

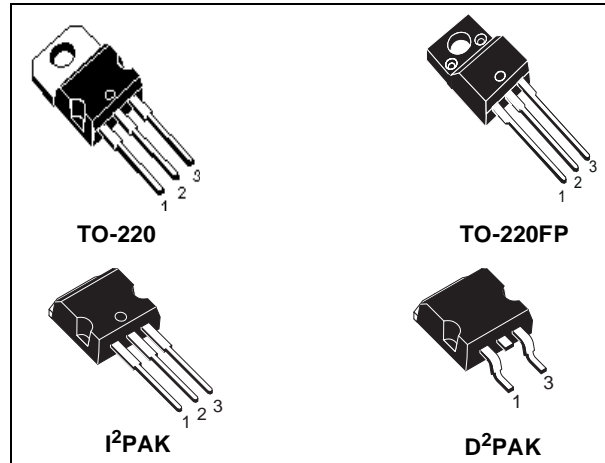


STP9NK60Z - STP9NK60ZFP STB9NK60Z - STB9NK60Z-1

N-CHANNEL 600V - 0.85Ω - 7A TO-220/FP/D²PAK/I²PAK
Zener-Protected SuperMESH™ Power MOSFET

| TYPE | V _{DSS} | R _{DS(on)} | I _D | P _w |
|-------------|------------------|---------------------|----------------|----------------|
| STP9NK60Z | 600 V | < 0.95 Ω | 7 A | 125 W |
| STP9NK60ZFP | 600 V | < 0.95 Ω | 7 A | 30 W |
| STB9NK60Z | 600 V | < 0.95 Ω | 7 A | 125 W |
| STB9NK60Z-1 | 600 V | < 0.95 Ω | 7 A | 125 W |

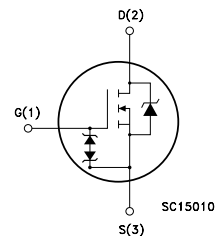
- TYPICAL R_{DS(on)} = 0.85 Ω
- EXTREMELY HIGH dv/dt CAPABILITY
- IMPROVED ESD CAPABILITY
- 100% AVALANCHE RATED
- GATE CHARGE MINIMIZED
- VERY LOW INTRINSIC CAPACITANCES
- VERY GOOD MANUFACTURING REPEATIBILITY



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.

INTERNAL SCHEMATIC DIAGRAM



APPLICATIONS

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

ORDERING INFORMATION

| SALES TYPE | MARKING | PACKAGE | PACKAGING |
|-------------|-----------|--------------------|-------------|
| STP9NK60Z | P9NK60Z | TO-220 | TUBE |
| STP9NK60ZFP | P9NK60ZFP | TO-220FP | TUBE |
| STB9NK60Z | B9NK60Z | D ² PAK | TUBE |
| STB9NK60ZT4 | B9NK60Z | D ² PAK | TAPE & REEL |
| STB9NK60Z-1 | B9NK60Z-1 | I ² PAK | TUBE |

STP9NK60Z / STP9NK60ZFP / STB9NK60Z / STB9NK60Z-1

ABSOLUTE MAXIMUM RATINGS

| Symbol | Parameter | Value | | Unit |
|------------------------------------|---|--|----------|----------|
| | | TO-220 / D ² PAK / I ² PAK | TO-220FP | |
| 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 | 7 | 7 (*) | A |
| I _D | Drain Current (continuous) at T _C = 100°C | 4.4 | 4.4 (*) | A |
| I _{DM} (•) | Drain Current (pulsed) | 28 | 28 (*) | A |
| P _{TOT} | Total Dissipation at T _C = 25°C | 125 | 30 | W |
| | Derating Factor | 1 | 0.24 | W/°C |
| V _{ESD(G-S)} | Gate source ESD(HBM-C=100pF, R=1.5KΩ) | 4000 | | V |
| dv/dt (1) | Peak Diode Recovery voltage slope | 4.5 | | V/ns |
| V _{ISO} | Insulation Withstand Voltage (DC) | - | 2500 | V |
| T _j T _{stg} | Operating Junction Temperature Storage Temperature | -55 to 150 -55 to 150 | | °C °C |

(•) Pulse width limited by safe operating area

(1) I_{SD} ≤ 7A, di/dt ≤ 200 μA, V_{DD} ≤ V_{(BR)DSS}, T_j ≤ T_{JMAX}.

(*) Limited only by maximum temperature allowed

THERMAL DATA

| | | TO-220 I ² PAK | D ² PAK | TO-220FP | |
|-----------------------|--|------------------------------|--------------------|----------|------|
| R _{thj-case} | Thermal Resistance Junction-case Max | 1 | | 4.16 | °C/W |
| R _{thj-pcb} | Thermal Resistance Junction-pcb Max (When mounted on minimum Footprint) | | 30 | | °C/W |
| R _{thj-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) | 7 | A |
| E _{AS} | Single Pulse Avalanche Energy (starting T _j = 25 °C, I _D = I _{AR} , V _{DD} = 50 V) | 235 | mJ |

GATE-SOURCE ZENER DIODE

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|-------------------|-------------------------------|--------------------------------------|------|------|------|------|
| BV _{GSO} | Gate-Source Breakdown Voltage | I _{gs} = ± 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.

