



# STD5NK60Z

## STP5NK60Z - STP5NK60ZFP

N-CHANNEL 650V @Tjmax - 1.2Ω - 5A TO-220/FP/DPAK  
Zener-Protected SuperMESH™ MOSFET

Table 1: General Features

| TYPE        | V <sub>DSS</sub> @<br>T <sub>Jmax</sub> | R <sub>DS(on)</sub> | I <sub>d</sub> | P <sub>TOT</sub> |
|-------------|---|---------------------|----------------|------------------|
| STP5NK60Z   | 650 V                                   | < 1.6 Ω             | 5 A            | 90 W             |
| STP5NK60ZFP | 650 V                                   | < 1.6 Ω             | 5 A            | 25 W             |
| STD5NK60Z   | 650 V                                   | < 1.6 Ω             | 5 A            | 90 W             |

- TYPICAL R<sub>DS(on)</sub> = 1.2 Ω
- EXTREMELY HIGH dv/dt CAPABILITY
- 100% AVALANCHE TESTED
- 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 strip-based 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

- HIGH CURRENT, HIGH SPEED SWITCHING
- IDEAL FOR OFF-LINE POWER SUPPLIES, ADAPTORS AND PFC
- LIGHTING

Table 2: Order Codes

| SALES TYPE  | MARKING   | PACKAGE  | PACKAGING   |
|-------------|-----------|----------|-------------|
| STP5NK60Z   | P5NK60Z   | TO-220   | TUBE        |
| STP5NK60ZFP | P5NK60ZFP | TO-220FP | TUBE        |
| STD5NK60ZT4 | D5NK60    | DPAK     | TAPE & REEL |

Figure 1: Package

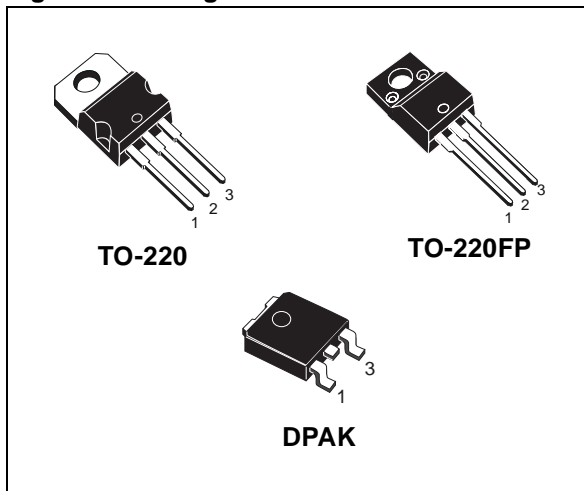
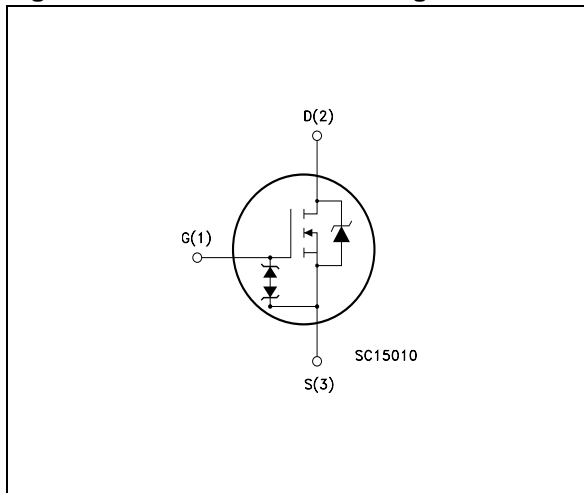


Figure 2: Internal Schematic Diagram



**Table 3: Absolute Maximum ratings**

| Symbol             | Parameter   | Value       |          | Unit                |
|--------------------|---|-------------|----------|---------------------|
|                    |   | TO-220/DPAK | TO-220FP |                     |
| $V_{DS}$           | Drain-source Voltage ( $V_{GS} = 0$ )                   | 600         |          | V                   |
| $V_{DGR}$          | Drain-gate Voltage ( $R_{GS} = 20\text{ k}\Omega$ )     | 600         |          | V                   |
| $V_{GS}$           | Gate- source Voltage                                    | $\pm 30$    |          | V                   |
| $I_D$              | Drain Current (continuous) at $T_C = 25^\circ\text{C}$  | 5           | 5 (*)    | A                   |
| $I_D$              | Drain Current (continuous) at $T_C = 100^\circ\text{C}$ | 3.16        | 3.16 (*) | A                   |
| $I_{DM} (\bullet)$ | Drain Current (pulsed)                                  | 20          | 20 (*)   | A                   |
| $P_{TOT}$          | Total Dissipation at $T_C = 25^\circ\text{C}$           | 90          | 25       | W                   |
|                    | Derating Factor   | 0.72        | 0.2      | W/ $^\circ\text{C}$ |
| $V_{ESD(G-S)}$     | Gate source ESD(HBM-C=100pF, R=1.5K $\Omega$ )          | 3000        |          | V                   |
| dv/dt (1)          | Peak Diode Recovery voltage slope                       | 4.5         |          | V/ns                |
| $V_{ISO}$          | Insulation Withstand Voltage (DC)                       | -           | 2500     | V                   |
| $T_j$<br>$T_{stg}$ | Operating Junction Temperature<br>Storage Temperature   | -55 to 150  |          | $^\circ\text{C}$    |

( $\bullet$ ) Pulse width limited by safe operating area

(1)  $I_{SD} \leq 5\text{A}$ ,  $di/dt \leq 200\text{A}/\mu\text{s}$ ,  $V_{DD} \leq V_{(BR)DSS}$ ,  $T_j \leq T_{JMAX}$ .

