

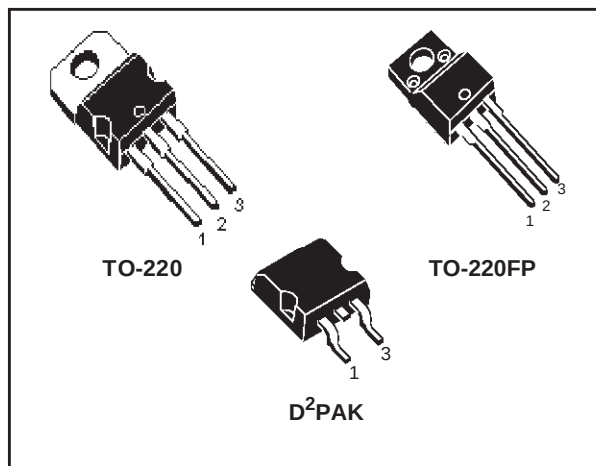


# STP9NK50Z - STP9NK50ZFP STB9NK50Z

N-CHANNEL 500V - 0.72Ω - 7.2A TO-220/TO-220FP/D<sup>2</sup>PAK  
Zener-Protected SuperMESH™ Power MOSFET

| TYPE        | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> | P <sub>w</sub> |
|-------------|------------------|---------------------|----------------|----------------|
| STP9NK50Z   | 500 V            | < 0.85 Ω            | 7.2 A          | 110 W          |
| STP9NK50ZFP | 500 V            | < 0.85 Ω            | 7.2 A          | 30 W           |
| STB9NK50Z   | 500 V            | < 0.85 Ω            | 7.2 A          | 110 W          |

- TYPICAL R<sub>DS(on)</sub> = 0.72 Ω
- EXTREMELY HIGH dv/dt CAPABILITY
- 100% AVALANCHE TESTED
- GATE CHARGE MINIMIZED
- VERY LOW INTRINSIC CAPACITANCES
- VERY GOOD MANUFACTURING REPEATABILITY



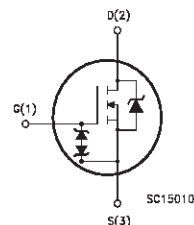
## DESCRIPTION

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

## INTERNAL SCHEMATIC DIAGRAM



## ORDERING INFORMATION

| SALES TYPE  | MARKING   | PACKAGE            | PACKAGING   |
|-------------|-----------|--------------------|-------------|
| STP9NK50Z   | P9NK50Z   | TO-220             | TUBE        |
| STP9NK50ZFP | P9NK50ZFP | TO-220FP           | TUBE        |
| STB9NK50ZT4 | B9NK50Z   | D <sup>2</sup> PAK | TAPE & REEL |

## STP9NK50Z - STP9NK50ZFP - STB9NK50Z

### ABSOLUTE MAXIMUM RATINGS

| Symbol                             | Parameter                                             | Value                    |             | Unit     |
|------------------------------------|-------------------------------------------------------|--------------------------|-------------|----------|
|                                    |                                                       | STP9NK50Z<br>STB9NK50Z   | STP9NK50ZFP |          |
| V <sub>DS</sub>                    | Drain-source Voltage (V <sub>GS</sub> = 0)            | 500                      |             | V        |
| V <sub>DGR</sub>                   | Drain-gate Voltage (R <sub>GS</sub> = 20 kΩ)          | 500                      |             | V        |
| V <sub>GS</sub>                    | Gate- source Voltage                                  | ± 30                     |             | V        |
| I <sub>D</sub>                     | Drain Current (continuous) at T <sub>C</sub> = 25°C   | 7.2                      | 7.2 (*)     | A        |
| I <sub>D</sub>                     | Drain Current (continuous) at T <sub>C</sub> = 100°C  | 4.5                      | 4.5 (*)     | A        |
| I <sub>DM</sub> (†)                | Drain Current (pulsed)                                | 28.8                     | 28.8 (*)    | A        |
| P <sub>TOT</sub>                   | Total Dissipation at T <sub>C</sub> = 25°C            | 110                      | 30          | W        |
|                                    | Derating Factor                                       | 0.88                     | 0.24        | W/°C     |
| V <sub>ESD(G-S)</sub>              | Gate source ESD(HBM-C=100pF, R=1.5KΩ)                 | 3500                     |             | V        |
| dv/dt (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<br>-55 to 150 |             | °C<br>°C |

(†) Pulse width limited by safe operating area

(1) I<sub>SD</sub> ≤ 7.2A, 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 |      |
|-----------------------|------------------------------------------------|------------------------------|----------|------|
| R <sub>thj-case</sub> | Thermal Resistance Junction-case Max           | 1.14                         | 4.2      | °C/W |
| R <sub>thj-amb</sub>  | Thermal Resistance Junction-ambient Max        | 62.5                         |          | °C/W |
| T <sub>l</sub>        | Maximum Lead Temperature For Soldering 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)                                | 7.2       | 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) | 190       | mJ   |

### GATE-SOURCE ZENER DIODE

| Symbol            | Parameter                     | Test Conditions                     | Min. | Typ. | Max. | Unit |
|-------------------|-------------------------------|-------------------------------------|------|------|------|------|
| BV <sub>GSO</sub> | Gate-Source Breakdown 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 souce. 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** (TCASE = 25°C UNLESS OTHERWISE SPECIFIED)  
ON/OFF

| Symbol        | Parameter                                        | Test Conditions                                                                          | Min. | Typ. | Max.     | Unit                           |
|---------------|--------------------------------------------------|------------------------------------------------------------------------------------------|------|------|----------|--------------------------------|
| $V_{(BR)DSS}$ | Drain-source Breakdown Voltage                   | $I_D = 1 \text{ mA}$ , $V_{GS} = 0$                                                      | 500  |      |          | 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                | $V_{GS} = 10\text{V}$ , $I_D = 3.6 \text{ A}$                                            |      | 0.72 | 0.85     | $\Omega$                       |

