



# THE DATASHEET OF F6NM60N





# STx6NM60N

N-channel 600 V, 0.85  $\Omega$ , 4.6 A MDmesh™ II Power MOSFET  
TO-220, TO-220FP, IPAK, DPAK, D<sup>2</sup>PAK

## Features

| Type        | V <sub>DSS</sub><br>(@T <sub>jmax</sub> ) | R <sub>DS(on)</sub><br>max | I <sub>D</sub>       |
|-------------|---|----------------------------|----------------------|
| STB6NM60N   | 650 V                                     | < 0.92 $\Omega$            | 4.6 A                |
| STD6NM60N   | 650 V                                     | < 0.92 $\Omega$            | 4.6 A                |
| STD6NM60N-1 | 650 V                                     | < 0.92 $\Omega$            | 4.6 A                |
| STF6NM60N   | 650 V                                     | < 0.92 $\Omega$            | 4.6 A <sup>(1)</sup> |
| STP6NM60N   | 650 V                                     | < 0.92 $\Omega$            | 4.6 A                |

1. Limited only 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 second generation MDmesh™ technology. This revolutionary Power MOSFET associates a new vertical structure to the STMicroelectronics' 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.

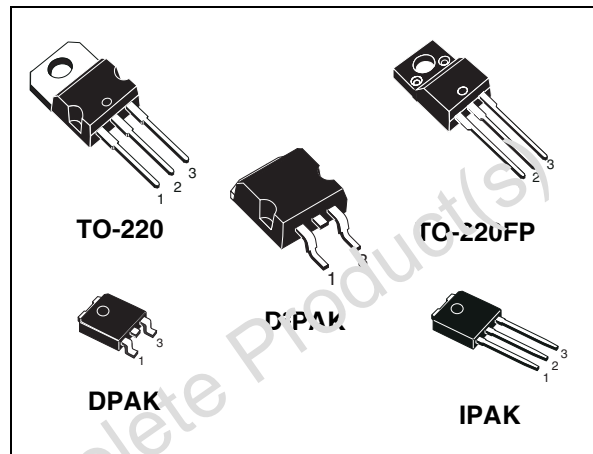
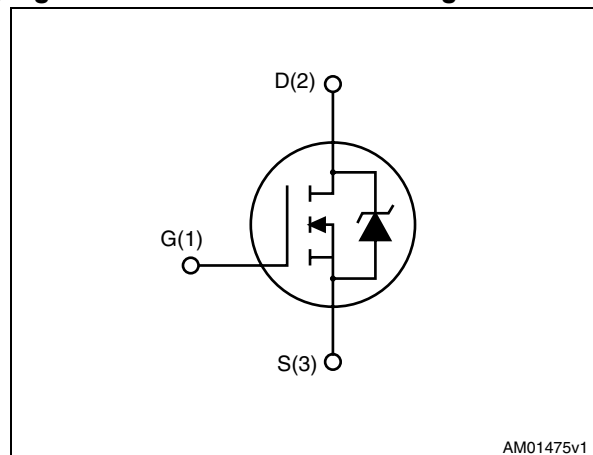


Figure 1. Internal schematic diagram



AM01475v1

Table 1. Device summary

| Order codes | Marking | Package            | Packaging     |
|-------------|---------|--------------------|---------------|
| STB6NM60N   | B6NM60N | D <sup>2</sup> PAK | Tape and reel |
| STD6NM60N-1 | D6NM60N | IPAK               | Tube          |
| STD6NM60N   | D6NM60N | DPAK               | Tape and reel |
| STF6NM60N   | F6NM60N | TO-220FP           | Tube          |
| STP6NM60N   | P6NM60N | TO-220             | Tube          |

# Contents

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Obsolete Product(s) - Obsolete Product(s)

# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol                             | Parameter  | Value                                  |                     | Unit |
|------------------------------------|--|--|---------------------|------|
|                                    |  | TO-220, D <sup>2</sup> PAK, DPAK, IPAK | 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   | 4.6                                    | 4.6 <sup>(1)</sup>  | A    |
| I <sub>D</sub>                     | Drain current (continuous) at T <sub>C</sub> = 100 °C  | 2.9                                    | 2.9 <sup>(1)</sup>  | A    |
| I <sub>DM</sub> <sup>(2)</sup>     | Drain current (pulsed)   | 18.4                                   | 18.4 <sup>(1)</sup> | A    |
| P <sub>TOT</sub>                   | Total dissipation at T <sub>C</sub> = 25 °C  | 45                                     | 20                  | 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>j</sub><br>T <sub>stg</sub> | Operating junction temperature<br>Storage temperature  | -55 to 150                             |                     | °C   |

- Limited by maximum temperature allowed
- Pulse width limited by safe operating area
- I<sub>SD</sub> ≤ 4.6A, di/dt ≤ 400V/µs, V<sub>DD</sub> = 80% V<sub>(BR)DSS</sub>

**Table 3. Thermal data**

| Symbol                | Parameter                                      | Value  |      |      |                    |          | Unit |
|-----------------------|--|--------|------|------|--------------------|----------|------|
|                       |  | TO-220 | IPAK | DPAK | D <sup>2</sup> PAK | TO-220FP |      |
| R <sub>thj-case</sub> | Thermal resistance junction-case               | 2.78   |      |      | 5                  | °C/W     |      |
| R <sub>thj-amb</sub>  | Thermal resistance junction-amb                | 62.5   | 100  |      | 62.5               | °C/W     |      |
| T <sub>l</sub>        | Maximum lead temperature for soldering purpose | 300    |      |      |                    |          | °C   |

**Table 4. Avalanche characteristics**

| Symbol          | Parameter   | Value | Unit |
|-----------------|---|-------|------|
| I <sub>AS</sub> | Avalanche current, repetitive or not-repetitive (pulse width limited by T <sub>j</sub> max)                             | 2     | 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) | 65    | mJ   |

