



# STP/F21NM60ND-STW21NM60ND STB21NM60ND-STI21NM60ND

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

## Features

| Type        | V <sub>DSS</sub> @ T <sub>J</sub> max | R <sub>DS(on)</sub> max | I <sub>D</sub>      |
|-------------|---------------------------------------|-------------------------|---------------------|
| STB21NM60ND | 650 V                                 | < 0.22 $\Omega$         | 17 A                |
| STI21NM60ND | 650 V                                 | < 0.22 $\Omega$         | 17 A                |
| STF21NM60ND | 650 V                                 | < 0.22 $\Omega$         | 17 A <sup>(1)</sup> |
| STP21NM60ND | 650 V                                 | < 0.22 $\Omega$         | 17 A                |
| STW21NM60ND | 650 V                                 | < 0.22 $\Omega$         | 17 A                |

1. Limited only by maximum temperature allowed

- The worldwide best R<sub>DS(on)</sub>\*area amongst the fast recovery diode devices
- 100% avalanche tested
- Low input capacitance and gate charge
- Low gate input resistance
- Extremely high dv/dt and avalanche capabilities

## Application

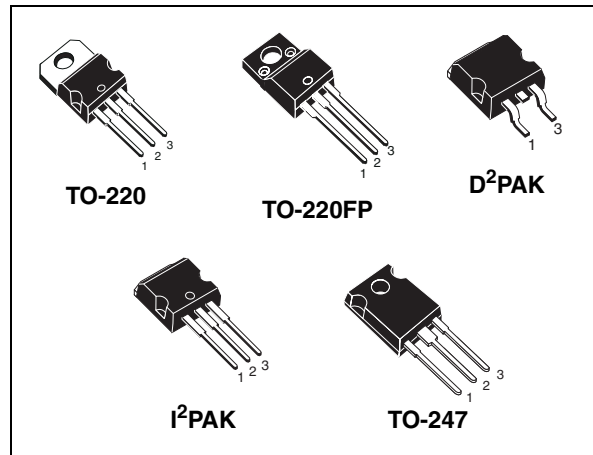
- Switching applications

## Description

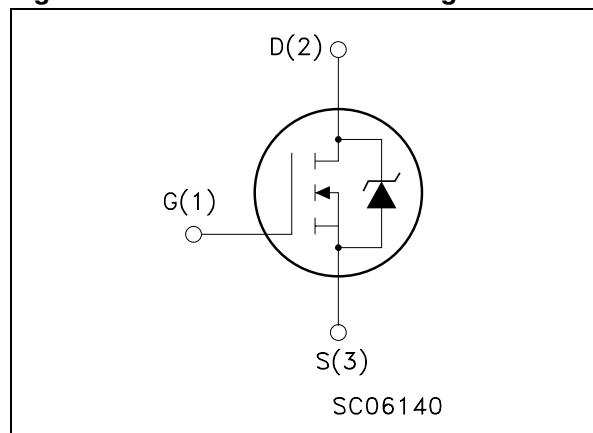
The FDmesh™ II series belongs to the second generation of MDmesh™ technology. This revolutionary Power MOSFET associates a new vertical structure to the company's strip layout and associates all advantages of reduced on-resistance and fast switching with an intrinsic fast-recovery body diode. It is therefore strongly recommended for bridge topologies, in ZVS phase-shift converters.

**Table 1. Device summary**

| Order codes | Marking  | Package            | Packaging     |
|-------------|----------|--------------------|---------------|
| STB21NM60ND | 21NM60ND | D <sup>2</sup> PAK | Tape and reel |
| STI21NM60ND | 21NM60ND | I <sup>2</sup> PAK | Tube          |
| STF21NM60ND | 21NM60ND | TO-220FP           | Tube          |
| STP21NM60ND | 21NM60ND | TO-220             | Tube          |
| STW21NM60ND | 21NM60ND | TO-247             | Tube          |



**Figure 1. Internal schematic diagram**



## 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  | 40   |                   | 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  |                   |      |

- Limited only by maximum temperature allowed
- Pulse width limited by safe operating area
- I<sub>SD</sub> ≤ 17 A, di/dt ≤ 600 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-247 | TO-220FP | Unit |
|-----------------------|--|--------|--------------------|--------------------|--------|----------|------|
| R <sub>thj-case</sub> | Thermal resistance junction-case max           | 0.89   |                    |                    |        | 4.17     | °C/W |
| R <sub>thj-amb</sub>  | Thermal resistance junction-ambient max        | 62.5   | --                 | 62.5               | 50     | 62.5     | °C/W |
| T <sub>I</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<sub>CASE</sub>=25°C unless otherwise specified)

**Table 5. On/off states**

| Symbol               | Parameter   | Test conditions  | Value |       |          | Unit     |
|----------------------|---|--|-------|-------|----------|----------|
|                      |   |  | Min.  | Typ.  | Max.     |          |
| V <sub>(BR)DSS</sub> | Drain-source breakdown voltage                        | I <sub>D</sub> = 1 mA, V <sub>GS</sub> = 0                             | 600   |       |          | V        |
| dv/dt <sup>(1)</sup> | Drain source voltage slope                            | V <sub>DD</sub> = 480 V, I <sub>D</sub> = 17 A, V <sub>GS</sub> = 10 V | 48    |       |          | V/ns     |
| I <sub>DSS</sub>     | Zero gate voltage drain current (V <sub>GS</sub> = 0) | V <sub>DS</sub> = Max rating<br>V <sub>DS</sub> = Max rating @ 125 °C  |       |       | 1<br>100 | μA<br>μA |
| I <sub>GSS</sub>     | Gate-body leakage current (V <sub>DS</sub> = 0)       | V <sub>GS</sub> = ± 20 V   |       |       | 100      | nA       |
| V <sub>GS(th)</sub>  | Gate threshold voltage                                | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250 μA            | 3     | 4     | 5        | V        |
| R <sub>DS(on)</sub>  | Static drain-source on resistance                     | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 8.5 A                         |       | 0.170 | 0.220    | Ω        |