**DYNAMIC**

| Symbol                              | Parameter                                                               | Test Conditions                                             | Min. | Typ.             | Max. | Unit           |
|-------------------------------------|-------------------------------------------------------------------------|-------------------------------------------------------------|------|------------------|------|----------------|
| $g_{fs} (1)$                        | Forward Transconductance                                                | $V_{DS} = 15 \text{ V}$ , $I_D = 3.6 \text{ A}$             |      | 5.3              |      | S              |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input Capacitance<br>Output Capacitance<br>Reverse Transfer Capacitance | $V_{DS} = 25\text{V}$ , $f = 1 \text{ MHz}$ , $V_{GS} = 0$  |      | 910<br>125<br>30 |      | pF<br>pF<br>pF |
| $C_{oss \text{ eq.}} (3)$           | Equivalent Output Capacitance                                           | $V_{GS} = 0\text{V}$ , $V_{DS} = 0\text{V to } 400\text{V}$ |      | 75               |      | pF             |

**SWITCHING ON**

| Symbol                        | Parameter                                                    | Test Conditions                                                                                                                   | Min. | Typ.          | Max. | Unit           |
|-------------------------------|--------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|------|---------------|------|----------------|
| $t_{d(on)}$<br>$t_r$          | Turn-on Delay Time<br>Rise Time                              | $V_{DD} = 250 \text{ V}$ , $I_D = 3.6 \text{ A}$<br>$R_G = 4.7\Omega$ , $V_{GS} = 10 \text{ V}$<br>(Resistive Load see, Figure 3) |      | 17<br>20      |      | ns<br>ns       |
| $Q_g$<br>$Q_{gs}$<br>$Q_{gd}$ | Total Gate Charge<br>Gate-Source Charge<br>Gate-Drain Charge | $V_{DD} = 400\text{V}$ , $I_D = 7.2 \text{ A}$ ,<br>$V_{GS} = 10\text{V}$                                                         |      | 32<br>6<br>18 |      | 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                      | $V_{DD} = 250 \text{ V}$ , $I_D = 3.6 \text{ A}$<br>$R_G = 4.7\Omega$ , $V_{GS} = 10 \text{ V}$<br>(Resistive Load see, Figure 3) |      | 45<br>22       |      | ns<br>ns       |
| $t_{r(Voff)}$<br>$t_f$<br>$t_c$ | Off-voltage Rise Time<br>Fall Time<br>Cross-over Time | $V_{DD} = 400\text{V}$ , $I_D = 7.2 \text{ A}$ ,<br>$R_G = 4.7\Omega$ , $V_{GS} = 10\text{V}$<br>(Inductive Load see, Figure 5)   |      | 15<br>13<br>30 |      | ns<br>ns<br>ns |

**SOURCE DRAIN DIODE**

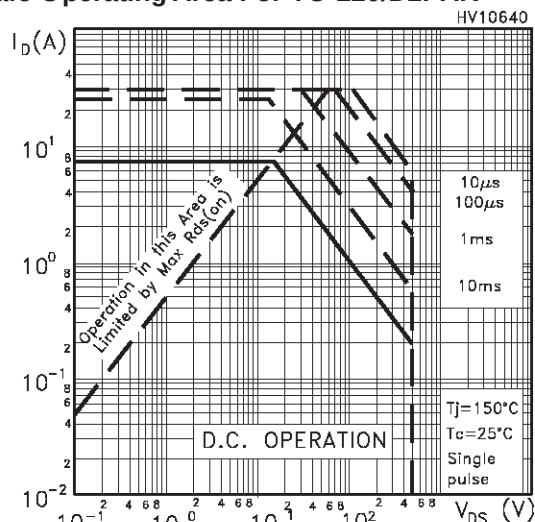
| Symbol                            | Parameter                                                                    | Test Conditions                                                                                                                                     | Min. | Typ.               | Max.        | Unit                     |
|-----------------------------------|------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|------|--------------------|-------------|--------------------------|
| $I_{SD}$<br>$I_{SDM} (2)$         | Source-drain Current<br>Source-drain Current (pulsed)                        |                                                                                                                                                     |      |                    | 7.2<br>28.8 | A<br>A                   |
| $V_{SD} (1)$                      | Forward On Voltage                                                           | $I_{SD} = 7.2 \text{ A}$ , $V_{GS} = 0$                                                                                                             |      |                    | 1.6         | V                        |
| $t_{rr}$<br>$Q_{rr}$<br>$I_{RRM}$ | Reverse Recovery Time<br>Reverse Recovery Charge<br>Reverse Recovery Current | $I_{SD} = 7.2 \text{ A}$ , $di/dt = 100\text{A}/\mu\text{s}$<br>$V_{DD} = 40 \text{ V}$ , $T_j = 150^\circ\text{C}$<br>(see test circuit, Figure 5) |      | 238<br>1.5<br>12.6 |             | ns<br>$\mu\text{C}$<br>A |