## 2 Electrical characteristics

(T<sub>CASE</sub> = 25 °C unless otherwise specified)

**Table 5. On/off states**

| Symbol               | Parameter   | Test conditions   | Min | Typ  | Max      | Unit     |
|----------------------|---|---|-----|------|----------|----------|
| 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> = 400 V, V <sub>GS</sub> = 10 V, I <sub>D</sub> = 4.6 A | 40  |      |          | V/ns     |
| I <sub>DSS</sub>     | Zero gate voltage drain current (V <sub>GS</sub> = 0) | V <sub>DS</sub> = Max rating, 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             | 2   | 3    | 4        | V        |
| R <sub>DS(on)</sub>  | Static drain-source on resistance                     | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 2.3 A                          |     | 0.85 | 0.92     | Ω        |

1. Characteristics 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> = 2.3 A  |      | 4              |      | S              |
| C <sub>iss</sub><br>C <sub>oss</sub><br>C <sub>res</sub> | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | V <sub>DS</sub> = 50 V, f = 1 MHz, V <sub>GS</sub> = 0  |      | 420<br>30<br>4 |      | pF<br>pF<br>pF |
| C <sub>oss eq.</sub> <sup>(2)</sup>                      | Output equivalent capacitance   | V <sub>GS</sub> = 0, V <sub>DS</sub> = 0 to 480 V   |      | 70             |      | pF             |
| R <sub>g</sub>   | Gate input resistance   | f = 1 MHz Gate DC Bias = 0 test signal level = 20 mV open drain                               |      | 6              |      | Ω              |
| 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> = 4.6 A<br>V <sub>GS</sub> = 10 V<br><i>Figure 19</i> |      | 13<br>2<br>7   |      | nC<br>nC<br>nC |

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. Switching times**

| Symbol       | Parameter           | Test conditions  | Min. | Typ. | Max. | Unit |
|--------------|---------------------|--|------|------|------|------|
| $t_{d(on)}$  | Turn-on delay time  | $V_{DD} = 300\text{ V}$ , $I_D = 2.3\text{ A}$ ,<br>$R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$<br><i>Figure 18</i> |      | 10   |      | ns   |
| $t_r$        | Rise time           |  |      | 8    |      | ns   |
| $t_{d(off)}$ | Turn-off delay time |  |      | 40   |      | ns   |
| $t_f$        | Fall time           |  |      | 9    |      | ns   |

**Table 8. Source drain diode**

| Symbol          | Parameter                     | Test conditions   | Min | Typ. | Max  | Unit          |
|-----------------|-------------------------------|---|-----|------|------|---------------|
| $I_{SD}$        | Source-drain current          |   |     |      | 4.6  | A             |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |   |     |      | 18.4 | A             |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD} = 4.6\text{ A}$ , $V_{GS} = 0$  |     |      | 1.3  | V             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 4.6\text{ A}$ ,<br>$di/dt = 100\text{ A}/\mu\text{s}$ ,<br>$V_{DD} = 20\text{ V}$ ,<br><i>Figure 20</i>                                   |     | 300  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |   |     | 2    |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |   |     | 12   |      | A             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 4.6\text{ A}$ ,<br>$di/dt = 100\text{ A}/\mu\text{s}$ ,<br>$V_{DD} = 20\text{ V}$ , $T_j = 150\text{ }^\circ\text{C}$<br><i>Figure 20</i> |     | 470  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |   |     | 3    |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |   |     | 12   |      | 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

