



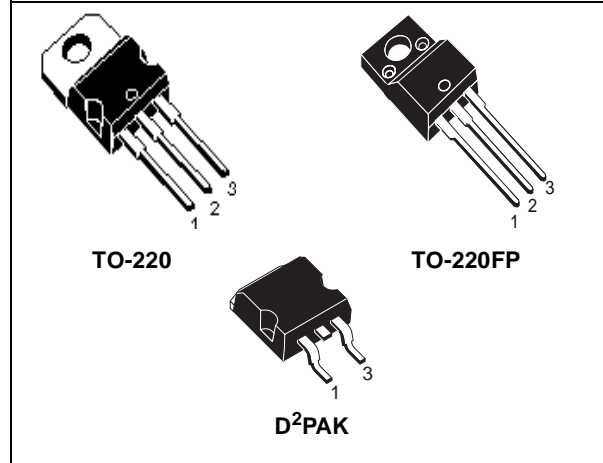
# STP9NK60ZFD - STP9NK60ZFDFP STB9NK60ZFD

N-CHANNEL 600V - 0.85Ω - 7A TO-220/TO-220FP/D<sup>2</sup>PAK  
Fast Diode SuperMESH™ MOSFET

TARGET DATA

| TYPE          | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> | P <sub>w</sub> |
|---------------|------------------|---------------------|----------------|----------------|
| STP9NK60ZFD   | 600 V            | < 0.95 Ω            | 7 A            | 104 W          |
| STP9NK60ZFDFP | 600 V            | < 0.95 Ω            | 7 A            | 32 W           |
| STB9NK60ZFD   | 600 V            | < 0.95 Ω            | 7 A            | 104 W          |

- TYPICAL R<sub>DS(on)</sub> = 0.85 Ω
- HIGH dv/dt CAPABILITY
- 100% AVALANCHE TESTED
- GATE CHARGE MINIMIZED
- LOW INTRINSIC CAPACITANCES
- VERY GOOD MANUFACTURING REPEATABILITY
- FAST INTERNAL RECOVERY DIODE



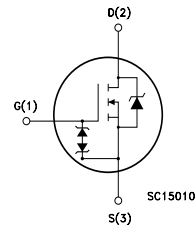
## DESCRIPTION

The Fast SuperMESH™ series associates all advantages of reduced on-resistance, zener gate protection and very good dv/dt capability with a Fast body-drain recovery diode. Such series complements the "FDmesh™" Advanced Technology.

## APPLICATIONS

- HID BALLAST
- ZVS PHASE-SHIFT FULL BRIDGE CONVERTERS

## INTERNAL SCHEMATIC DIAGRAM



## ORDERING INFORMATION

| SALES TYPE    | MARKING     | PACKAGE            | PACKAGING   |
|---------------|-------------|--------------------|-------------|
| STP9NK60ZFD   | P9NK60ZFD   | TO-220             | TUBE        |
| STP9NK60ZFDFP | P9NK60ZFDFP | TO-220FP           | TUBE        |
| STB9NK60ZFDT4 | B9NK60ZFD   | D <sup>2</sup> PAK | TAPE & REEL |

## STP9NK60ZFD - STP9NK60ZFDFP - STB9NK60ZFD

### ABSOLUTE MAXIMUM RATINGS

| Symbol                             | Parameter   | Value                       |          | Unit |
|------------------------------------|---|-----------------------------|----------|------|
|                                    |   | TO-220 / D <sup>2</sup> PAK | TO-220FP |      |
| 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> = 20 kΩ)          | 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   | 7                           | 7 (*)    | A    |
| I <sub>D</sub>                     | Drain Current (continuous) at T <sub>C</sub> = 100°C  | 4.3                         | 4.3 (*)  | A    |
| I <sub>DM</sub> (•)                | Drain Current (pulsed)                                | 28                          | 28 (*)   | A    |
| P <sub>TOT</sub>                   | Total Dissipation at T <sub>C</sub> = 25°C            | 104                         | 32       | W    |
|                                    | Derating Factor                                       | 0.83                        | 0.26     | W/°C |
| V <sub>ESD(G-S)</sub>              | Gate source ESD (HBM-C=100pF, R=1.5KΩ)                | 4000                        |          | V    |
| dv/dt (1)                          | Peak Diode Recovery voltage slope                     | TBD                         |          | 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   |