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

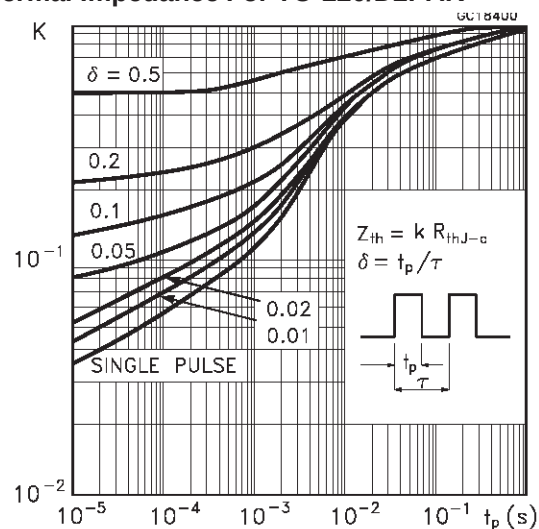
2. Pulse width limited by safe operating area.

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%  $V_{DSS}$ .

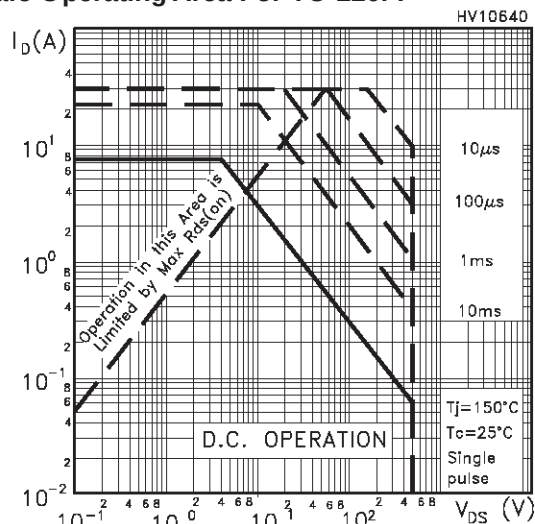
Safe Operating Area For TO-220/D2PAK



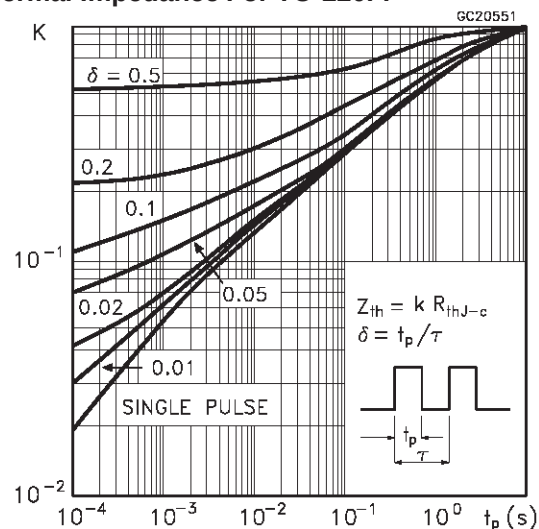
Thermal Impedance For TO-220/D2PAK



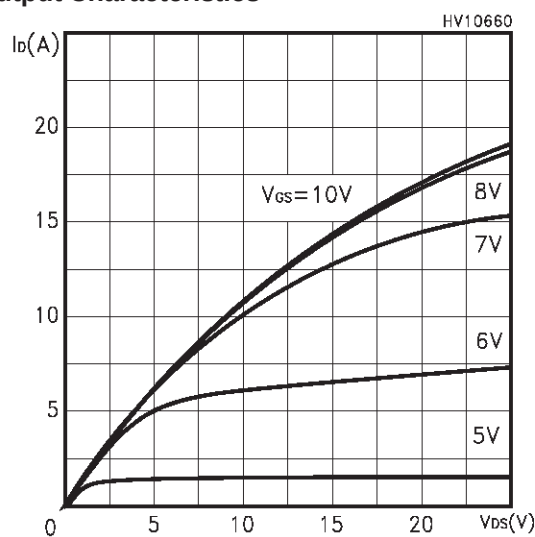
Safe Operating Area For TO-220FP



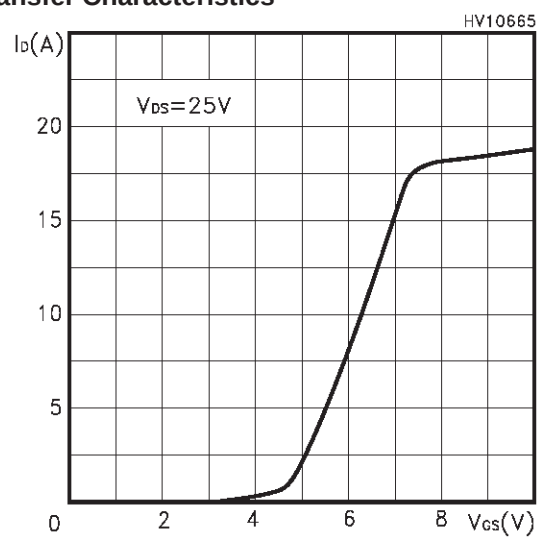
