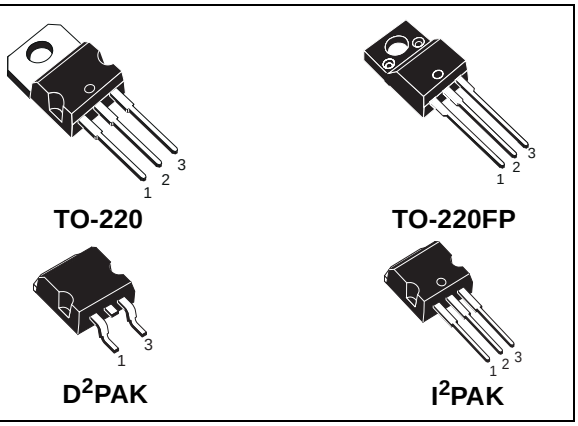
# STP11NM60 - STP11NM60FP
# STB11NM60 - STB11NM60-1

## N-CHANNEL 600V - 0.4Ω-11A TO-220/TO-220FP/D²PAK/I²PAK
## MDmesh™ Power MOSFET

| TYPE | $V_{DSS}$ | $R_{DS(on)}$ | $I_D$ |
|---|---|---|---|
| STP11NM60 | 600 V | < 0.45 Ω | 11 A |
| STP11NM60FP | 600 V | < 0.45 Ω | 11 A |
| STB11NM60 | 600 V | < 0.45 Ω | 11 A |
| STB11NM60-1 | 600 V | < 0.45 Ω | 11 A |

- TYPICAL $R_{DS}(on)$ = 0.4Ω
- HIGH dv/dt AND AVALANCHE CAPABILITIES
- 100% AVALANCHE TESTED
- LOW INPUT CAPACITANCE AND GATE CHARGE
- LOW GATE INPUT RESISTANCE



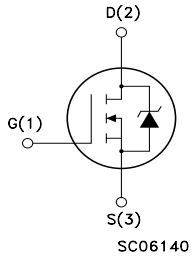

### DESCRIPTION

The MDmesh™ is a new revolutionary MOSFET technology that associates the Multiple Drain process with the Company's PowerMESH™ horizontal layout. The resulting product has an outstanding low on-resistance, impressively high dv/dt and excellent avalanche characteristics. The adoption of the Company's proprietary strip technique yields overall dynamic performance that is significantly better than that of similar competition's products.

### APPLICATIONS

The MDmesh™ family is very suitable for increasing power density of high voltage converters allowing system miniaturization and higher efficiencies.

### INTERNAL SCHEMATIC DIAGRAM




### ABSOLUTE MAXIMUM RATINGS

| Symbol | Parameter | Value | | Unit |
|---|---|---|---|---|
| | | STP(B)11NM60(-1) | STP11NM60FP | |
| $V_{DS}$ | Drain-source Voltage ($V_{GS}$ = 0) | 600 | | V |
| $V_{DGR}$ | Drain-gate Voltage ($R_{GS}$ = 20 kΩ) | 600 | | V |
| $V_{GS}$ | Gate- source Voltage | ±30 | | V |
| $I_D$ | Drain Current (continuous) at $T_C$ = 25°C | 11 | 11 (*) | A |
| $I_D$ | Drain Current (continuous) at $T_C$ = 100°C | 7 | 7 (*) | A |
| $I_{DM}$ (•) | Drain Current (pulsed) | 44 | 44 (*) | A |
| $P_{TOT}$ | Total Dissipation at $T_C$ = 25°C | 160 | 35 | W |
| | Derating Factor | 1.28 | 0.28 | W/°C |
| dv/dt(1) | Peak Diode Recovery voltage slope | 15 | | V/ns |
| $V_{ISO}$ | Insulation Winthstand Voltage (DC) | -- | 2500 | V |
| $T_{stg}$ | Storage Temperature | –65 to 150 | | °C |
| $T_j$ | Max. Operating Junction Temperature | 150 | | °C |

(•)Pulse width limited by safe operating area

(*)Limited only by maximum temperature allowed

(1)$I_{SD}$<11A, di/dt<400A/µs, $V_{DD}$<$V_{(BR)DSS}$, $T_J$<$T_{JMAX}$

## THERMAL DATA

| | | | TO-220/D²PAK/I²PAK | TO-220FP | |
|---|---|---|---|---|---|
| Rthj-case | Thermal Resistance Junction-case | Max | 0.78 | 3.57 | °C/W |
| Rthj-amb | Thermal Resistance Junction-ambient | Max | 62.5 | | °C/W |
| $T_l$ | Maximum Lead Temperature For Soldering Purpose | | 300 | | °C |

## AVALANCHE CHARACTERISTICS

| Symbol | Parameter | Max Value | Unit |
|---|---|---|---|
| $I_{AR}$ | Avalanche Current, Repetitive or Not-Repetitive (pulse width limited by $T_j$ max) | 5.5 | A |
| $E_{AS}$ | Single Pulse Avalanche Energy (starting $T_j$ = 25 °C, $I_D = I_{AR}$, $V_{DD}$ = 50 V) | 350 | mJ |

