



# STB10NK60Z/-1 - STP10NK60Z/FP STW10NK60Z

N-CHANNEL 600V-0.65Ω-10A - TO220/FP-D<sup>2</sup>/I<sup>2</sup>PAK-TO-247  
Zener-Protected SuperMESH™ MOSFET

## General features

| Type         | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> | P <sub>w</sub> |
|--------------|------------------|---------------------|----------------|----------------|
| STB10NK60Z   | 600 V            | <0.75 Ω             | 10 A           | 115            |
| STB10NK60Z-1 | 600 V            | <0.75 Ω             | 10 A           | 115            |
| STP10NK60ZFP | 600 V            | <0.75 Ω             | 10 A           | 35             |
| STP10NK60Z   | 600 V            | <0.75 Ω             | 10 A           | 115            |
| STW10NK60Z   | 600 V            | <0.75 Ω             | 10 A           | 156            |

- TYPICAL R<sub>DS(on)</sub> = 0.65 Ω
- EXTREMELY HIGH dv/dt CAPABILITY
- 100% AVALANCHE TESTED
- GATE CHARGE MINIMIZED
- VERY LOW INTRINSIC CAPACITANCES
- VERY GOOD MANUFACTURING REPEATABILITY

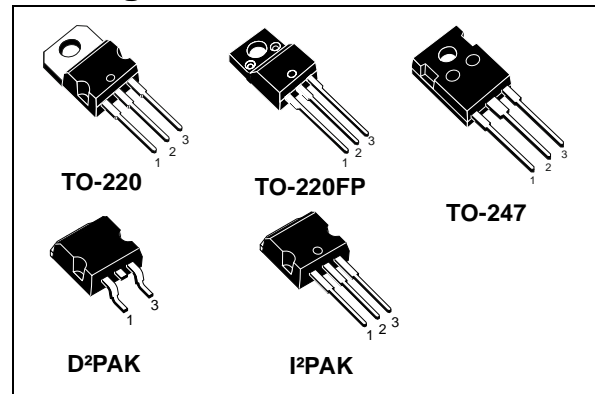
## Description

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.

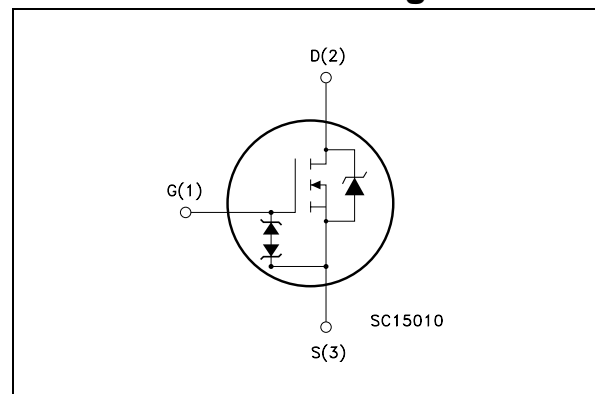
## Applications

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

## Package



## Internal schematic diagram



# 1 Absolute maximum ratings

**Table 1. Absolute maximum ratings**

| Symbol                             | Parameter   | Value                                    |                 |        | Unit |
|------------------------------------|---|--|-----------------|--------|------|
|                                    |   | TO-220/D <sup>2</sup> I <sup>2</sup> PAK | TO-220FP        | TO-247 |      |
| V <sub>DS</sub>                    | Drain-Source Voltage (V <sub>GS</sub> = 0)            | 600                                      |                 |        | V    |
| V <sub>DGR</sub>                   | Drain-gate Voltage (R <sub>GS</sub> = 20kΩ)           | 600                                      |                 |        | V    |
| V <sub>GS</sub>                    | Gate-Source Voltage                                   | ± 30                                     |                 |        | V    |
| I <sub>D</sub>                     | Drain Current (continuous) at T <sub>C</sub> = 25°C   | 10                                       | 10<br>(Note 3)  | 10     | A    |
| I <sub>D</sub>                     | Drain Current (continuous) at T <sub>C</sub> = 100°C  | 5.7                                      | 5.7<br>(Note 3) | 5.7    | A    |
| I <sub>DM</sub><br>Note 2          | Drain Current (pulsed)                                | 36                                       | 36<br>(Note 3)  | 36     | A    |
| P <sub>TOT</sub>                   | Total Dissipation at T <sub>C</sub> = 25°C            | 115                                      | 35              | 156    | W    |
|                                    | Derating Factor                                       | 0.92                                     | 0.28            | 1.25   | W/°C |
| Vesd(G-S)                          | G-S ESD (HBM C=100pF, R=1.5kΩ)                        | 4000                                     |                 |        | V    |
| dv/dt<br>Note 1                    | Peak Diode Recovery voltage slope                     | 4.5                                      |                 |        | V/ns |
| V <sub>ISO</sub>                   | Insulation Withstand Voltage (DC)                     | --                                       | 2500            | --     | V    |
| T <sub>j</sub><br>T <sub>stg</sub> | Operating Junction Temperature<br>Storage Temperature | -55 to 150                               |                 |        | °C   |