Thermal Impedance For TO-220FP



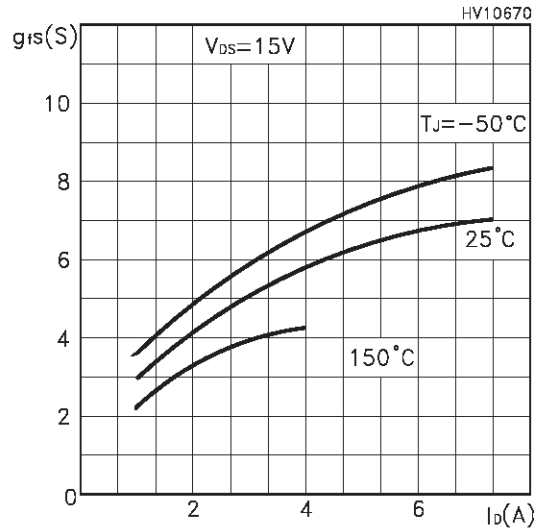
Output Characteristics



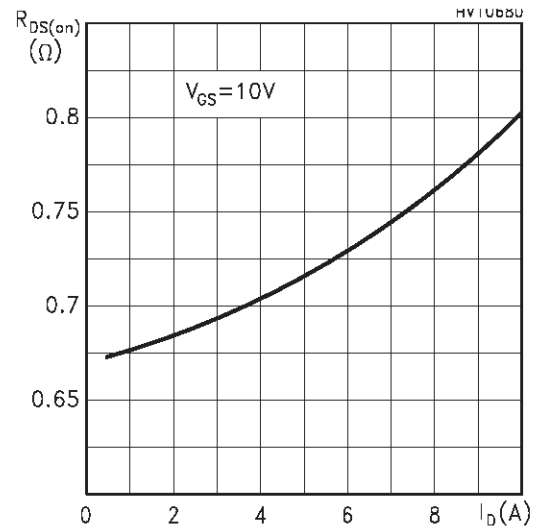
Transfer Characteristics



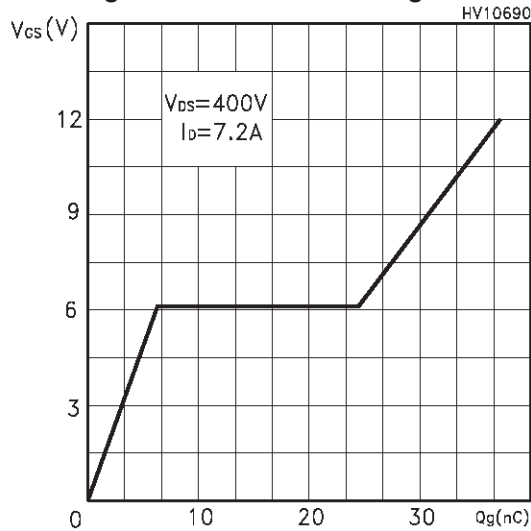
Transconductance



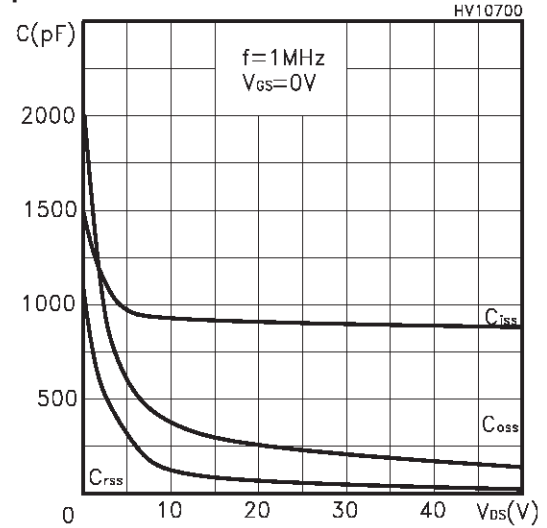
Static Drain-source On Resistance



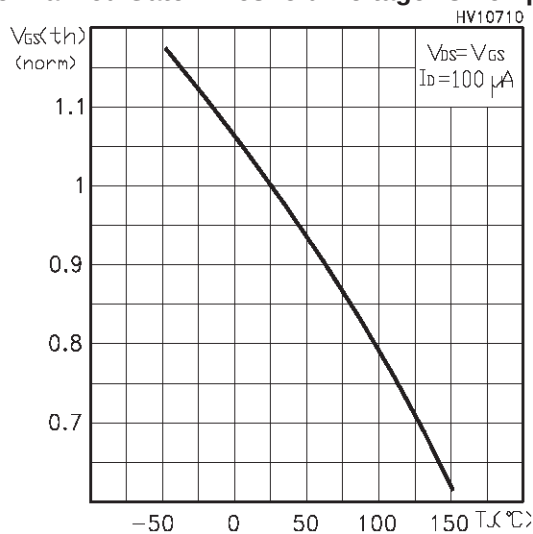
Gate Charge vs Gate-source Voltage



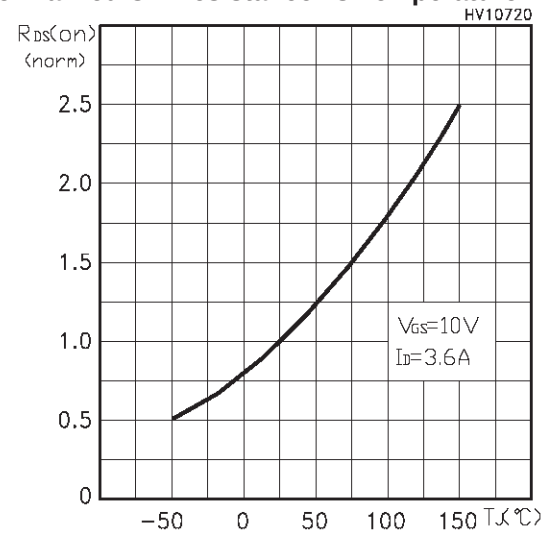
Capacitance Variations



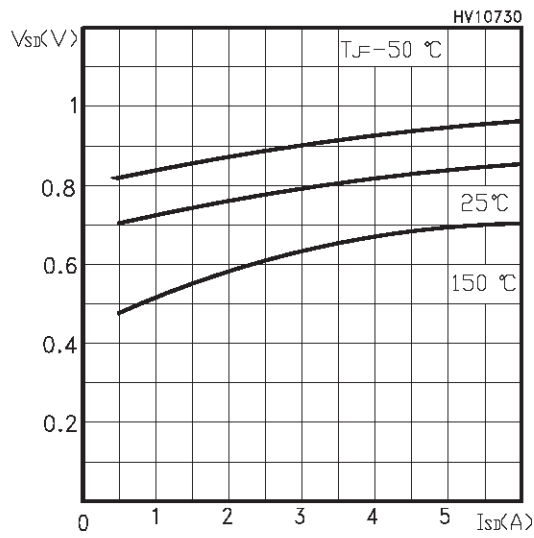
