



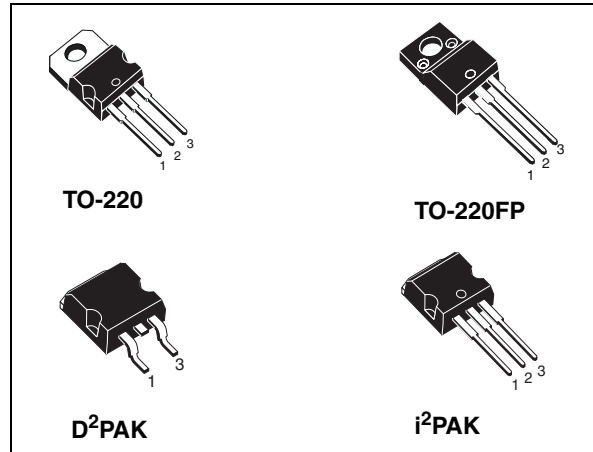
# STP11NM60 - STP11NM60FP STB11NM60 - STB11NM60-1

N-channel 650V @  $T_{Jmax}$  -  $0.4\Omega$  - 11A TO-220/FP/D<sup>2</sup>PAK/I<sup>2</sup>PAK  
MDmesh™ Power MOSFET

## General features

| Type        | $V_{DSS}$<br>(@ $T_J = T_{Jmax}$ ) | $R_{DS(on)}$  | $I_D$ |
|-------------|------------------------------------|---------------|-------|
| STP11NM60   | 650 V                              | $<0.45\Omega$ | 11A   |
| STP11NM60FP | 650 V                              | $<0.45\Omega$ | 11A   |
| STB11NM60   | 650 V                              | $<0.45\Omega$ | 11A   |
| STB11NM60-1 | 650 V                              | $<0.45\Omega$ | 11A   |

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



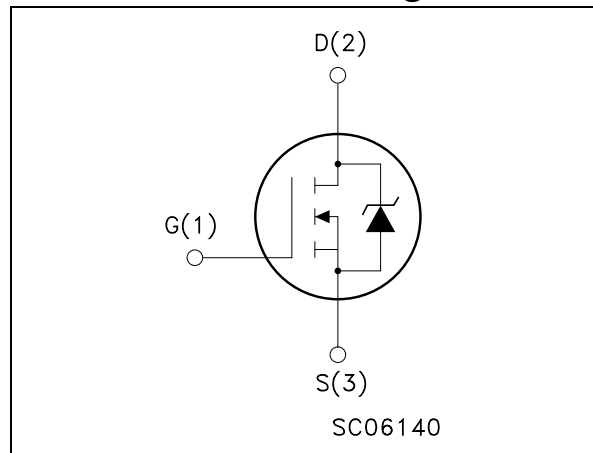
## Description

The MDmesh™ is a new revolutionary MOSFET technology that associates the Multiple Drain process with the Company's PowerMESH™ horizontal layout. The resulting product has an outstanding low on-resistance, impressively high dv/dt and excellent avalanche characteristics. The adoption of the Company's proprietary strip technique yields overall dynamic performance that is significantly better than that of similar competition's products.

## Applications

- Switching application

## Internal schematic diagram



## Order codes

| Part number  | Marking    | Package            | Packaging   |
|--------------|------------|--------------------|-------------|
| STB11NK60ZT4 | B11NK60Z   | D <sup>2</sup> PAK | Tape & reel |
| STB11NK60Z-1 | B11NK60Z   | I <sup>2</sup> PAK | Tube        |
| STP11NK60Z   | P11NK60Z   | TO-220             | Tube        |
| STP11NK60ZFP | P11NK60ZFP | TO-220FP           | Tube        |

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# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

| Symbol                         | Parameter                                           | Value                                        |                   | Unit |
|--------------------------------|-----------------------------------------------------|----------------------------------------------|-------------------|------|
|                                |                                                     | TO-220/D <sup>2</sup> PAK/I <sup>2</sup> PAK | TO-220FP          |      |
| V <sub>GS</sub>                | Gate- source voltage                                | ±30                                          |                   | V    |
| I <sub>D</sub>                 | Drain current (continuous) at T <sub>C</sub> = 25°C | 11                                           | 11 <sup>(1)</sup> | A    |
| I <sub>D</sub>                 | Drain current (continuous) at T <sub>C</sub> =100°C | 7                                            | 7 <sup>(1)</sup>  | A    |
| I <sub>DM</sub> <sup>(2)</sup> | Drain current (pulsed)                              | 44                                           | 44 <sup>(1)</sup> | A    |
| P <sub>TOT</sub>               | Total dissipation at T <sub>C</sub> = 25°C          | 160                                          | 35                | W    |
|                                | Derating Factor                                     | 1.28                                         | 0.28              | W/°C |
| dv/dt <sup>(3)</sup>           | Peak diode recovery voltage slope                   | 15                                           |                   | V/ns |
| V <sub>ISO</sub>               | Insulation withstand voltage (DC)                   | --                                           | 2500              | V    |
| T <sub>J</sub>                 | Operating junction temperature                      | -65 to 150                                   |                   | °C   |
| T <sub>stg</sub>               | Storage temperature                                 | 150                                          |                   | °C   |

1. Limited only by maximum temperature allowed
2. Pulse width limited by safe operating area
3. I<sub>SD</sub> ≤ 11A, di/dt ≤ 400A/μs, V<sub>DD</sub> ≤ V<sub>(BR)DSS</sub>, T<sub>j</sub> ≤ T<sub>JMAX</sub>.

