



STB11NM60FD - STB11NM60FD-1 STP11NM60FD - STP11NM60FD FP

N-channel 600V - 0.40Ω - 11A - TO-220/TO-220FP/D²PAK/I²PAK
FDmesh™ Power MOSFET (with fast diode)

General features

| Type | V _{DSS} | R _{DS(on)} | I _D |
|----------------|------------------|---------------------|----------------|
| STB11NM60FD | 600V | <0.45Ω | 11A |
| STB11NM60FD-1 | 600V | <0.45Ω | 11A |
| STP11NM60FD | 600V | <0.45Ω | 11A |
| STP11NM60FD FP | 600V | <0.45Ω | 11A |

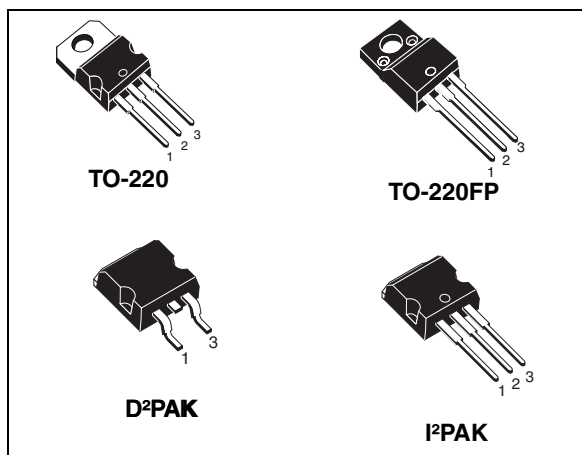
- 100% avalanche tested
- High dv/dt and avalanche capabilities
- Low input capacitance and gate charge
- Low gate input resistance
- Tight process control and high manufacturing yields

Description

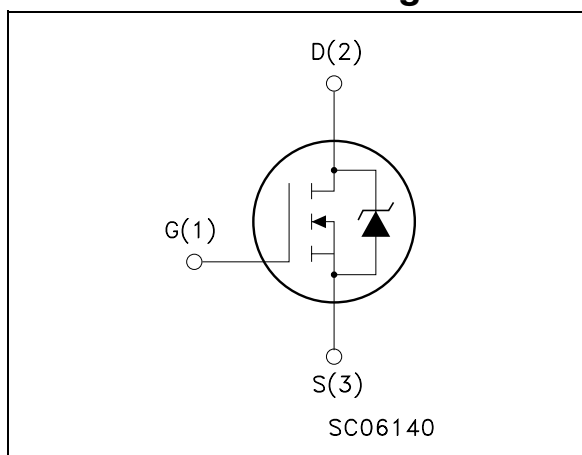
The FDmesh™ associates all advantages of reduced on-resistance and fast switching with an intrinsic fast-recovery body diode. It is therefore strongly recommended for bridge topologies, in particular ZVS phase-shift converters.

Applications

- Switching application



Internal schematic diagram



Order codes

| Part number | Marking | Package | Packaging |
|----------------|--------------|--------------------|-------------|
| STB11NM60FD | B11NM60FD | D ² PAK | Tape & reel |
| STB11NM60FD-1 | B11NM60FD | I ² PAK | Tube |
| STP11NM60FD | P11NM60FD | TO-220 | Tube |
| STP11NM60FD FP | P11NM60FD FP | TO-220FP | Tube |

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1 Electrical ratings

Table 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 | 11 | 11 ⁽¹⁾ | A |
| I _D | Drain current (continuous) at T _C = 100°C | 7 | 7 ⁽¹⁾ | A |
| I _{DM} ⁽²⁾ | Drain current (pulsed) | 44 | 44 ⁽¹⁾ | A |
| P _{TOT} | Total dissipation at T _C = 25°C | 160 | 35 | W |
| | Derating factor | 0.88 | 0.28 | W/°C |
| dv/dt ⁽³⁾ | Peak diode recovery voltage slope | 20 | | V/ns |
| V _{ISO} | Insulation withstand voltage (dc) | -- | 2500 | V |
| T _{stg} | Storage temperature | -65 to 150 | | °C |