## ELECTRICAL CHARACTERISTICS ($T_{CASE}$ = 25 °C UNLESS OTHERWISE SPECIFIED)

OFF

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{(BR)DSS}$ | Drain-source Breakdown Voltage | $I_D$ = 250 µA, $V_{GS}$ = 0 | 600 | | | V |
| $I_{DSS}$ | Zero Gate Voltage Drain Current ($V_{GS}$ = 0) | $V_{DS}$ = Max Rating | | | 1 | µA |
| | | $V_{DS}$ = Max Rating, $T_C$ = 125 °C | | | 10 | µA |
| $I_{GSS}$ | Gate-body Leakage Current ($V_{DS}$ = 0) | $V_{GS}$ = ±30V | | | ±100 | nA |

ON (1)

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{GS(th)}$ | Gate Threshold Voltage | $V_{DS} = V_{GS}$, $I_D$ = 250µA | 3 | 4 | 5 | V |
| $R_{DS(on)}$ | Static Drain-source On Resistance | $V_{GS}$ = 10V, $I_D$ = 5.5A | | 0.4 | 0.45 | Ω |

DYNAMIC

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $g_{fs}$ (1) | Forward Transconductance | $V_{DS} > I_{D(on)} \times R_{DS(on)max}$, $I_D$ = 5.5A | | 5.2 | | S |
| $C_{iss}$ | Input Capacitance | $V_{DS}$ = 25V, f = 1 MHz, $V_{GS}$ = 0 | | 1000 | | pF |
| $C_{oss}$ | Output Capacitance | | | 230 | | pF |
| $C_{rss}$ | Reverse Transfer Capacitance | | | 25 | | pF |
| $C_{oss\ eq.}$ (2) | Equivalent Output Capacitance | $V_{GS}$ = 0V, $V_{DS}$ = 0V to 480V | | 100 | | pF |
| $R_G$ | Gate Input Resistance | f=1 MHz Gate DC Bias = 0 Test Signal Level = 20mV Open Drain | | 1.6 | | Ω |

1. Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %.
2. $C_{oss\ eq.}$ is defined as a constant equivalent capacitance giving the same charging time as $C_{oss}$ when $V_{DS}$ increases from 0 to 80% $V_{DSS}$.

**ELECTRICAL CHARACTERISTICS** (CONTINUED)

SWITCHING ON

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $t_{d(on)}$ | Turn-on Delay Time | $V_{DD}$ = 300V, $I_D$ = 5.5A<br>$R_G$ = 4.7Ω $V_{GS}$ = 10V<br>(see test circuit, Figure 3) | | 20 | | ns |
| $t_r$ | Rise Time | | | 20 | | ns |
| $Q_g$ | Total Gate Charge | $V_{DD}$ = 400V, $I_D$ = 11A,<br>$V_{GS}$ = 10V | | 30 | | nC |
| $Q_{gs}$ | Gate-Source Charge | | | 10 | | nC |
| $Q_{gd}$ | Gate-Drain Charge | | | 15 | | nC |

SWITCHING OFF

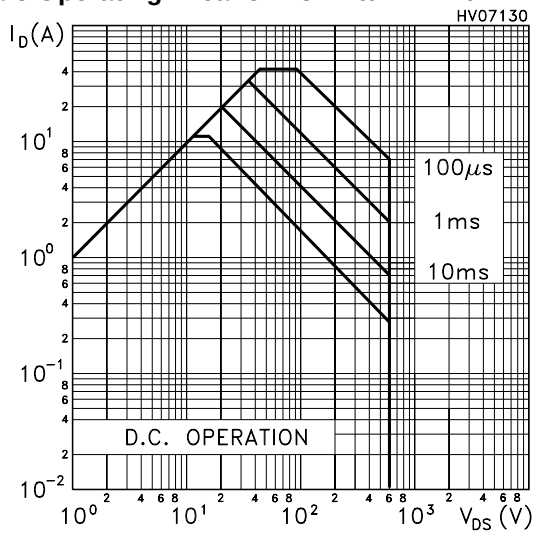
| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $t_{r(Voff)}$ | Off-voltage Rise Time | $V_{DD}$ = 400V, $I_D$ = 11A,<br>$R_G$ = 4.7Ω, $V_{GS}$ = 10V<br>(see test circuit, Figure 5) | | 6 | | ns |
| $t_f$ | Fall Time | | | 11 | | ns |
| $t_c$ | Cross-over Time | | | 19 | | ns |

