



# STP5NK90Z STF5NK90Z

N-channel 900V - 2Ω - 4.5A - TO-220/TO-220FP  
Zener - Protected SuperMESH™ MOSFET

## General features

| Type      | V <sub>DSS</sub><br>(@T <sub>Jmax</sub> ) | R <sub>DS(on)</sub> | I <sub>D</sub>       | P <sub>W</sub> |
|-----------|-------------------------------------------|---------------------|----------------------|----------------|
| STP5NK90Z | 900 V                                     | < 2.5 Ω             | 4.5 A                | 125W           |
| STF5NK90Z | 900 V                                     | < 2.5 Ω             | 4.5 A <sup>(1)</sup> | 30W            |

1. Limited only by maximum temperature allowed

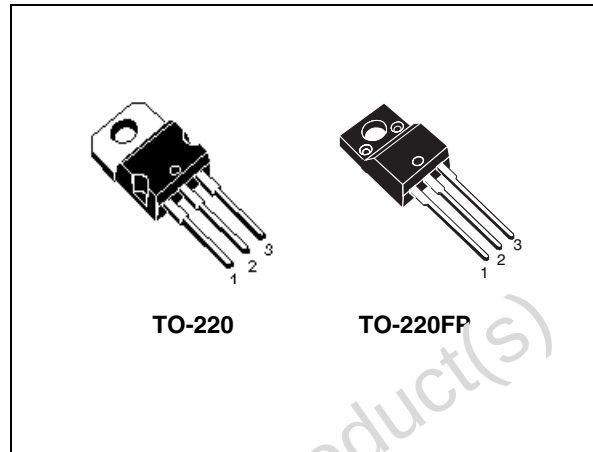
- Extremely high dv/dt capability
- Improved esd capability
- 100% avalanche rated
- Gate charge minimized
- Very low intrinsic capacitances
- Very good manufacturing repeatability

## Description

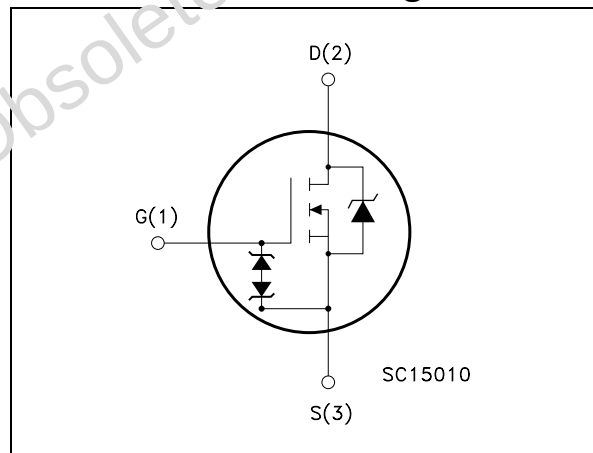
The SuperMESH™ series is obtained through an extreme optimization of ST's well established stripbased PowerMESH™ layout. In addition to pushing on-resistance significantly down, special care is taken to ensure a very good dv/dt capability for the most demanding applications. Such series complements ST full range of high voltage MOSFETs including revolutionary MDmesh™ products.

## Applications

- Switching application



## Internal schematic diagram



## Order codes

| Part number | Marking | Package  | Packaging |
|-------------|---------|----------|-----------|
| STP5NK90Z   | P5NK90Z | TO-220   | Tube      |
| STF5NK90Z   | F5NK90Z | TO-220FP | Tube      |

## Contents

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# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

| Symbol         | Parameter                                         | Value      |                    | Unit |
|----------------|---------------------------------------------------|------------|--------------------|------|
|                |                                                   | STP5NK90Z  | STF5NK90Z          |      |
| $V_{DS}$       | Drain-source voltage ( $V_{GS} = 0$ )             | 900        |                    | V    |
| $V_{DGR}$      | Drain-gate voltage ( $R_{GS} = 20K\Omega$ )       | 900        |                    | V    |
| $V_{GS}$       | Gate-source voltage                               | $\pm 30$   |                    | V    |
| $I_D$          | Drain current (continuous) at $T_C = 25^\circ C$  | 4.5        | 4.5 <sup>(2)</sup> | A    |
| $I_D$          | Drain current (continuous) at $T_C = 100^\circ C$ | 2.8        | 2.8 <sup>(2)</sup> | A    |
| $I_{DM}^{(1)}$ | Drain current (pulsed)                            | 18         | 18 <sup>(2)</sup>  | A    |
| $P_{TOT}$      | Total dissipation at $T_C = 25^\circ C$           | 125        | 30                 | W    |
|                | Derating Factor                                   | 1          | 0.24               | W/°C |
| $V_{ESD(G-S)}$ | Gate source ESD (HBM-C=100pF, R=1.5K $\Omega$ )   | 4000       |                    | V    |
| $dv/dt^{(3)}$  | Peak diode recovery voltage slope                 | 4.5        |                    | V/ns |
| $V_{ISO}$      | Insulation withstand voltage (DC)                 | -          | 2500               | V    |
| $T_J$          | Operating junction temperature                    | -55 to 150 |                    | °C   |
| $T_{stg}$      | Storage temperature                               | -55 to 150 |                    | °C   |