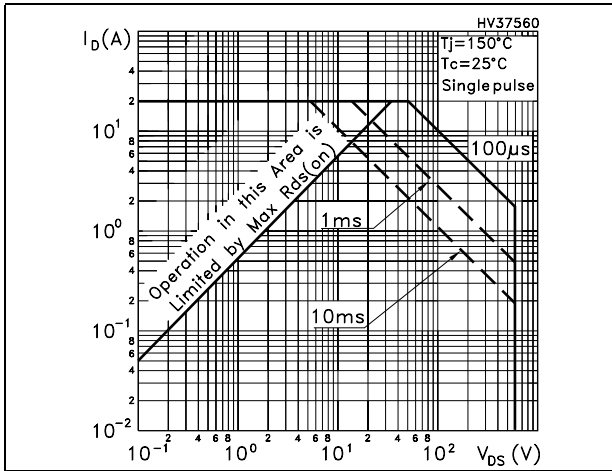


Figure 3. Thermal impedance for TO-220, D<sup>2</sup>PAK

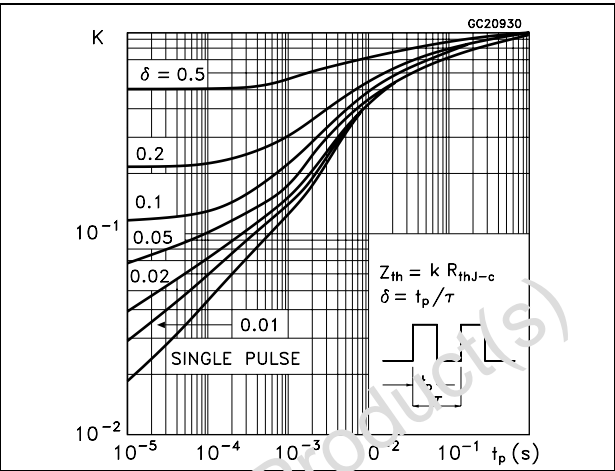


Figure 4. Safe operating area for TO-220FP

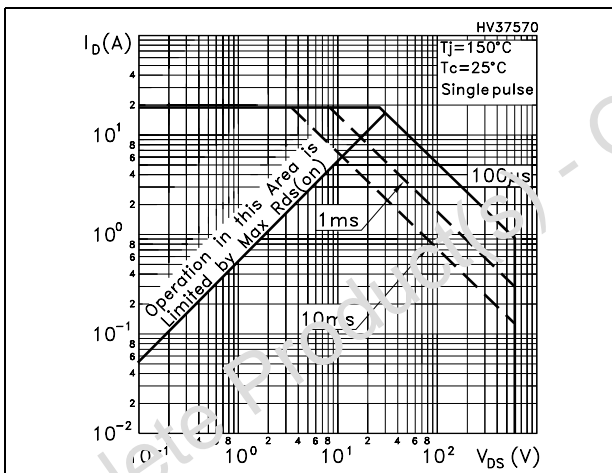


Figure 5. Thermal impedance for TO-220FP

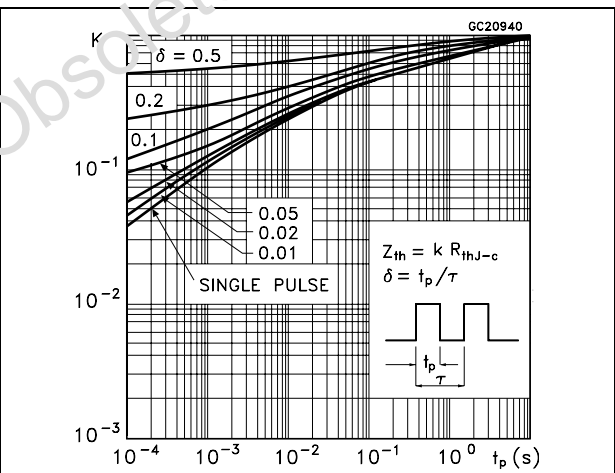


Figure 6. Safe operating area for DPAK, IPAK

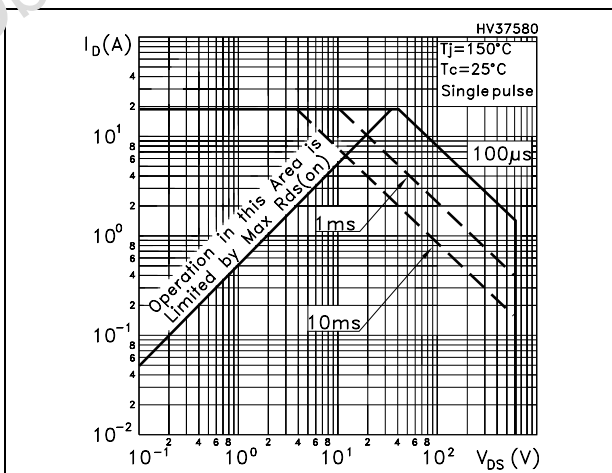


Figure 7. Thermal impedance for DPAK, IPAK

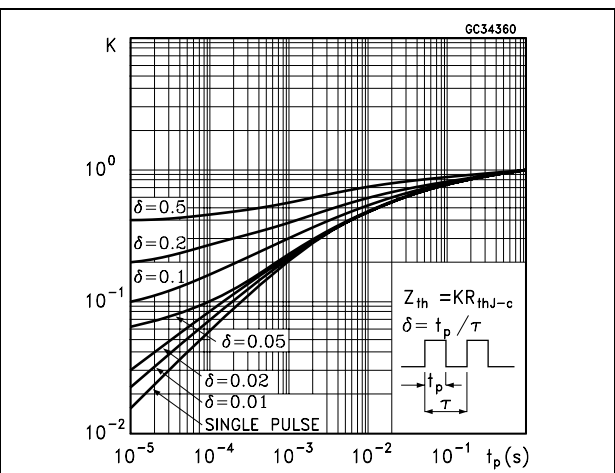