SOURCE DRAIN DIODE

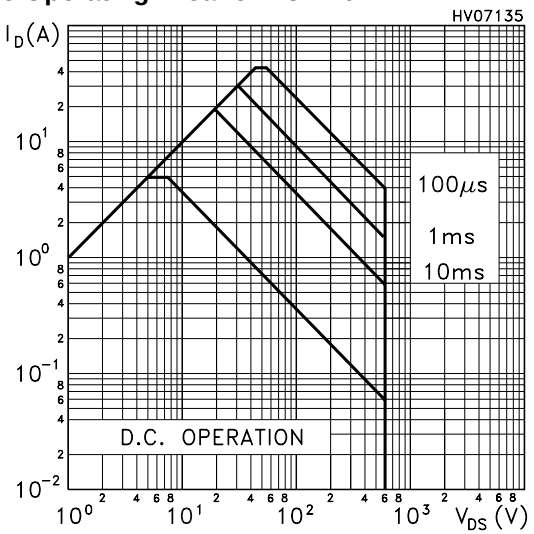
| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $I_{SD}$ | Source-drain Current | | | | 11 | A |
| $I_{SDM}$ (2) | Source-drain Current (pulsed) | | | | 44 | A |
| $V_{SD}$ (1) | Forward On Voltage | $I_{SD}$ = 11A, $V_{GS}$ = 0 | | | 1.5 | V |
| $t_{rr}$<br>$Q_{rr}$<br>$I_{rrm}$ | Reverse Recovery Time<br>Reverse Recovery Charge<br>Reverse Recovery Current | $I_{SD}$ = 11A, di/dt = 100A/µs,<br>$V_{DD}$ = 100 V, $T_j$ = 25°C<br>(see test circuit, Figure 5) | | 390<br>3.8<br>19.5 | | ns<br>µC<br>A |
| $t_{rr}$<br>$Q_{rr}$<br>$I_{rrm}$ | Reverse Recovery Time<br>Reverse Recovery Charge<br>Reverse Recovery Current | $I_{SD}$ = 11A, di/dt = 100A/µs,<br>$V_{DD}$ = 100 V, $T_j$ = 150°C<br>(see test circuit, Figure 5) | | 570<br>5.7<br>20 | | ns<br>µC<br>A |

Note: 1. Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %.
2. Pulse width limited by safe operating area.

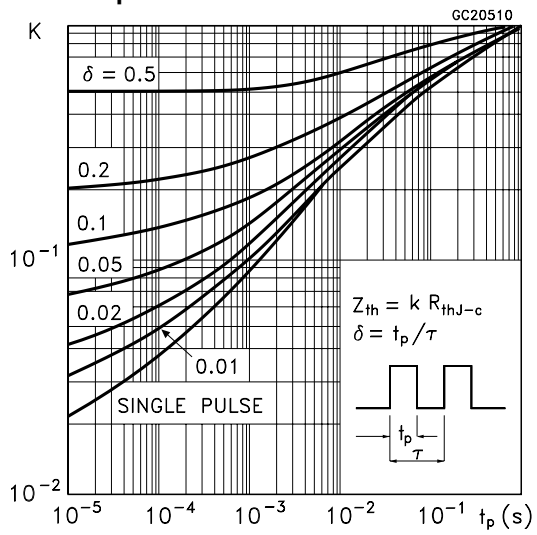
**Safe Operating Area for TO-220/D2PAK/I2PAK**



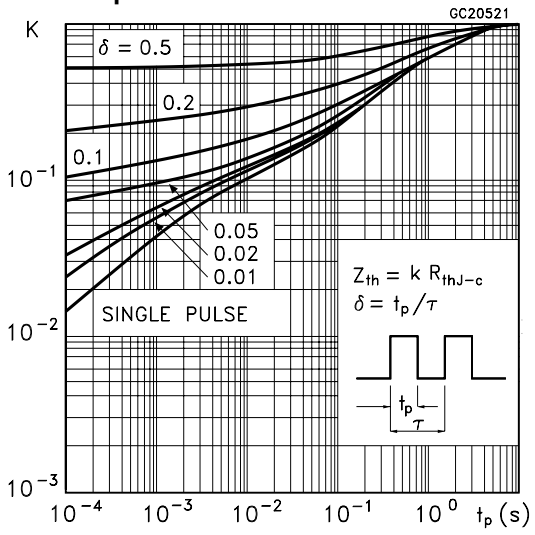

**Safe Operating Area for TO-220FP**



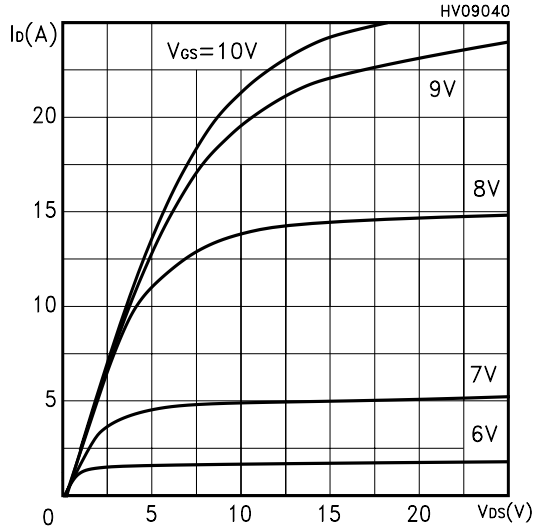
**Thermal Impedance for TO-220/D2PAK/I2PAK**