**Table 2. Thermal data**

|                |  | TO-220<br>I <sup>2</sup> PAK | D <sup>2</sup> PAK | TO-220FP | TO-247 | Unit |
|----------------|--|------------------------------|--------------------|----------|--------|------|
| Rthj-case      | Thermal Resistance Junction-case Max                                       | 1.09                         |                    | 3.6      | 0.8    | °C/W |
| Rthj-pcb       | Thermal Resistance Junction-pcb Max<br>(when mounted on minimum Footprint) |                              | 60                 |          |        | °C/W |
| Rthj-amb       | Thermal Resistance Junction-amb Max  | 62.5                         |                    |          | 50     | °C/W |
| T <sub>l</sub> | 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)                    | 9         | A    |
| $E_{AS}$ | Single Pulse Avalanche Energy (starting $T_j=25^\circ\text{C}$ , $I_D=I_{AR}$ , $V_{DD}=50\text{V}$ ) | 300       | mJ   |
| $E_{AR}$ | Repetitive Avalanche Energy (pulse width limited by $T_j$ max)  | 3.5       | 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

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

**Table 5. On/Off**

| Symbol        | Parameter  | Test Conditions                   | Min. | Typ. | Max.     | Unit     |
|---------------|--|-----------------------------------|------|------|----------|----------|
| $V_{(BR)DSS}$ | Drain-Source Breakdown Voltage                   | $I_D = 250\mu A, V_{GS} = 0$      | 600  |      |          | V        |
| $I_{DSS}$     | Zero Gate Voltage Drain Current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating,}$     |      |      | 1<br>50  | $\mu A$  |
| $I_{GSS}$     | Gate Body Leakage Current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 15V, V_{DS} = 0$    |      |      | $\pm 10$ | $\mu A$  |
| $V_{GS(th)}$  | Gate Threshold Voltage                           | $V_{DS} = V_{GS}, I_D = 250\mu A$ | 3    | 3.75 | 4.5      | V        |
| $R_{DS(on)}$  | Static Drain-Source On Resistance                | $V_{GS} = 10V, I_D = 20A$         |      | 0.65 | 0.75     | $\Omega$ |

**Table 6. Dynamic**

| Symbol                              | Parameter   | Test Conditions  | Min. | Typ.              | Max. | Unit           |
|-------------------------------------|---|--|------|-------------------|------|----------------|
| $g_{fs}$ <i>Note 4</i>              | Forward Transconductance  | $V_{DS} = 15V, I_D = 4.5A$                                     |      | 7.8               |      | S              |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input Capacitance<br>Output Capacitance<br>Reverse Transfer Capacitance | $V_{DS} = 25V, f = 1\text{ MHz}, V_{GS} = 0$                   |      | 1370<br>156<br>37 |      | pF<br>pF<br>pF |
| $C_{oss\ eq.}$<br><i>Note 5</i>     | Equivalent Output Capacitance   | $V_{GS} = 0, V_{DS} = 0V\text{ to }480V$                       |      | 90                |      | pF             |
| $Q_g$<br>$Q_{gs}$<br>$Q_{gd}$       | Total Gate Charge<br>Gate-Source Charge<br>Gate-Drain Charge            | $V_{DD} = 480V, I_D = 8A$<br>$V_{GS} = 10V$<br>(see Figure 19) |      | 50<br>10<br>25    | 70   | nC<br>nC<br>nC |

**Table 7. Switching on/off**

| Symbol                           | Parameter   | Test Conditions  | Min. | Typ.           | Max. | Unit           |
|----------------------------------|---|--|------|----------------|------|----------------|
| $t_{d(on)}$<br>$t_r$             | Turn-on Delay Time<br>Rise Time                       | $V_{DD} = 300V, I_D = 4A,$<br>$R_G = 4.7\Omega, V_{GS} = 10V$<br>(see Figure 20) |      | 20<br>20       |      | ns<br>ns       |
| $t_{d(off)}$<br>$t_f$            | Turn-off Delay Time<br>Fall Time                      | $V_{DD} = 300V, I_D = 4A,$<br>$R_G = 4.7\Omega, V_{GS} = 10V$<br>(see Figure 20) |      | 55<br>30       |      | ns<br>ns       |
| $t_r(V_{off})$<br>$t_f$<br>$t_c$ | Off-voltage Rise Time<br>Fall Time<br>Cross-over Time | $V_{DD} = 480V, I_D = 8A,$<br>$R_G = 4.7\Omega, V_{GS} = 10V$<br>(see Figure 20) |      | 18<br>18<br>36 |      | ns<br>ns<br>ns |

Table 8. Source drain diode

| Symbol                  | Parameter                     | Test Conditions  | Min. | Typ. | Max. | Unit    |
|-------------------------|-------------------------------|--|------|------|------|---------|
| $I_{SD}$                | Source-drain Current          |  |      |      | 10   | A       |
| $I_{SDM}$ <i>Note 2</i> | Source-drain Current (pulsed) |  |      |      | 36   | A       |
| $V_{SD}$ <i>Note 4</i>  | Forward on Voltage            | $I_{SD}=10A, V_{GS}=0$   |      |      | 1.6  | V       |
| $t_{rr}$                | Reverse Recovery Time         | $I_{SD}=8A, di/dt = 100A/\mu s,$<br>$V_{DD}=40 V, T_j=150^\circ C$ |      | 570  |      | ns      |
| $Q_{rr}$                | Reverse Recovery Charge       |  |      | 4.3  |      | $\mu C$ |
| $I_{RRM}$               | Reverse Recovery Current      |  |      | 15   |      | A       |