STP9NK60Z / STP9NK60ZFP / STB9NK60Z / STB9NK60Z-1

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 | $I_D = 1 \text{ mA}, V_{GS} = 0$ | 600 | | | V |
| I_{DSS} | Zero Gate Voltage Drain Current ($V_{GS} = 0$) | $V_{DS} = \text{Max Rating}$ $V_{DS} = \text{Max Rating}, T_C = 125^\circ\text{C}$ | | | 1 50 | μA μA |
| I_{GSS} | Gate-body Leakage Current ($V_{DS} = 0$) | $V_{GS} = \pm 20\text{V}$ | | | ± 10 | μA |
| $V_{GS(th)}$ | 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 | Ω |

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} C_{oss} C_{rss} | Input Capacitance Output Capacitance Reverse Transfer Capacitance | $V_{DS} = 25\text{V}, f = 1 \text{ MHz}, V_{GS} = 0$ | | 1110 135 30 | | pF pF 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 |
|-------------------------------|--|---|------|---------------|------|----------------|
| $t_{d(on)}$ t_r | Turn-on Delay Time Rise Time | $V_{DD} = 300 \text{ V}, I_D = 3.5 \text{ A}$ $R_G = 4.7\Omega, V_{GS} = 10 \text{ V}$ (Resistive Load see, Figure 3) | | 19 17 | | ns ns |
| Q_g Q_{gs} Q_{gd} | Total Gate Charge Gate-Source Charge Gate-Drain Charge | $V_{DD} = 480 \text{ V}, I_D = 7 \text{ A},$ $V_{GS} = 10\text{V}$ | | 38 7 21 | 53 | nC nC nC |

SWITCHING OFF

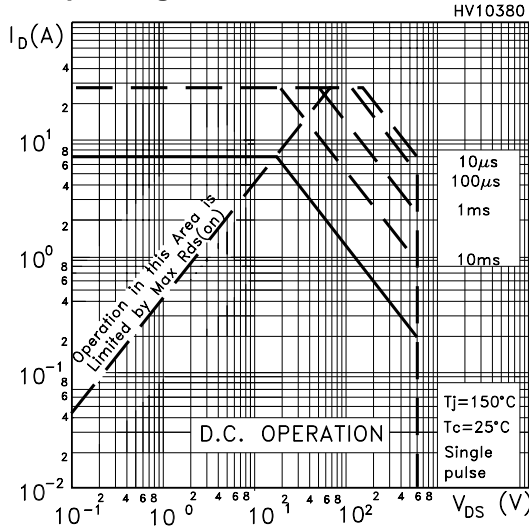
| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---------------------------------|---|---|------|---------------|------|----------------|
| $t_{d(off)}$ t_f | Turn-off Delay Time Fall Time | $V_{DD} = 300 \text{ V}, I_D = 3.5 \text{ A}$ $R_G = 4.7\Omega, V_{GS} = 10 \text{ V}$ (Resistive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

SOURCE DRAIN DIODE

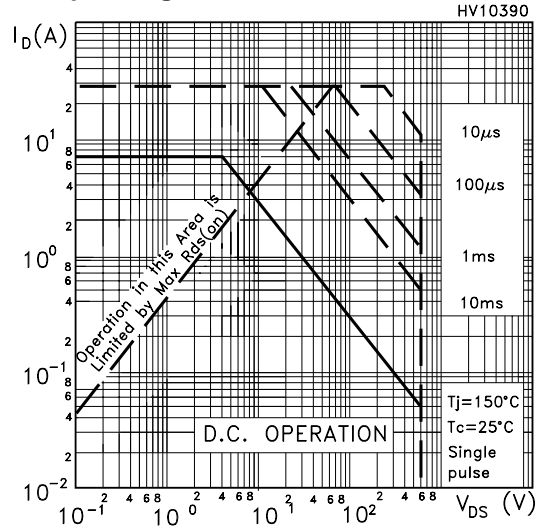
| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|-----------------------------------|--|---|------|--------------------|---------|--------------------------|
| I_{SD} $I_{SDM} (2)$ | Source-drain Current Source-drain Current (pulsed) | | | | 7 28 | A A |
| $V_{SD} (1)$ | Forward On Voltage | $I_{SD} = 7 \text{ A}, V_{GS} = 0$ | | | 1.6 | V |
| t_{rr} Q_{rr} I_{RRM} | Reverse Recovery Time Reverse Recovery Charge Reverse Recovery Current | $I_{SD} = 7 \text{ A}, di/dt = 100\text{A}/\mu\text{s}$ $V_{DD} = 30\text{V}, T_j = 150^\circ\text{C}$ (see test circuit, Figure 5) | | 480 3.5 14.5 | | ns μC A |

Note: 1. Pulsed: Pulse duration = 300 μs , 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} .