1. Pulse width limited by safe operation area
2. Limited only by maximum temperature allowed
3.  $I_{SD} \leq 4.5$  A,  $di/dt \leq 200$  A/ $\mu$ s,  $V_{DD} \leq V_{(BR)DSS}$ ,  $T_J \leq T_{JMAX}$

**Table 2. Thermal data**

| Symbol         | Parameter                                      | Value  |          | Unit |
|----------------|------------------------------------------------|--------|----------|------|
|                |                                                | TO-220 | TO-220FP |      |
| $R_{thj-case}$ | Thermal resistance junction-case Max           | 1      | 4.2      | °C/W |
| $R_{thj-a}$    | Thermal resistance junction-ambient Max        | 62.5   |          | °C/W |
| $T_I$          | Maximum lead temperature for soldering purpose | 300    |          | °C   |

**Table 3. Avalanche characteristics**

| Symbol   | Parameter                                                                                      | Max Value | Unit |
|----------|------------------------------------------------------------------------------------------------|-----------|------|
| $I_{AR}$ | Avalanche current, repetitive or not-repetitive (pulse width limited by $T_J$ Max)             | 4.5       | A    |
| $E_{AS}$ | Single pulse avalanche energy (starting $T_J = 25^\circ C$ , $I_d = I_{AR}$ , $V_{dd} = 50V$ ) | 230       | mJ   |

**Table 4. Gate-source zener diode**

| Symbol     | Parameter                     | Test conditions                         | Min | Typ. | Max | Unit |
|------------|-------------------------------|-----------------------------------------|-----|------|-----|------|
| $BV_{GSO}$ | Gate-Source breakdown voltage | $I_{GS}=\pm 1\text{mA}$<br>(Open drain) | 30  |      |     | V    |

## 1.1 Protection features of gate-to-source zener diodes

The built-in back-to-back Zener diodes have specifically been designed to enhance not only the device's ESD capability, but also to make them safely absorb possible voltage transients that may occasionally be applied from gate to source. In this respect the Zener voltage is appropriate to achieve an efficient and cost-effective intervention to protect the device's integrity. These integrated Zener diodes thus avoid the usage of external components.

## 2 Electrical characteristics

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

**Table 5. On/off states**

| Symbol        | Parameter                                        | Test conditions                                                                            | Min. | Typ. | Max.     | Unit                           |
|---------------|--------------------------------------------------|--------------------------------------------------------------------------------------------|------|------|----------|--------------------------------|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage                   | $I_D = 1\text{mA}$ , $V_{GS} = 0$                                                          | 900  |      |          | V                              |
| $I_{DSS}$     | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max rating}$ ,<br>$V_{DS} = \text{Max rating}$ , $T_c=125^{\circ}\text{C}$ |      |      | 1<br>50  | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$     | Gate body leakage current ( $V_{GS} = 0$ )       | $V_{GS} = \pm 20\text{V}$                                                                  |      |      | $\pm 10$ | $\mu\text{A}$                  |
| $V_{GS(th)}$  | Gate threshold voltage                           | $V_{DS} = V_{GS}$ , $I_D = 100\mu\text{A}$                                                 | 3    | 3.75 | 4.5      | V                              |
| $R_{DS(on)}$  | Static drain-source on resistance                | $V_{GS} = 10\text{V}$ , $I_D = 2.25\text{A}$                                               |      | 2    | 2.5      | $\Omega$                       |