(1)  $I_{SD} \leq 10A, di/dt \leq 200A/\mu s, V_{DD} \leq V_{(BR)DSS}, T_j \leq T_{JMAX}$

(2) Pulse width limited by safe operating area

(3) Limited only by maximum temperature allowed

(4) Pulsed: pulse duration = 300 $\mu s$ , duty cycle 1.5%

(5)  $C_{OSS\ eq}$  is defined as a constant equivalent capacitance giving the same charging time as  $C_{OSS}$  when  $V_{DS}$  increases from 0 to 80%

## 2.1 Typical characteristics

Figure 1. Safe Operating Area for TO-220/D<sup>2</sup>/I<sup>2</sup>PAK

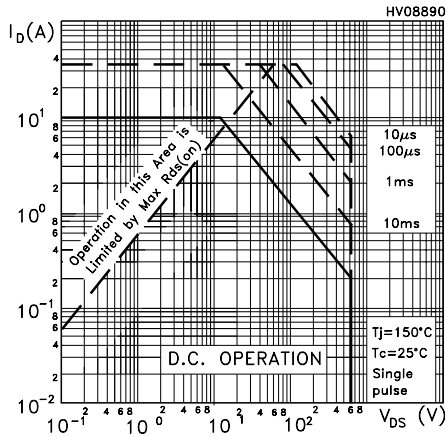


Figure 2. Thermal Impedance for TO-220/D<sup>2</sup>/I<sup>2</sup>PAK

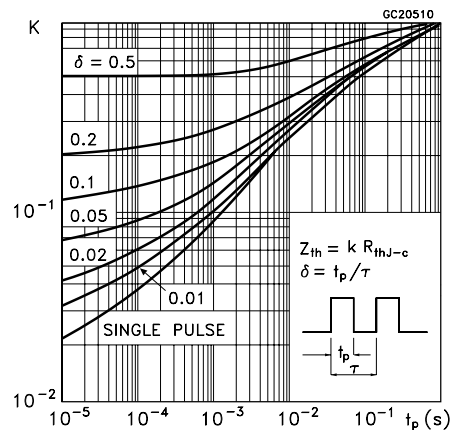


Figure 3. Safe Operating Area for TO-220FP

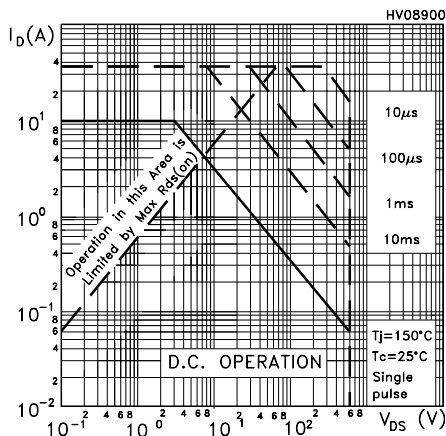