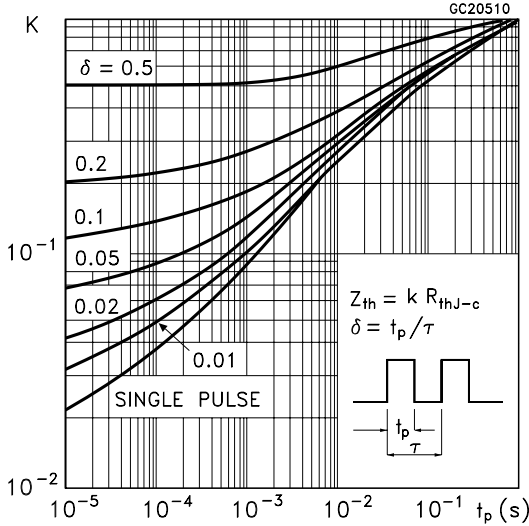
Safe Operating Area For TO-220/D2PAK/I2PAK



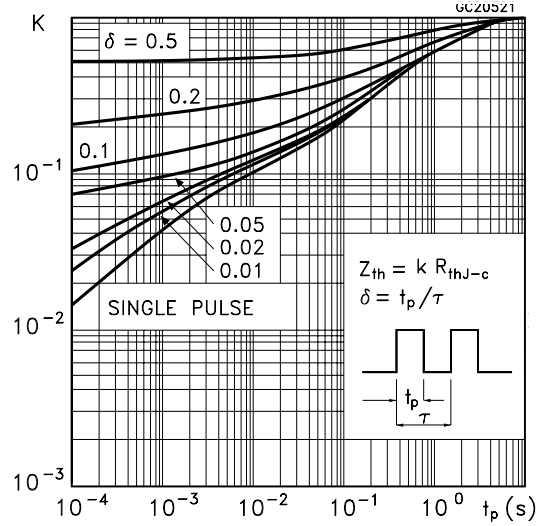
Safe Operating Area For TO-220FP



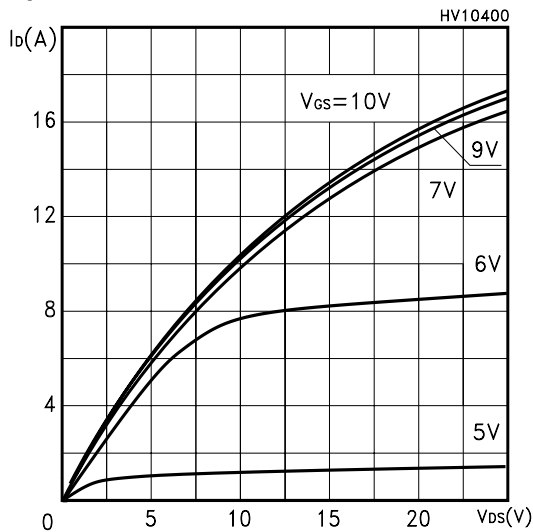
Thermal Impedance For TO-220/D2PAK/I2PAK