1. Characteristic value at turn off on inductive load

**Table 6. Dynamic**

| Symbol  | Parameter   | Test conditions  | Min. | Typ.                 | Max. | Unit                 |
|---|---|--|------|----------------------|------|----------------------|
| g <sub>fs</sub> <sup>(1)</sup>  | Forward transconductance  | V <sub>DS</sub> = 15 V, I <sub>D</sub> = 8 A   |      | 12                   |      | S                    |
| C <sub>iss</sub><br>C <sub>oss</sub><br>C <sub>rss</sub>                      | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | V <sub>DS</sub> = 50 V, f = 1 MHz,<br>V <sub>GS</sub> = 0  |      | 1800<br>90<br>8      |      | pF<br>pF<br>pF       |
| C <sub>oss eq.</sub> <sup>(2)</sup>   | Equivalent output capacitance   | V <sub>GS</sub> = 0, V <sub>DS</sub> = 0 to 480 V  |      | 300                  |      | pF                   |
| t <sub>d(on)</sub><br>t <sub>r</sub><br>t <sub>d(off)</sub><br>t <sub>f</sub> | Turn-on delay time<br>Rise time<br>Turn-off delay time<br>Fall time     | V <sub>DD</sub> = 300 V, I <sub>D</sub> = 8.5 A<br>R <sub>G</sub> = 4.7 Ω, V <sub>GS</sub> = 10 V<br><i>(see Figure 23),</i><br><i>(see Figure 18)</i> |      | 18<br>16<br>70<br>48 |      | ns<br>ns<br>ns<br>ns |
| Q <sub>g</sub><br>Q <sub>gs</sub><br>Q <sub>gd</sub>                          | Total gate charge<br>Gate-source charge<br>Gate-drain charge            | V <sub>DD</sub> = 480 V, I <sub>D</sub> = 17 A,<br>V <sub>GS</sub> = 10 V,<br><i>(see Figure 19)</i>   |      | 60<br>10<br>30       |      | nC<br>nC<br>nC       |
| R <sub>g</sub>  | Gate input resistance   | f=1 MHz Gate DC Bias=0<br>Test signal level=20 mV<br>Open drain  |      | 3                    |      | Ω                    |

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

2. C<sub>oss eq.</sub> is defined as a constant equivalent capacitance giving the same charging time as C<sub>oss</sub> when V<sub>DS</sub> increases from 0 to 80% V<sub>DSS</sub>

**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            | $I_{SD} = 17\text{ A}, V_{GS} = 0$  |      |      | 1.6  | V             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 17\text{ A}, V_{DD} = 60\text{ V}$<br>$di/dt = 100\text{ A}/\mu\text{s}$<br><i>(see Figure 20)</i>  |      | 150  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |   |      | 0.90 |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |   |      | 13   |      | A             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 17\text{ A}, V_{DD} = 60\text{ V}$<br>$di/dt = 100\text{ A}/\mu\text{s}$ ,<br>$T_J = 150\text{ }^\circ\text{C}$<br><i>(see Figure 20)</i> |      | 210  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |   |      | 1.6  |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |   |      | 15   |      | 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