Figure 8. Output characteristics

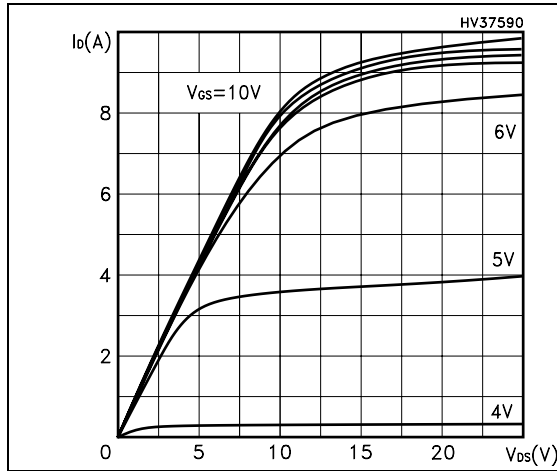


Figure 9. Transfer characteristics

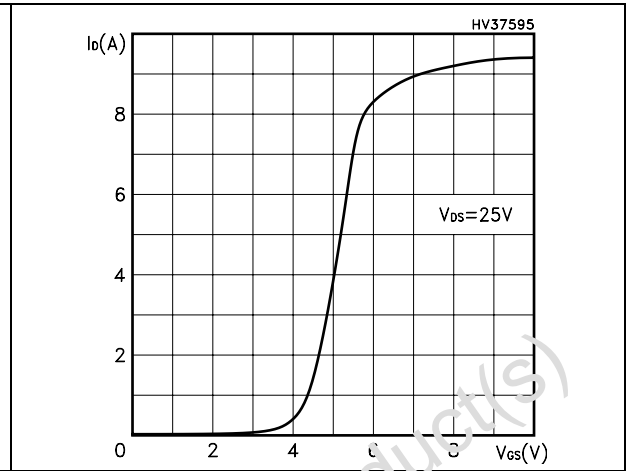


Figure 10. Transconductance

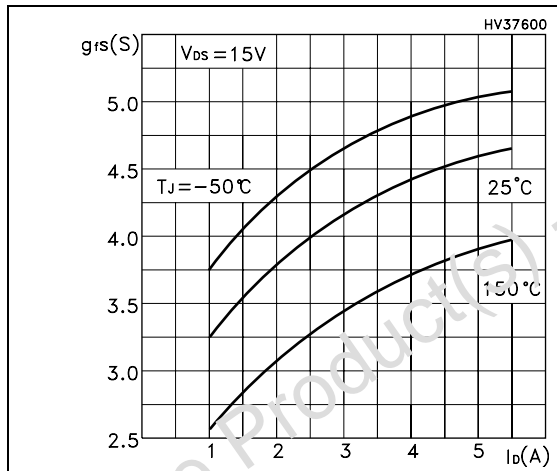


Figure 11. Static drain-source on resistance

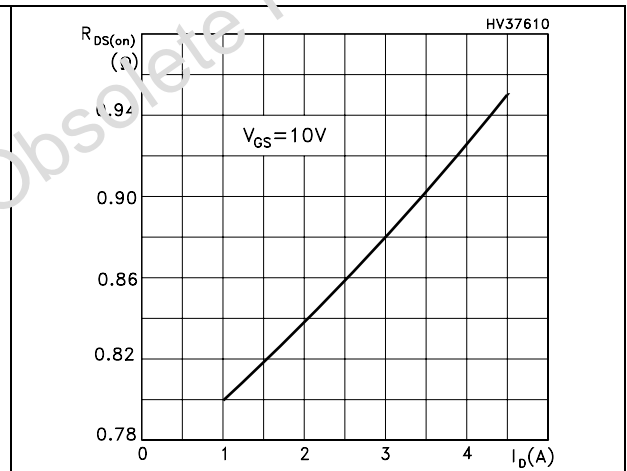


Figure 12. Gate charge vs gate-source voltage Figure 13. Capacitance variations

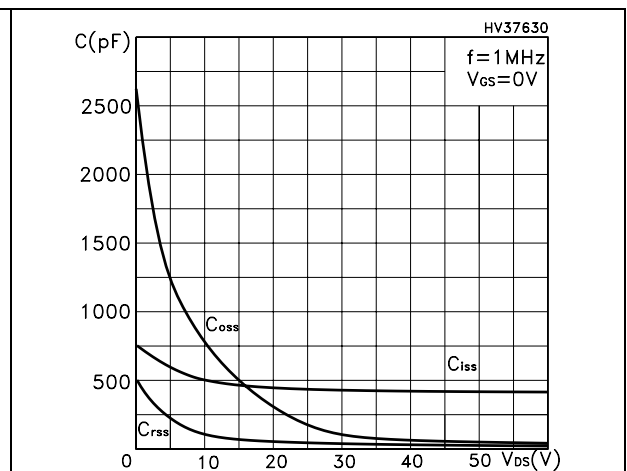
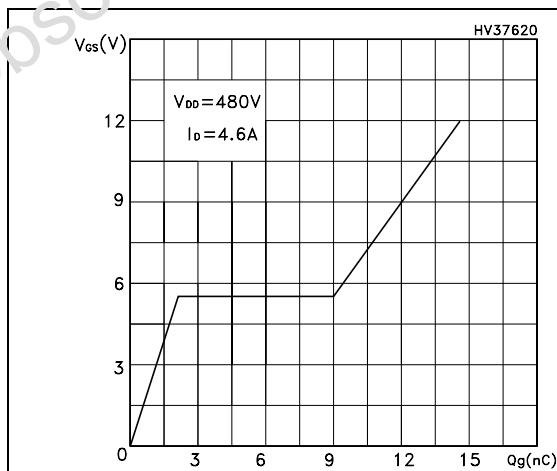