Figure 4. Thermal Impedance for TO-220FP

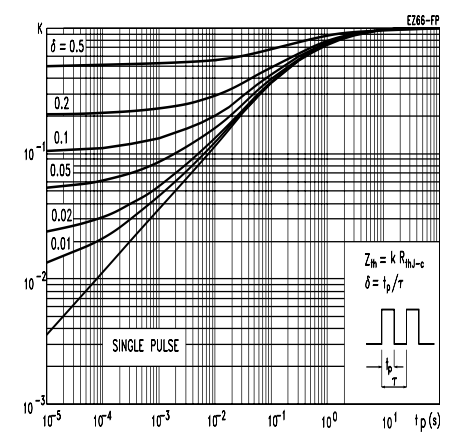


Figure 5. Safe Operating Area for TO-247

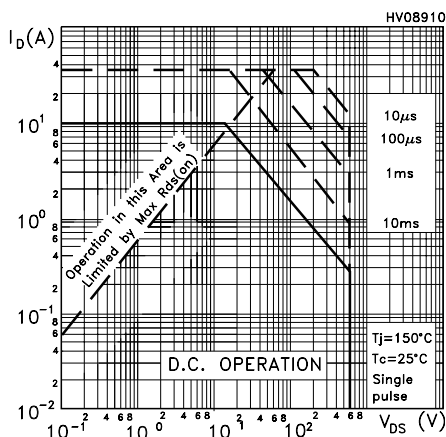


Figure 6. Thermal Impedance for TO-247

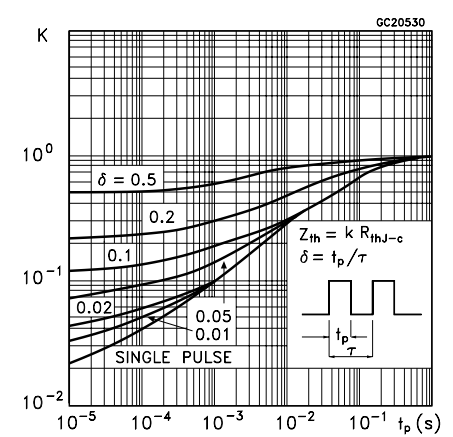


Figure 7. Output Characteristics

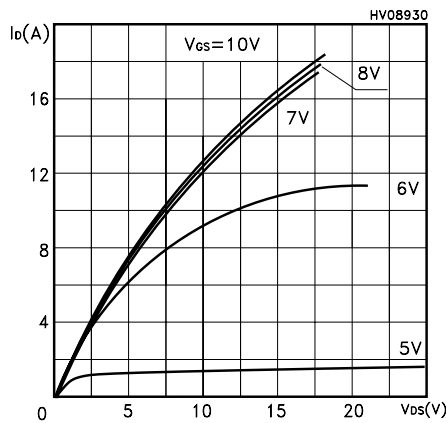


Figure 8. Transfer Characteristics

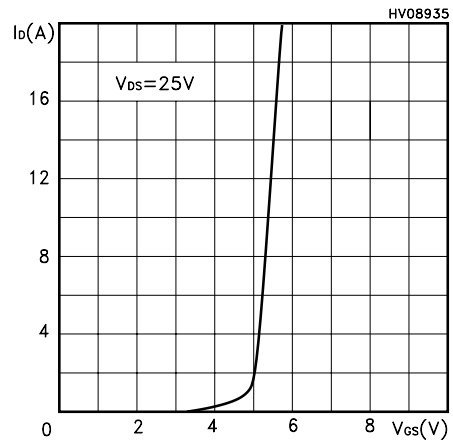


Figure 9. Transconductance

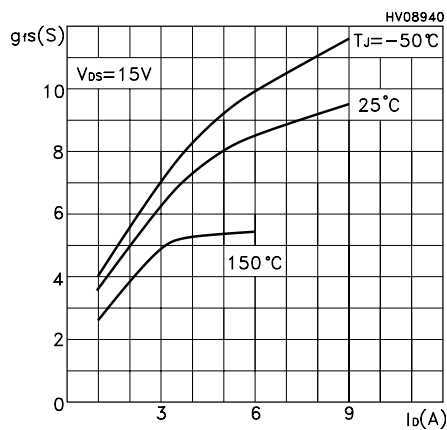


Figure 10. Static Drain-Source on Resistance

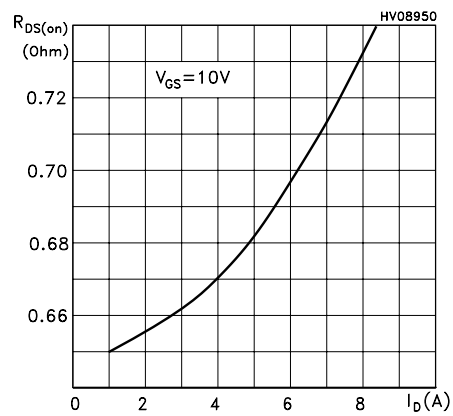


Figure 11. Gate Charge vs Gate -Source Voltage

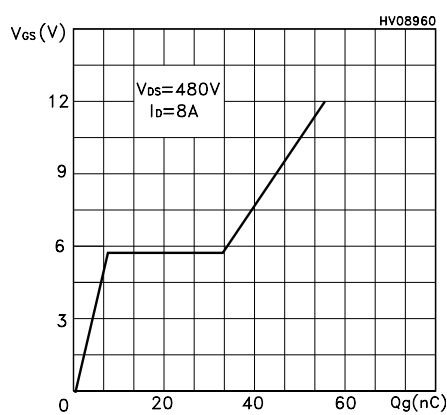
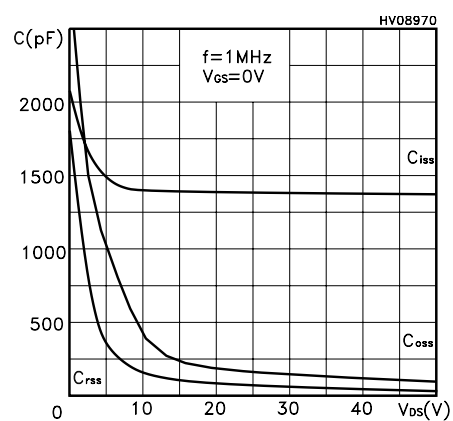
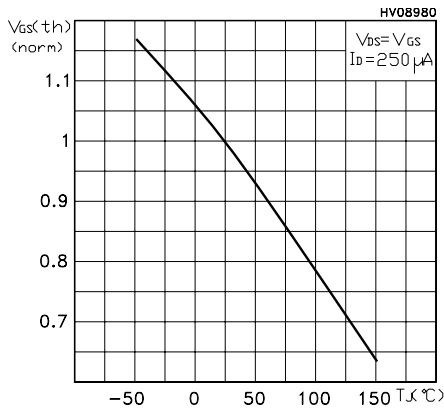