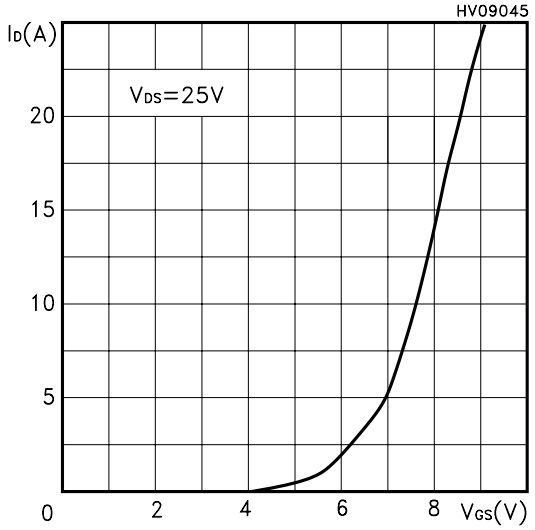

**Thermal Impedance for TO-220FP**



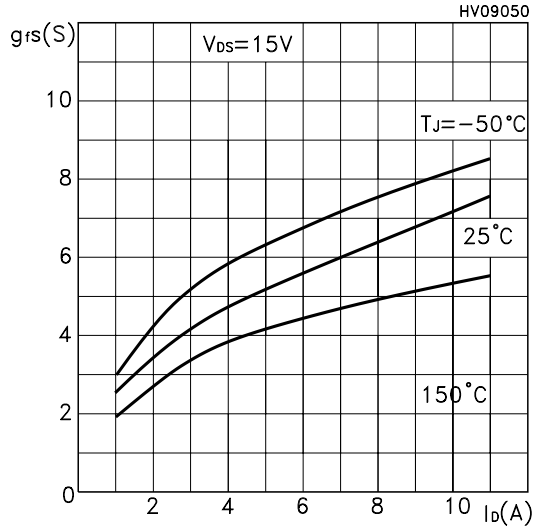

**Output Characteristics**



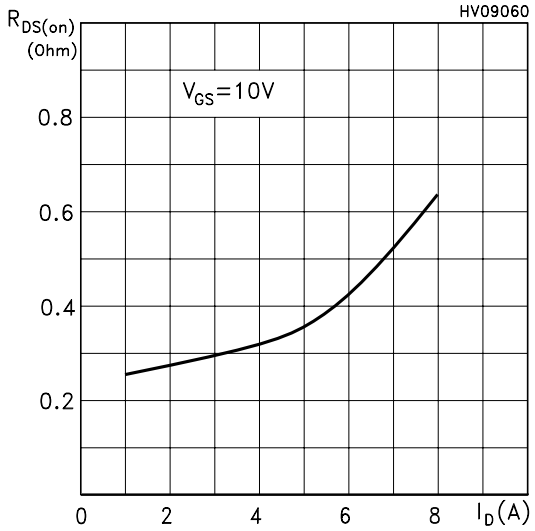

**Transfer Characteristics**



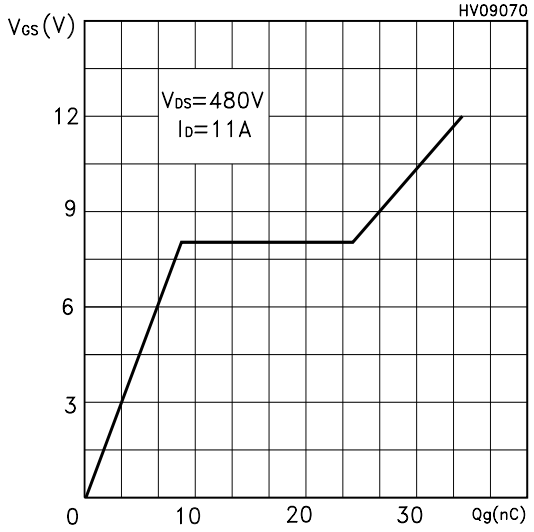

**Transconductance**



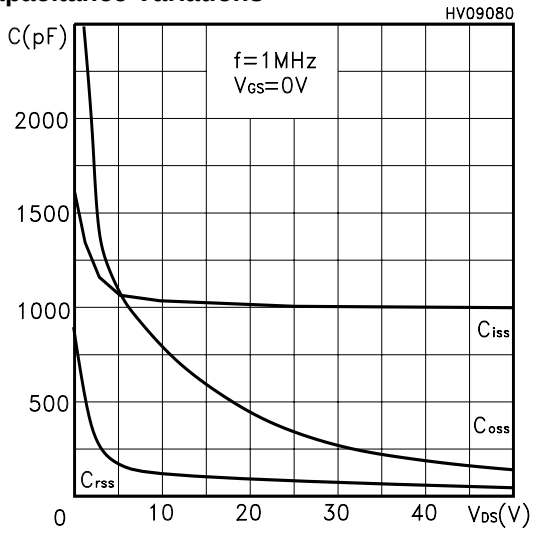

**Static Drain-source On Resistance**



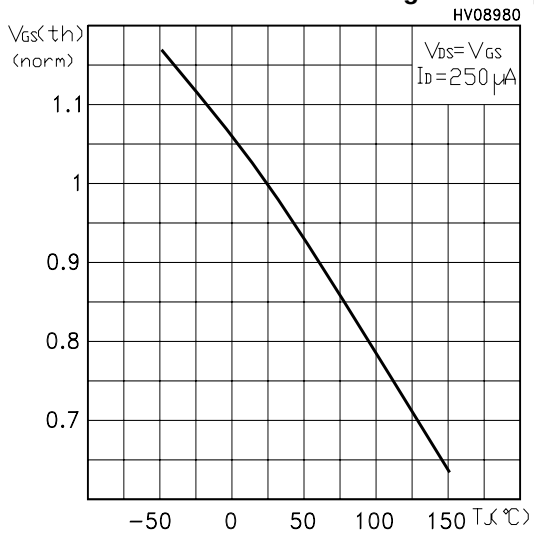
