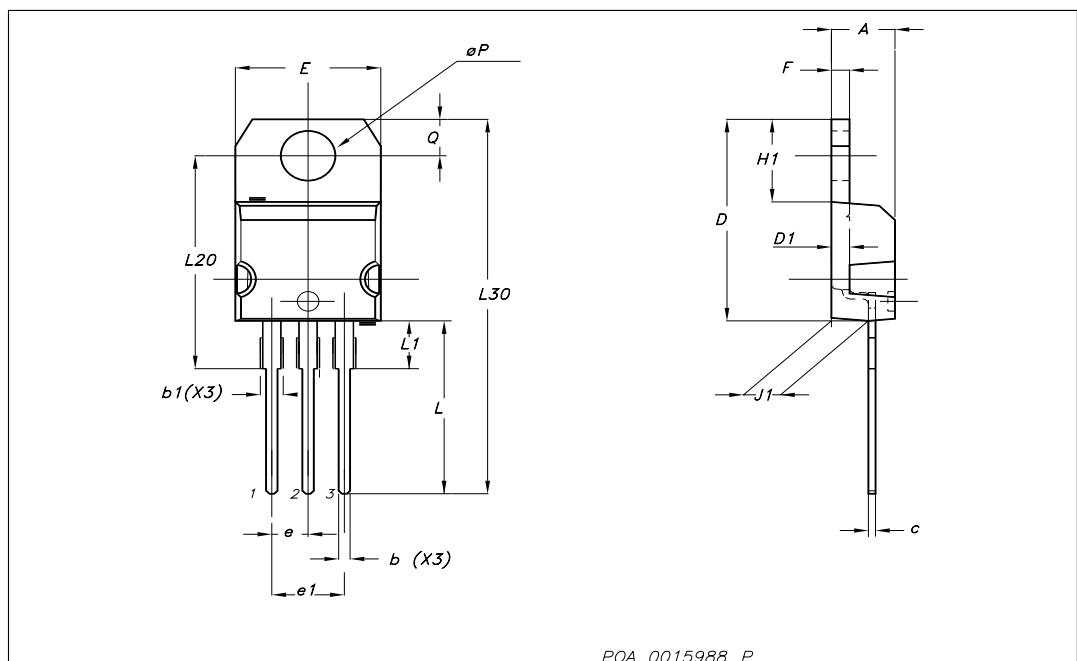


## 4 Package mechanical data

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)