(\*) Limited only by maximum temperature allowed

**Thermal Data**

|           |  | TO-220/DPAK | TO-220FP |                           |
|-----------|--|-------------|----------|---------------------------|
| Rthj-case | Thermal Resistance Junction-case Max           | 1.39        | 5        | $^\circ\text{C}/\text{W}$ |
| Rthj-amb  | Thermal Resistance Junction-ambient Max        | 62.5        |          | $^\circ\text{C}/\text{W}$ |
| $T_l$     | Maximum Lead Temperature For Soldering Purpose | 300         |          | $^\circ\text{C}$          |

(#) When mounted on 1inch<sup>2</sup> FR-4, 2 Oz copper board.

**Table 4: Avalanche Characteristics**

| Symbol   | Parameter  | Max Value | Unit |
|----------|--|-----------|------|
| $I_{AR}$ | Avalanche Current, Repetitive or Not-Repetitive (pulse width limited by $T_j$ max)                           | 5         | A    |
| $E_{AS}$ | Single Pulse Avalanche Energy (starting $T_j = 25^\circ\text{C}$ , $I_D = I_{AR}$ , $V_{DD} = 50\text{ V}$ ) | 220       | mJ   |

**Table 5: Gate-Source Zener Diode**

| Symbol     | Parameter                     | Test Conditions                        | Min. | Typ. | Max. | Unit |
|------------|-------------------------------|--|------|------|------|------|
| $BV_{GSO}$ | Gate-Source Breakdown Voltage | $I_{GS} = \pm 1\text{mA}$ (Open Drain) | 30   |      |      | V    |

**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.

**ELECTRICAL CHARACTERISTICS** ( $T_{CASE} = 25^{\circ}C$  UNLESS OTHERWISE SPECIFIED)**Table 6: On/Off**

| Symbol        | Parameter  | Test Conditions  | Min. | Typ. | Max.     | Unit                           |
|---------------|--|--|------|------|----------|--------------------------------|
| $V_{(BR)DSS}$ | Drain-source Breakdown Voltage                   | $I_D = 1 \text{ mA}, V_{GS} = 0$   | 600  |      |          | V                              |
| $I_{DSS}$     | Zero Gate Voltage Drain Current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating}, T_C = 125^{\circ}C$ |      |      | 1<br>50  | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$     | Gate-body Leakage Current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20\text{V}$  |      |      | $\pm 10$ | $\mu\text{A}$                  |
| $V_{GS(th)}$  | Gate Threshold Voltage                           | $V_{DS} = V_{GS}, I_D = 50\mu\text{A}$   | 3    | 3.75 | 4.5      | V                              |
| $R_{DS(on)}$  | Static Drain-source On Resistance                | $V_{GS} = 10\text{V}, I_D = 2.5 \text{ A}$                                       |      | 1.2  | 1.6      | $\Omega$                       |

**Table 7: Dynamic**

| Symbol  | Parameter   | Test Conditions  | Min. | Typ.                 | Max. | Unit                 |
|---|---|--|------|----------------------|------|----------------------|
| $g_{fs} (1)$                                  | Forward Transconductance  | $V_{DS} = 8 \text{ V}, I_D = 2.5 \text{ A}$  |      | 4                    |      | S                    |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$           | Input Capacitance<br>Output Capacitance<br>Reverse Transfer Capacitance | $V_{DS} = 25\text{V}, f = 1 \text{ MHz}, V_{GS} = 0$   |      | 690<br>90<br>20      |      | pF<br>pF<br>pF       |
| $C_{oss \text{ eq.}} (3)$                     | Equivalent Output Capacitance   | $V_{GS} = 0\text{V}, V_{DS} = 0\text{V to } 480\text{V}$   |      | 40                   |      | pF                   |
| $t_{d(on)}$<br>$t_r$<br>$t_{d(off)}$<br>$t_f$ | Turn-on Delay Time<br>Rise Time<br>Turn-off Delay Time<br>Fall Time     | $V_{DD} = 300 \text{ V}, I_D = 2.5 \text{ A}$<br>$R_G = 4.7\Omega, V_{GS} = 10 \text{ V}$<br>(see Figure 20) |      | 16<br>25<br>36<br>25 |      | ns<br>ns<br>ns<br>ns |
| $t_{r(Voff)}$<br>$t_f$<br>$t_c$               | Off-voltage Rise Time<br>Fall Time<br>Cross-over Time                   | $V_{DD} = 480\text{V}, I_D = 5 \text{ A},$<br>$R_G = 4.7\Omega, V_{GS} = 10\text{V}$<br>(see Figure 20)      |      | 12<br>10<br>24       |      | ns<br>ns<br>ns       |
| $Q_g$<br>$Q_{gs}$<br>$Q_{gd}$                 | Total Gate Charge<br>Gate-Source Charge<br>Gate-Drain Charge            | $V_{DD} = 400\text{V}, I_D = 5 \text{ A},$<br>$V_{GS} = 10\text{V}$<br>(see Figure 23)                       |      | 26<br>6<br>20        | 34   | nC<br>nC<br>nC       |