**Gate Charge vs Gate-source Voltage**



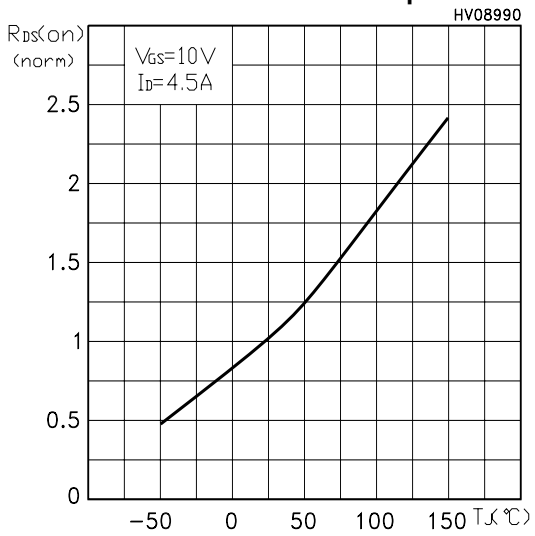

**Capacitance Variations**




**Normalized Gate Thereshold Voltage vs Temp.**




**Normalized On Resistance vs Temperature**




**Source-drain Diode Forward Characteristics**

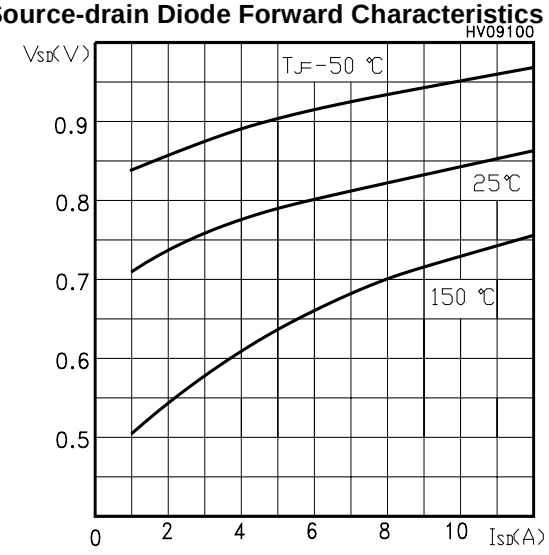


**Fig. 1:** Unclamped Inductive Load Test Circuit

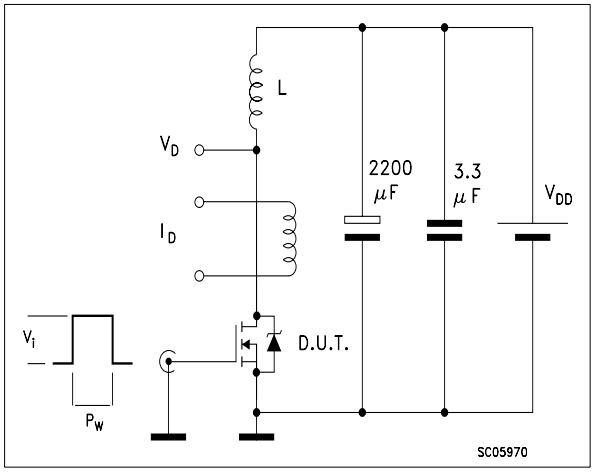