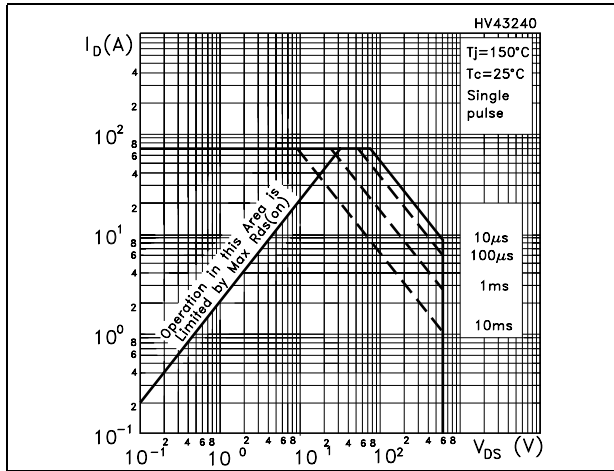


Figure 3. Thermal impedance for TO-220 / D<sup>2</sup>PAK / I<sup>2</sup>PAK

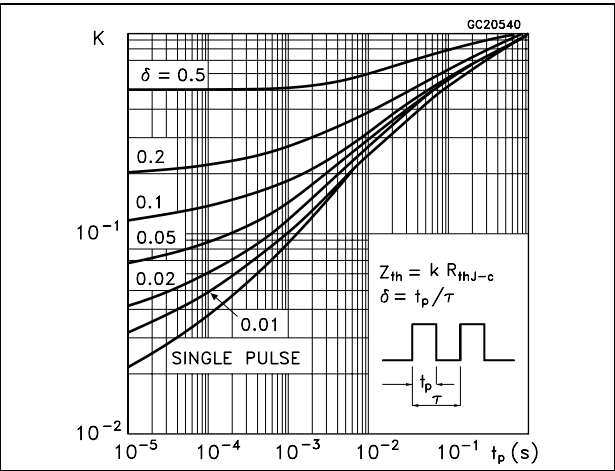


Figure 4. Safe operating area for TO-220FP

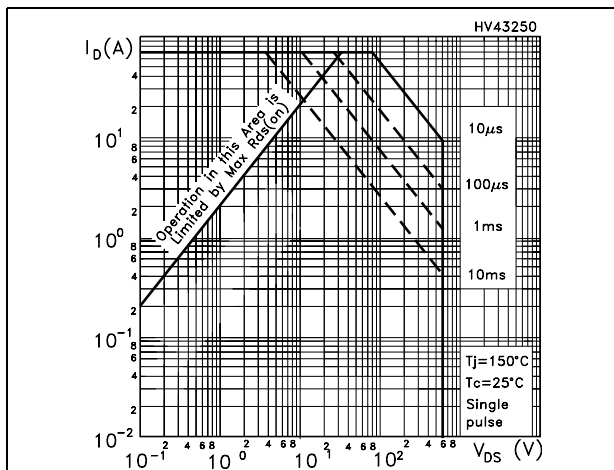


Figure 5. Thermal impedance for TO-220FP

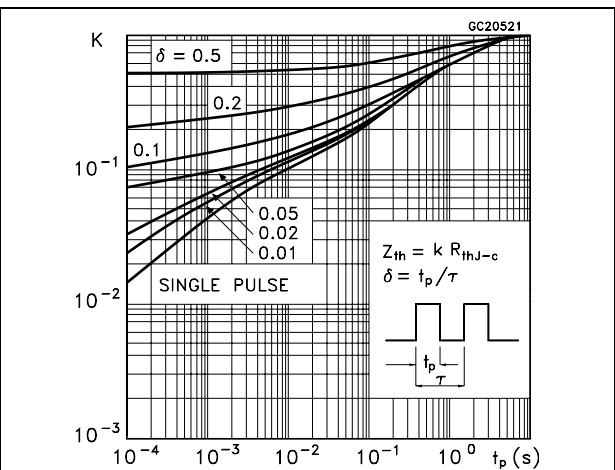


Figure 6. Safe operating area for TO-247

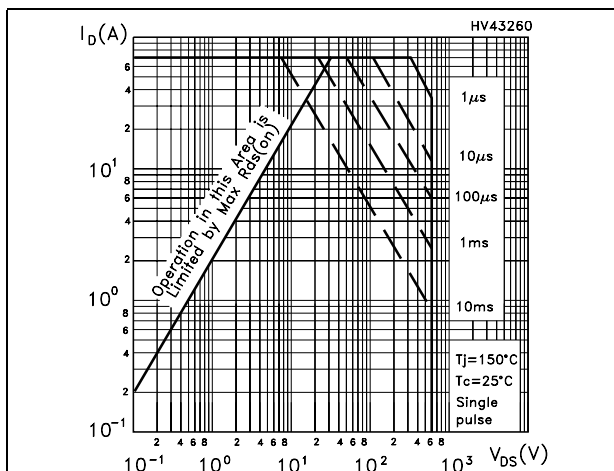


Figure 7. Thermal impedance for TO-247

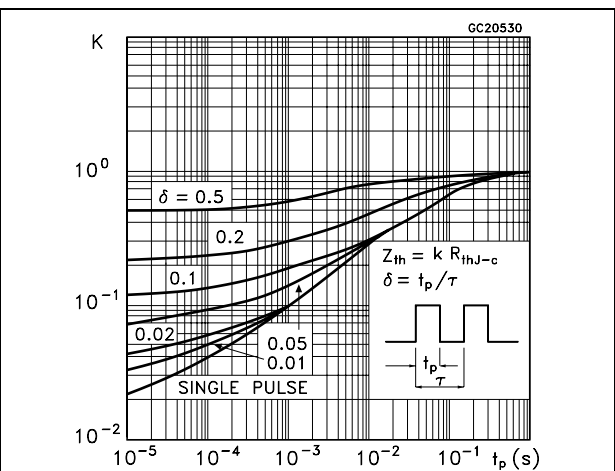