**Table 6. Dynamic**

| Symbol                                        | Parameter                                                               | Test conditions                                                                                                         | Min. | Typ.                  | Max. | Unit                 |
|-----------------------------------------------|-------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|------|-----------------------|------|----------------------|
| $g_{fs}^{(1)}$                                | Forward transconductance                                                | $V_{DS}=15\text{V}$ , $I_D = 2.25\text{A}$                                                                              |      | 4.8                   |      | S                    |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$           | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS}=25\text{V}$ , $f=1\text{MHz}$ , $V_{GS}=0$                                                                      |      | 1160<br>105<br>21.5   |      | pF<br>pF<br>pF       |
| $C_{osseq}^{(2)}$                             | Equivalent output capacitance                                           | $V_{GS}=0$ , $V_{DS}=0\text{V}$ to $720\text{V}$                                                                        |      | 65.5                  |      | pF                   |
| $t_{d(on)}$<br>$t_r$<br>$t_{d(off)}$<br>$t_f$ | Turn-on delay time<br>Rise time<br>Off-voltage rise time<br>Fall time   | $V_{DD}=400\text{V}$ , $I_D=2.2\text{A}$ ,<br>$R_G=4.7\Omega$ , $V_{GS}=10\text{V}$<br>(see <a href="#">Figure 19</a> ) |      | 27<br>7.2<br>52<br>19 |      | 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            | $V_{DD}=720\text{V}$ , $I_D = 4.4\text{A}$<br>$V_{GS}=10\text{V}$<br>(see <a href="#">Figure 18</a> )                   |      | 41.5<br>69<br>21.9    |      | nC<br>nC<br>nC       |

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

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

**Table 7. Source drain diode**

| Symbol          | Parameter                     | Test conditions                                                  | Min | Typ. | Max | Unit    |
|-----------------|-------------------------------|------------------------------------------------------------------|-----|------|-----|---------|
| $I_{SD}$        | Source-drain current          |                                                                  |     |      | 4.5 | A       |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |                                                                  |     |      | 18  | A       |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD} = 4.5A, V_{GS}=0$                                        |     |      | 1.6 | V       |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 4.5 A, di/dt = 100 A/\mu s$                            |     | 635  |     | ns      |
| $Q_{rr}$        | Reverse recovery charge       | $V_{DD} = 35 V$                                                  |     | 5.9  |     | $\mu C$ |
| $I_{RRM}$       | Reverse recovery current      | (see <a href="#">Figure 18</a> )                                 |     | 18.5 |     | A       |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 4.5 A, di/dt = 100 A/\mu s$                            |     | 712  |     | ns      |
| $Q_{rr}$        | Reverse recovery charge       | $V_{DD} = 35 V,$                                                 |     | 4.66 |     | $\mu C$ |
| $I_{RRM}$       | Reverse recovery current      | $T_J = 150\text{ }^{\circ}C$<br>(see <a href="#">Figure 18</a> ) |     | 13.1 |     | A       |