Figure 14. Normalized gate threshold voltage vs temperature

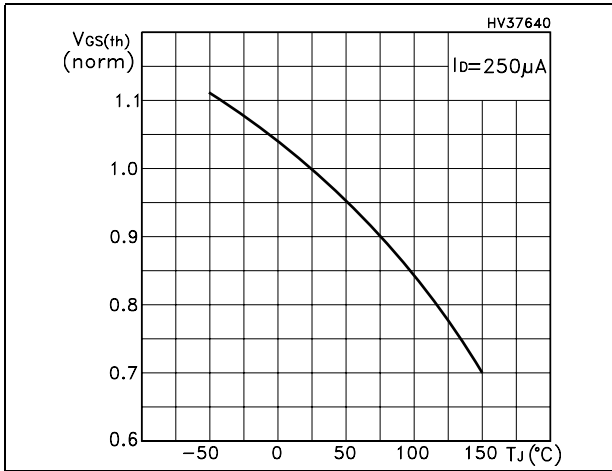


Figure 15. Normalized on resistance vs temperature

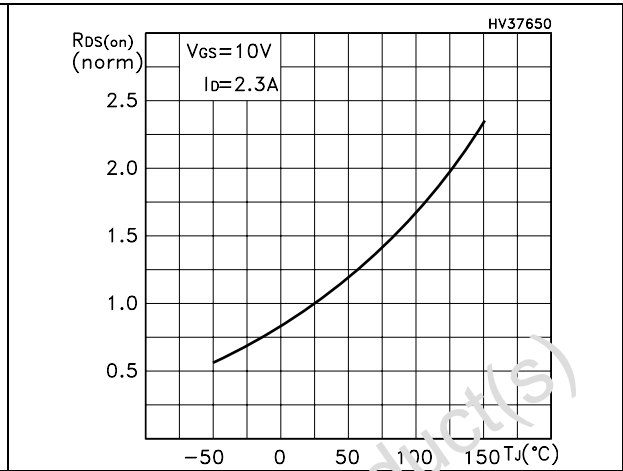


Figure 16. Source-drain diode forward characteristics

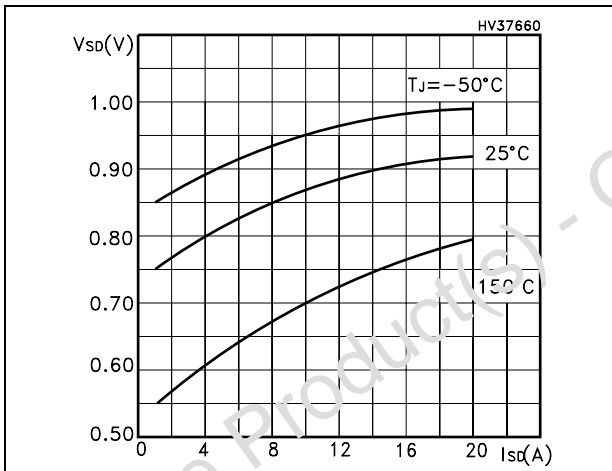
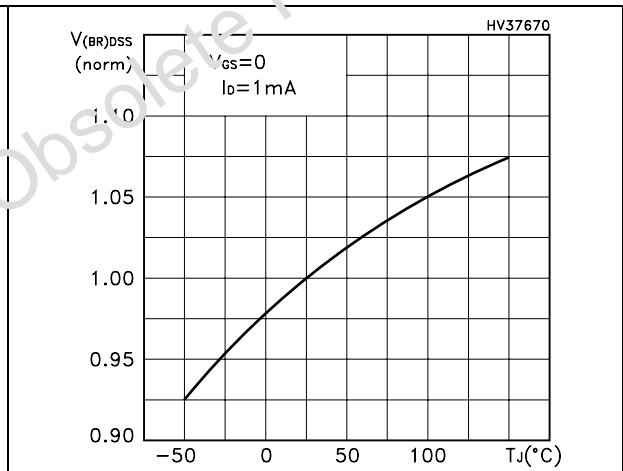