Figure 8. Output characteristics

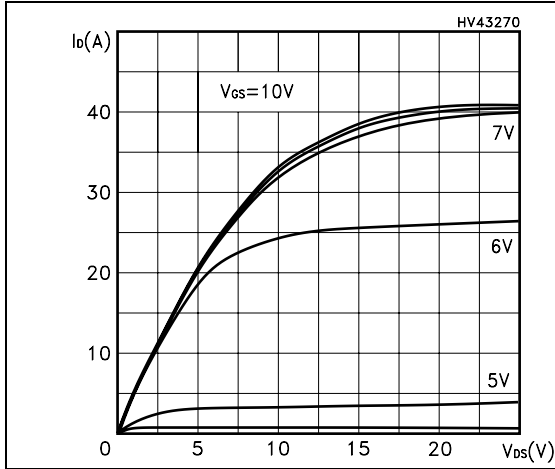


Figure 9. Transfer characteristics

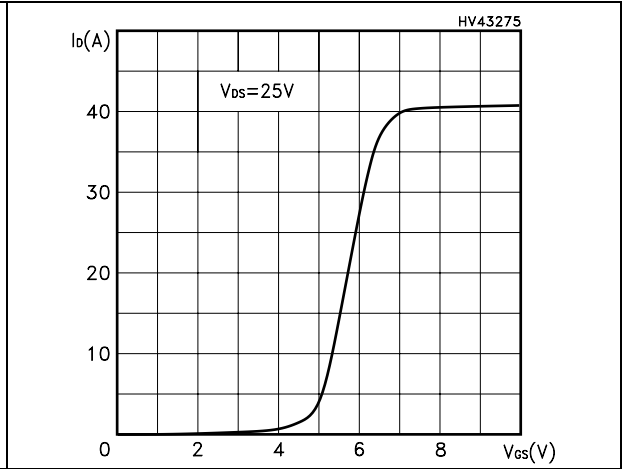


Figure 10. Transconductance

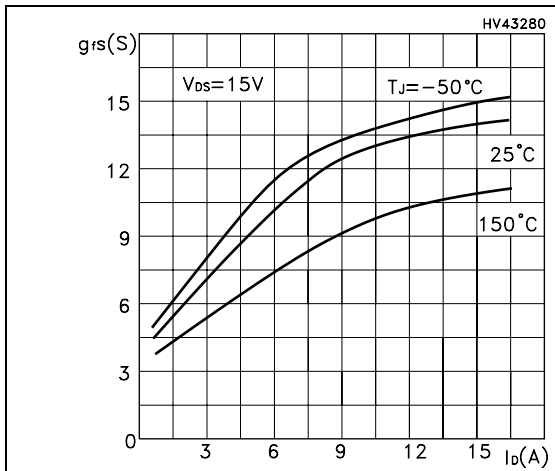


Figure 11. Static drain-source on resistance

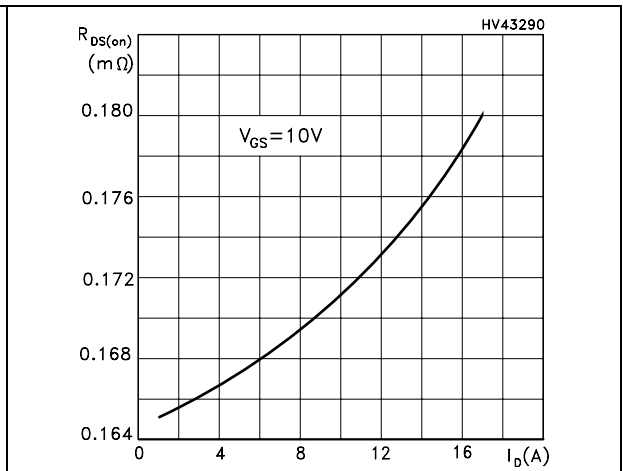


Figure 12. Gate charge vs gate-source voltage Figure 13. Capacitance variations

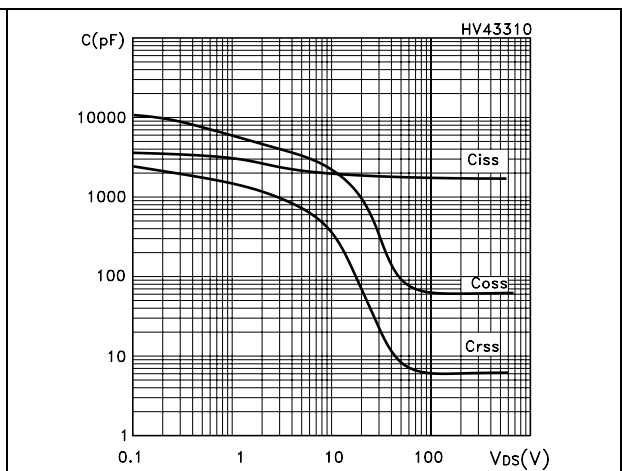
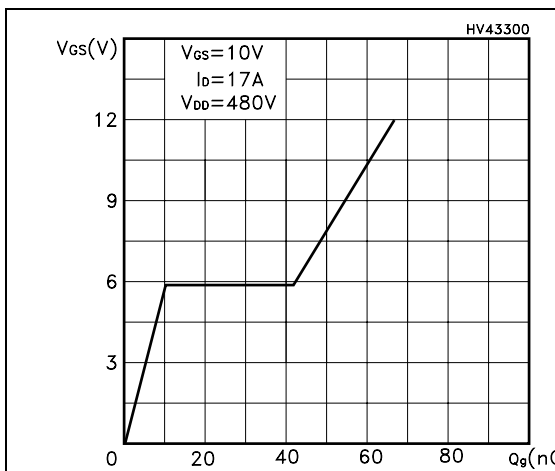