1. Pulse width limited by safe operating area

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

2.1 Electrical characteristics (curves)

Figure 1. Safe operating area for TO 220

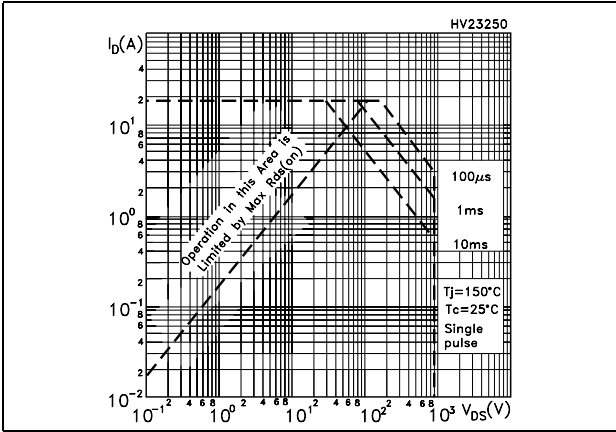


Figure 2. Thermal impedance for TO-220

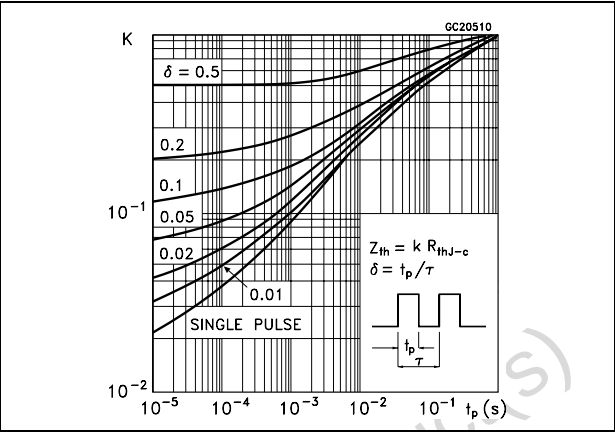


Figure 3. Safe operating area for TO-220FP

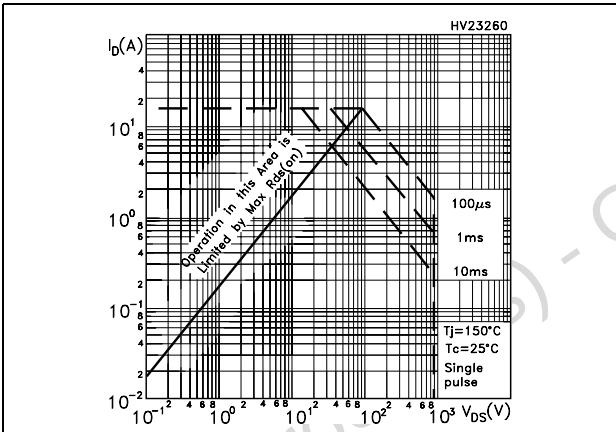


Figure 4. Thermal impedance for TO-220FP

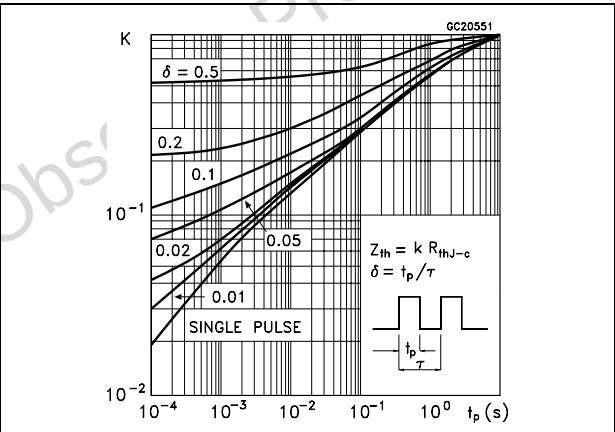