Normalized Gate Threshold Voltage vs Temp.



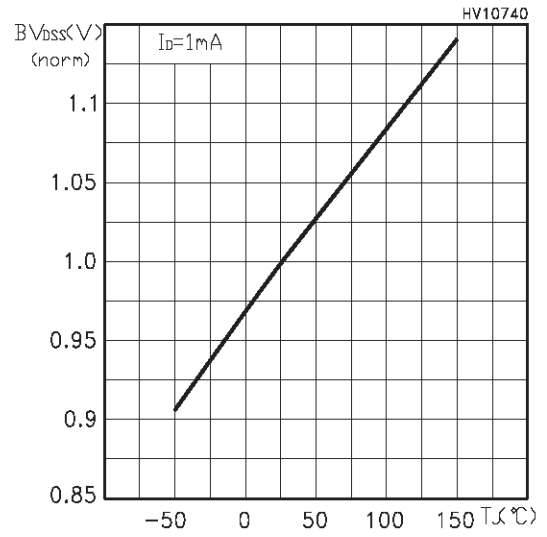
Normalized On Resistance vs Temperature



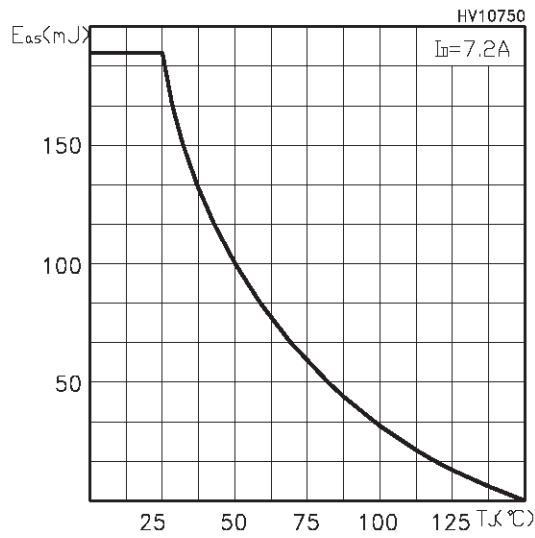
Source-drain Diode Forward Characteristics



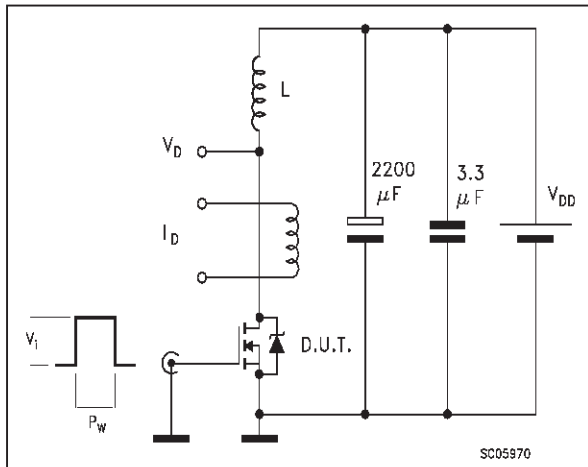
Normalized BVDSS vs Temperature



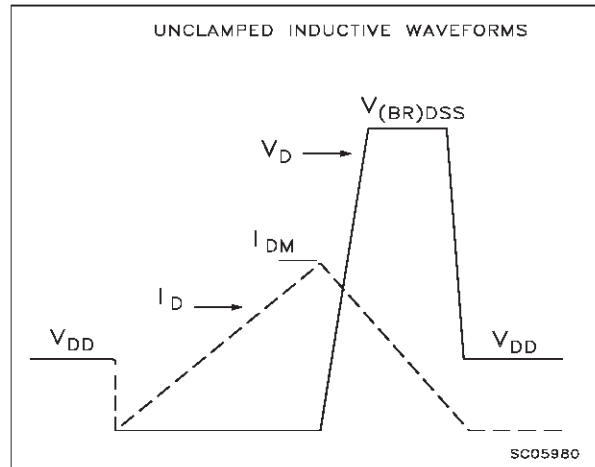
Maximum Avalanche Energy vs Temperature



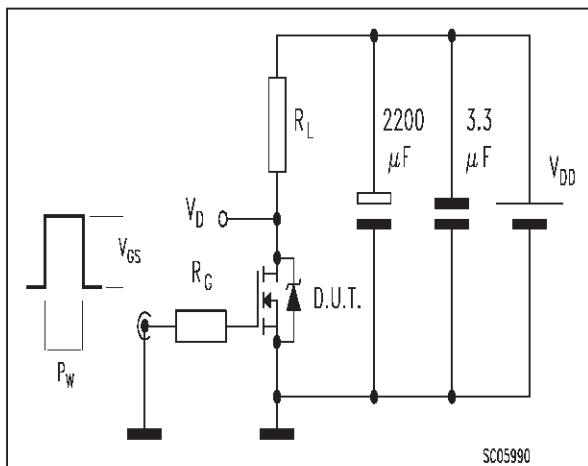
**Fig. 1: Unclamped Inductive Load Test Circuit**