**Table 2. Thermal data**

| Symbol                | Parameter                                      | Value                                        |          | Unit |
|-----------------------|------------------------------------------------|----------------------------------------------|----------|------|
|                       |                                                | TO-220/D <sup>2</sup> PAK/I <sup>2</sup> PAK | TO-220FP |      |
| R <sub>thj-case</sub> | Thermal resistance junction-case Max           | 0.78                                         | 3.57     | °C/W |
| R <sub>thj-a</sub>    | Thermal resistance junction-ambient Max        | 62.5                                         |          | °C/W |
| T <sub>I</sub>        | Maximum lead temperature for soldering purpose | 300                                          |          | °C   |

**Table 3. Avalanche characteristics**

| Symbol          | Parameter                                                                                                             | Value | Unit |
|-----------------|-----------------------------------------------------------------------------------------------------------------------|-------|------|
| I <sub>AR</sub> | Avalanche current, repetitive or not-repetitive (pulse width limited by T <sub>j</sub> Max)                           | 5.5   | A    |
| E <sub>AS</sub> | Single pulse avalanche energy (starting T <sub>j</sub> =25°C, I <sub>d</sub> =I <sub>ar</sub> , V <sub>dd</sub> =50V) | 350   | mJ   |

## 2 Electrical characteristics

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

**Table 4. On/off states**

| Symbol        | Parameter                                        | Test conditions                                                                  | Min. | Typ. | Max.      | Unit                           |
|---------------|--------------------------------------------------|----------------------------------------------------------------------------------|------|------|-----------|--------------------------------|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage                   | $I_D = 250\ \mu\text{A}$ , $V_{GS} = 0$                                          | 600  |      |           | V                              |
| $I_{DSS}$     | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = 600\ \text{V}$<br>$V_{DS} = 600\ \text{V}$ , $T_C=125^{\circ}\text{C}$ |      |      | 1<br>10   | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$     | Gate body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 30\text{V}$                                                        |      |      | $\pm 100$ | nA                             |
| $V_{GS(th)}$  | Gate threshold voltage                           | $V_{DS} = V_{GS}$ , $I_D = 250\ \mu\text{A}$                                     | 3    | 4    | 5         | V                              |
| $R_{DS(on)}$  | Static drain-source on resistance                | $V_{GS} = 10\text{V}$ , $I_D = 5.5\text{A}$                                      |      | 0.4  | 0.45      | $\Omega$                       |

**Table 5. Dynamic**

| Symbol                              | Parameter                                                               | Test conditions                                                                | Min. | Typ.              | Max. | Unit           |
|-------------------------------------|-------------------------------------------------------------------------|--------------------------------------------------------------------------------|------|-------------------|------|----------------|
| $g_{fs}^{(1)}$                      | Forward transconductance                                                | $V_{DS} > I_{D(on)} \times R_{DS(on)max}$ ,<br>$I_D = 5.5\text{A}$             |      | 5.2               |      | S              |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25\text{V}$ , $f = 1\ \text{MHz}$ , $V_{GS} = 0$                     |      | 1000<br>230<br>25 |      | pF<br>pF<br>pF |
| $C_{oss\ eq}^{(2)}$                 | Equivalent output capacitance                                           | $V_{GS} = 0$ , $V_{DS} = 0\text{V}$ to $480\text{V}$                           |      | 100               |      | pF             |
| $R_G$                               | Gate input resistance                                                   | $f = 1\ \text{MHz}$ gate DC bias = 0<br>Test signal level = 20mV<br>open drain |      | 1.6               |      | $\Omega$       |
| $Q_g$<br>$Q_{gs}$<br>$Q_{gd}$       | Total gate charge<br>Gate-source charge<br>Gate-drain charge            | $V_{DD} = 480\text{V}$ , $I_D = 11\text{A}$<br>$V_{GS} = 10\text{V}$           |      | 30<br>10<br>15    |      | nC<br>nC<br>nC |

1. Pulsed: pulse duration=300 $\mu\text{s}$ , duty cycle 1.5%

2.  $C_{oss\ eq.}$  is defined as a constant equivalent capacitance giving the same charging time as  $C_{oss}$  when  $V_{DS}$  increases from 0 to 80%  $V_{DSS}$

**Table 6. Switching times**

| Symbol                          | Parameter                                             | Test conditions                                                                                           | Min. | Typ.          | Max. | Unit           |
|---------------------------------|-------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|------|---------------|------|----------------|
| $t_{d(on)}$<br>$t_r$            | Turn-on Delay Time<br>Rise Time                       | $V_{DD}=300\text{ V}$ , $I_D=5.5\text{ A}$ ,<br>$R_G=4.7\Omega$ , $V_{GS}=10\text{ V}$<br>(see Figure 16) |      | 20<br>20      |      | ns<br>ns       |
| $t_{r(Voff)}$<br>$t_f$<br>$t_c$ | Off-voltage Rise Time<br>Fall Time<br>Cross-over Time | $V_{DD}=480\text{ V}$ , $I_D=11\text{ A}$ ,<br>$R_G=4.7\Omega$ , $V_{GS}=10\text{ V}$<br>(see Figure 16)  |      | 6<br>11<br>19 |      | ns<br>ns<br>ns |