(•) Pulse width limited by safe operating area

(1) I<sub>SD</sub> ≤ 7A, di/dt ≤ 200A/μs, V<sub>DD</sub> ≤ V<sub>(BR)DSS</sub>, T<sub>j</sub> ≤ T<sub>JMAX</sub>.

(\*) Limited only by maximum temperature allowed

### THERMAL DATA

|                       |  | TO-220<br>D <sup>2</sup> PAK | TO-220FP | Unit |
|-----------------------|--|------------------------------|----------|------|
| R <sub>thj-case</sub> | Thermal Resistance Junction-case Max                                       | 1.02                         | 3.85     | °C/W |
| R <sub>thj-pcb</sub>  | Thermal Resistance Junction-pcb Max<br>(When mounted on minimum Footprint) | 30                           |          | °C/W |
| R <sub>thj-amb</sub>  | Thermal Resistance Junction-ambient Max                                    | 62.5                         |          | °C/W |
| T <sub>I</sub>        | Maximum Lead Temperature For Soldering<br>Purpose                          | 300                          |          | °C   |

### AVALANCHE CHARACTERISTICS

| Symbol          | Parameter   | Max Value | Unit |
|-----------------|---|-----------|------|
| I <sub>AR</sub> | Avalanche Current, Repetitive or Not-Repetitive<br>(pulse width limited by T <sub>j</sub> max)                                | 7         | A    |
| E <sub>AS</sub> | Single Pulse Avalanche Energy<br>(starting T <sub>j</sub> = 25 °C, I <sub>D</sub> = I <sub>AR</sub> , V <sub>DD</sub> = 50 V) | 280       | mJ   |

### GATE-SOURCE ZENER DIODE

| Symbol            | Parameter                        | Test Conditions                      | Min. | Typ. | Max. | Unit |
|-------------------|----------------------------------|--------------------------------------|------|------|------|------|
| BV <sub>GSO</sub> | Gate-Source Breakdown<br>Voltage | I <sub>gs</sub> = ± 1mA (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.

## STP9NK60ZFD - STP9NK60ZFDFP - STB9NK60ZFD

### ELECTRICAL CHARACTERISTICS (TCASE = 25°C UNLESS OTHERWISE SPECIFIED) ON/OFF

| Symbol        | Parameter  | Test Conditions   | Min. | Typ. | Max.     | Unit                           |
|---------------|--|---|------|------|----------|--------------------------------|
| $V_{(BR)DSS}$ | Drain-source Breakdown Voltage                   | $I_D = \text{mA}, V_{GS} = 0$   | 600  |      |          | V                              |
| $I_{DSS}$     | Zero Gate Voltage Drain Current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating}, T_C = 125^\circ\text{C}$ |      |      | 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                           | $V_{DS} = V_{GS}, I_D = 100\mu\text{A}$   | 3    | 3.75 | 4.5      | V                              |
| $R_{DS(on)}$  | Static Drain-source On Resistance                | $V_{GS} = 10\text{V}, I_D = 3.5\text{A}$  |      | 0.85 | 0.95     | $\Omega$                       |

### DYNAMIC

| Symbol                              | Parameter   | Test Conditions  | Min. | Typ.              | Max. | Unit           |
|-------------------------------------|---|--|------|-------------------|------|----------------|
| $g_{fs} (1)$                        | Forward Transconductance  | $V_{DS} = 15\text{V}, I_D = 3.5\text{A}$                 |      | 5.3               |      | S              |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input Capacitance<br>Output Capacitance<br>Reverse Transfer Capacitance | $V_{DS} = 25\text{V}, f = 1\text{MHz}, V_{GS} = 0$       |      | 1110<br>135<br>30 |      | pF<br>pF<br>pF |
| $C_{oss \text{ eq.}} (3)$           | Equivalent Output Capacitance   | $V_{GS} = 0\text{V}, V_{DS} = 0\text{V to } 480\text{V}$ |      | 72                |      | pF             |