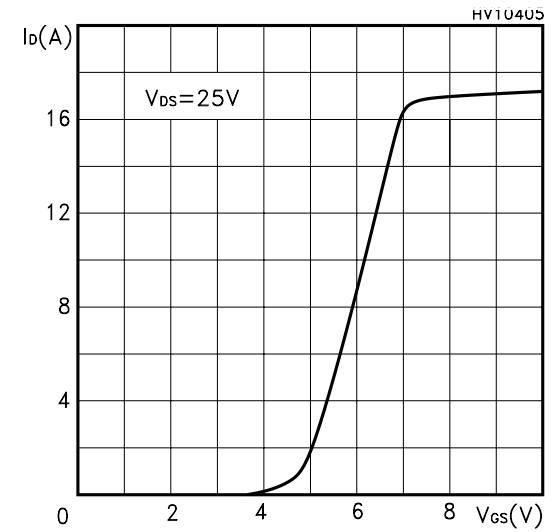
Thermal Impedance For TO-220FP



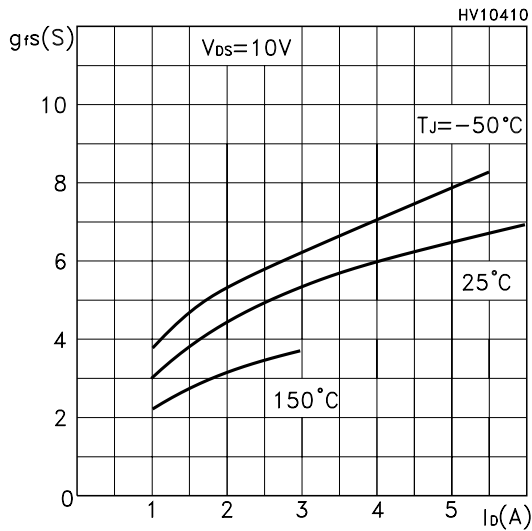
Output Characteristics



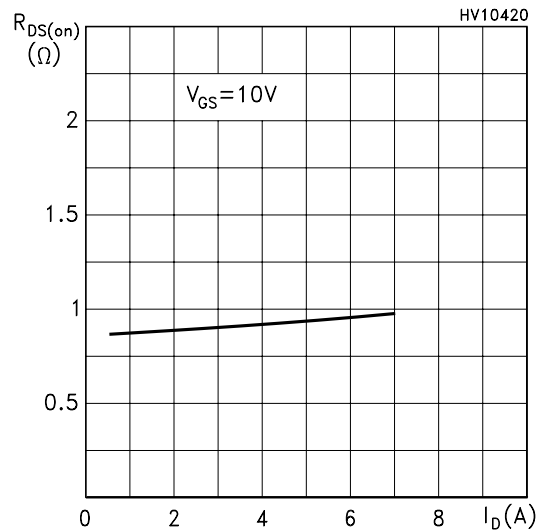
Transfer Characteristics



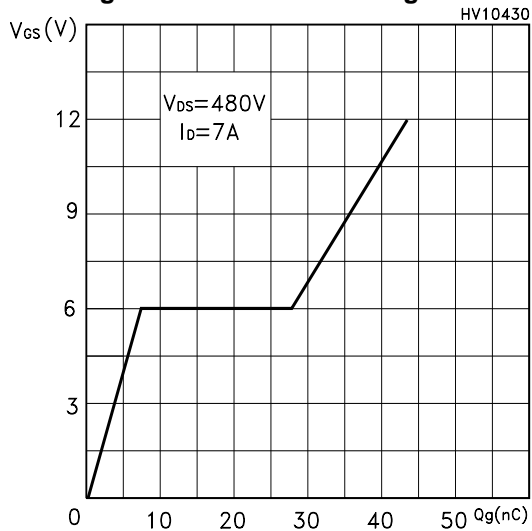
Transconductance



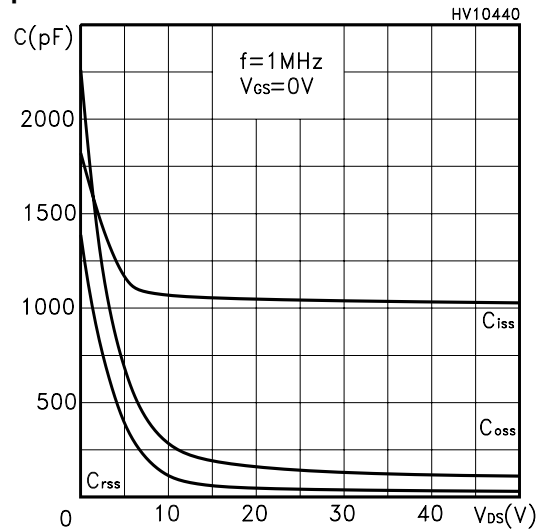
Static Drain-source On Resistance



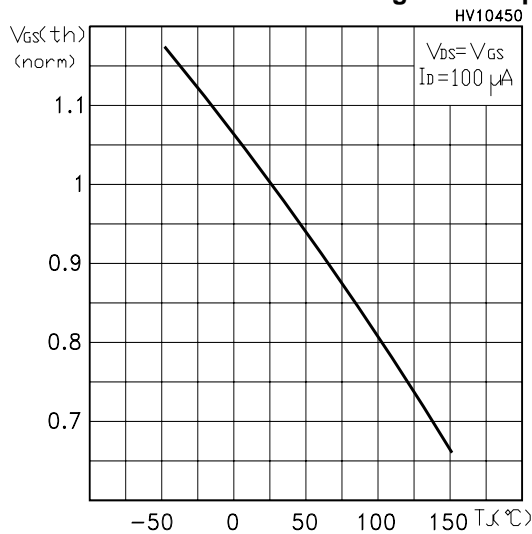
Gate Charge vs Gate-source Voltage



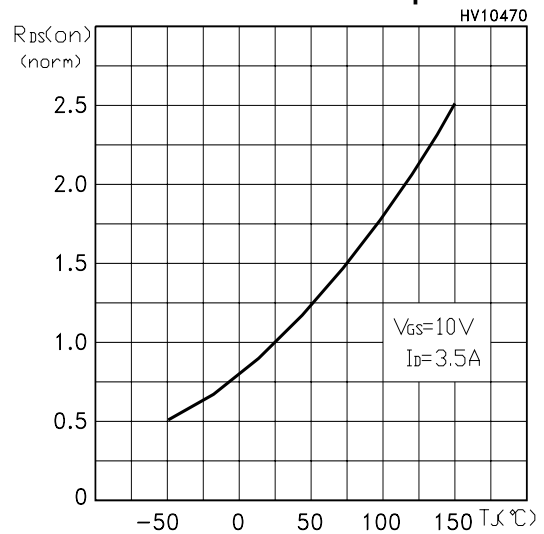
Capacitance Variations



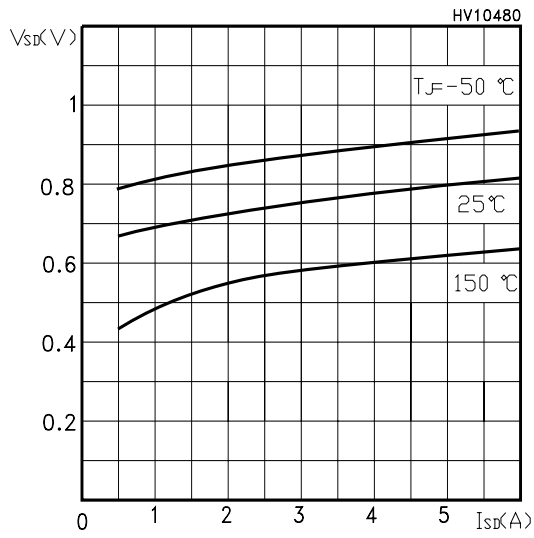
Normalized Gate Threshold Voltage vs Temp.