**Table 7. Source drain diode**

| Symbol                            | Parameter                                                                    | Test conditions                                                                                                                      | Min | Typ.               | Max | Unit                     |
|-----------------------------------|------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|-----|--------------------|-----|--------------------------|
| $I_{SD}$                          | Source-drain current                                                         |                                                                                                                                      |     |                    | 11  | A                        |
| $I_{SDM}^{(1)}$                   | Source-drain current (pulsed)                                                |                                                                                                                                      |     |                    | 44  | A                        |
| $V_{SD}^{(2)}$                    | Forward on voltage                                                           | $I_{SD}=11\text{ A}$ , $V_{GS}=0$                                                                                                    |     |                    | 1.5 | V                        |
| $t_{rr}$<br>$Q_{rr}$<br>$I_{RRM}$ | Reverse recovery time<br>Reverse recovery charge<br>Reverse recovery current | $I_{SD}=11\text{ A}$ ,<br>$di/dt = 100\text{ A}/\mu\text{s}$ ,<br>$V_{DD}=100\text{ V}$ , $T_j=25^\circ\text{C}$<br>(see Figure 16)  |     | 390<br>3.8<br>19.5 |     | ns<br>$\mu\text{C}$<br>A |
| $t_{rr}$<br>$Q_{rr}$<br>$I_{RRM}$ | Reverse recovery time<br>Reverse recovery charge<br>Reverse recovery current | $I_{SD}=11\text{ A}$ ,<br>$di/dt = 100\text{ A}/\mu\text{s}$ ,<br>$V_{DD}=100\text{ V}$ , $T_j=150^\circ\text{C}$<br>(see Figure 16) |     | 570<br>5.7<br>20   |     | 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 1. Safe operating area for TO-220/D<sup>2</sup>PAK/I<sup>2</sup>PAK