Figure 5. Output characteristics

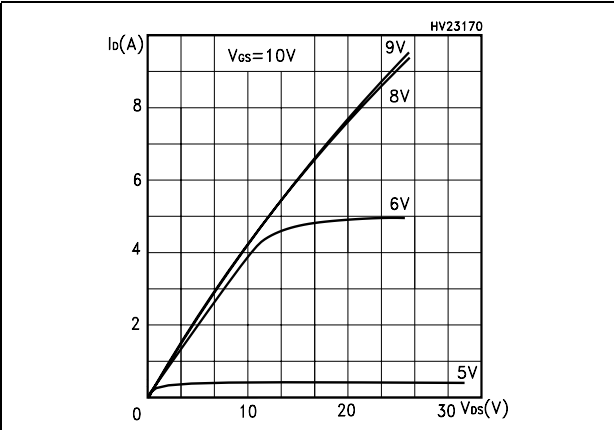


Figure 6. Transfer characteristics

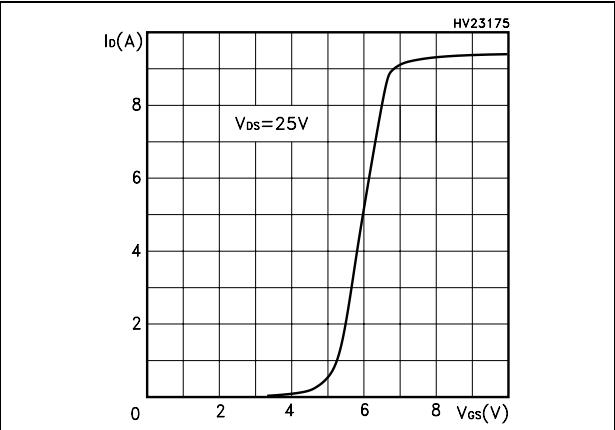


Figure 7. Transconductance

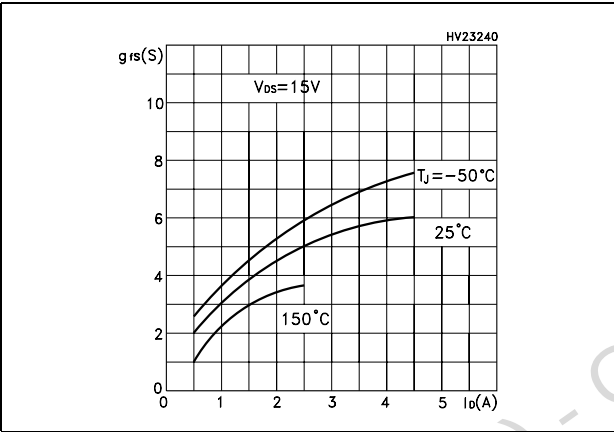


Figure 8. Static drain-source on resistance

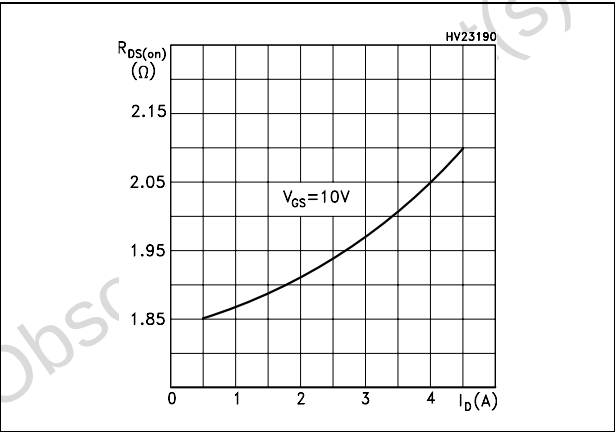


Figure 9. Gate charge vs gate-source voltage

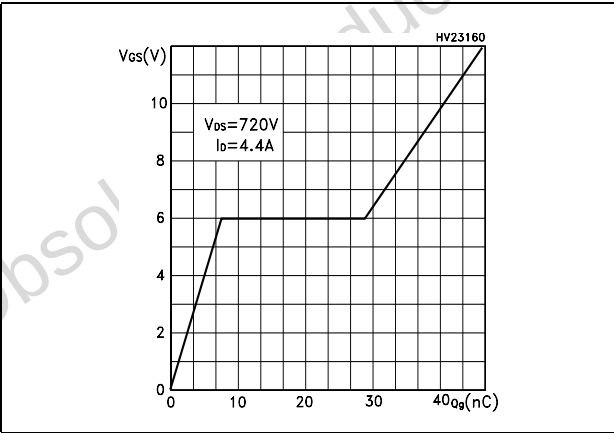


Figure 10. Capacitance variations