### SWITCHING ON

| Symbol                        | Parameter  | Test Conditions   | Min. | Typ.          | Max. | Unit           |
|-------------------------------|--|---|------|---------------|------|----------------|
| $t_{d(on)}$<br>$t_r$          | Turn-on Delay Time<br>Rise Time                              | $V_{DD} = 300\text{V}, I_D = 3.5\text{A}$<br>$R_G = 4.7\Omega, V_{GS} = 10\text{V}$<br>(Resistive Load see, Figure 3) |      | 19<br>17      |      | ns<br>ns       |
| $Q_g$<br>$Q_{gs}$<br>$Q_{gd}$ | Total Gate Charge<br>Gate-Source Charge<br>Gate-Drain Charge | $V_{DD} = 480\text{V}, I_D = 7\text{A},$<br>$V_{GS} = 10\text{V}$   |      | 38<br>7<br>21 | 53   | nC<br>nC<br>nC |

### SWITCHING OFF

| Symbol                           | Parameter   | Test Conditions   | Min. | Typ.          | Max. | Unit           |
|----------------------------------|---|---|------|---------------|------|----------------|
| $t_{d(off)}$<br>$t_f$            | Turn-off Delay Time<br>Fall Time                      | $V_{DD} = 300\text{V}, I_D = 3.5\text{A}$<br>$R_G = 4.7\Omega, V_{GS} = 10\text{V}$<br>(Resistive Load see, Figure 3) |      | 43<br>15      |      | ns<br>ns       |
| $t_r(V_{off})$<br>$t_f$<br>$t_c$ | Off-voltage Rise Time<br>Fall Time<br>Cross-over Time | $V_{DD} = 480\text{V}, I_D = 7\text{A},$<br>$R_G = 4.7\Omega, V_{GS} = 10\text{V}$<br>(Inductive Load see, Figure 5)  |      | 11<br>8<br>20 |      | ns<br>ns<br>ns |

### 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)                        |   |      |                   | 7<br>28 | A<br>A                   |
| $V_{SD} (1)$                      | Forward On Voltage   | $I_{SD} = 7\text{A}, V_{GS} = 0$  |      |                   | 1.6     | V                        |
| $t_{rr}$<br>$Q_{rr}$<br>$I_{RRM}$ | Reverse Recovery Time<br>Reverse Recovery Charge<br>Reverse Recovery Current | $I_{SD} = 7\text{A}, di/dt = 100\text{A}/\mu\text{s}$<br>$V_{DD} = 30\text{V}, T_j = 150^\circ\text{C}$<br>(see test circuit, Figure 5) |      | 150<br>TBD<br>TBD |         | ns<br>$\mu\text{C}$<br>A |

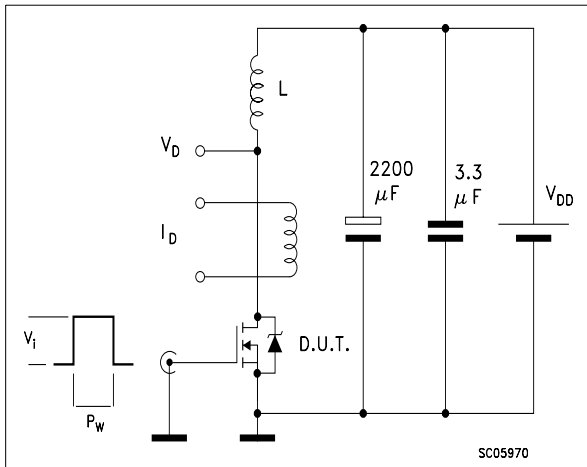
Note: 1. Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5 %.