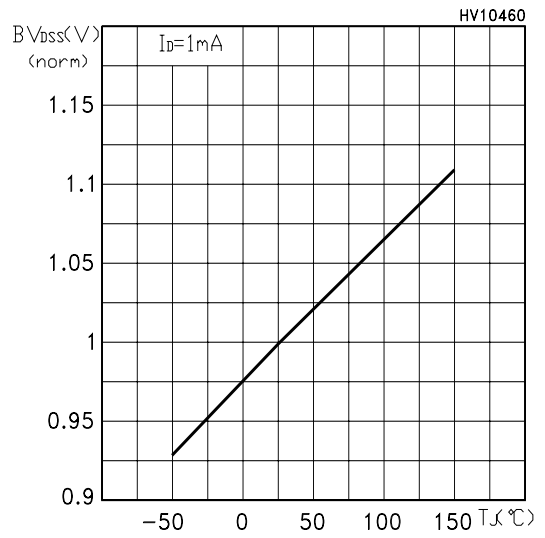
Normalized On Resistance vs Temperature



Source-drain Diode Forward Characteristics



Normalized BVDSS vs Temperature



Maximum Avalanche Energy vs Temperature

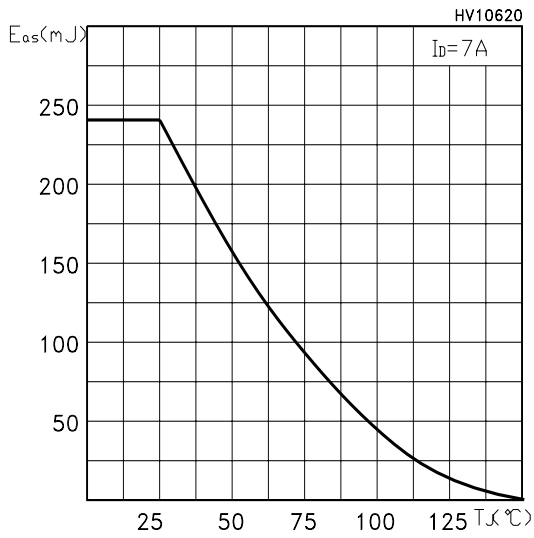


Fig. 1: Unclamped Inductive Load Test Circuit

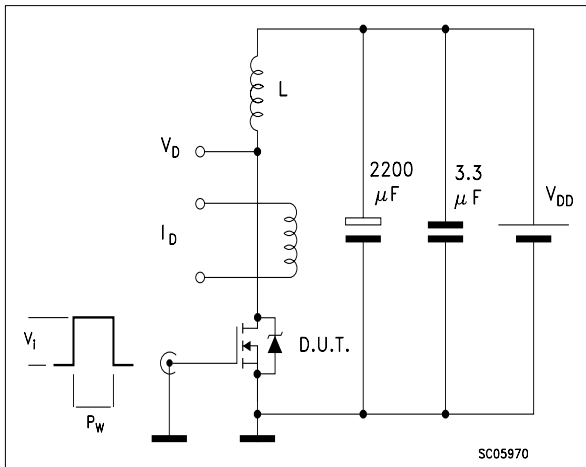