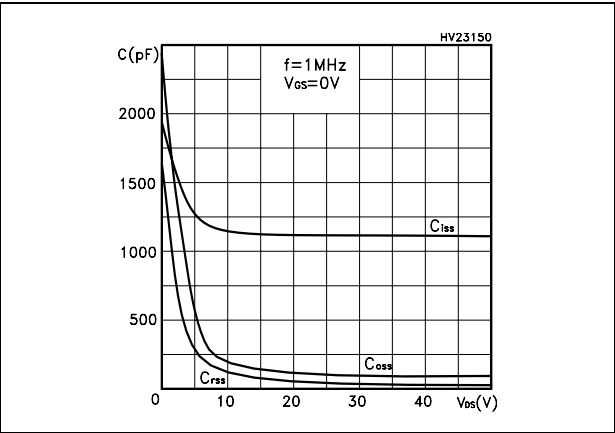


Figure 11. Normalized gate threshold voltage vs temperature

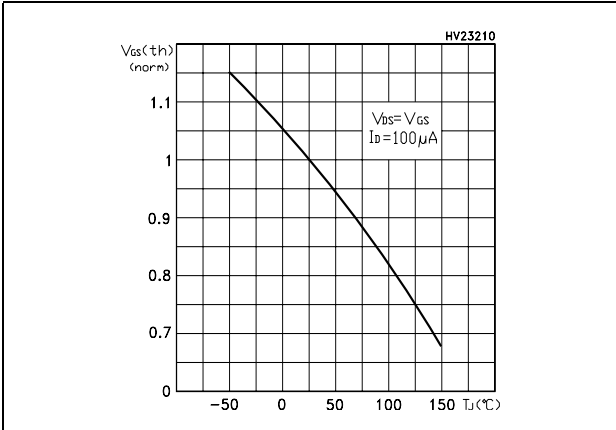


Figure 12. Normalized on resistance vs temperature

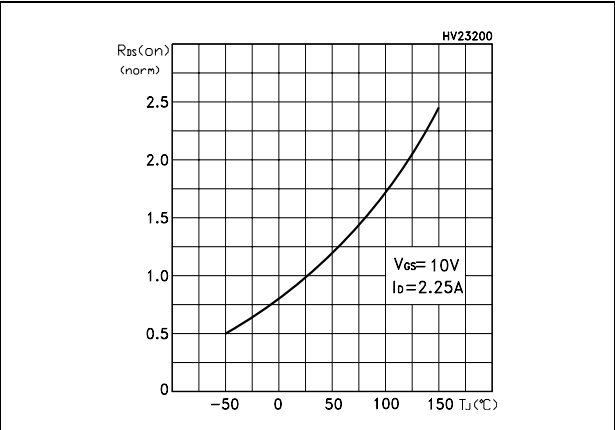


Figure 13. Source-drain diode forward characteristics

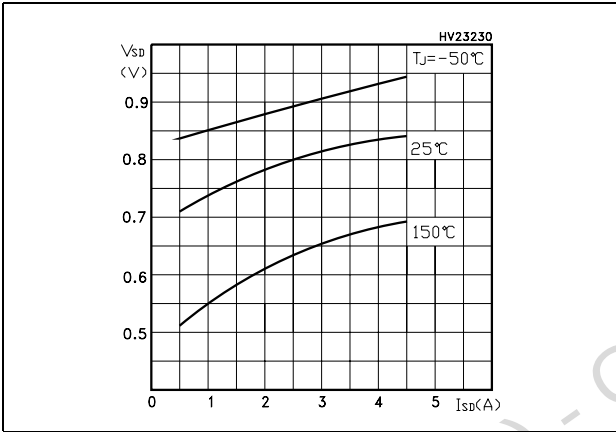


Figure 14. Avalanche Energy vs starting Tj

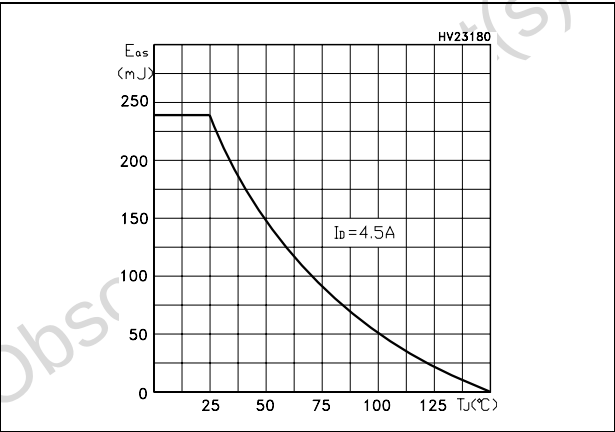
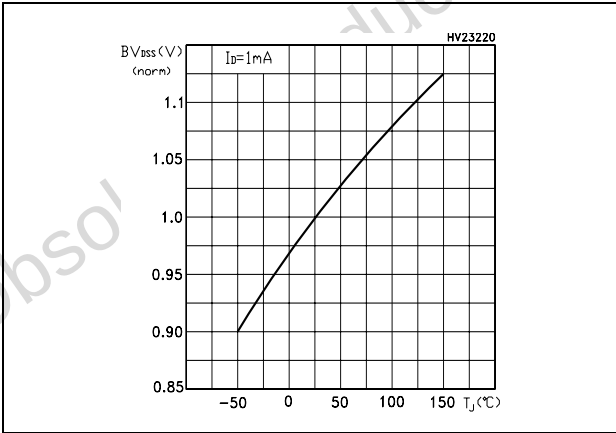