2. Pulse width limited by safe operating area.

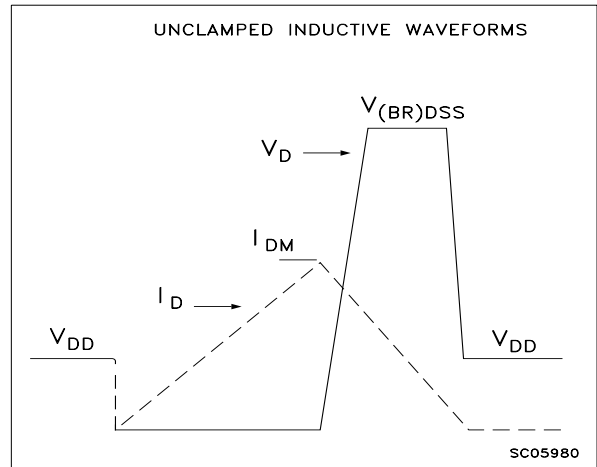
3.  $C_{oss \text{ eq.}}$  is defined as a constant equivalent capacitance giving the same charging time as  $C_{oss}$  when  $V_{DS}$  increases from 0 to 80%  $V_{DSS}$ .

**STP9NK60ZFD - STP9NK60ZFDFP - STB9NK60ZFD**

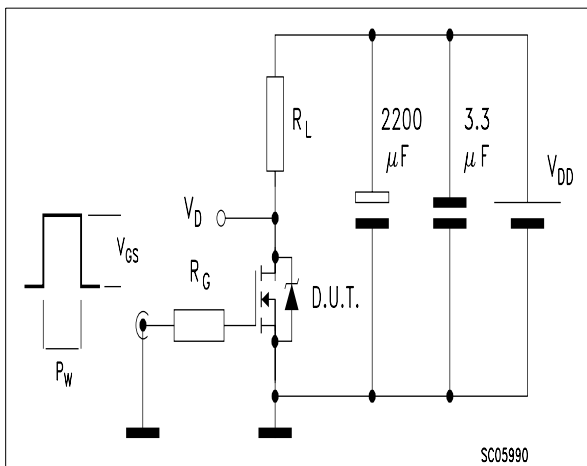
**Fig. 1: Unclamped Inductive Load Test Circuit**



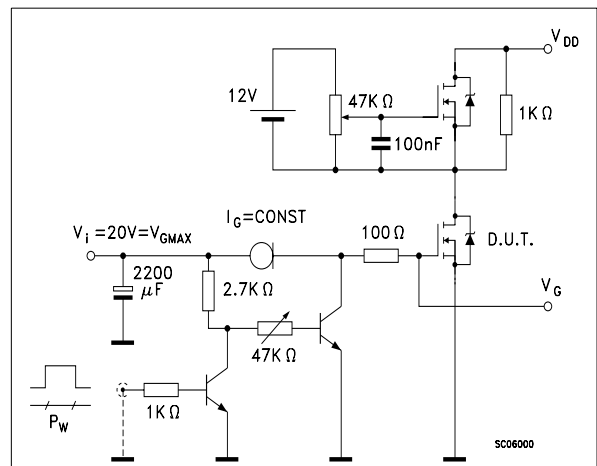
**Fig. 2: Unclamped Inductive Waveform**



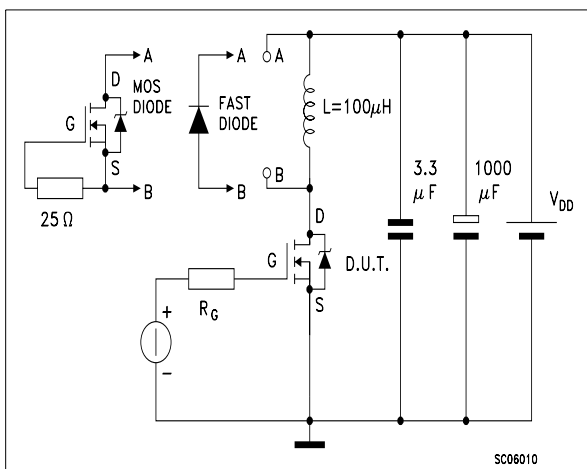
**Fig. 3: Switching Times Test Circuit For Resistive Load**