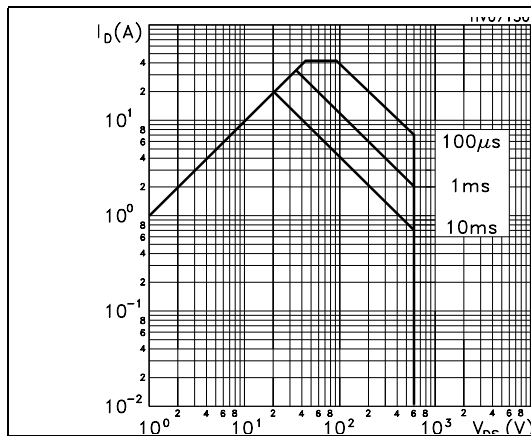


Figure 2. Thermal impedance TO-220/D<sup>2</sup>PAK/I<sup>2</sup>PAK

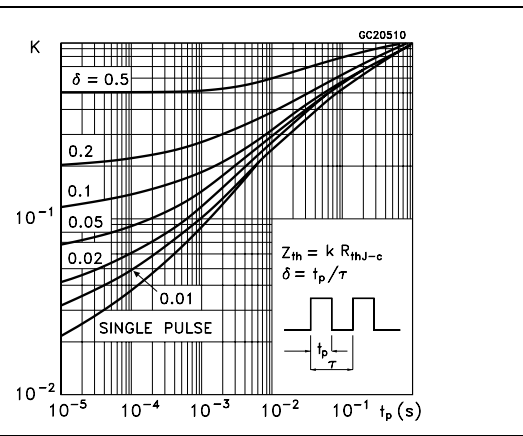


Figure 3. Safe operating area for TO-220FP

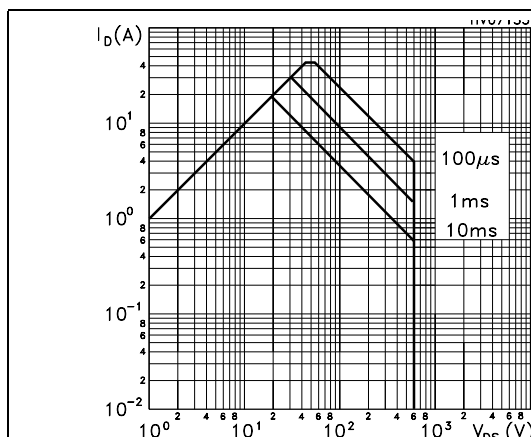


Figure 4. Thermal impedance for TO-220FP

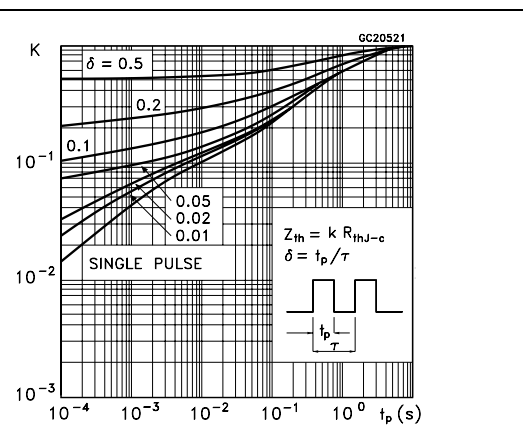


Figure 5. Output characteristics

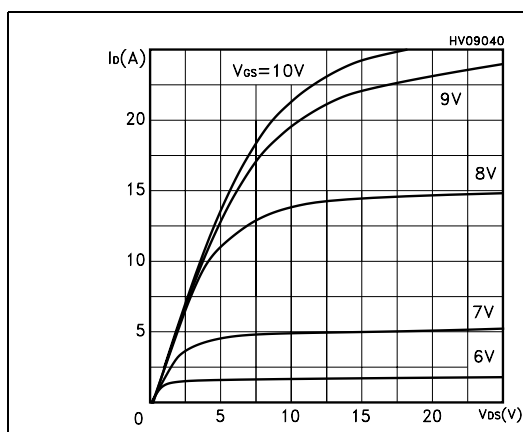


Figure 6. Transfer characteristics

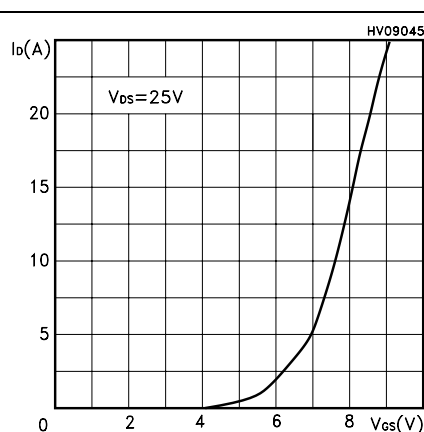


Figure 7. Transconductance