Figure 15. Normalized breakdown voltage vs temperature



### 3 Test circuit Package mechanical data

Figure 16. Unclamped inductive load test circuit

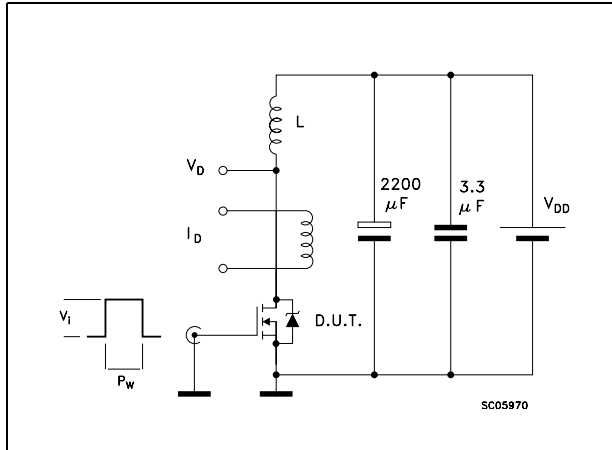


Figure 17. Unclamped inductive waveform

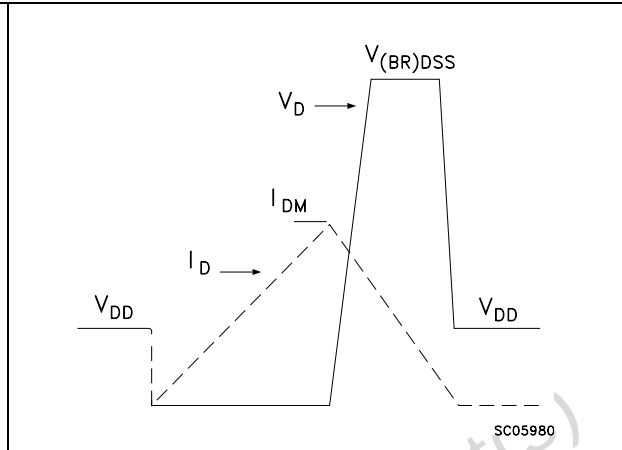


Figure 18. Switching times test circuit for resistive load

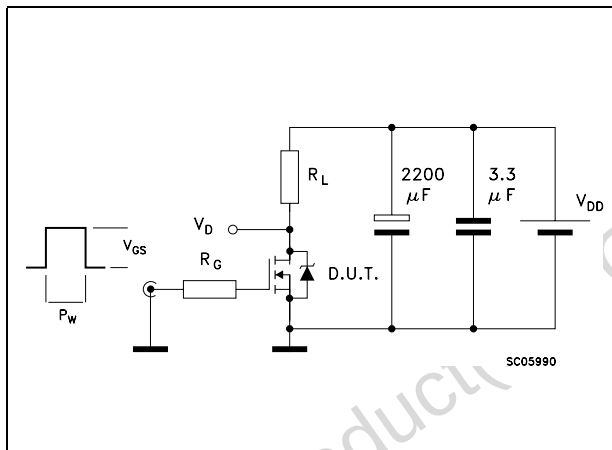


Figure 19. Gate charge test circuit

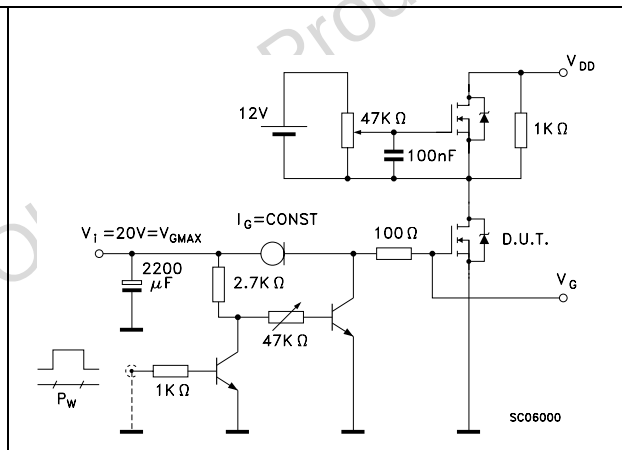
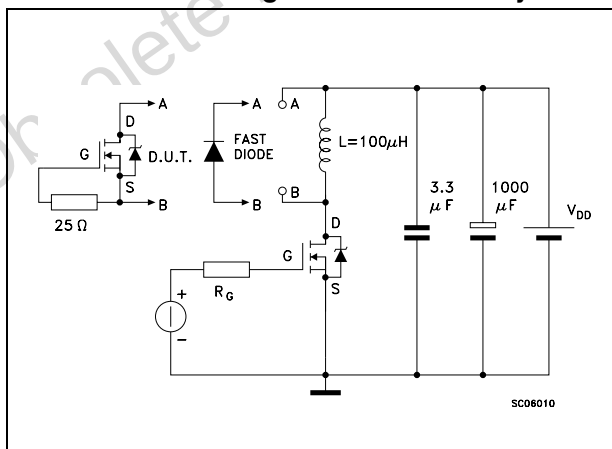