Fig. 2: Unclamped Inductive Waveform

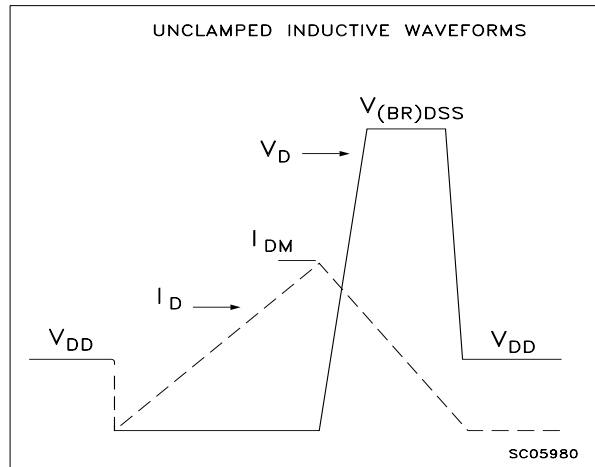


Fig. 3: Switching Times Test Circuit For Resistive Load

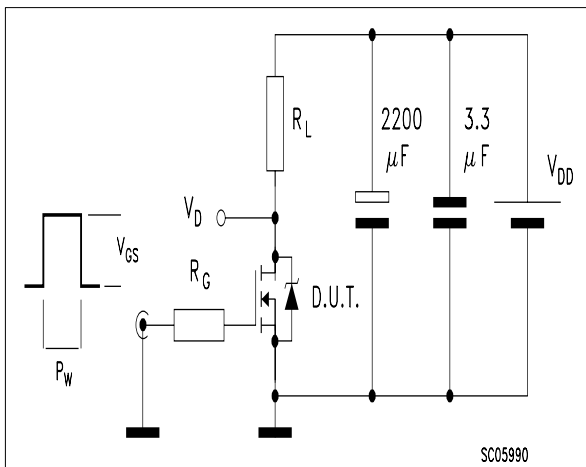


Fig. 4: Gate Charge test Circuit

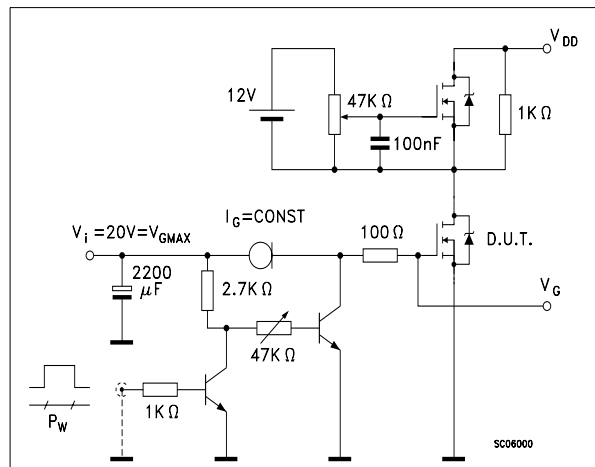
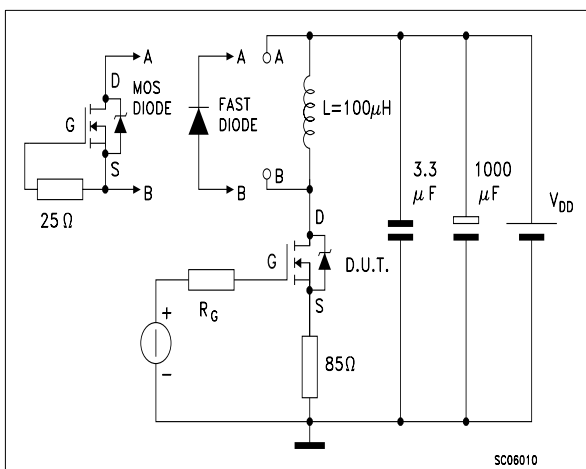
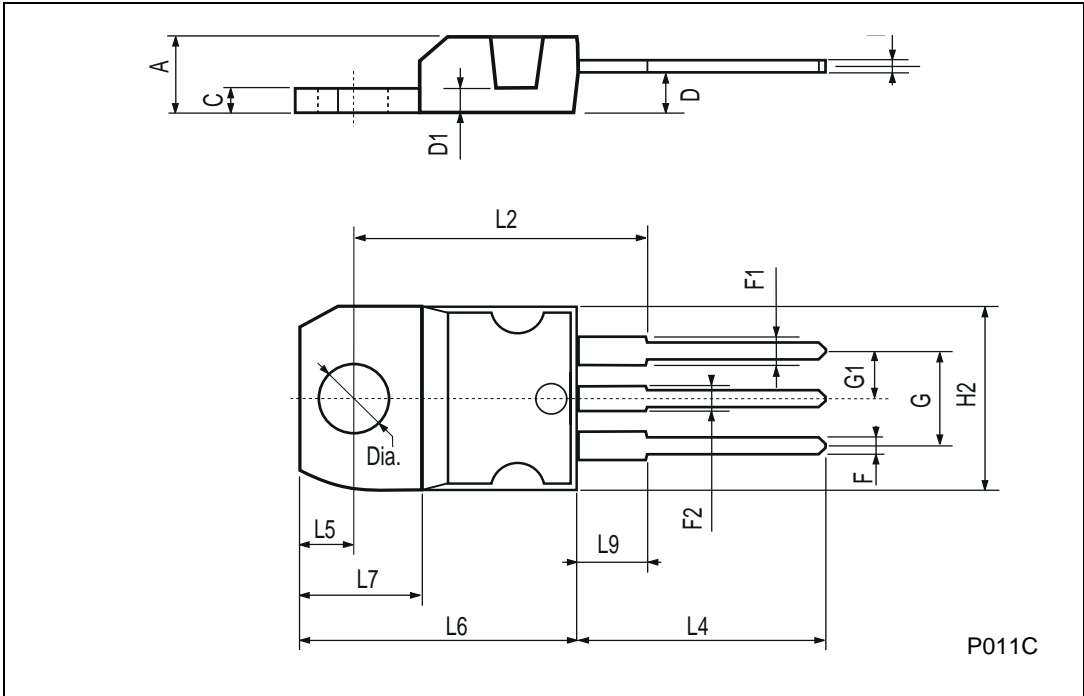