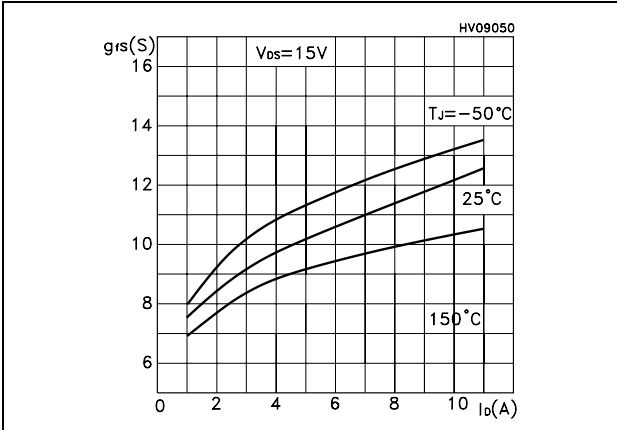


Figure 8. Static drain-source on resistance

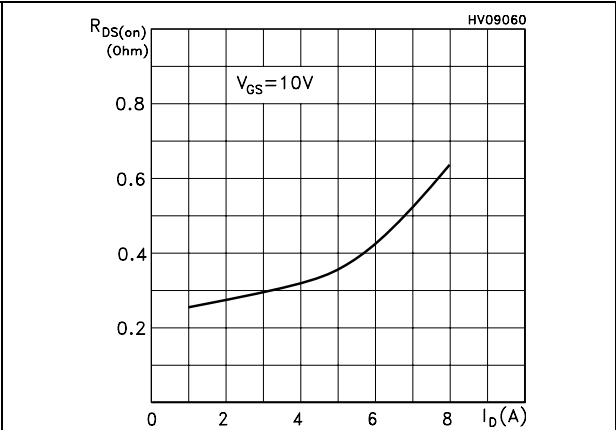


Figure 9. Gate charge vs gate-source voltage

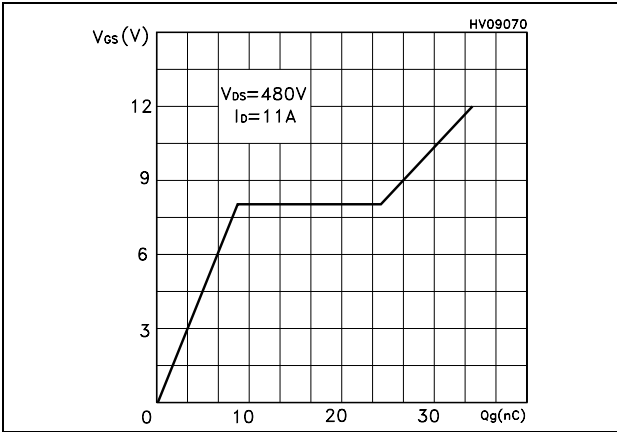


Figure 10. Capacitance variations

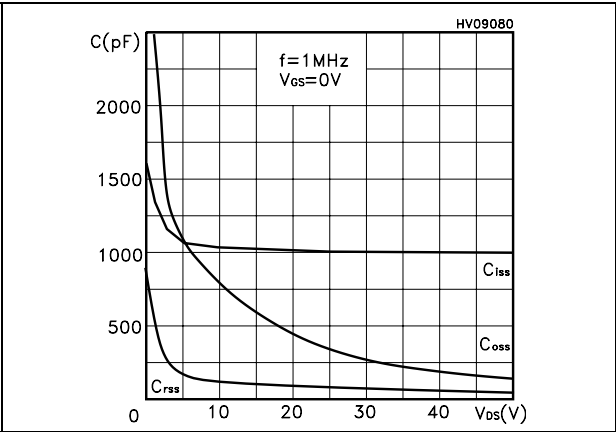


Figure 11. Normalized gate threshold voltage vs temperature

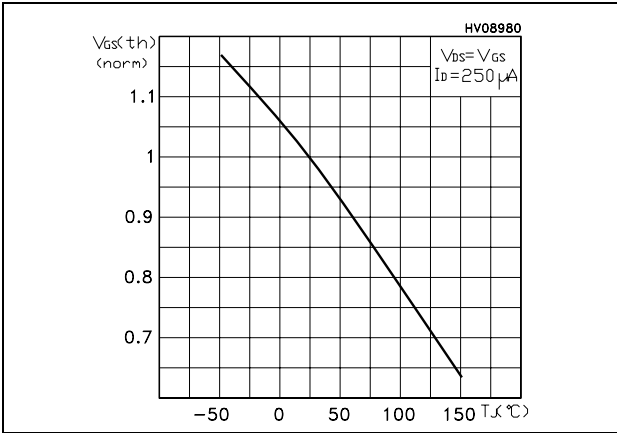


Figure 12. Normalized on resistance vs temperature

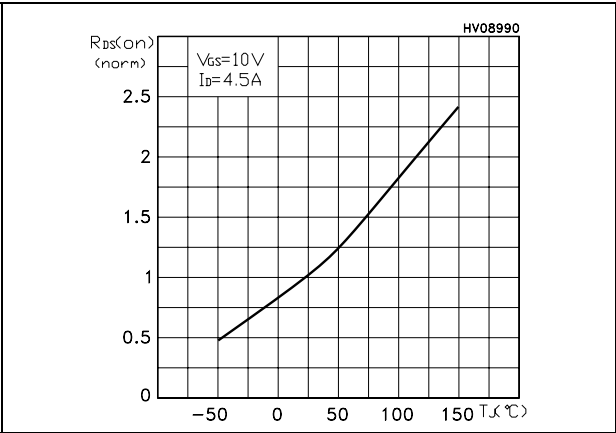
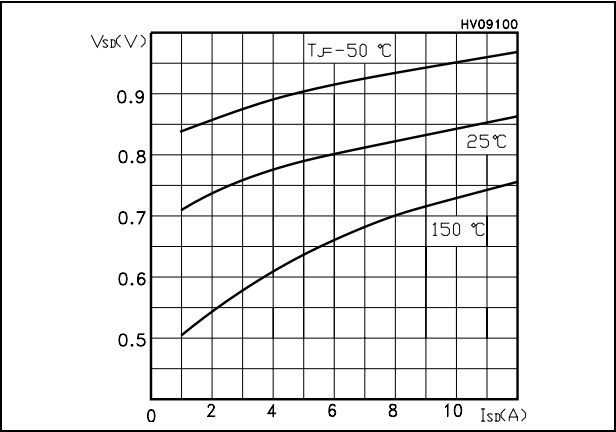