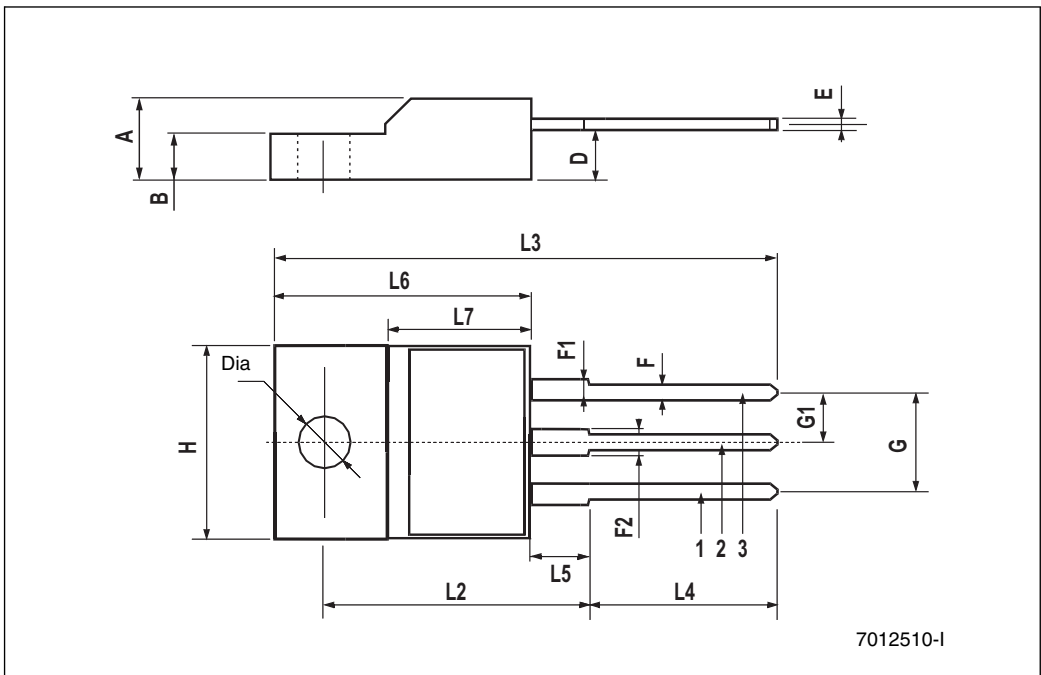
## TO-220 mechanical data

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



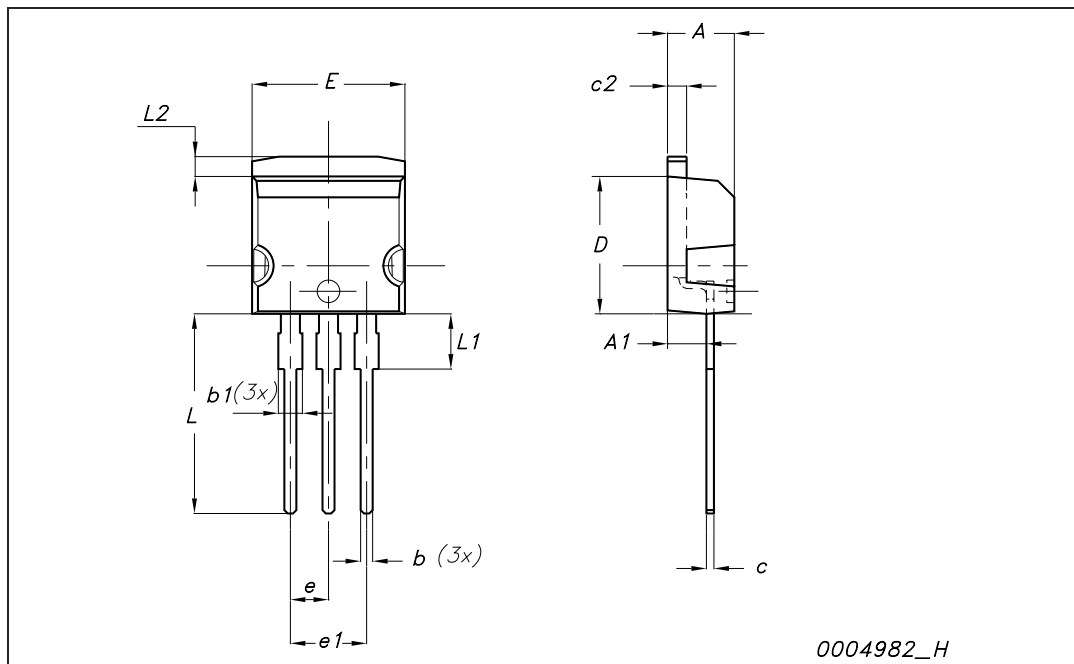
TO-220FP mechanical data

| 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 |



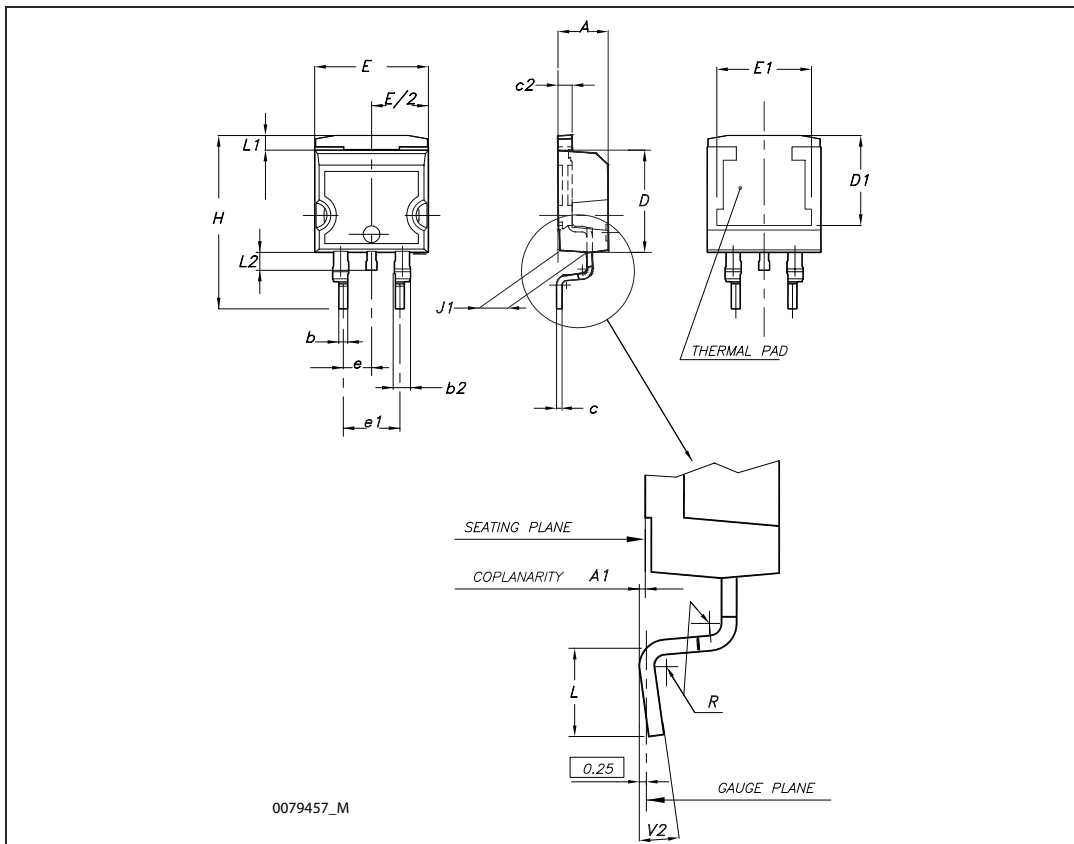
TO-262 mechanical data

| 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 |



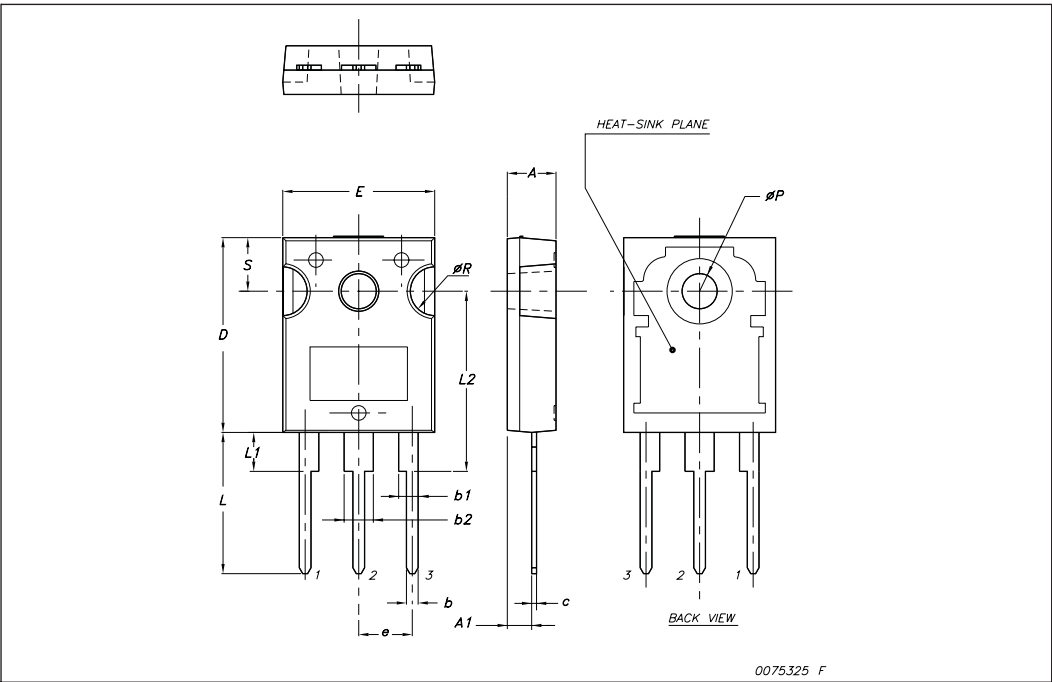
D<sup>2</sup>PAK (TO-263) mechanical data

| 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°    |



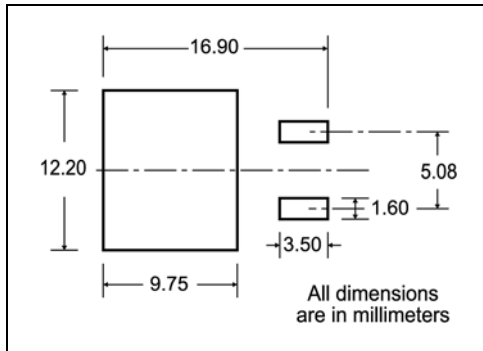
**TO-247 mechanical data**

| 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  |       |



# 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     |

10 pitches cumulative tolerance on tape +/- 0.2 mm

Center line of cavity

User Direction of Feed

FEED DIRECTION

Bending radius R min.

\* on sales type



## 6 Revision history

**Table 8. Document revision history**

| Date        | Revision | Changes   |
|-------------|----------|---|
| 19-Oct-2005 | 1        | First release.  |
| 07-Nov-2005 | 2        | Modified curves <i>Figure 12</i>                      |
| 29-Nov-2005 | 3        | Complete version                                      |
| 11-Jan-2007 | 4        | The document has been reformatted                     |
| 19-Jan-2007 | 5        | Typo mistake on <i>Table 6</i>                        |
| 27-Apr-2007 | 6        | Modified curves <i>Figure 11</i> and <i>Figure 15</i> |
| 19-Feb-2008 | 7        | <i>Figure 13</i> has been modified                    |

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