Figure 14. Normalized gate threshold voltage vs temperature

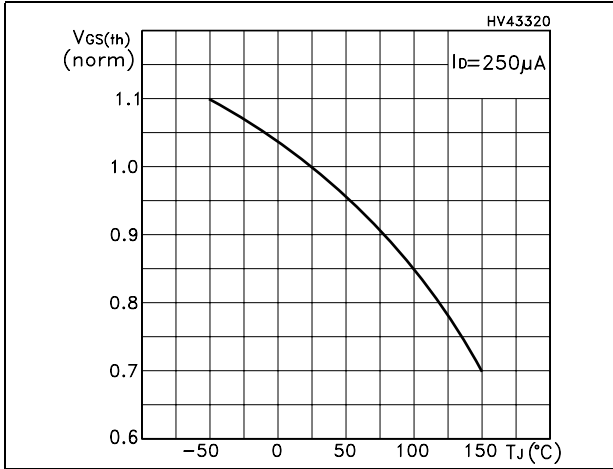


Figure 15. Normalized on resistance vs temperature

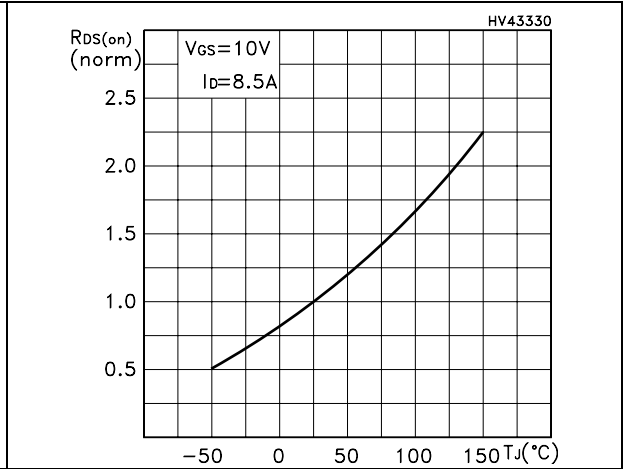


Figure 16. Source-drain diode forward characteristics

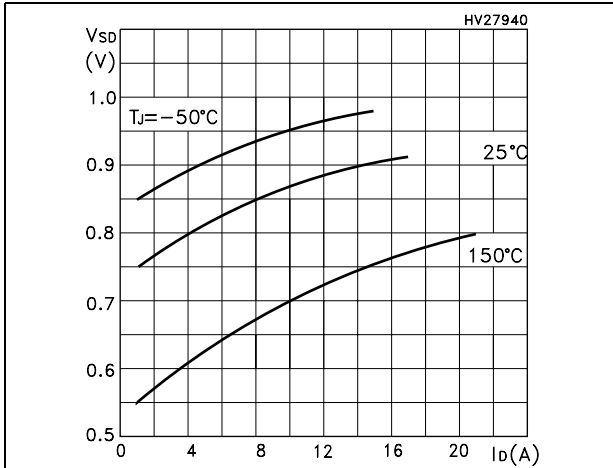
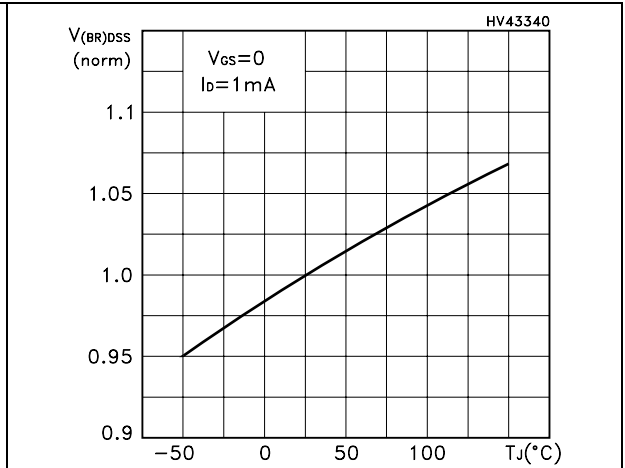


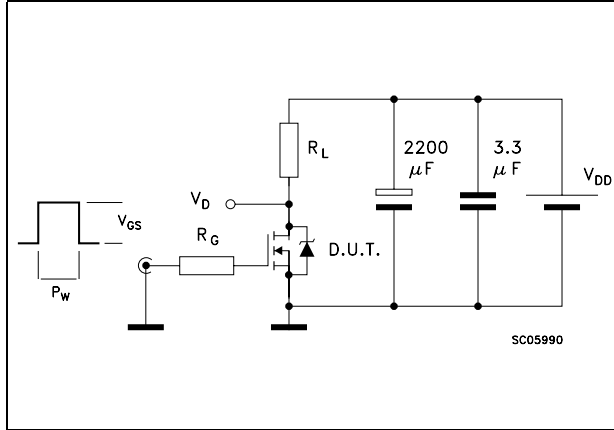
Figure 17. Normalized BV<sub>DSS</sub> vs temperature



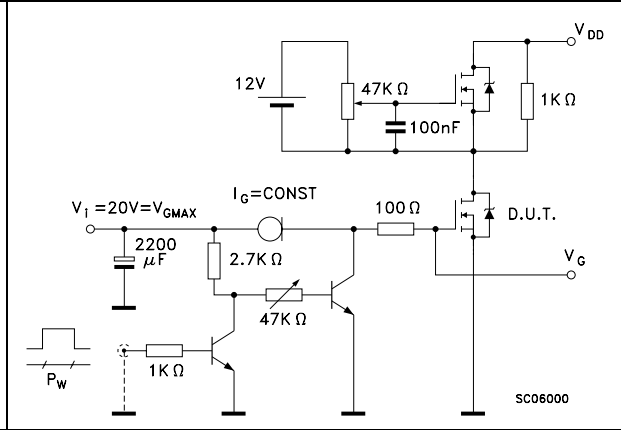


### 3 Test circuits

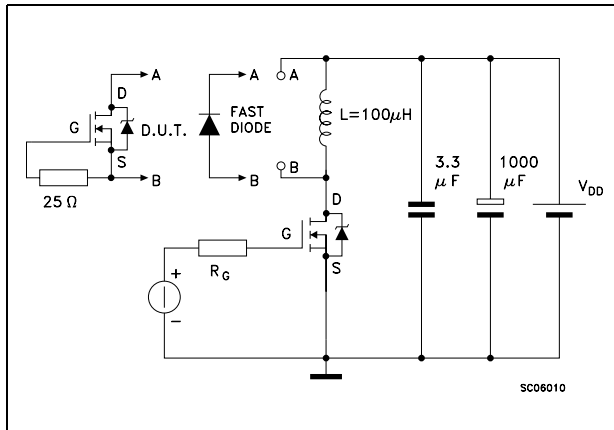
**Figure 18. Switching times test circuit for resistive load**