Figure 13. Source-drain diode forward characteristics



### 3 Test circuit

Figure 14. Switching times test circuit for resistive load

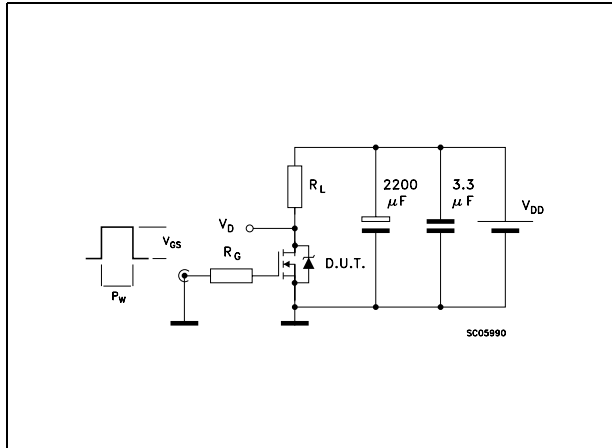


Figure 15. Gate charge test circuit

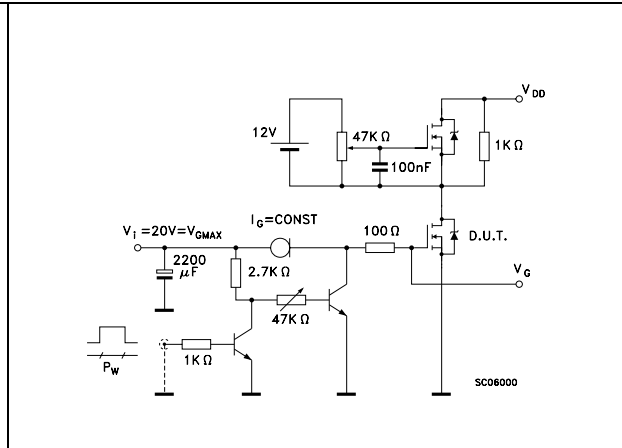


Figure 16. Test circuit for inductive load switching and diode recovery times

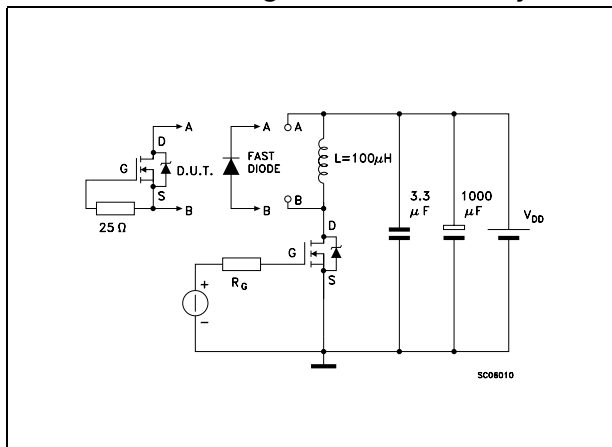


Figure 17. Unclamped Inductive load test circuit

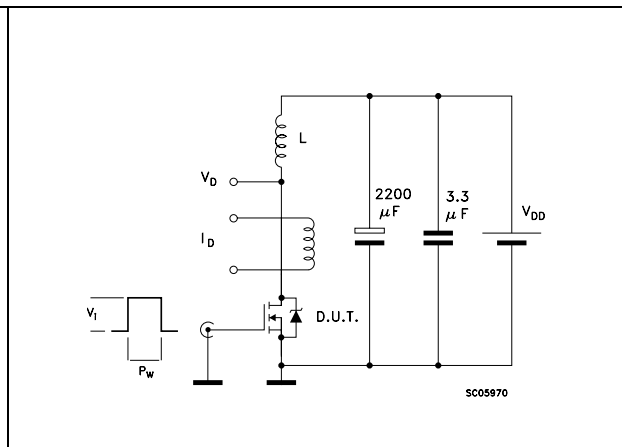


Figure 18. Unclamped inductive waveform

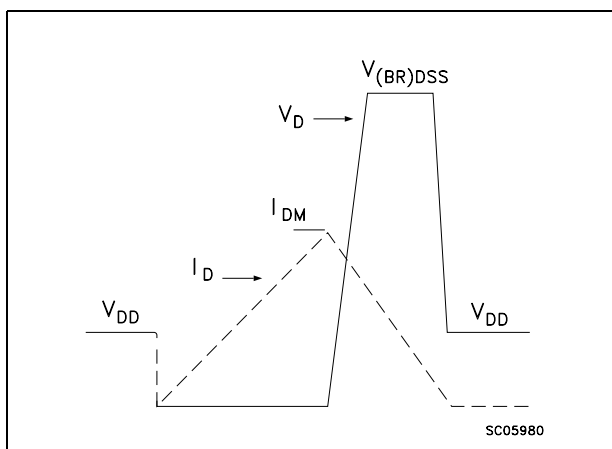
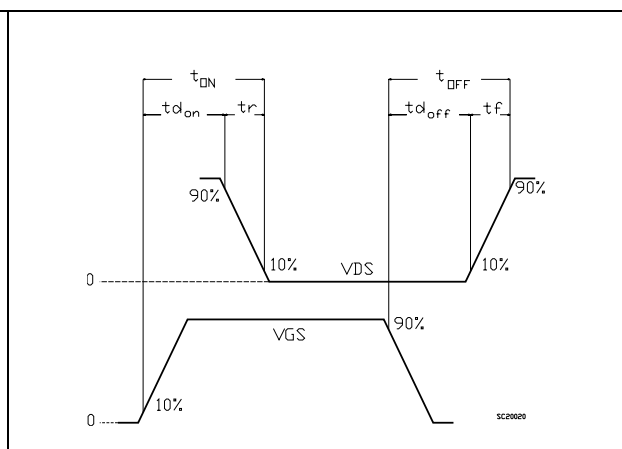