Figure 20. Test circuit for inductive load switching and diode recovery times



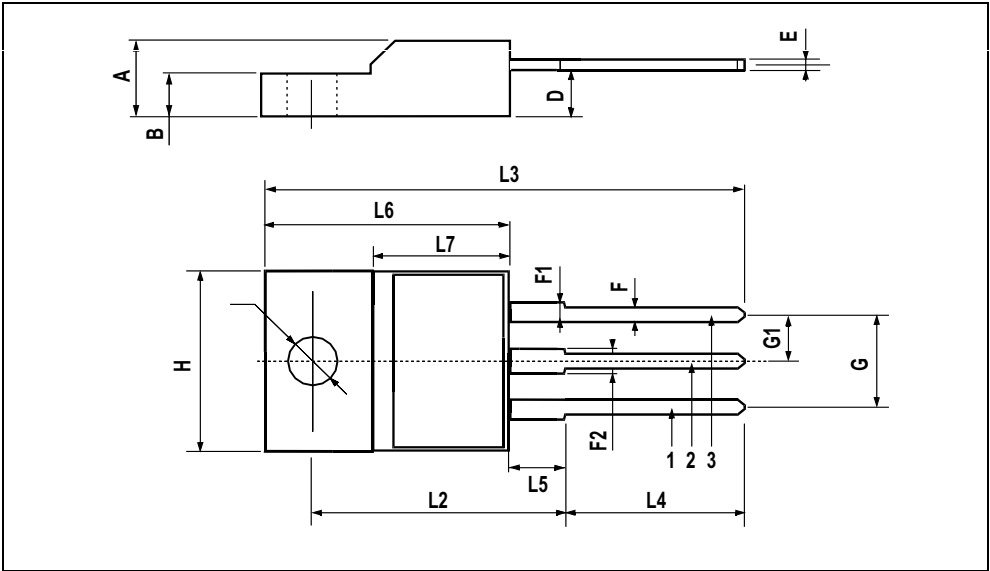
## 4 Package mechanical data

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)

Obsolete Product(s) - Obsolete Product(s)

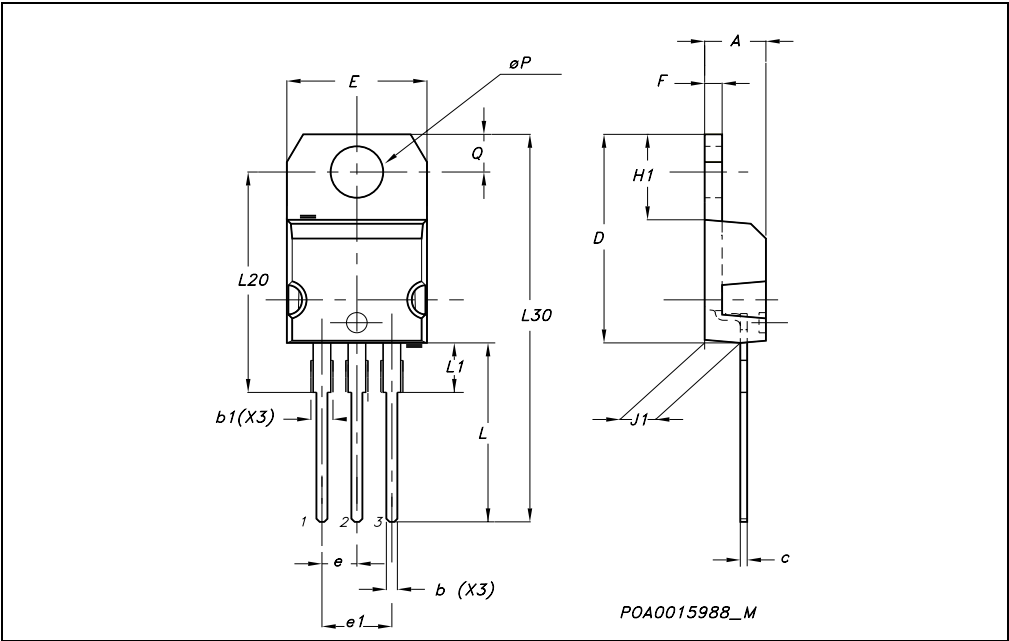
TO-220FP MECHANICAL DATA

| 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-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 |



## 5 Revision history

**Table 8. Revision history**

| Date        | Revision | Changes                         |
|-------------|----------|---------------------------------|
| 06-Oct-2004 | 1        | First release                   |
| 08-Sep-2005 | 2        | Complete datasheet              |
| 14-Dec-2005 | 3        | Inserted Ecopack indication     |
| 31-Jul-2005 | 4        | New template, no content change |

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