**Fig. 2:** Unclamped Inductive Waveform

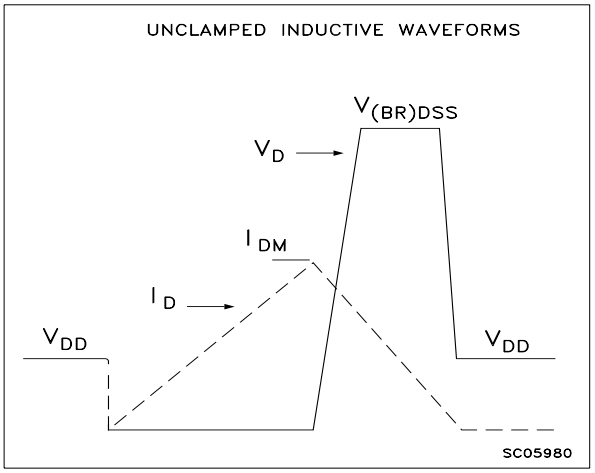



**Fig. 3:** Switching Times Test Circuit For Resistive Load

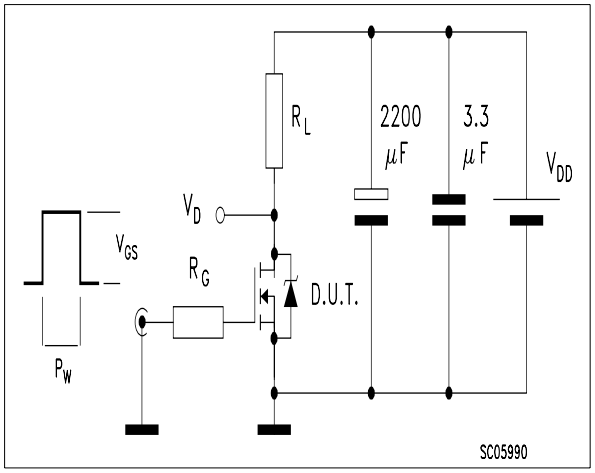



**Fig. 4:** Gate Charge test Circuit

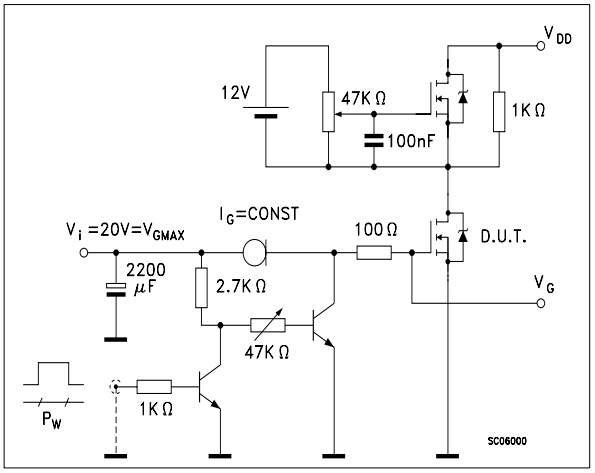
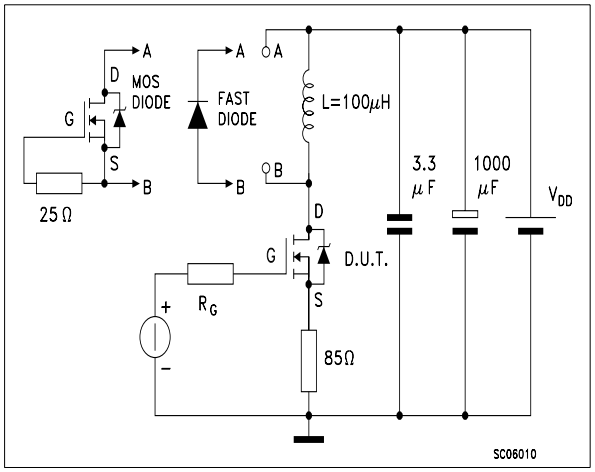
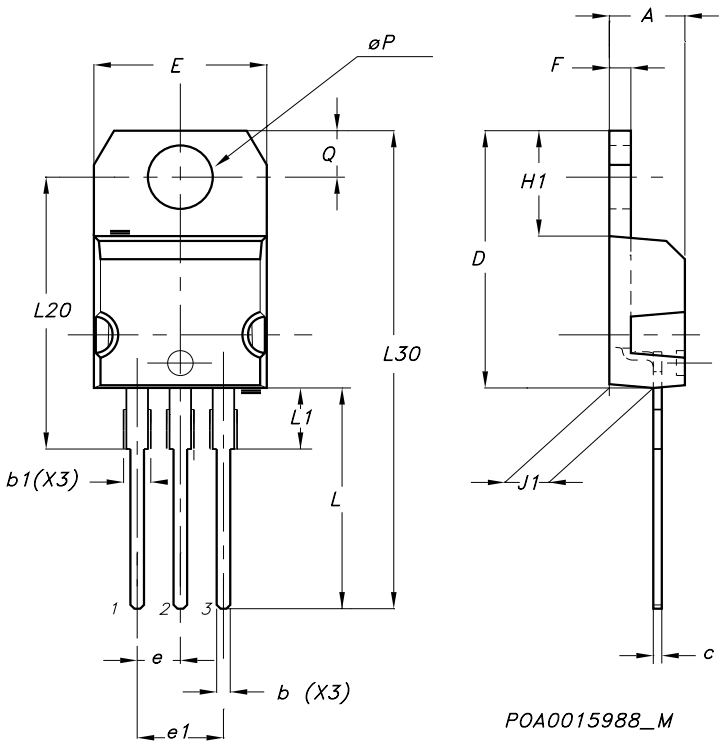