Fig. 5: Test Circuit For Inductive Load Switching And Diode Recovery Times



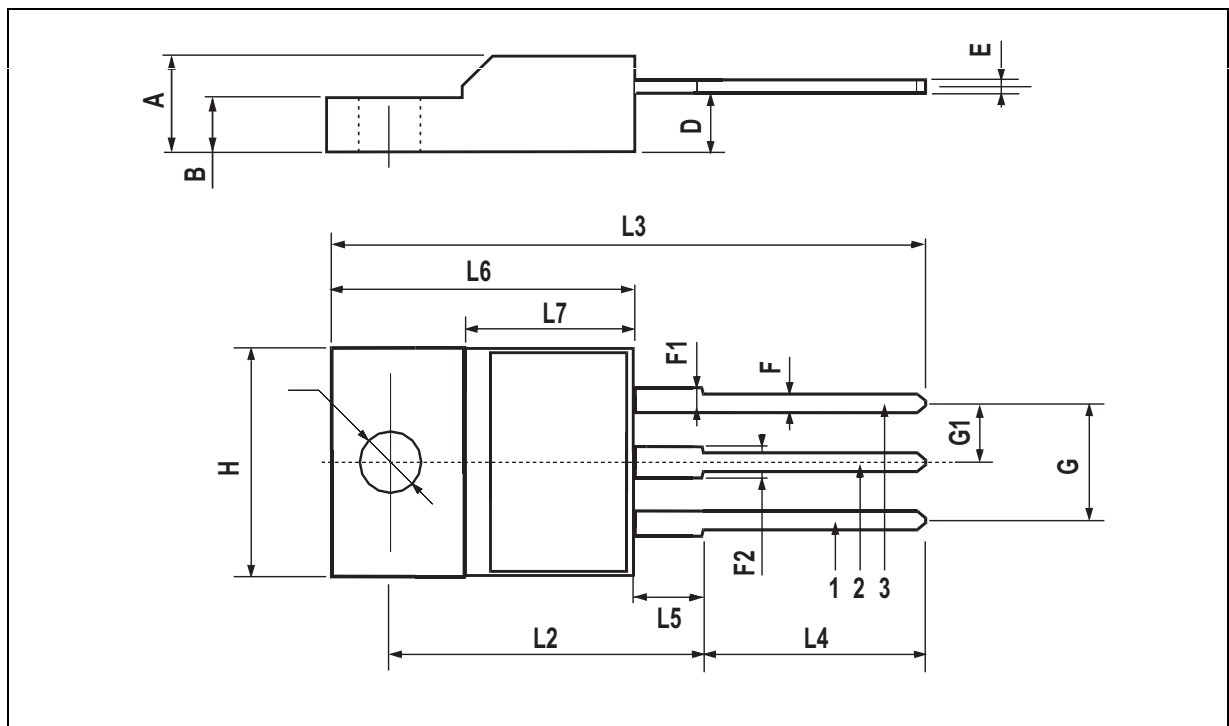
TO-220 MECHANICAL DATA

| 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 |



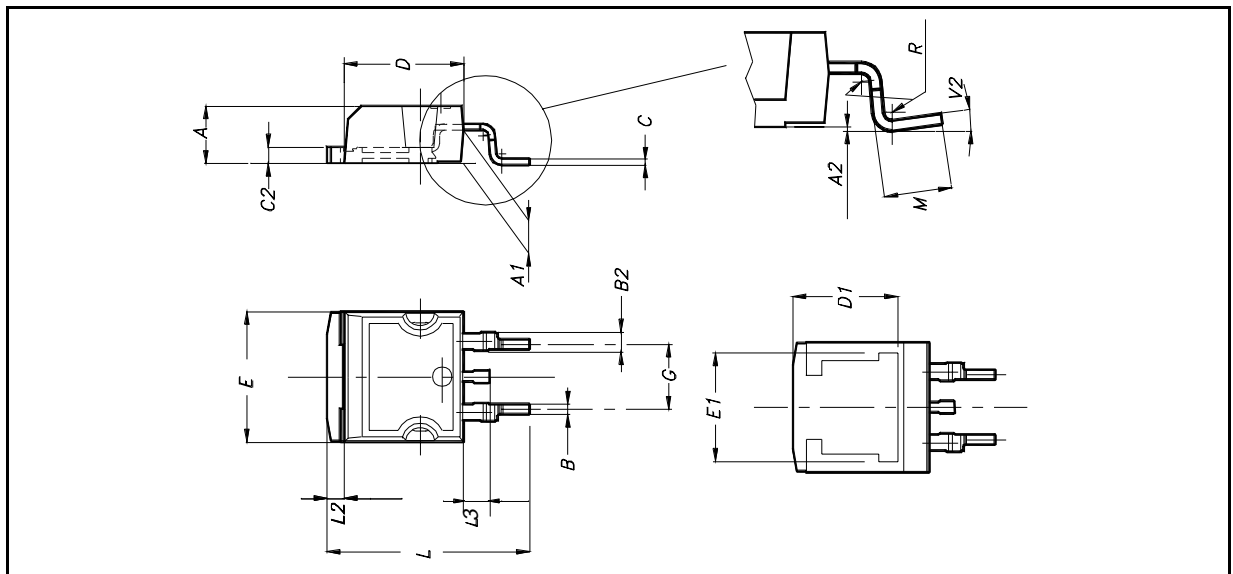
TO-220FP MECHANICAL DATA

| 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 |
| ∅ | 3 | | 3.2 | 0.118 | | 0.126 |