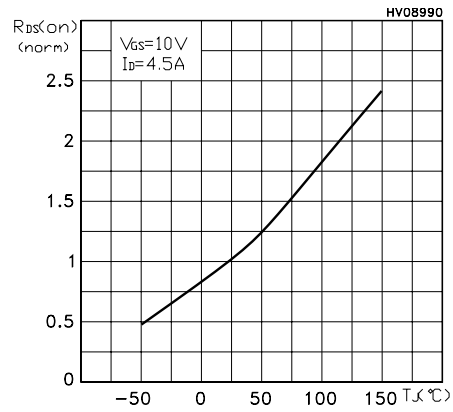
Figure 12. Capacitance Variations



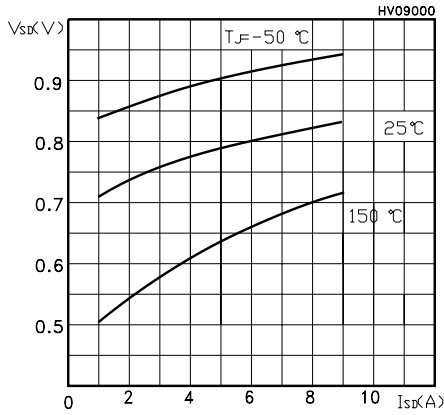
**Figure 13. Normalized Gate Threshold Voltage vs Temperature**



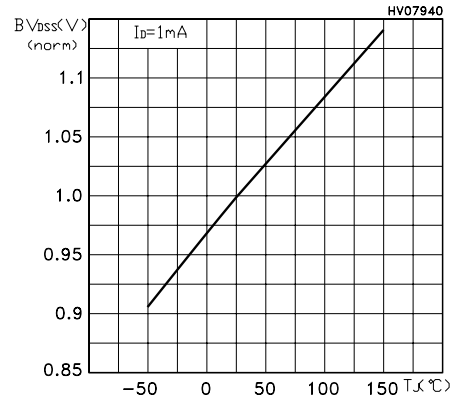
**Figure 14. Normalized on Resistance vs Temperature**



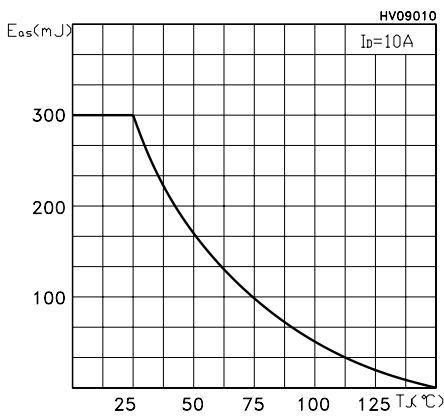
**Figure 15. Source-drain Diode Forward Characteristics**



**Figure 16. Normalized BVDSS vs Temperature**



**Figure 17. Maximum Avalanche Energy vs Temperature**





### 3 Test circuits

Figure 18. Switching Times Test Circuit For Resistive Load

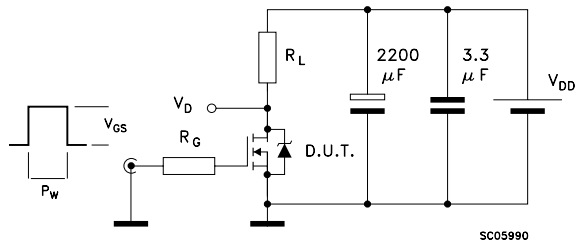


Figure 19. Gate Charge Test Circuit

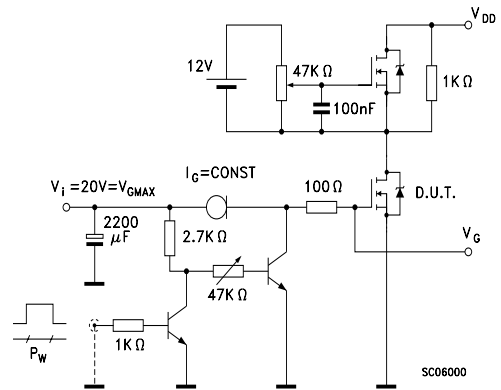
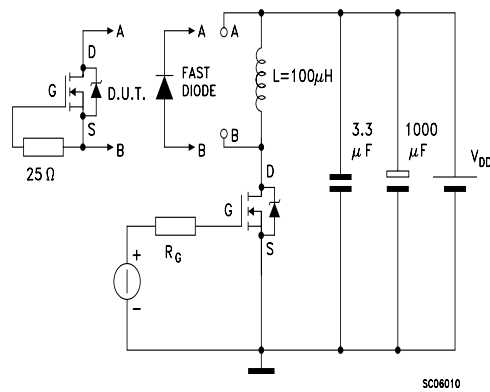