**Fig. 5:** Test Circuit For Inductive Load Switching And Diode Recovery Times



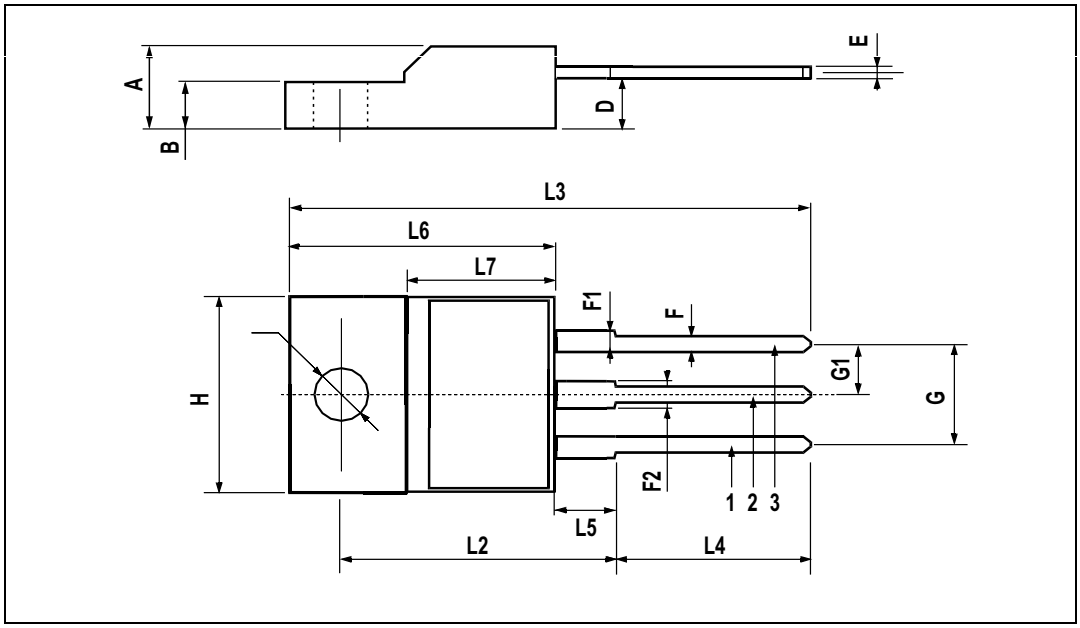
## TO-220 MECHANICAL DATA

| 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 |



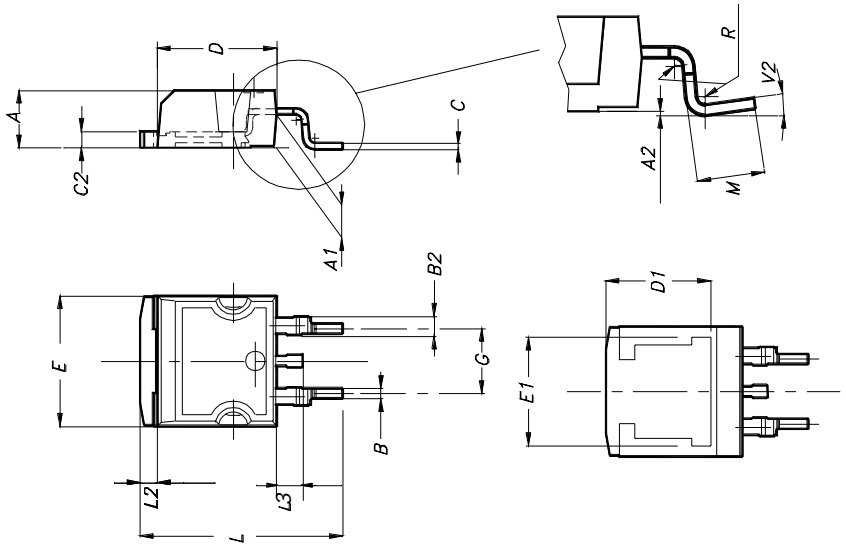
## TO-220FP MECHANICAL DATA

| 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 | | 1.7 | 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 |



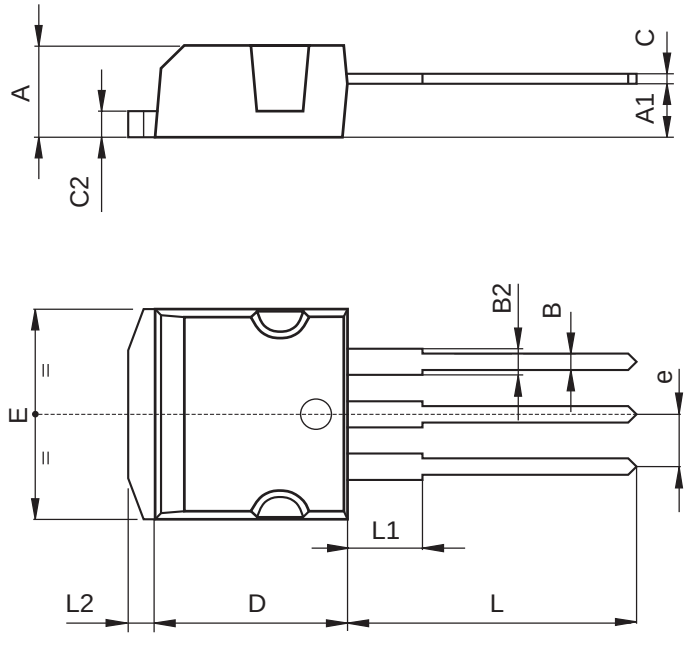
# D²PAK MECHANICAL DATA

| 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 | 0º | | 8º | | | |



## TO-262 ($I^2$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 |
| 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 |
| e | 2.4 | | 2.7 | 0.094 | | 0.106 |
| E | 10 | | 10.4 | 0.393 | | 0.409 |
| L | 13.1 | | 13.6 | 0.515 | | 0.531 |
| L1 | 3.48 | | 3.78 | 0.137 | | 0.149 |
| L2 | 1.27 | | 1.4 | 0.050 | | 0.055 |