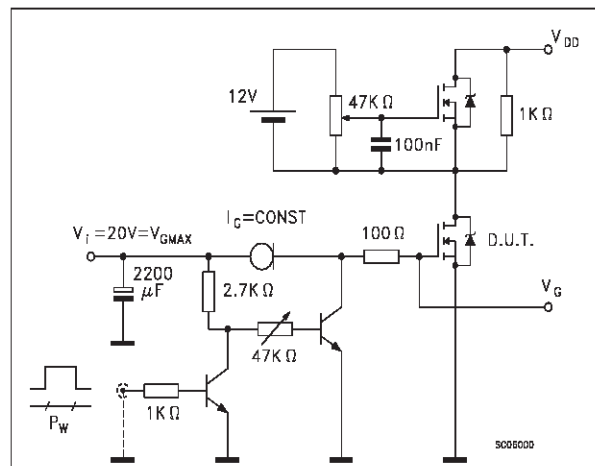
**Fig. 2: Unclamped Inductive Waveform**



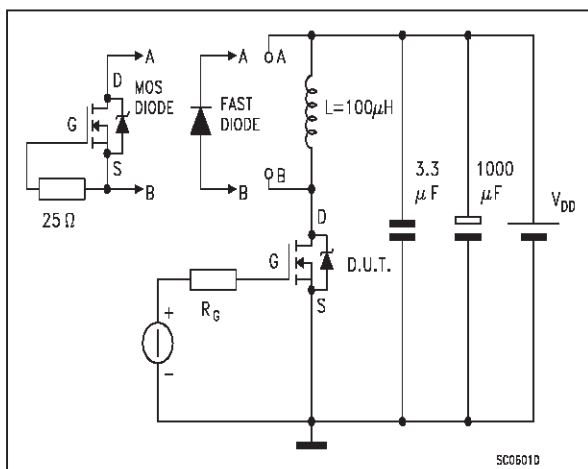
**Fig. 3: Switching Times Test Circuit For Resistive Load**