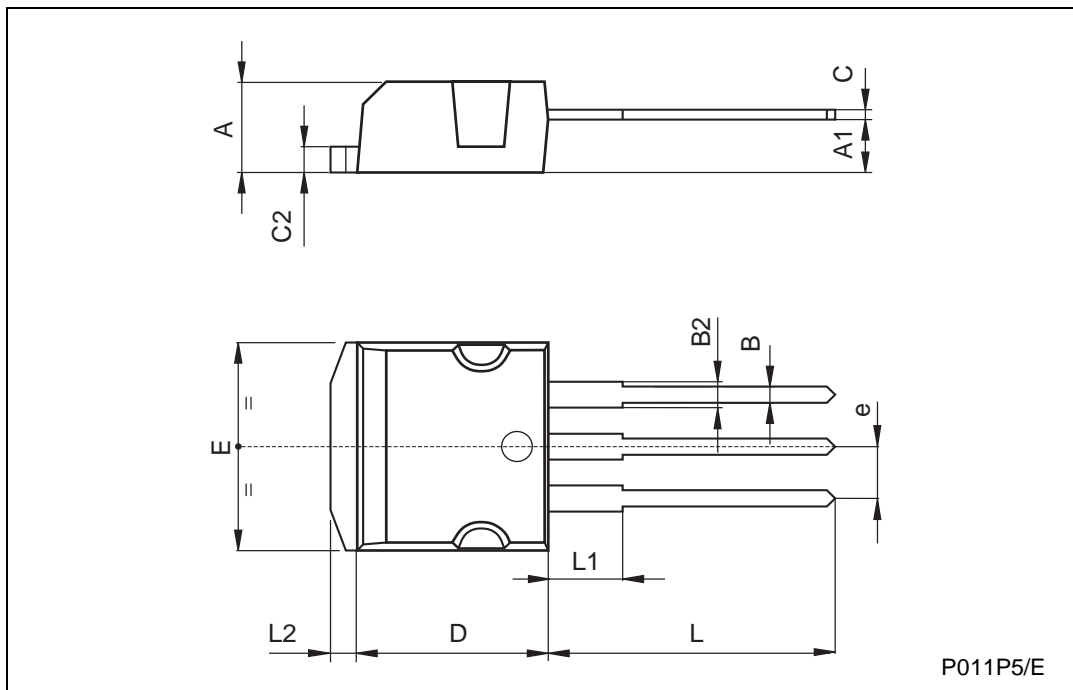
D²PAK MECHANICAL DATA

| 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 | 0° | | 8° | | | |

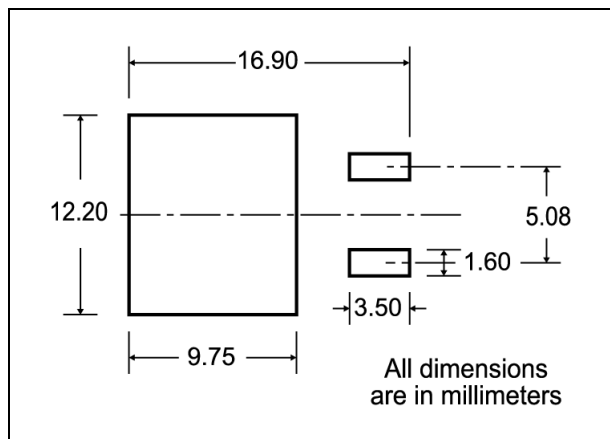


TO-262 (I²PAK) MECHANICAL DATA

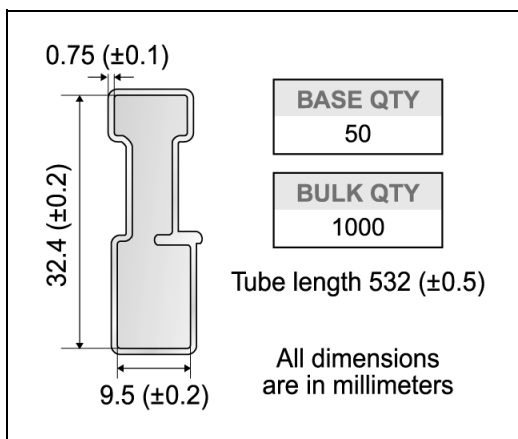
| DIM. | mm | | | inch | | |
|------|------|------|------|-------|------|-------|
| | MIN. | TYP. | MAX. | MIN. | TYP. | MAX. |
| A | 4.4 | | 4.6 | 0.173 | | 0.181 |
| A1 | 2.49 | | 2.69 | 0.098 | | 0.106 |
| B | 0.7 | | 0.93 | 0.027 | | 0.036 |
| B2 | 1.14 | | 1.7 | 0.044 | | 0.067 |
| C | 0.45 | | 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 |



D²PAK 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 (radius), B (slot width), C (slot depth), D (slot width), and D1 (slot width). 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 (thickness), C (width), N (width), and G (width measured at the hub).

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 |

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 |

Diagrams showing the tape and reel shipment details. The top diagram shows a cross-section of the tape with dimensions K₀, T, D, P₂, P₀, E, F, W, B₀, D₁, A₀, P₁, and the center line of the cavity. A note indicates a 10-pitch cumulative tolerance on the tape of ±0.2 mm. The bottom diagram shows the reel with dimensions TRL, FEED DIRECTION, and Bending radius (R min.).

* on sales type



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