Figure 17. Normalized V(BR)DSS vs temperature



### 3 Test circuit

Figure 18. Switching times test circuit for resistive load

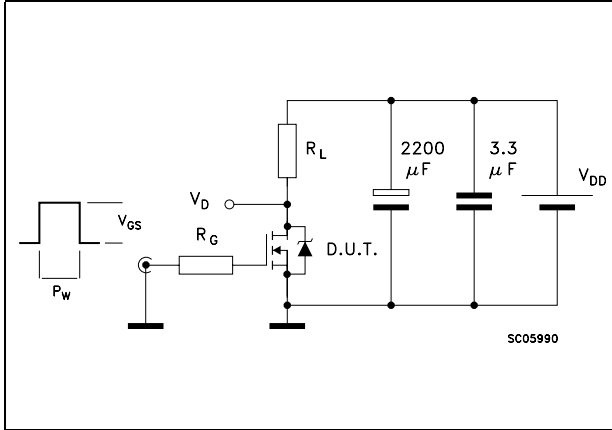


Figure 19. Gate charge test circuit

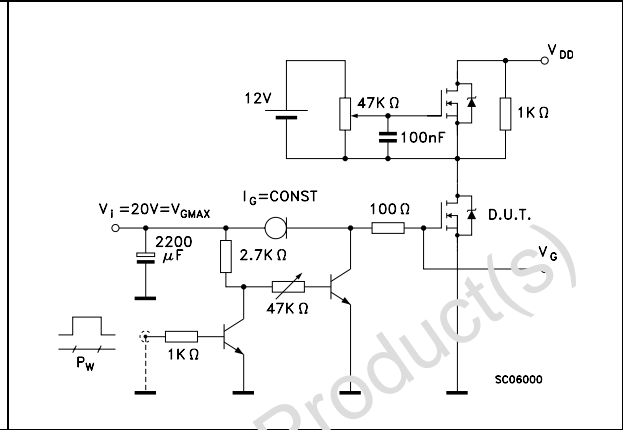


Figure 20. Test circuit for inductive load switching and diode recovery times

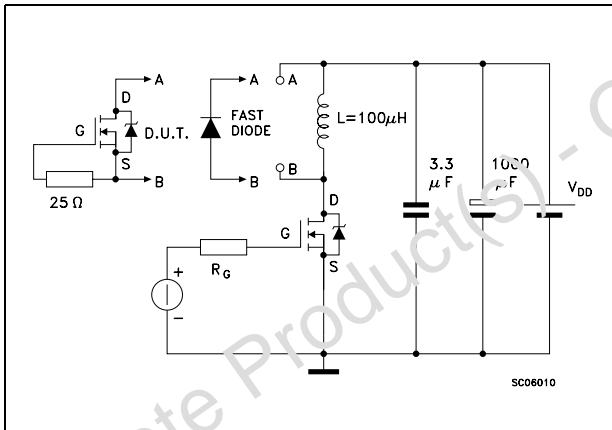


Figure 21. Unclamped inductive load test circuit

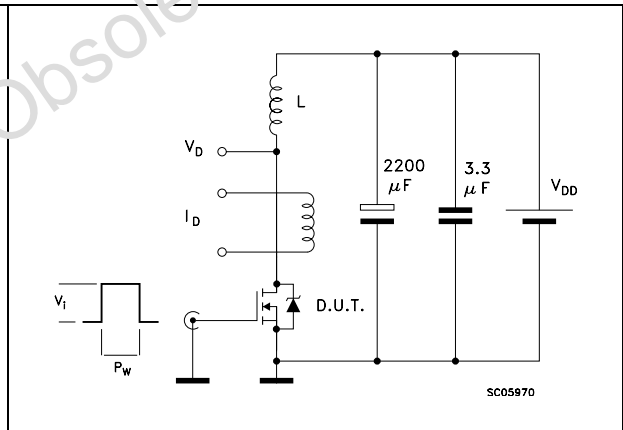


Figure 22. Unclamped inductive waveform

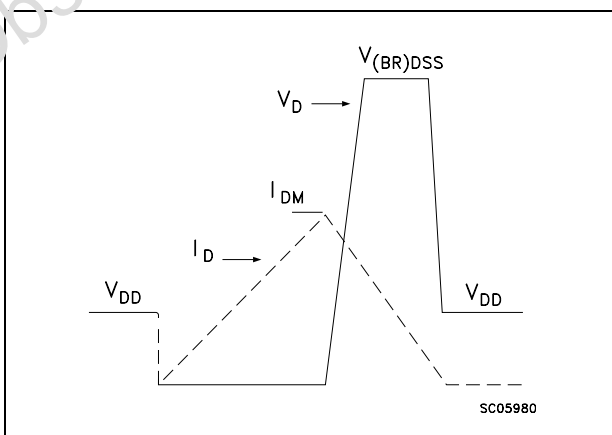
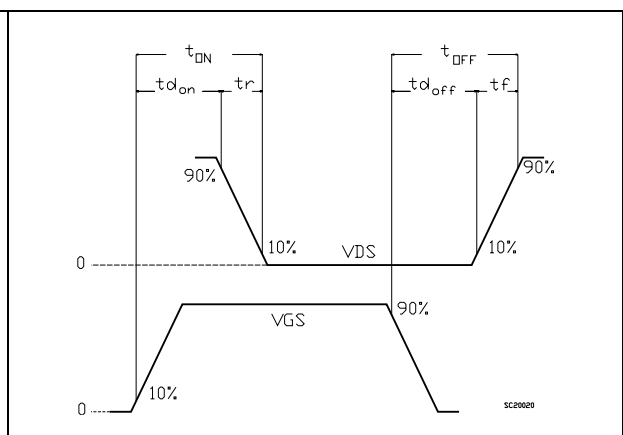


Figure 23. Switching time waveform



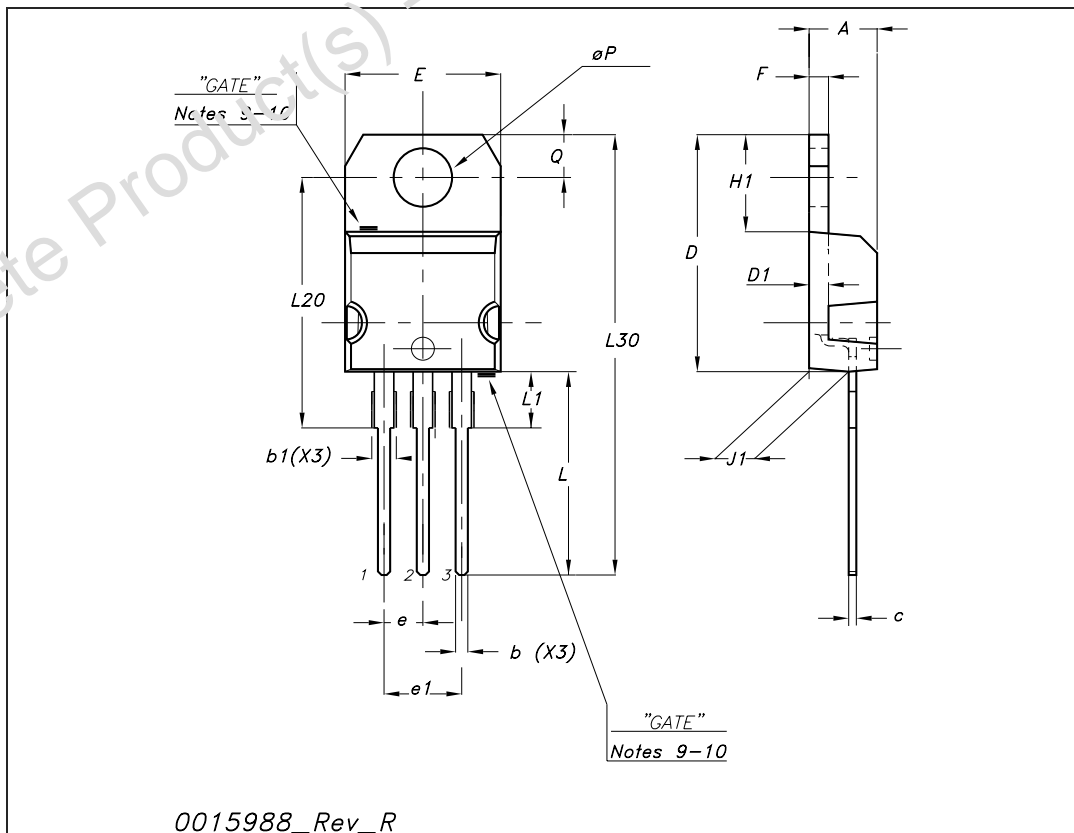
## 4 Package mechanical data

In order to meet environmental requirements, ST offers these devices in 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.

Obsolete Product(s) - Obsolete Product(s)