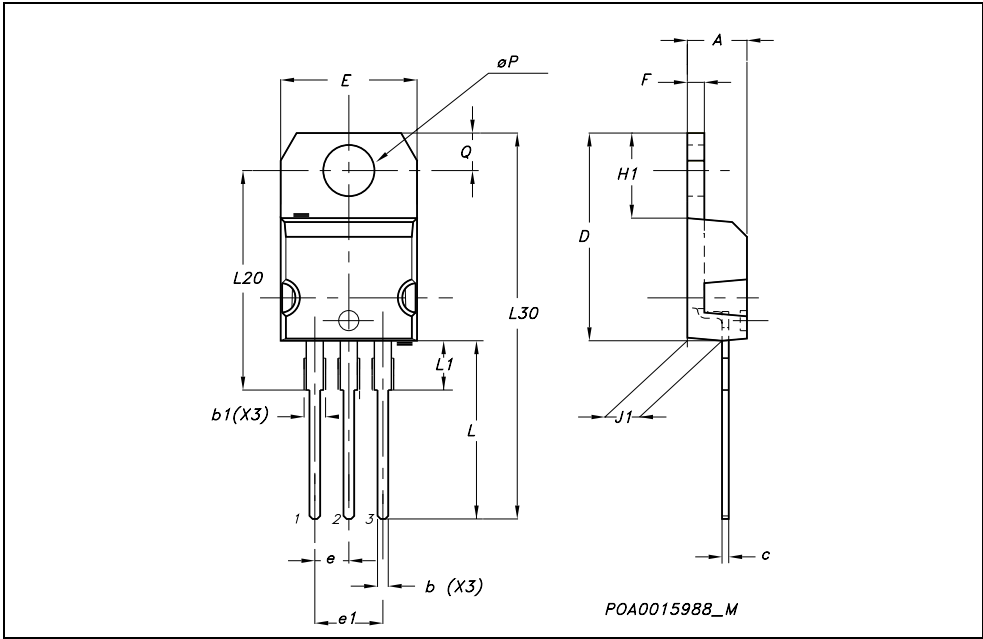
Figure 19. Switching time waveform



## 4 Package mechanical data

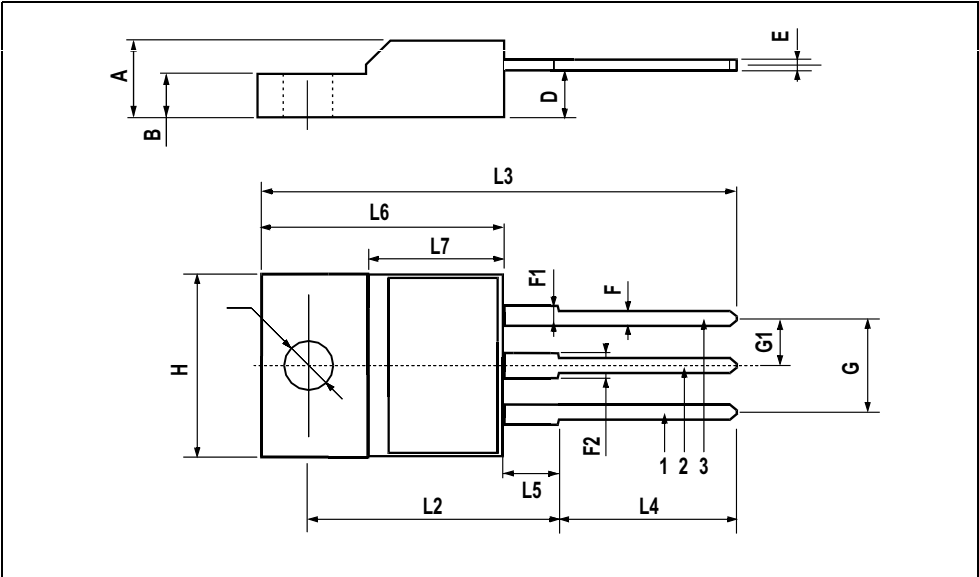
In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a Lead-free second level interconnect . The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings 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                     | 1.15  |       | 1.70  | 0.045 |       | 0.066 |
| c                      | 0.49  |       | 0.70  | 0.019 |       | 0.027 |
| D                      | 15.25 |       | 15.75 | 0.60  |       | 0.620 |
| 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 |       | 0.052 |
| 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 |       |
| øP                     | 3.75  |       | 3.85  | 0.147 |       | 0.151 |
| Q                      | 2.65  |       | 2.95  | 0.104 |       | 0.116 |