Figure 20. Test Circuit For Inductive Load Switching and Diode Recovery Times

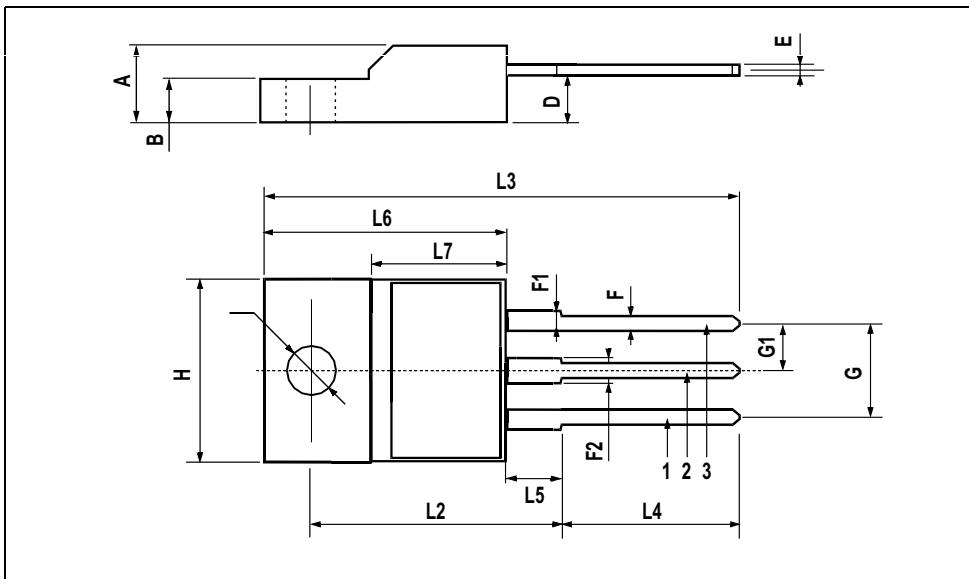


## 4 Package mechanical data

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)