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

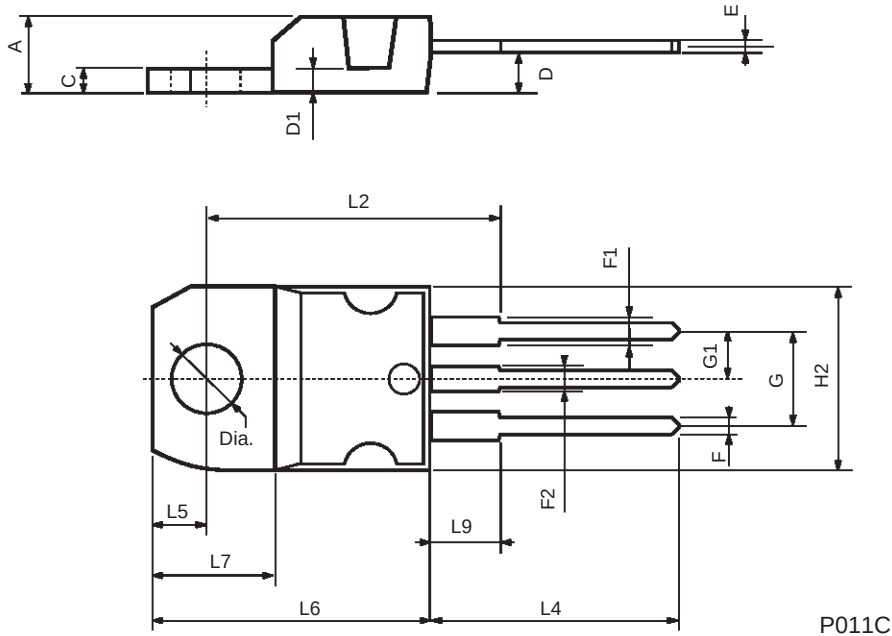


**Fig. 5: Test Circuit For Inductive Load Switching And Diode Recovery Times**



TO-220 MECHANICAL DATA

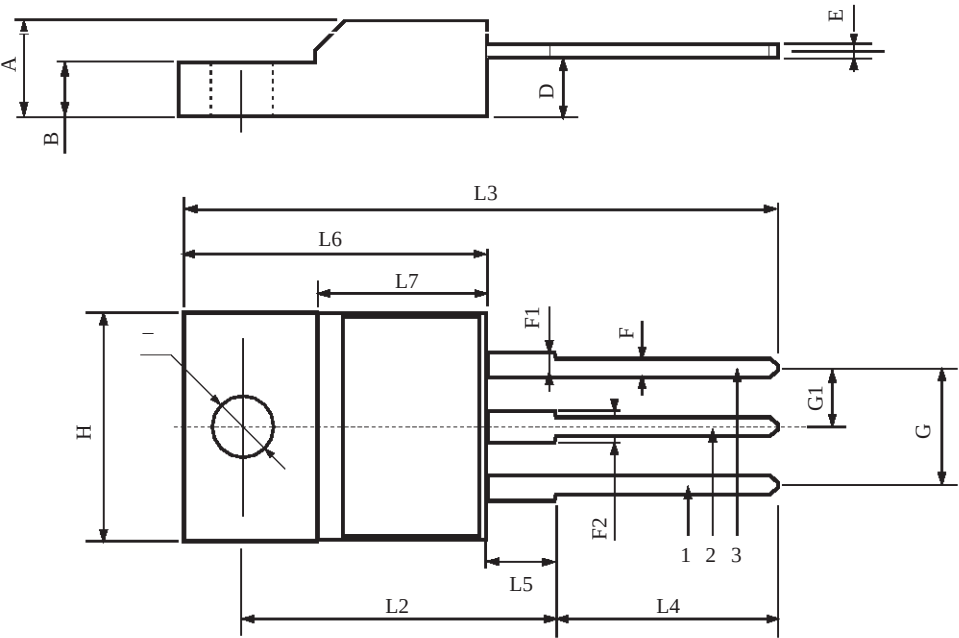
| DIM. | mm    |      |       | inch  |       |       |
|------|-------|------|-------|-------|-------|-------|
|      | MIN.  | TYP. | MAX.  | MIN.  | TYP.  | MAX.  |
| A    | 4.40  |      | 4.60  | 0.173 |       | 0.181 |
| C    | 1.23  |      | 1.32  | 0.048 |       | 0.051 |
| D    | 2.40  |      | 2.72  | 0.094 |       | 0.107 |
| D1   |       | 1.27 |       |       | 0.050 |       |
| E    | 0.49  |      | 0.70  | 0.019 |       | 0.027 |
| F    | 0.61  |      | 0.88  | 0.024 |       | 0.034 |
| F1   | 1.14  |      | 1.70  | 0.044 |       | 0.067 |
| F2   | 1.14  |      | 1.70  | 0.044 |       | 0.067 |
| G    | 4.95  |      | 5.15  | 0.194 |       | 0.203 |
| G1   | 2.4   |      | 2.7   | 0.094 |       | 0.106 |
| H2   | 10.0  |      | 10.40 | 0.393 |       | 0.409 |
| L2   |       | 16.4 |       |       | 0.645 |       |
| L4   | 13.0  |      | 14.0  | 0.511 |       | 0.551 |
| L5   | 2.65  |      | 2.95  | 0.104 |       | 0.116 |
| L6   | 15.25 |      | 15.75 | 0.600 |       | 0.620 |
| L7   | 6.2   |      | 6.6   | 0.244 |       | 0.260 |
| L9   | 3.5   |      | 3.93  | 0.137 |       | 0.154 |
| DIA. | 3.75  |      | 3.85  | 0.147 |       | 0.151 |