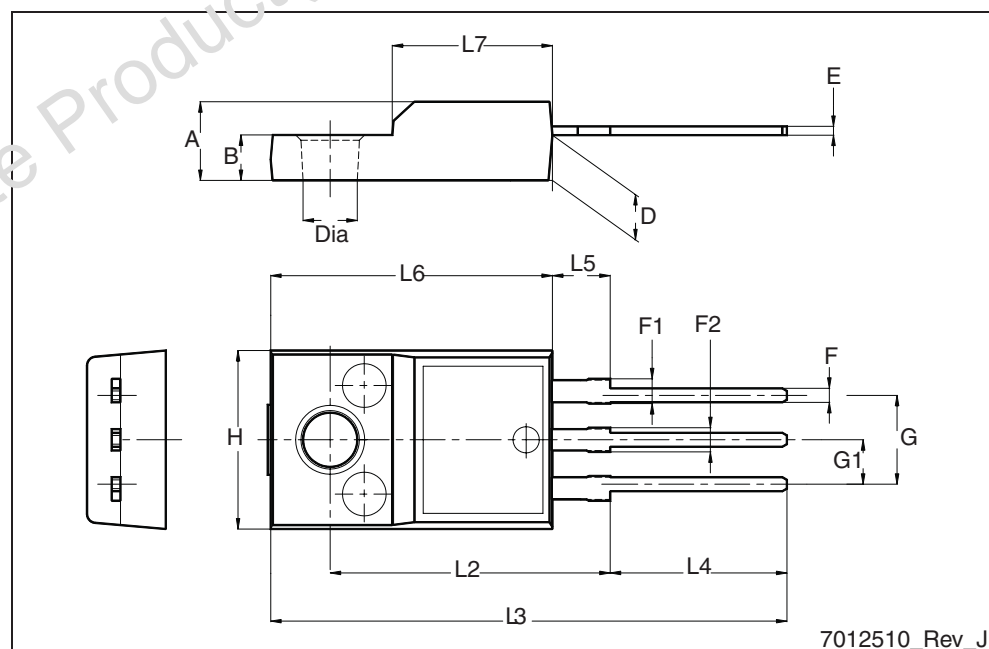
TO-220 mechanical data

| 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 |



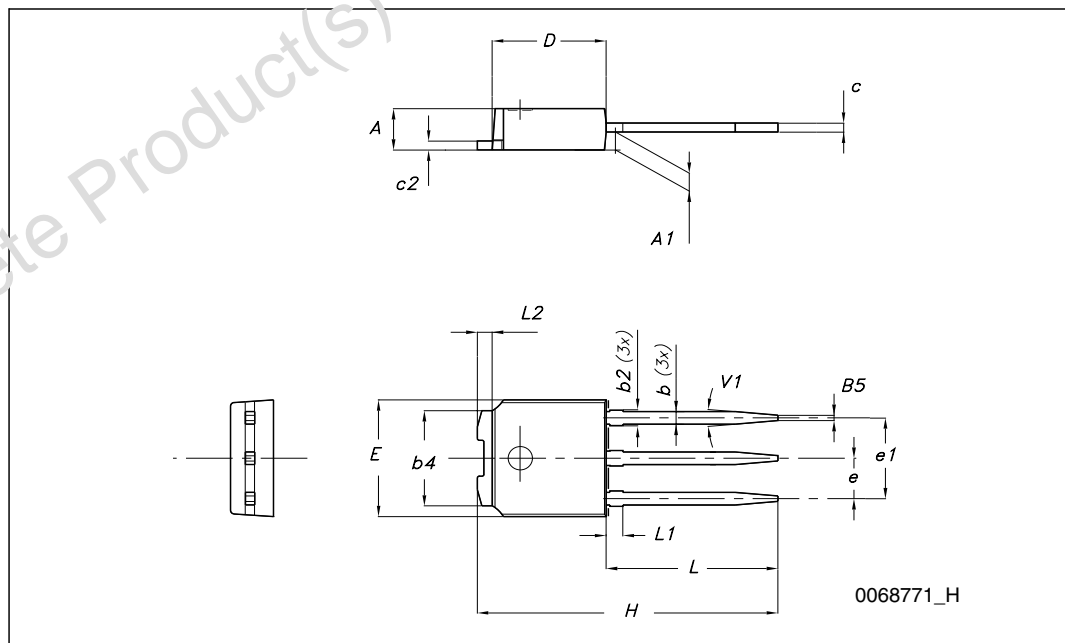
TO-220FP mechanical data

| Dim. | mm   |      |      |
|------|------|------|------|
|      | Min. | Typ. | Max. |
| A    | 4.4  |      | 4.6  |
| B    | 2.5  |      | 2.7  |
| D    | 2.5  |      | 2.75 |
| E    | 0.45 |      | 0.7  |
| F    | 0.75 |      | 1    |
| F1   | 1.15 |      | 1.70 |
| F2   | 1.15 |      | 1.5  |
| G    | 4.95 |      | 5.2  |
| G1   | 2.4  |      | 2.7  |
| H    | 10   |      | 10.4 |
| L2   |      | 16   |      |
| L3   | 28.6 |      | 30.6 |
| L4   | 9.8  |      | 10.6 |
| L5   | 2.9  |      | 3.6  |
| L6   | 15.9 |      | 16.4 |
| L7   | 9    |      | 9.3  |
| Dia  | 3    |      | 3.2  |