**Table 8: Source Drain Diode**

| Symbol                            | Parameter  | Test Conditions   | Min. | Typ.             | Max.    | Unit                     |
|-----------------------------------|--|---|------|------------------|---------|--------------------------|
| $I_{SD}$<br>$I_{SDM} (2)$         | Source-drain Current<br>Source-drain Current (pulsed)                        |   |      |                  | 5<br>20 | A<br>A                   |
| $V_{SD} (1)$                      | Forward On Voltage   | $I_{SD} = 5 \text{ A}, V_{GS} = 0$  |      |                  | 1.6     | V                        |
| $t_{rr}$<br>$Q_{rr}$<br>$I_{RRM}$ | Reverse Recovery Time<br>Reverse Recovery Charge<br>Reverse Recovery Current | $I_{SD} = 5 \text{ A}, di/dt = 100\text{A}/\mu\text{s}$<br>$V_{DD} = 30\text{V}, T_j = 150^{\circ}C$<br>(see Figure 21) |      | 485<br>2.7<br>11 |         | ns<br>$\mu\text{C}$<br>A |

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

2. Pulse width limited by safe operating area.

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

Figure 3: Safe Operating Area For TO-220/ DPAK

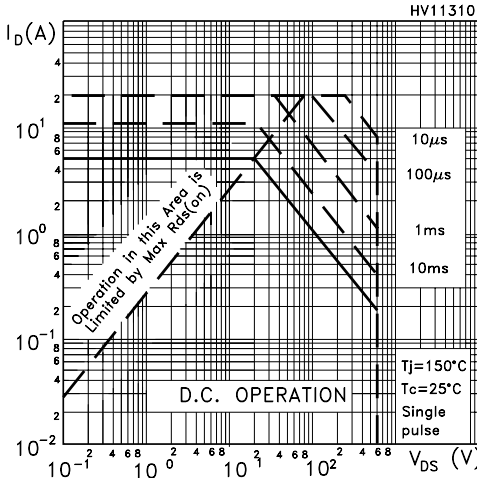


Figure 4: Safe Operating Area For TO-220FP

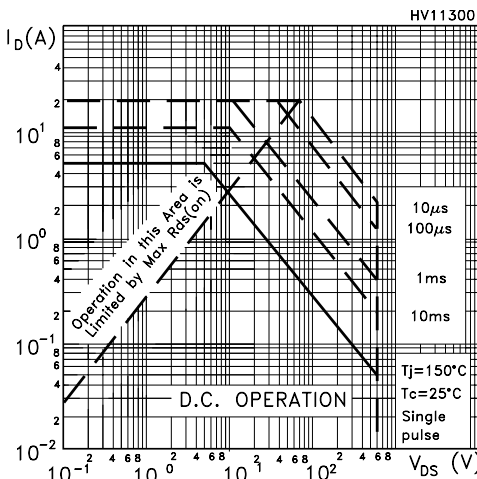


Figure 5: Output Characteristics

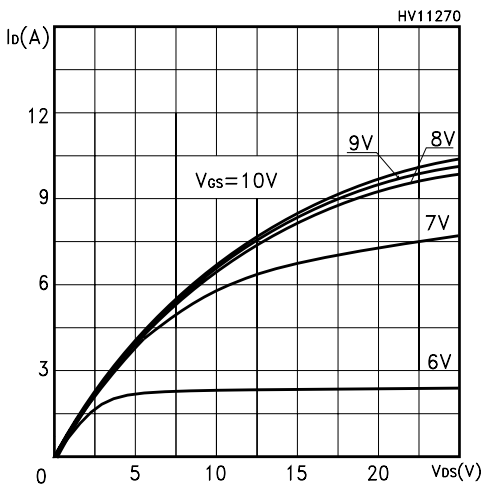


Figure 6: Thermal Impedance For TO-220/ DPAK

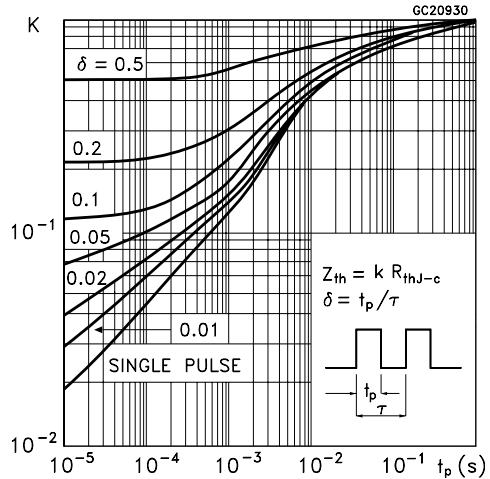


Figure 7: Thermal Impedance For TO-220FP

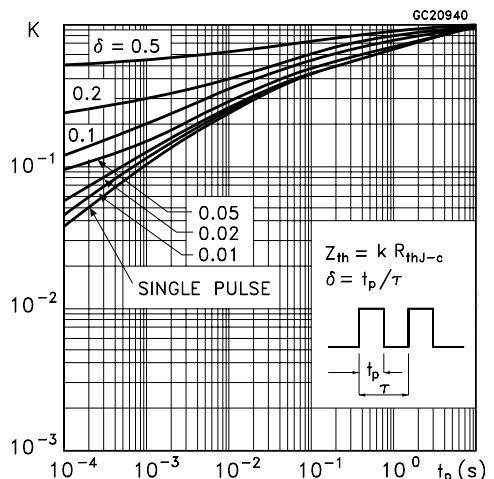


Figure 8: Transfer Characteristics

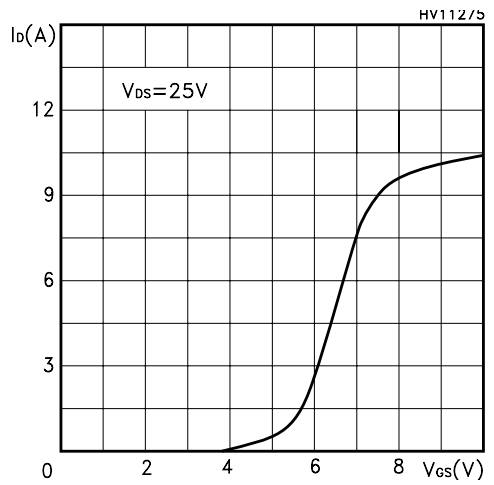


Figure 9: Transconductance

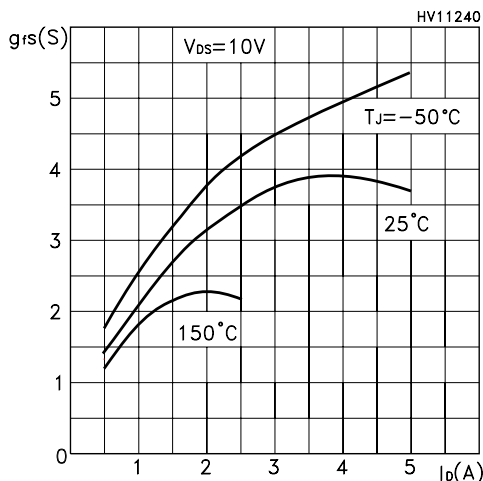


Figure 10: Gate Charge vs Gate-source Voltage

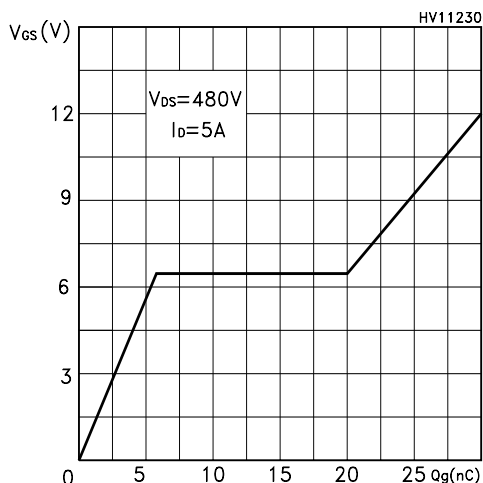


Figure 11: Normalized Gate Threshold Voltage vs Temperature

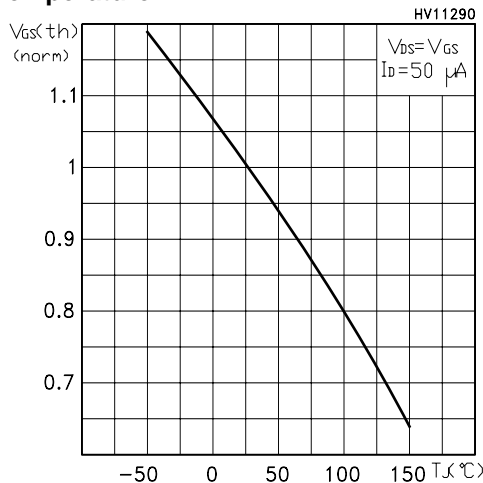


Figure 12: Static Drain-source On Resistance

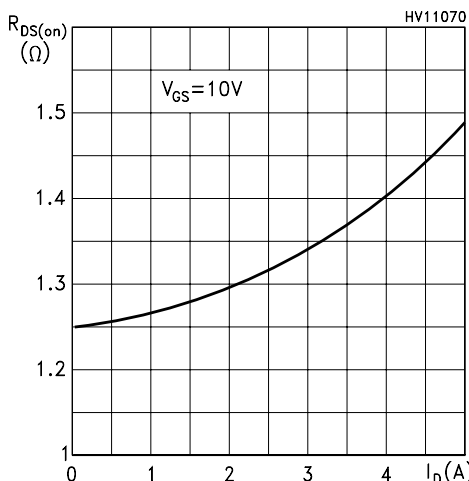


Figure 13: Capacitance Variations

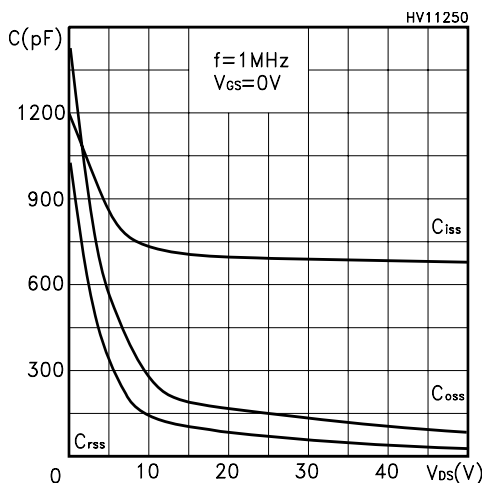


Figure 14: Normalized On Resistance vs Temperature

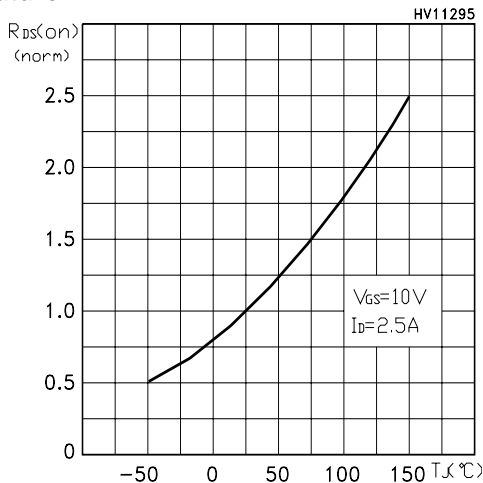


Figure 15:

Figure 16: Source-Drain Forward Characteristics

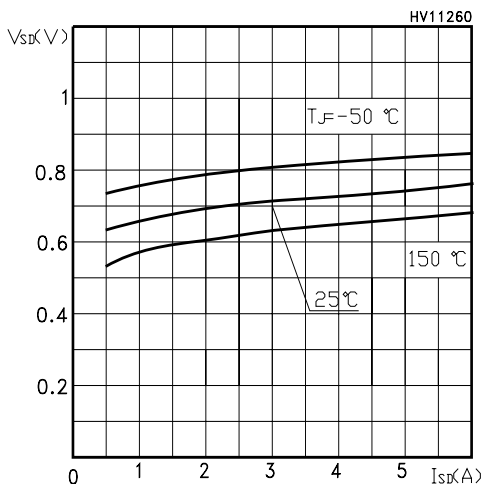


Figure 18: Normalized  $BV_{dss}$  vs Temperature

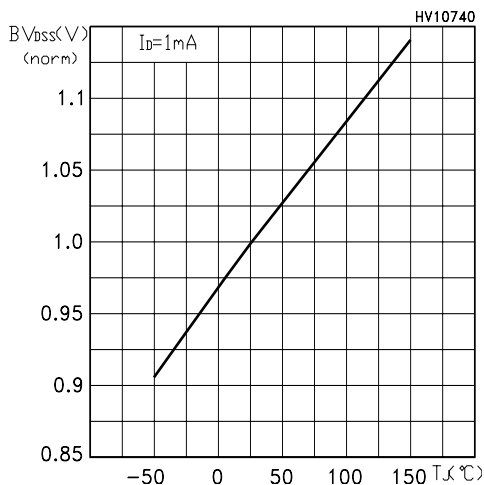


Figure 17: Maximum Avalanche Energy vs Temperature

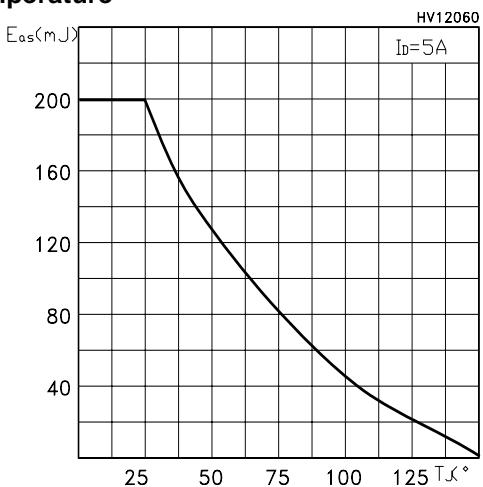


Figure 19: Unclamped Inductive Load Test Circuit

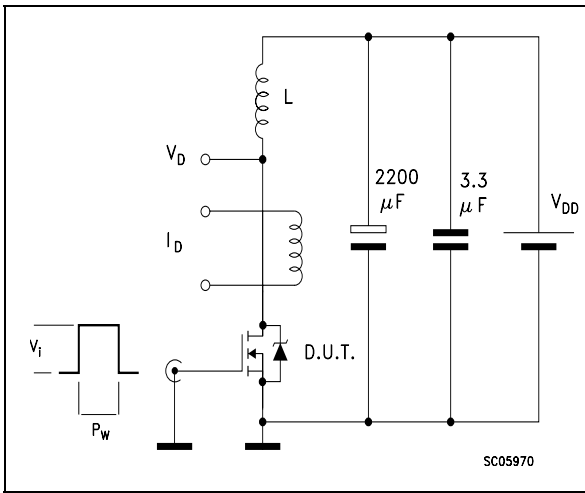


Figure 20: Switching Times Test Circuit For Resistive Load

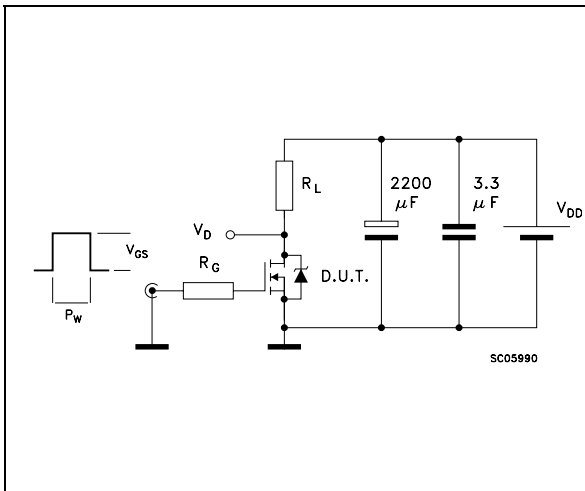


Figure 21: Test Circuit For Inductive Load Switching and Diode Recovery Times

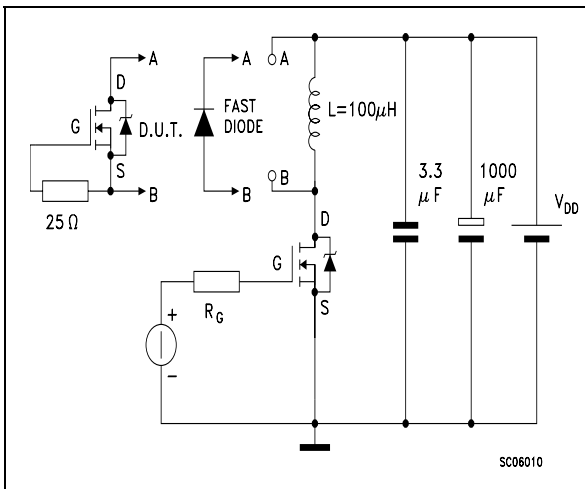


Figure 22: Unclamped Inductive Waferform

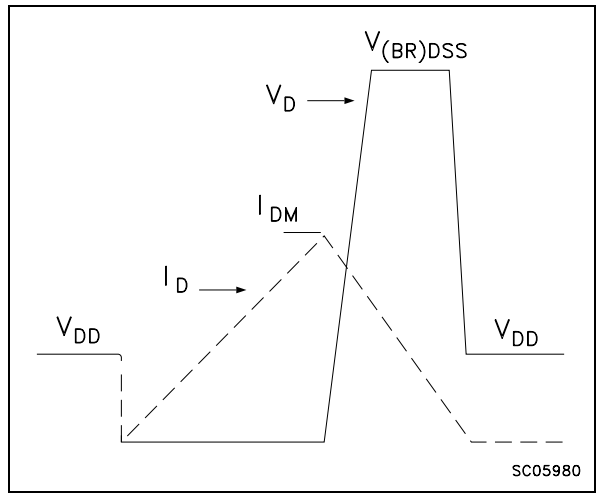
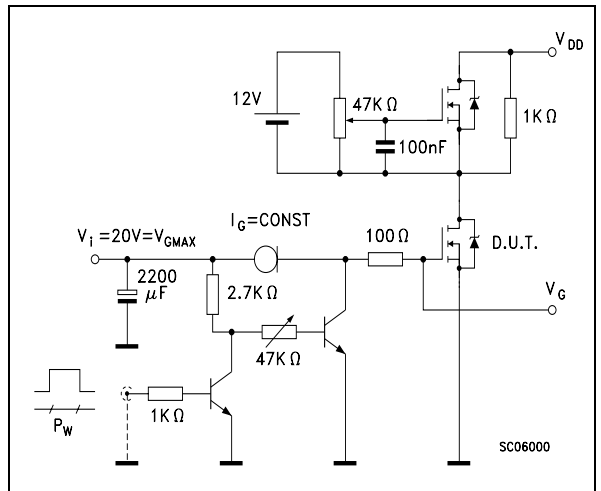