**Fig. 4: Gate Charge test Circuit**

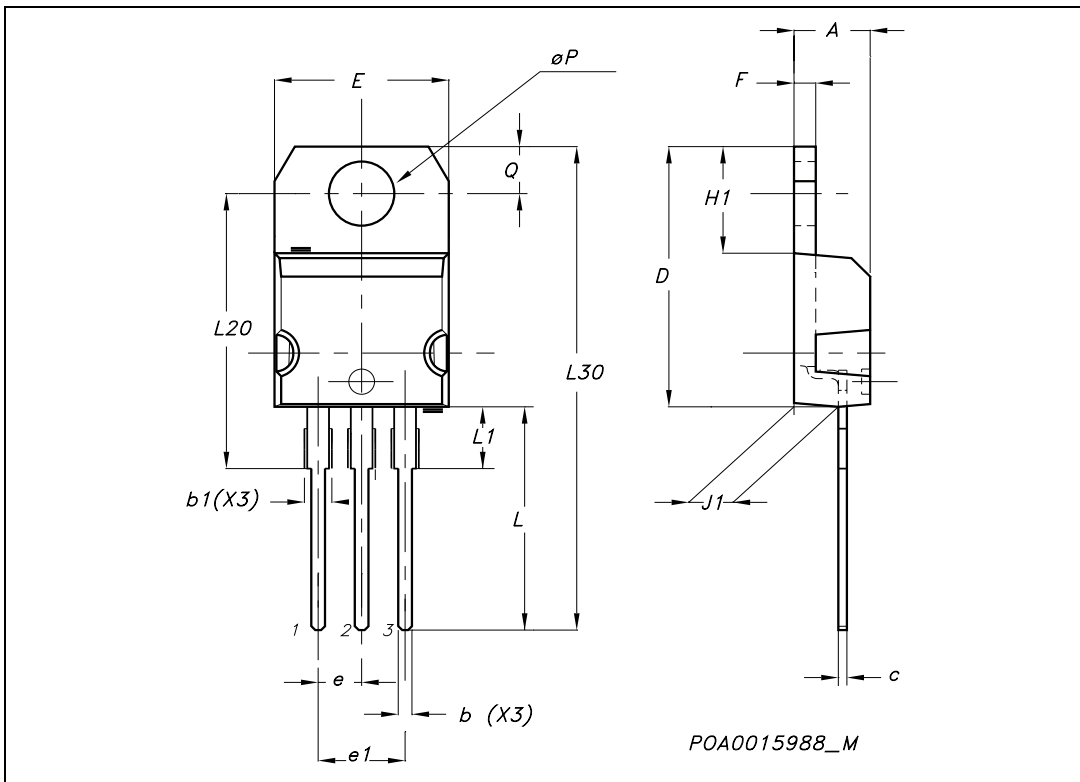


**Fig. 5: Test Circuit For Inductive Load Switching And Diode Recovery Times**



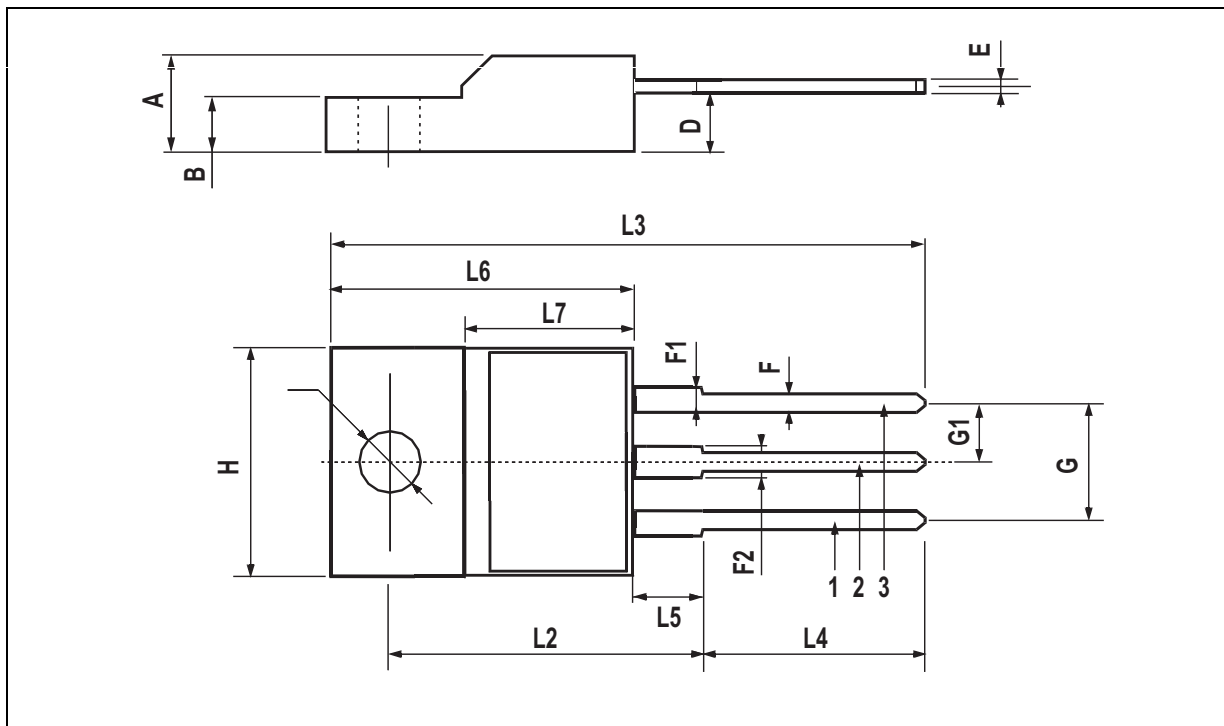
**TO-220 MECHANICAL DATA**

| 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 |



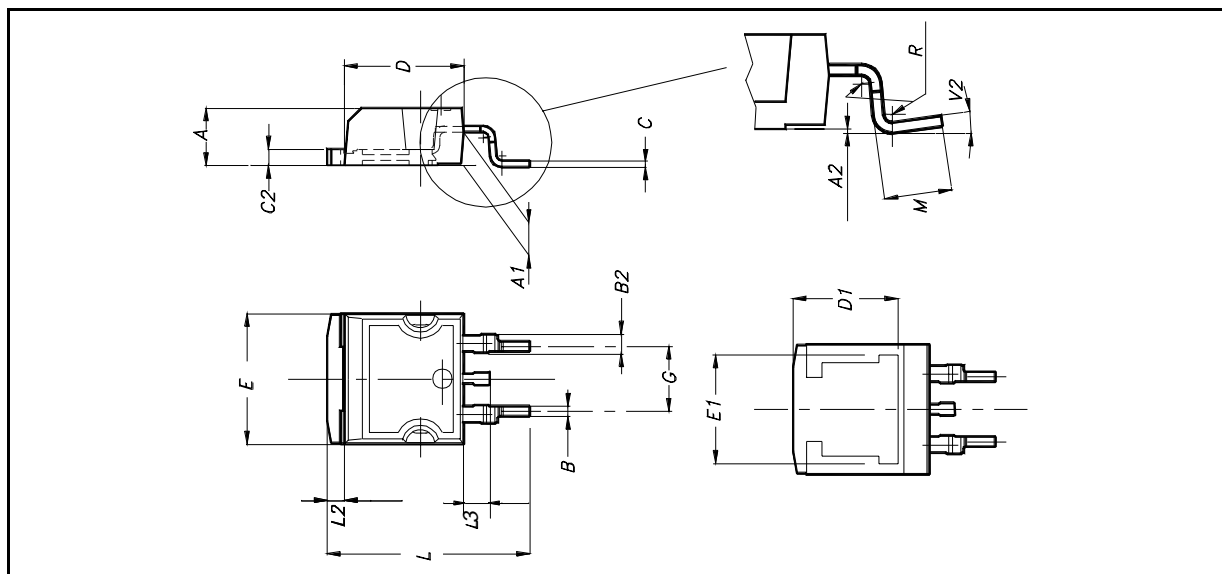
**TO-220FP MECHANICAL DATA**

| 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 |     | 1.5  | 0.045 |       | 0.067 |
| F2   | 1.15 |     | 1.5  | 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 |

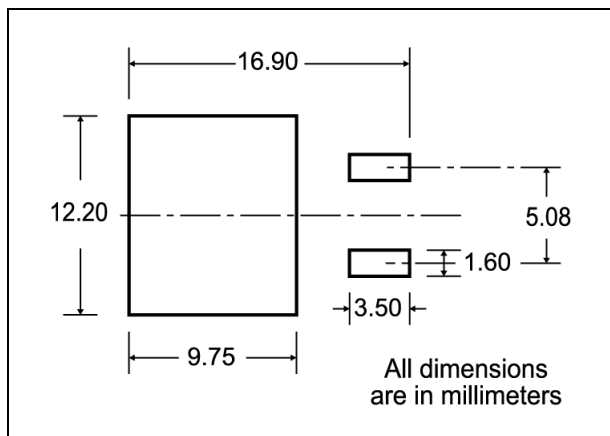


**D<sup>2</sup>PAK MECHANICAL DATA**

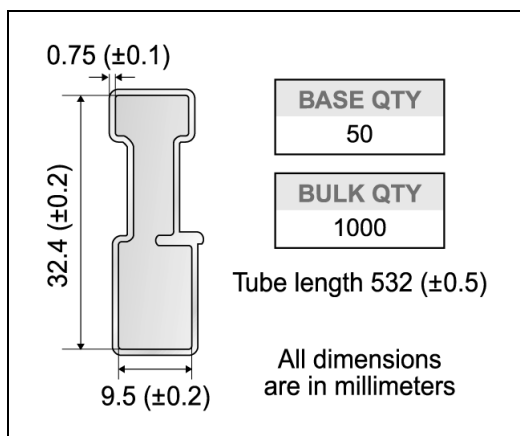
| DIM. | mm.  |     |       | inch  |       |       |
|------|------|-----|-------|-------|-------|-------|