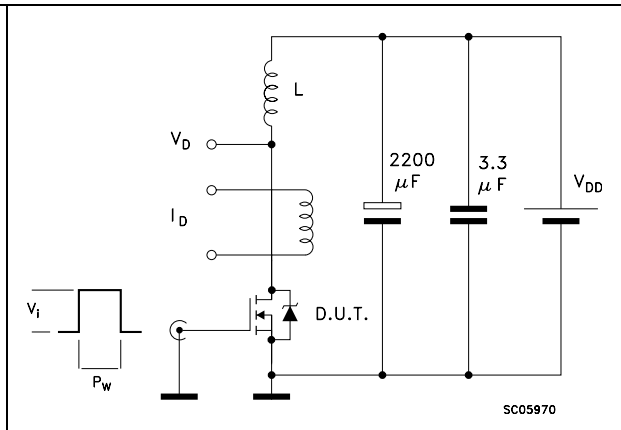
**Figure 19. Gate charge test circuit**



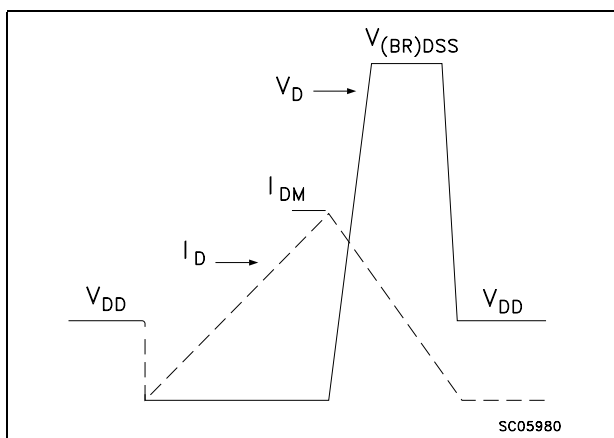
**Figure 20. Test circuit for inductive load switching and diode recovery times**



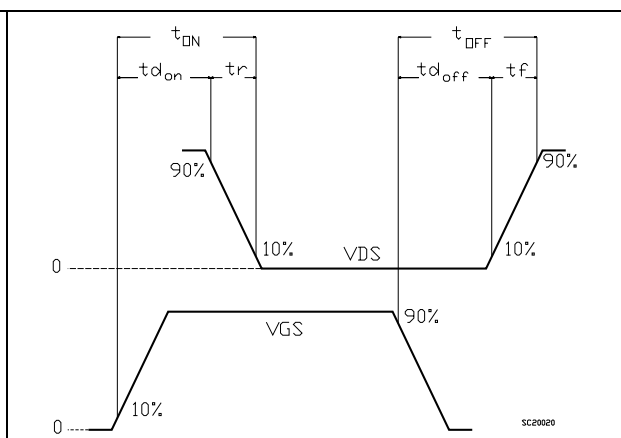
**Figure 21. Unclamped inductive load test circuit**