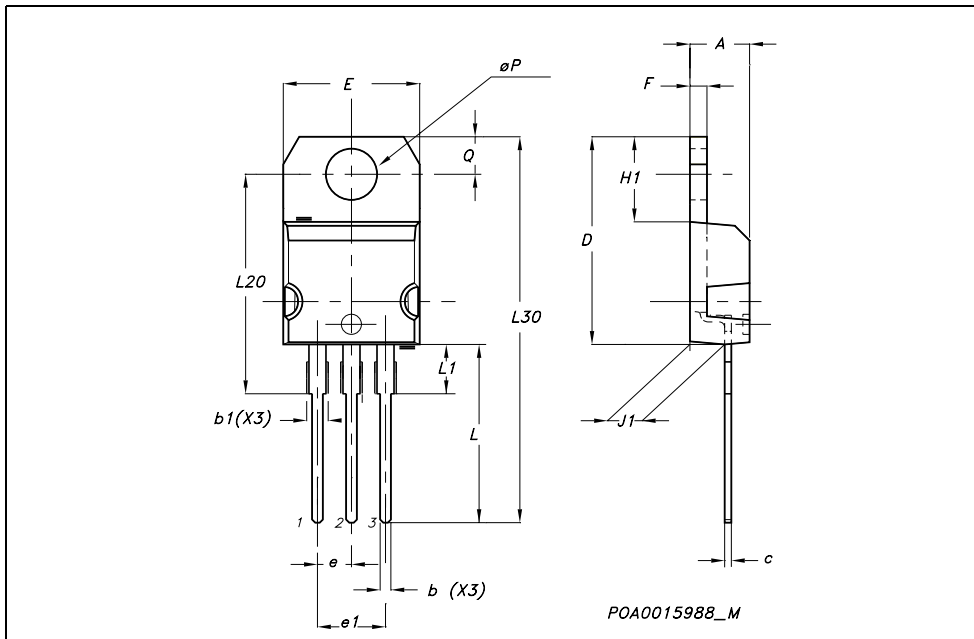
**TO-220FP MECHANICAL DATA**

| 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 |



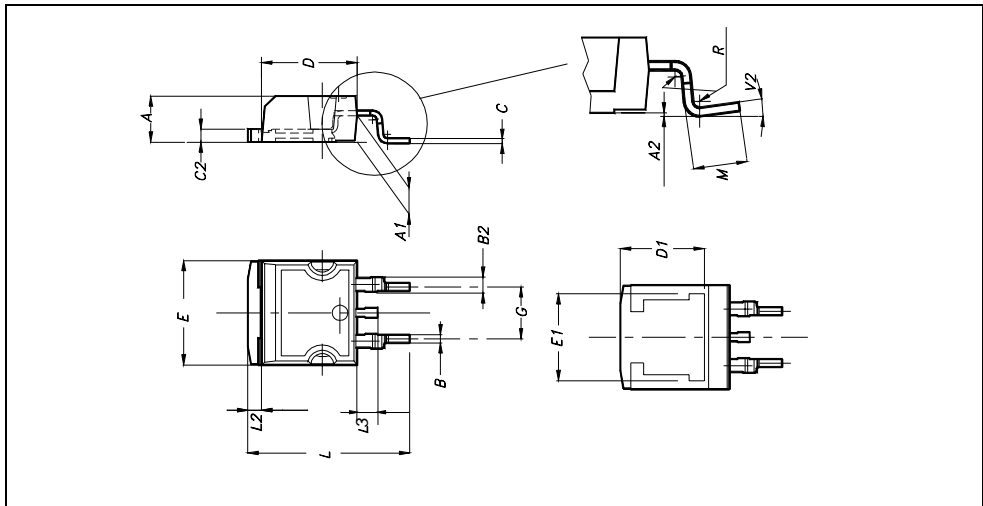
TO-220 MECHANICAL DATA

| 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 |



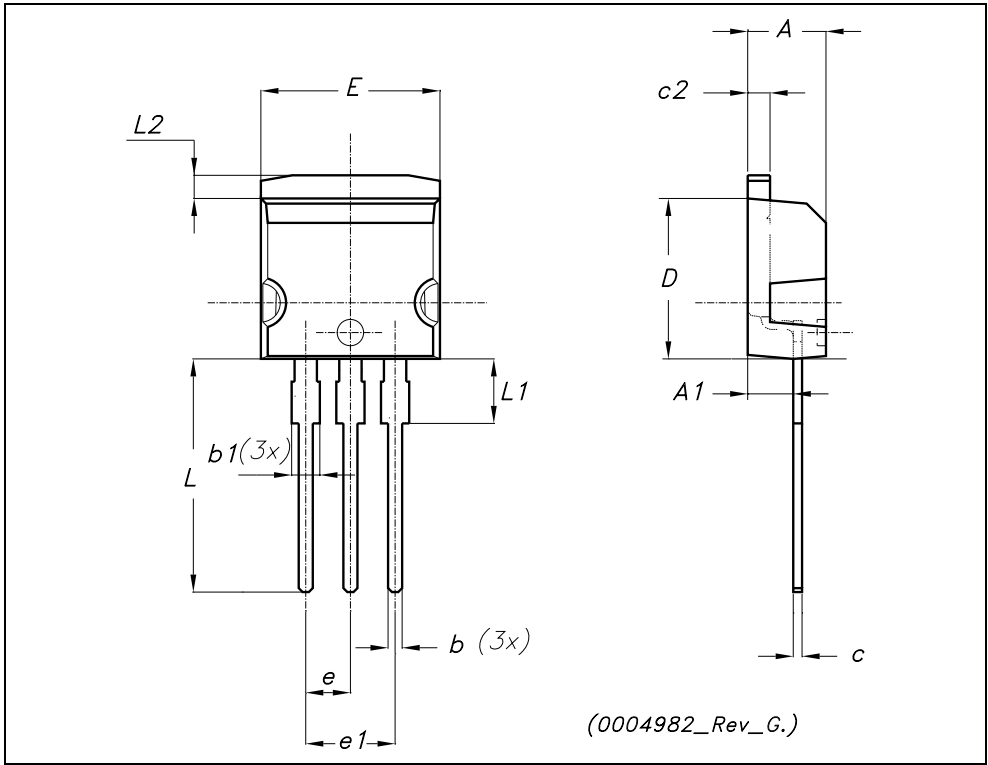
**D<sup>2</sup>PAK MECHANICAL DATA**

| 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°    |       |       |       |



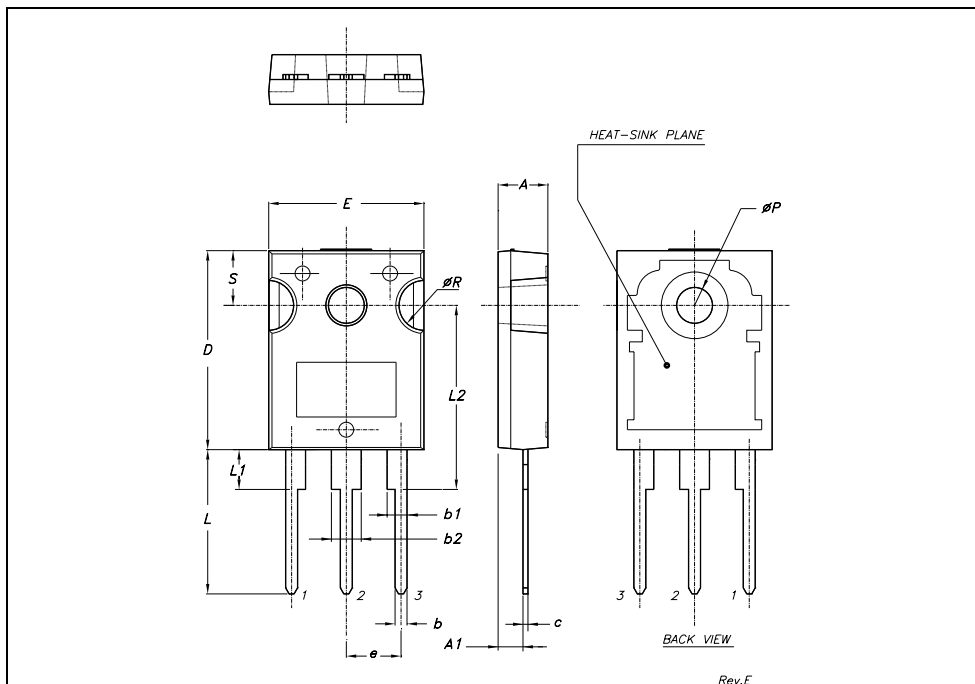
**TO-262 (I<sup>2</sup>PAK) MECHANICAL DATA**