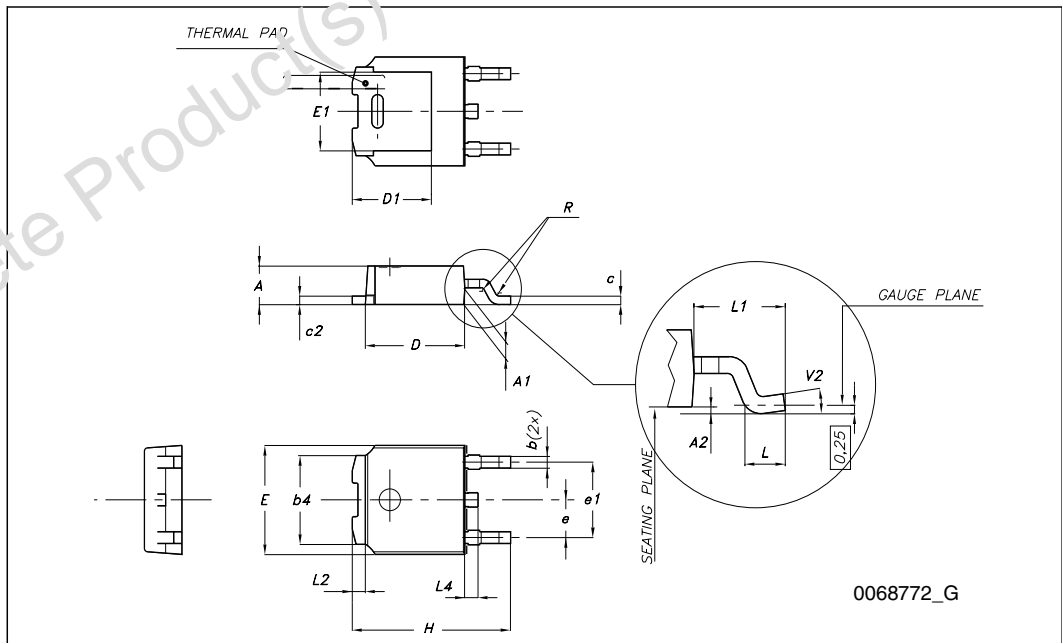
## TO-251 (IPAK) mechanical data

| 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°   |      |



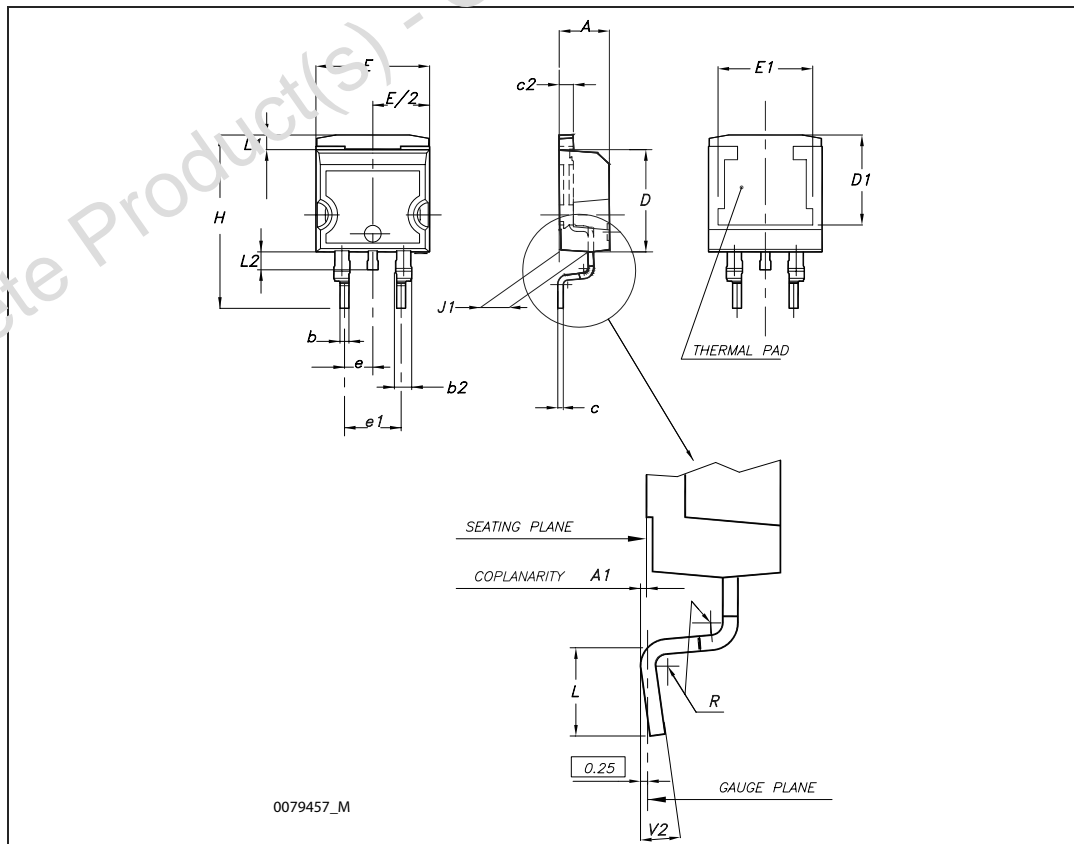
**TO-252 (DPAK) mechanical data**

| 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   |      | 2.90 |       |
| L2   |      | 0.80 |       |
| L4   | 0.60 |      | 1     |
| R    |      | 0.20 |       |
| V2   | 0°   |      | 8°    |



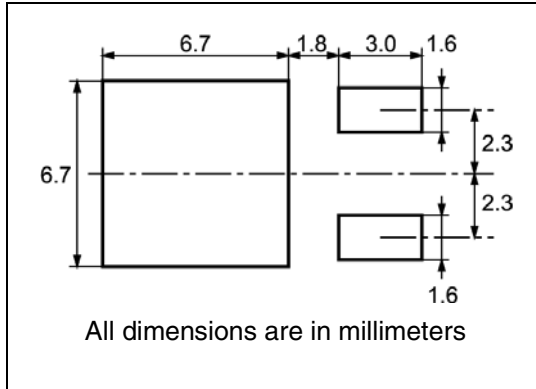
**D<sup>2</sup>PAK (TO-263) mechanical data**

| 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  | 0.098 |       | 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 Packaging mechanical data

## DPAK FOOTPRINT



## TAPE AND REEL SHIPMENT

### FEEL 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  |

### 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 |

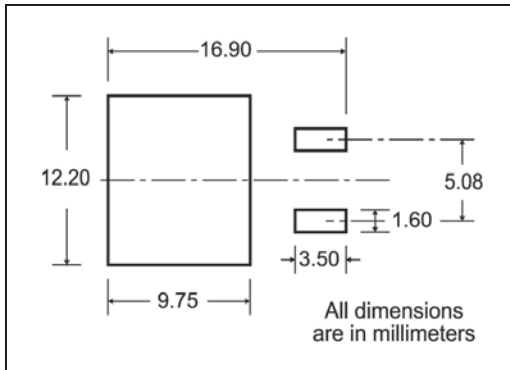
### BASE QTY

|      |
|------|
| 2500 |
|------|

### BULK QTY

|      |
|------|
| 2500 |
|------|

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  |

**FEEL 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     |

## 6 Revision history

**Table 9. Document revision history**

| Date        | Revision | Changes  |
|-------------|----------|--|
| 09-May-2007 | 1        | First release  |
| 01-Jun-2007 | 2        | Corrected value on <a href="#">Table 8: Source drain diode</a> |
| 21-Jan-2009 | 3        | Added new package, mechanical data D <sup>2</sup> PAK          |

Obsolete Product(s) - Obsolete Product(s)

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