**Figure 22. Unclamped inductive waveform**



**Figure 23. Switching time waveform**

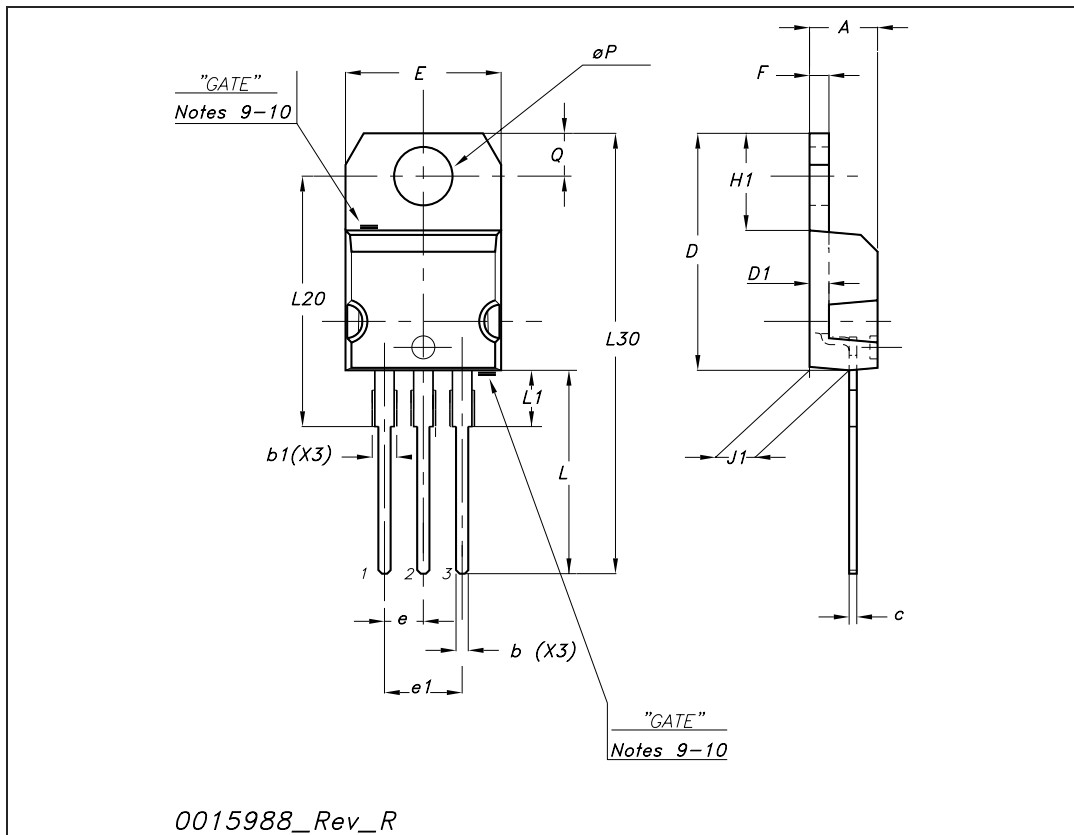


## 4      **Package mechanical data**

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

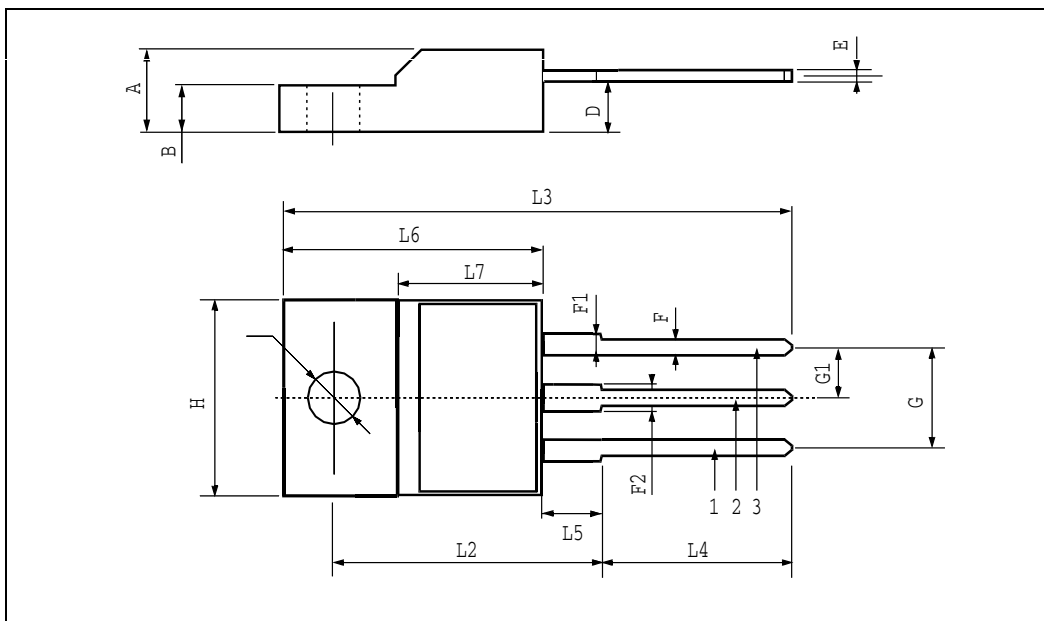
TO-220 mechanical data

| 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   | 0.48  |       | 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 |