Figure 23: Gate Charge Test Circuit

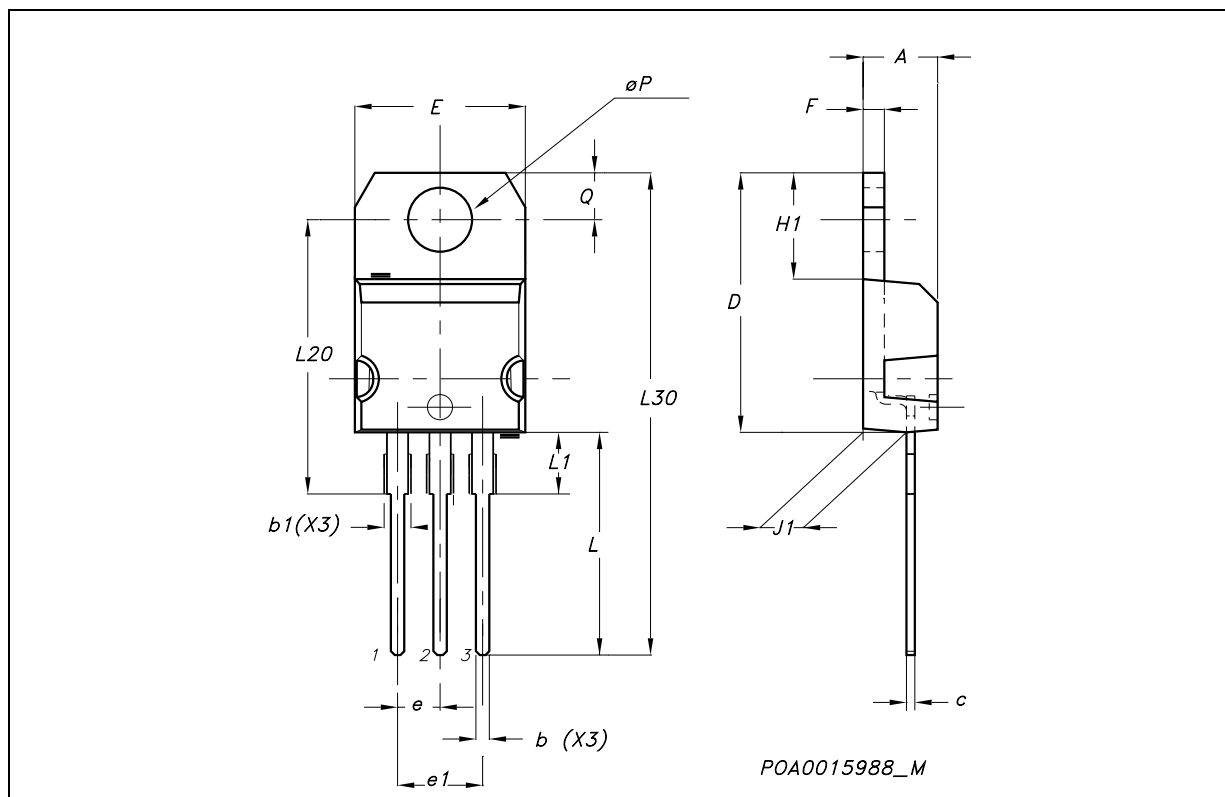


In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a Lead-free second level interconnect . The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings 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)