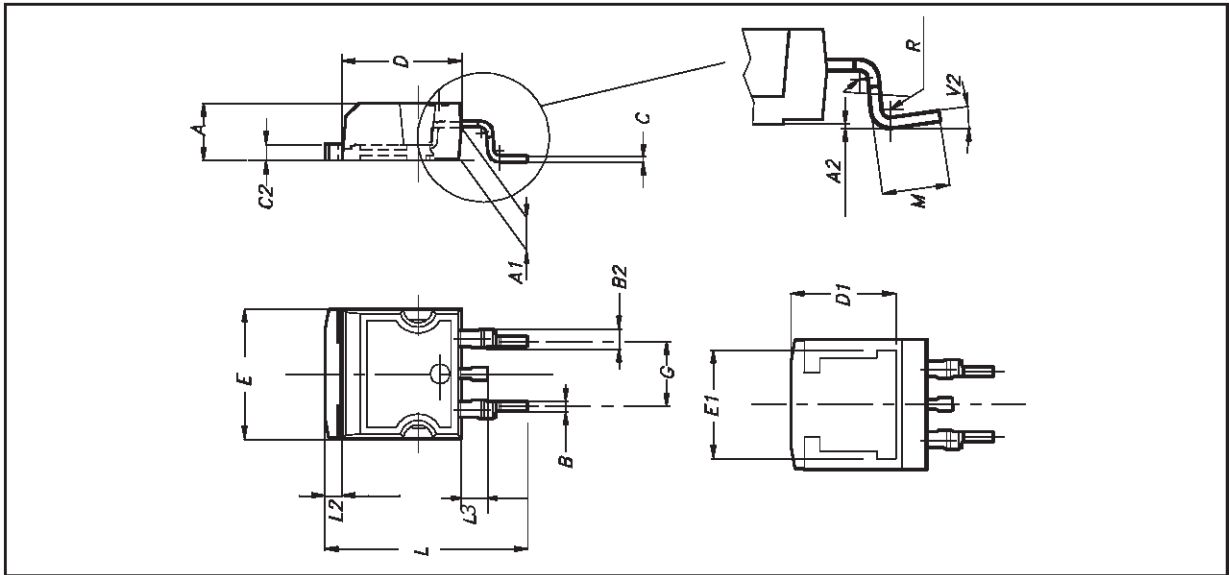
TO-220FP MECHANICAL DATA

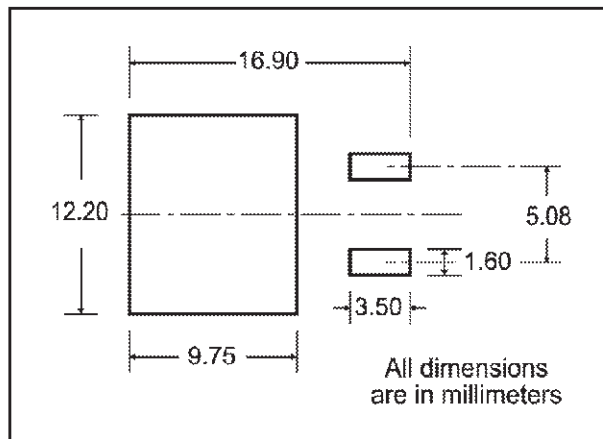
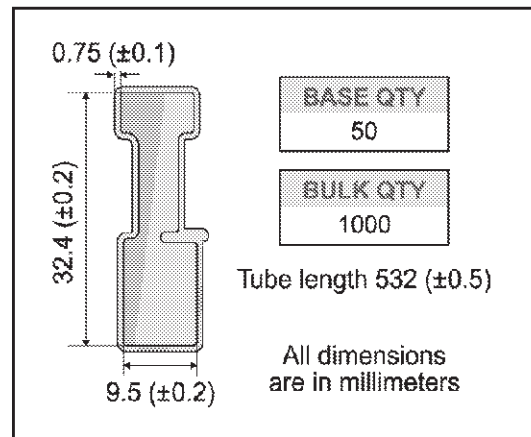
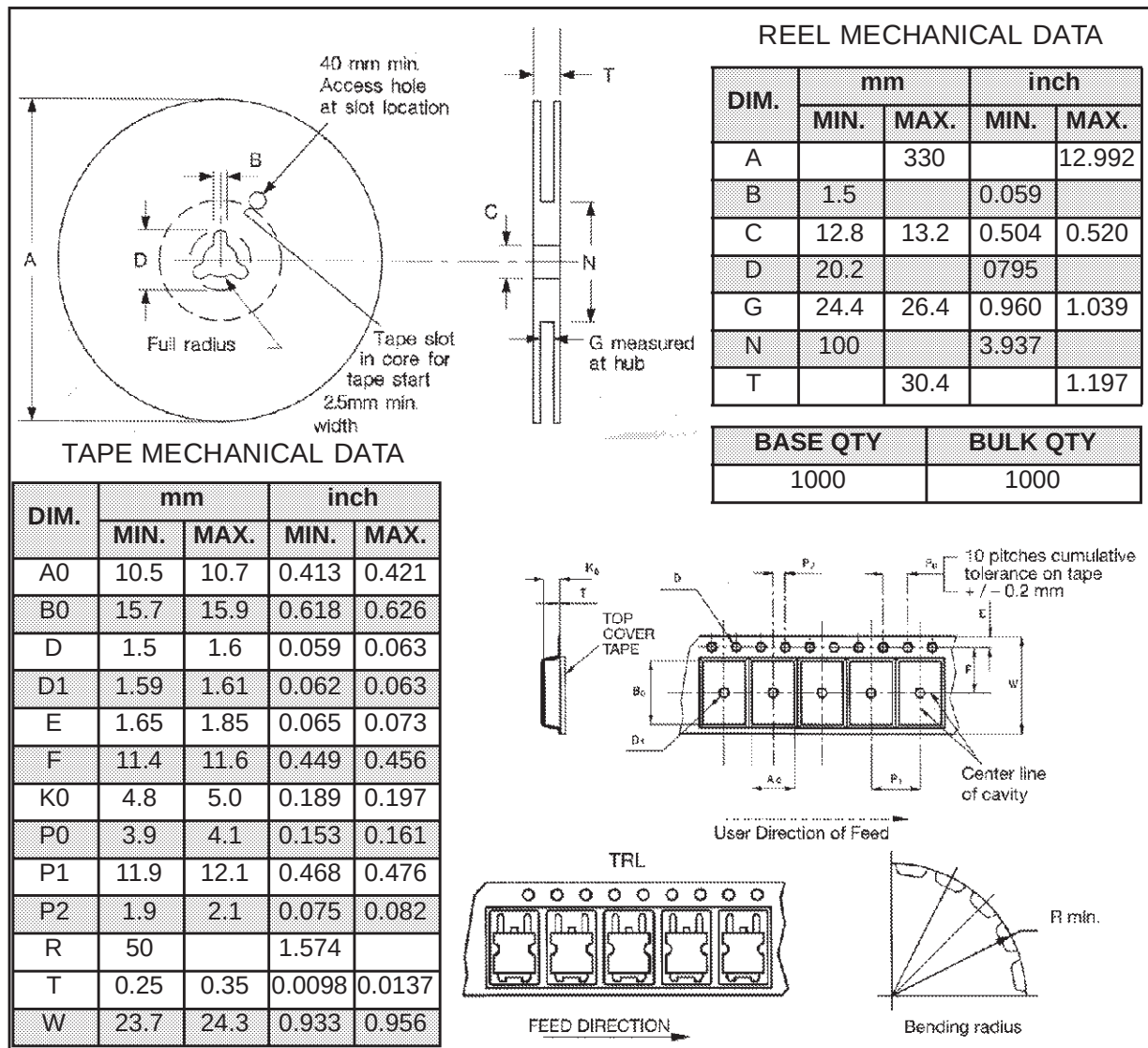
| DIM. | mm.  |     |      | inch  |       |       |
|------|------|-----|------|-------|-------|-------|
|      | MIN. | TYP | MAX. | MIN.  | TYP.  | MAX.  |
| A    | 4.4  |     | 4.6  | 0.173 |       | 0.181 |
| B    | 2.5  |     | 2.7  | 0.098 |       | 0.106 |
| D    | 2.5  |     | 2.75 | 0.098 |       | 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")\***

\* on sales type

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