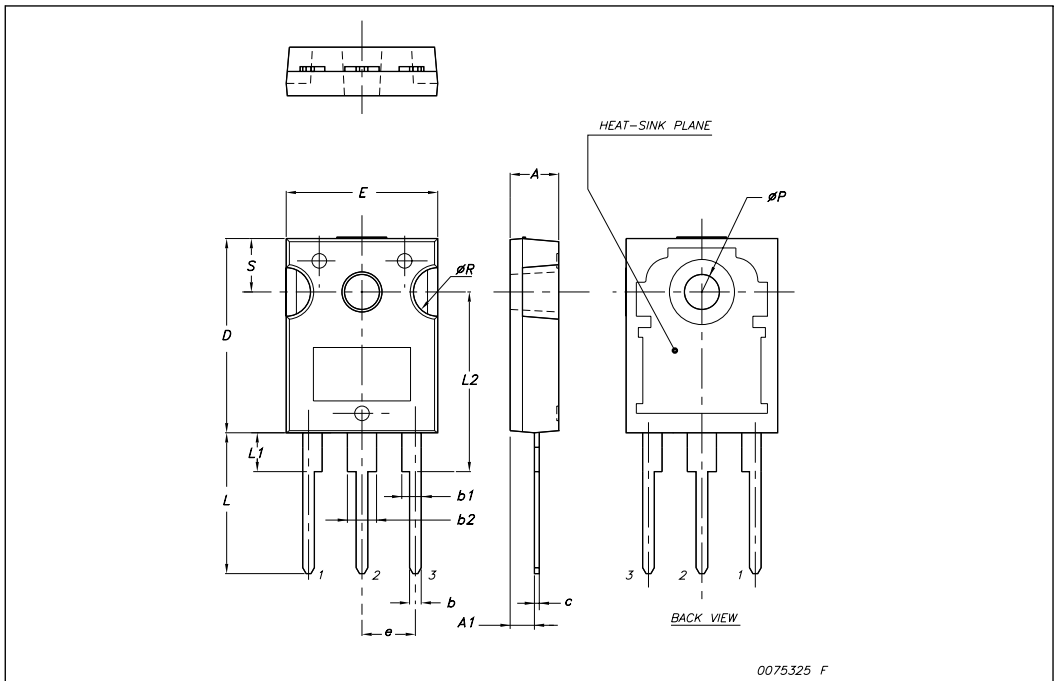
**TO-220FP mechanical data**

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



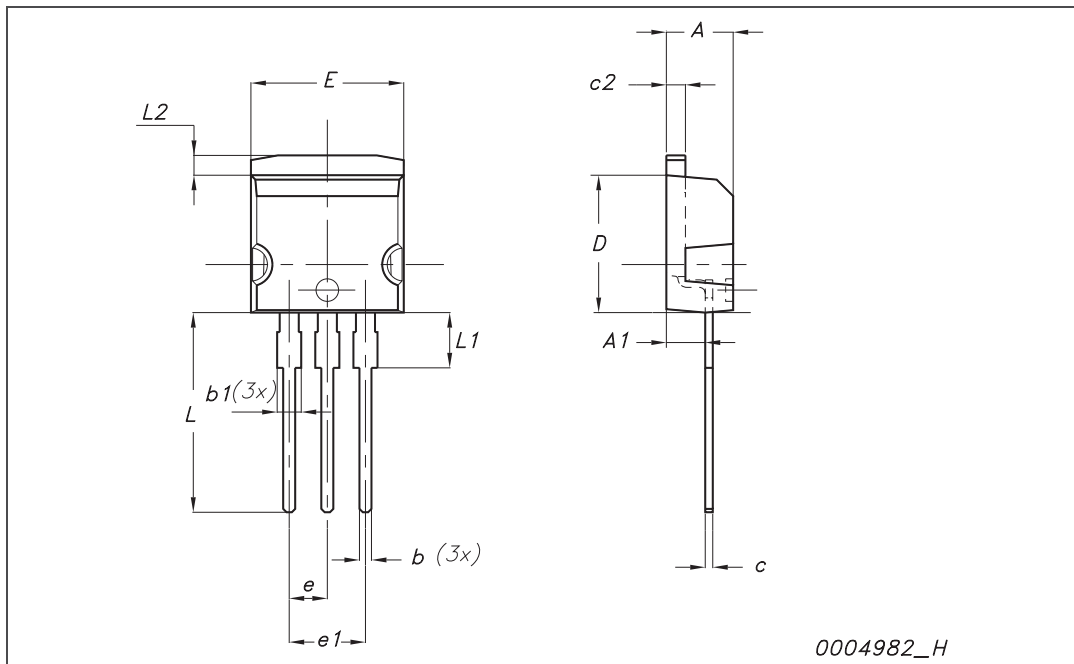
**TO-247 Mechanical data**

| 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  |       |



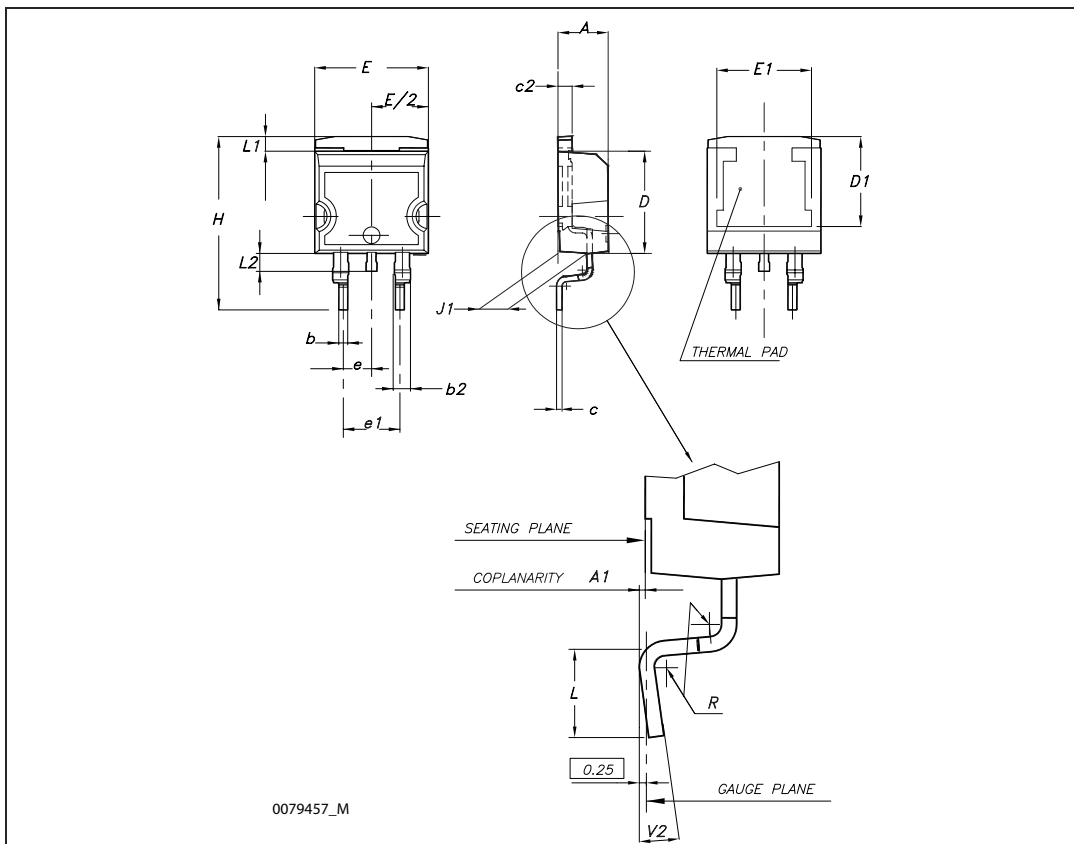
**I<sup>2</sup>PAK (TO-262) mechanical data**

| 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 |



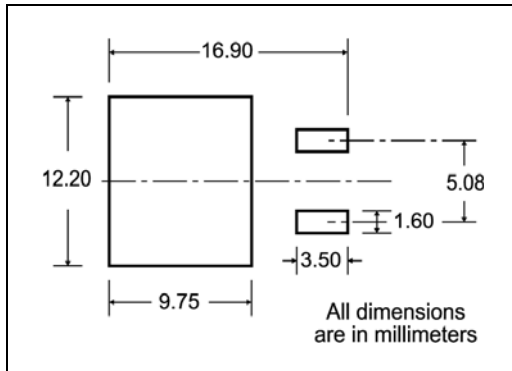
**D<sup>2</sup>PAK (TO-263) mechanical data**

| 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°    |



## 5 Packing mechanical data

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



### TAPE AND REEL SHIPMENT

40 mm min. Access hole at slot location

Full radius

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

**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

TRL

FEED DIRECTION

Bending radius R min.

\* on sales type



## 6 Revision history

**Table 8. Document revision history**

| Date        | Revision | Changes  |
|-------------|----------|--|
| 05-Sep-2007 | 1        | First release.   |
| 22-Apr-2008 | 2        | Datasheet status promoted from preliminary data to datasheet.  |
| 27-Mar-2009 | 3        | <i>Figure 13</i> has been updated.<br>Updated ECOPACK <sup>®</sup> statement ( <i>Section 4: Package mechanical data</i> ) |

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