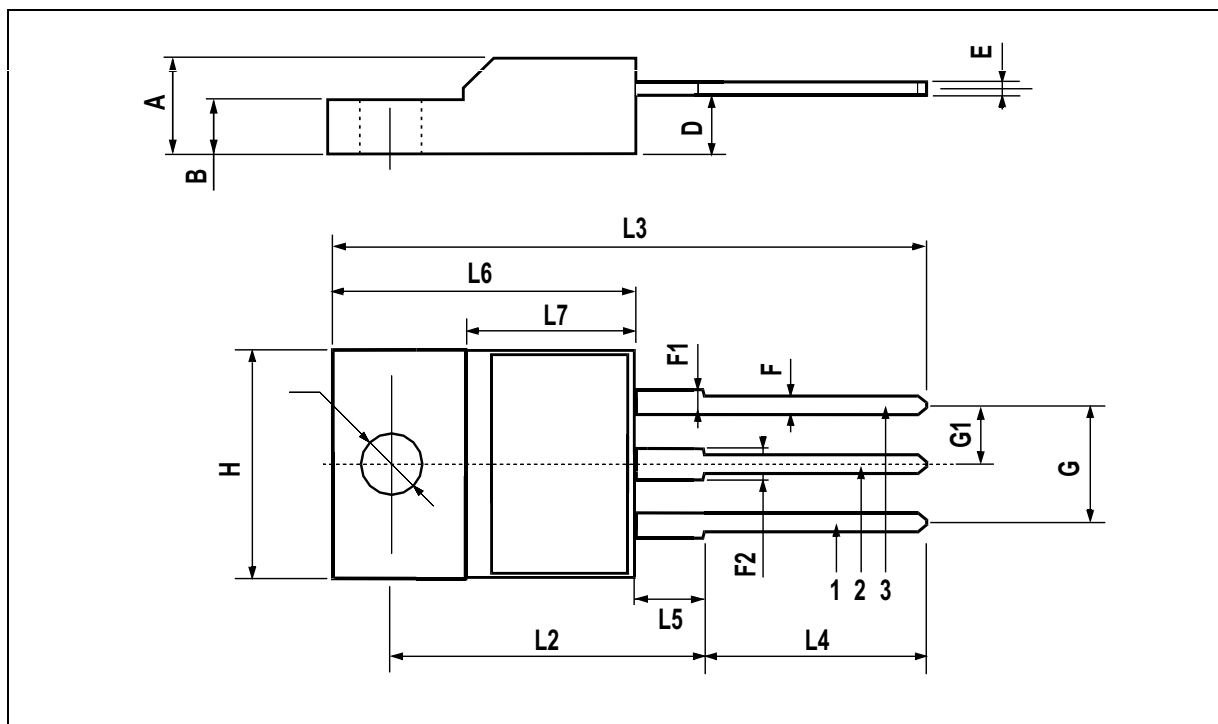
## TO-220 MECHANICAL DATA

| 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 |



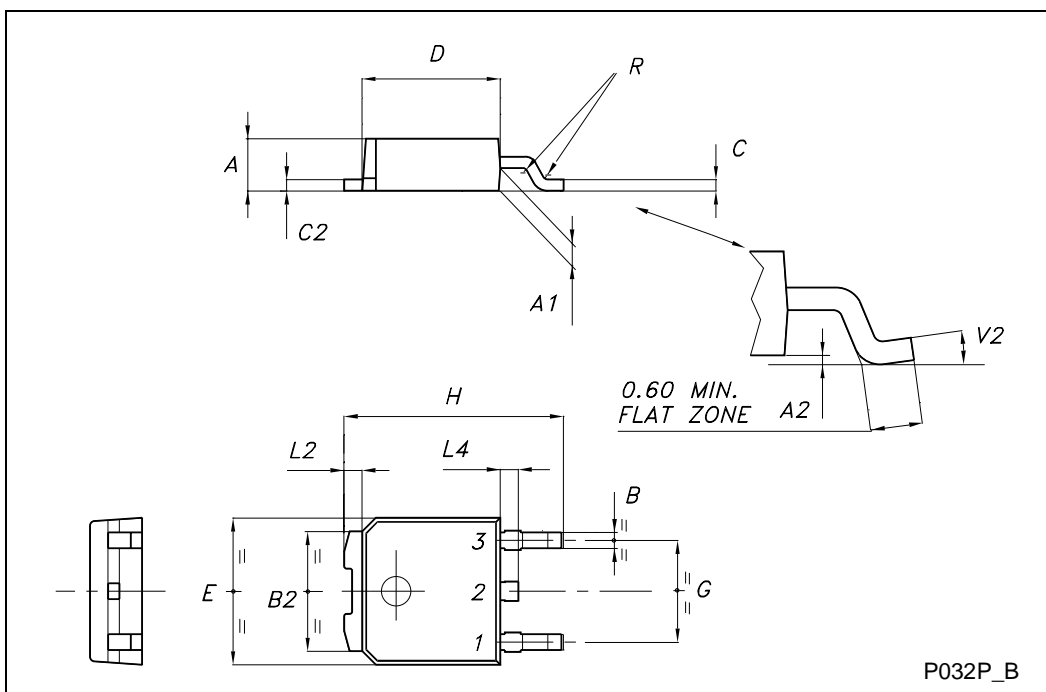
TO-220FP MECHANICAL DATA

| 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 |

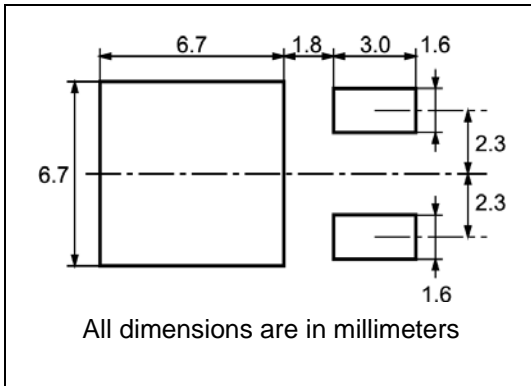


TO-252 (DPAK) MECHANICAL DATA

| DIM. | mm   |      |       | inch  |       |       |
|------|------|------|-------|-------|-------|-------|
|      | MIN. | TYP. | MAX.  | MIN.  | TYP.  | MAX.  |
| A    | 2.20 |      | 2.40  | 0.087 |       | 0.094 |
| A1   | 0.90 |      | 1.10  | 0.035 |       | 0.043 |
| A2   | 0.03 |      | 0.23  | 0.001 |       | 0.009 |
| B    | 0.64 |      | 0.90  | 0.025 |       | 0.035 |
| B2   | 5.20 |      | 5.40  | 0.204 |       | 0.213 |
| C    | 0.45 |      | 0.60  | 0.018 |       | 0.024 |
| C2   | 0.48 |      | 0.60  | 0.019 |       | 0.024 |
| D    | 6.00 |      | 6.20  | 0.236 |       | 0.244 |
| E    | 6.40 |      | 6.60  | 0.252 |       | 0.260 |
| G    | 4.40 |      | 4.60  | 0.173 |       | 0.181 |
| H    | 9.35 |      | 10.10 | 0.368 |       | 0.398 |
| L2   |      | 0.8  |       |       | 0.031 |       |
| L4   | 0.60 |      | 1.00  | 0.024 |       | 0.039 |
| V2   | 0°   |      | 8°    | 0°    |       | 0°    |



DPAK FOOTPRINT



TAPE AND REEL SHIPMENT

**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    | 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 |

Table 9: Revision History

| Date        | Revision | Description of Changes      |
|-------------|----------|-----------------------------|
| 05-Apr-2005 | 1        | First issue                 |
| 29-Apr-2005 | 2        | Modified value in Table 7.  |
| 06-Sep-2005 | 3        | Inserted Ecopack indication |
| 14-Oct-2005 | 4        | Modified value on Table 1   |
| 28-Oct-2005 | 5        | Tape & Reel info added      |
| 14-Nov-2005 | 6        | Modified value on Table 6   |
| 15-Dec-2005 | 7        | Various corrections         |

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