| DIM. | mm.  |      |       | inch  |      |       |
|------|------|------|-------|-------|------|-------|
|      | MIN. | TYP. | MAX.  | MIN.  | TYP. | MAX.  |
| A    | 4.40 |      | 4.60  | 0.173 |      | 0.181 |
| A1   | 2.40 |      | 2.72  | 0.094 |      | 0.107 |
| b    | 0.61 |      | 0.88  | 0.024 |      | 0.034 |
| b1   | 1.14 |      | 1.70  | 0.044 |      | 0.066 |
| c    | 0.49 |      | 0.70  | 0.019 |      | 0.027 |
| c2   | 1.23 |      | 1.32  | 0.048 |      | 0.052 |
| D    | 8.95 |      | 9.35  | 0.352 |      | 0.368 |
| e    | 2.40 |      | 2.70  | 0.094 |      | 0.106 |
| e1   | 4.95 |      | 5.15  | 0.194 |      | 0.202 |
| E    | 10   |      | 10.40 | 0.393 |      | 0.410 |
| L    | 13   |      | 14    | 0.511 |      | 0.551 |
| L1   | 3.50 |      | 3.93  | 0.137 |      | 0.154 |
| L2   | 1.27 |      | 1.40  | 0.050 |      | 0.055 |



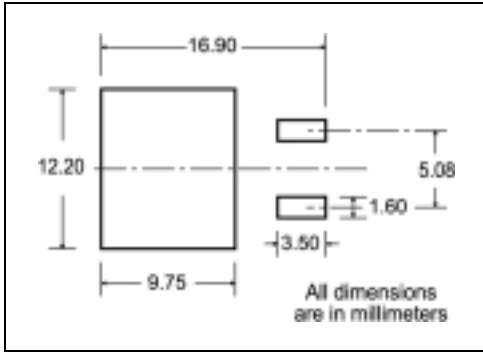
**TO-247 MECHANICAL DATA**

| DIM. | mm.   |       |       | inch  |       |       |
|------|-------|-------|-------|-------|-------|-------|
|      | MIN.  | TYP.  | MAX.  | MIN.  | TYP.  | MAX.  |
| A    | 4.85  |       | 5.15  | 0.19  |       | 0.20  |
| A1   | 2.20  |       | 2.60  | 0.086 |       | 0.102 |
| b    | 1.0   |       | 1.40  | 0.039 |       | 0.055 |
| b1   | 2.0   |       | 2.40  | 0.079 |       | 0.094 |
| b2   | 3.0   |       | 3.40  | 0.118 |       | 0.134 |
| c    | 0.40  |       | 0.80  | 0.015 |       | 0.03  |
| D    | 19.85 |       | 20.15 | 0.781 |       | 0.793 |
| E    | 15.45 |       | 15.75 | 0.608 |       | 0.620 |
| e    |       | 5.45  |       |       | 0.214 |       |
| L    | 14.20 |       | 14.80 | 0.560 |       | 0.582 |
| L1   | 3.70  |       | 4.30  | 0.14  |       | 0.17  |
| L2   |       | 18.50 |       |       | 0.728 |       |
| øP   | 3.55  |       | 3.65  | 0.140 |       | 0.143 |
| øR   | 4.50  |       | 5.50  | 0.177 |       | 0.216 |
| S    |       | 5.50  |       |       | 0.216 |       |



# 5 Packing mechanical data

## 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  |

**REEL MECHANICAL DATA**

| DIM. | mm   |      | inch  |        |
|------|------|------|-------|--------|
|      | MIN. | MAX. | MIN.  | MAX.   |
| A    |      | 330  |       | 12.992 |
| B    | 1.5  |      | 0.059 |        |
| C    | 12.8 | 13.2 | 0.504 | 0.520  |
| D    | 20.2 |      | 0.795 |        |
| G    | 24.4 | 26.4 | 0.960 | 1.039  |
| N    | 100  |      | 3.937 |        |
| T    |      | 30.4 |       | 1.197  |

| BASE QTY | BULK QTY |
|----------|----------|
| 1000     | 1000     |

\* on sales type



## 6 Order codes

| Sales Type   | Marking    | Package            | Packaging   |
|--------------|------------|--------------------|-------------|
| STB10NK60Z-1 | B10NK60Z-1 | I <sup>2</sup> PAK | TUBE        |
| STB10NK60ZT4 | B10NK60Z   | D <sup>2</sup> PAK | TAPE & REEL |
| STP10NK60ZFP | P10NK60ZFP | TO-220FP           | TUBE        |
| STP10NK60Z   | P10NK60Z   | TO-220             | TUBE        |
| STW10NK60Z   | W10NK60Z   | TO-247             | TUBE        |

## 7 Revision History

| Date        | Revision | Changes                     |
|-------------|----------|-----------------------------|
| 26-Jul-2005 | 2        | Inserted Ecopack indication |

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