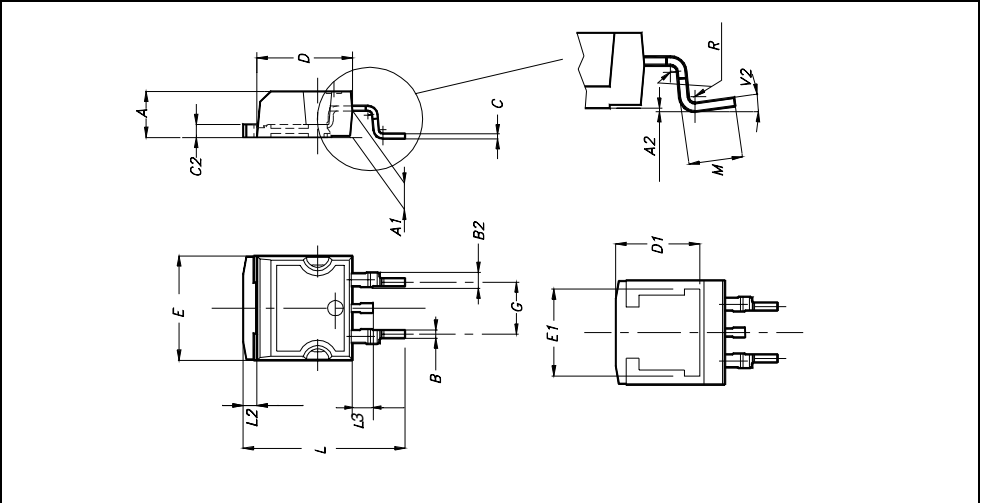
TO-220FP MECHANICAL DATA

| 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 |



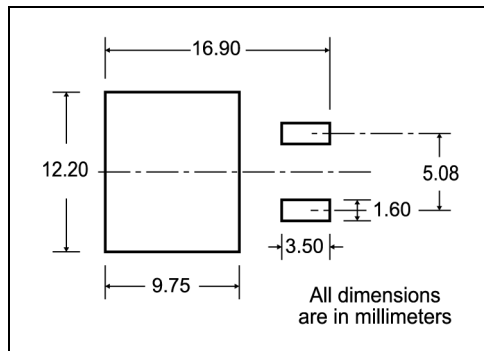
D<sup>2</sup>PAK MECHANICAL DATA

| DIM. | mm.  |     |       | inch  |       |       |
|------|------|-----|-------|-------|-------|-------|
|      | MIN. | TYP | MAX.  | MIN.  | TYP.  | MAX.  |
| A    | 4.4  |     | 4.6   | 0.173 |       | 0.181 |
| A1   | 2.49 |     | 2.69  | 0.098 |       | 0.106 |
| A2   | 0.03 |     | 0.23  | 0.001 |       | 0.009 |
| B    | 0.7  |     | 0.93  | 0.027 |       | 0.036 |
| B2   | 1.14 |     | 1.7   | 0.044 |       | 0.067 |
| C    | 0.45 |     | 0.6   | 0.017 |       | 0.023 |
| C2   | 1.23 |     | 1.36  | 0.048 |       | 0.053 |
| D    | 8.95 |     | 9.35  | 0.352 |       | 0.368 |
| D1   |      | 8   |       |       | 0.315 |       |
| E    | 10   |     | 10.4  | 0.393 |       |       |
| E1   |      | 8.5 |       |       | 0.334 |       |
| G    | 4.88 |     | 5.28  | 0.192 |       | 0.208 |
| L    | 15   |     | 15.85 | 0.590 |       | 0.625 |
| L2   | 1.27 |     | 1.4   | 0.050 |       | 0.055 |
| L3   | 1.4  |     | 1.75  | 0.055 |       | 0.068 |
| M    | 2.4  |     | 3.2   | 0.094 |       | 0.126 |
| R    |      | 0.4 |       |       | 0.015 |       |
| V2   | 0°   |     | 4°    |       |       |       |

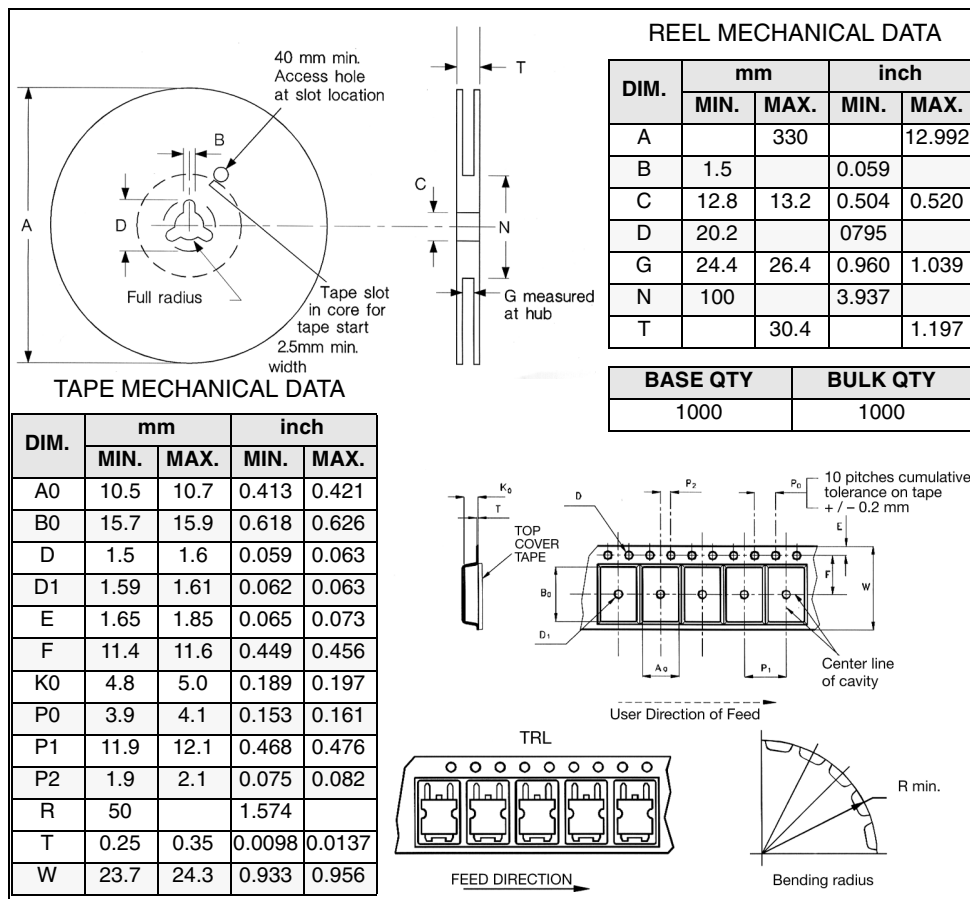


## 5 Packaging mechanical data

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



### TAPE AND REEL SHIPMENT



\* on sales type

## 6 Revision history

**Table 8. Revision history**

| Date        | Revision | Changes                                                                                        |
|-------------|----------|------------------------------------------------------------------------------------------------|
| 09-Sep-2004 | 1        | First Release                                                                                  |
| 10-Jun-2005 | 2        | Typing error, wrong description                                                                |
| 26-Jul-2006 | 3        | The document has been reformatted, no content change                                           |
| 31-Aug-2006 | 4        | Typo mistake on order code                                                                     |
| 21-Dec-2006 | 5        | Various changes on "Test conditions" for <a href="#">Table 5.</a> and <a href="#">Table 6.</a> |

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