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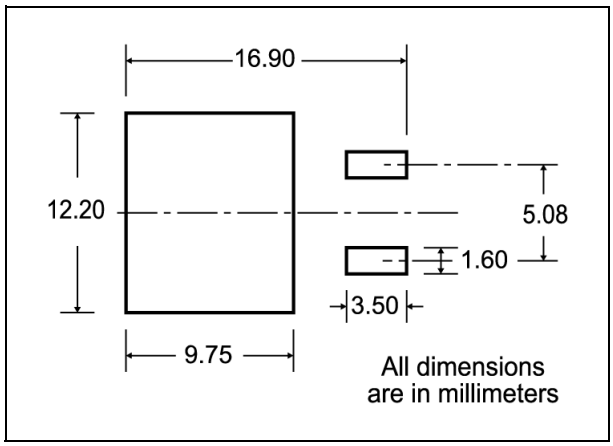
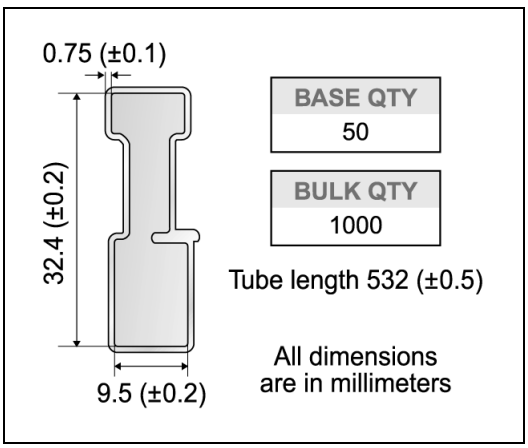
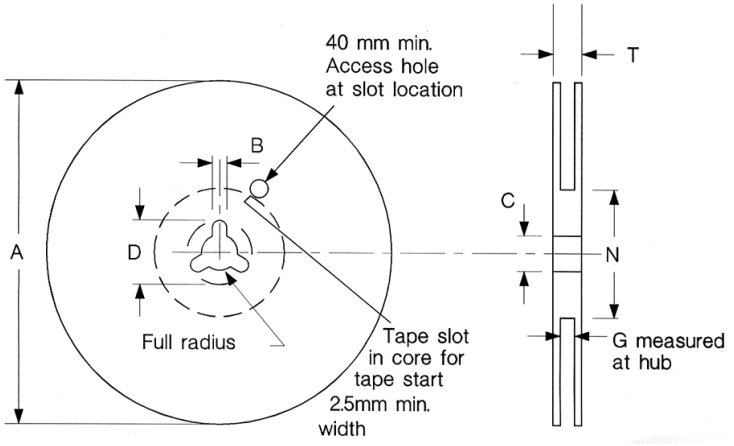
## $D^2PAK$ FOOTPRINT




## TUBE SHIPMENT (no suffix)*




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



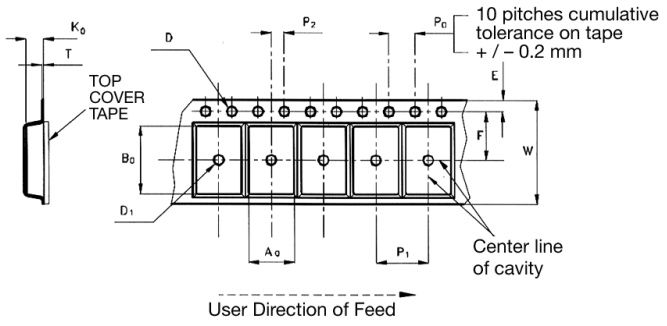

REEL MECHANICAL DATA

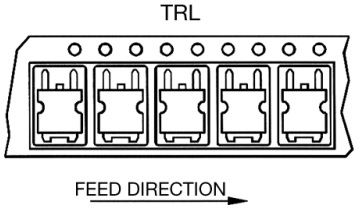
| DIM. | mm | | inch | |
|---|---|---|---|---|
| | MIN. | MAX. | MIN. | MAX. |
| A | | 330 | | 12.992 |
| B | 1.5 | | 0.059 | |
| C | 12.8 | 13.2 | 0.504 | 0.520 |
| D | 20.2 | | 0795 | |
| G | 24.4 | 26.4 | 0.960 | 1.039 |
| N | 100 | | 3.937 | |
| T | | 30.4 | | 1.197 |

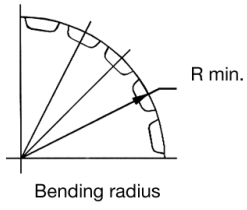
| BASE QTY | BULK QTY |
|---|---|
| 1000 | 1000 |

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 |




* on sales type