|      | MIN. | TYP | MAX.  | MIN.  | TYP.  | MAX.  |
| A    | 4.4  |     | 4.6   | 0.173 |       | 0.181 |
| A1   | 2.49 |     | 2.69  | 0.098 |       | 0.106 |
| A2   | 0.03 |     | 0.23  | 0.001 |       | 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°   |     | 8°    |       |       |       |



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



**TUBE SHIPMENT (no suffix)\***



**TAPE AND REEL SHIPMENT (suffix "T4")\***

Diagram showing the tape mechanical data. It includes a circular reel view with dimensions A (outer diameter), B (slot width), C (slot depth), D (slot diameter), and D1 (inner diameter). A note indicates a 40 mm min. access hole at the slot location. Another note indicates a tape slot in the core for tape start with a 2.5 mm min. width. A side view shows dimensions T (tape thickness), N (slot depth), and G (measured at hub).

**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     |

Diagram showing the reel mechanical data. It includes a top view of the reel with dimensions K0 (reel width), D (reel diameter), D1 (inner diameter), A0 (pitch), P1 (pitch), P2 (pitch), P0 (pitch), E (pitch), F (pitch), W (pitch), and B0 (pitch). A note indicates a 10 pitches cumulative tolerance on tape +/- 0.2 mm. A side view shows dimensions T (tape thickness), N (slot depth), and G (measured at hub). A bottom view shows the user direction of feed and the bending radius R min.

\* on sales type  
8/9





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