1. Limited only by maximum temperature allowed
2. Pulse width limited by safe operating area
3. I_{SD} < 11A, di/dt < 400A/μs, V_{DD} = 80% V_{(BR)DSS}

Table 2. Thermal resistance

| Symbol | Parameter | Value | | Unit |
|-----------------------|--|---|----------|------|
| | | TO-220 D ² PAK/I ² PAK | TO-220FP | |
| R _{thj-case} | Thermal resistance junction-case Max | 0.78 | 3.57 | °C/W |
| R _{thj-a} | Thermal resistance junction-ambient Max | 62.5 | | °C/W |
| T _I | Maximum lead temperature for soldering purpose | 300 | | °C |

Table 3. Avalanche data

| Symbol | Parameter | 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} = 35V) | 350 | mJ |

2 Electrical characteristics

($T_{CASE}=25^{\circ}C$ unless otherwise specified)

Table 4. On/off states

| 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 | $V_{DS} = \text{Max rating}$ | | | 1 | μA |
| | Drain current ($V_{GS} = 0$) | $V_{DS} = \text{Max rating}, T_C = 125^{\circ}C$ | | | 100 | μA |
| I_{GSS} | Gate-body leakage current ($V_{DS} = 0$) | $V_{GS} = \pm 30V$ | | | ± 100 | nA |
| $V_{GS(th)}$ | Gate threshold voltage | $V_{DS} = V_{GS}, I_D = 250\mu A$ | 3 | 4 | 5 | V |
| $R_{DS(on)}$ | Static drain-source on resistance | $V_{GS} = 10V, I_D = 5.5A$ | | 0.40 | 0.45 | W |

Table 5. 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 | $V_{DS} = 25V, f = 1 \text{ MHz}, V_{GS} = 0$ | | 900 | | pF |
| C_{oss} | Output capacitance | | | 350 | | pF |
| C_{rss} | Reverse transfer capacitance | | | 35 | | pF |
| $C_{oss eq}^{(2)}$ | Equivalent output capacitance | $V_{GS} = 0V, V_{DS} = 0V \text{ to } 400V$ | | 100 | | pF |
| R_G | Gate input resistance | $f=1 \text{ MHz Gate DC Bias}= 0$ test signal level = 20mV open drain | | 3 | | Ω |
| Q_g | Total gate charge | $V_{DD} = 400V, I_D = 11A,$ $V_{GS} = 10V$ (see Figure 15) | | 28 | 40 | nC |
| Q_{gs} | Gate-source charge | | | 7.8 | | nC |
| Q_{gd} | Gate-drain charge | | | 13 | | nC |

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} .

Table 6. Switching times

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---------------------------------|---|--|------|----------------|------|----------------|
| $t_{d(on)}$ t_r | Turn-on delay time Rise time | $V_{DD} = 250V$, $I_D = 5.5A$ $R_G = 4.7\Omega$, $V_{GS} = 10V$ (see Figure 14) | | 20 16 | | ns ns |
| $t_{r(Voff)}$ t_f t_c | Off-voltage rise time Fall time Cross-over time | $V_{DD} = 400V$, $I_D = 11A$, $R_G = 4.7\Omega$, $V_{GS} = 10V$ (see Figure 16) | | 10 15 24 | | ns ns ns |

Table 7. Source drain diode

| Symbol | Parameter | Test conditions | Min | Typ. | Max | Unit |
|-----------------------------------|--|---|-----|-------------------|-----|---------------|
| I_{SD} | Source-drain current | | | | 11 | A |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) | | | | 44 | A |
| $V_{SD}^{(2)}$ | Forward on voltage | $I_{SD} = 11A$, $V_{GS} = 0$ | | | 1.5 | V |
| t_{rr} Q_{rr} I_{RRM} | Reverse recovery time Reverse recovery charge Reverse recovery current | $I_{SD} = 11A$, $V_{DD} = 50V$ $di/dt = 100A/\mu s$, (see Figure 19) | | 140 680 A | | ns nC A |
| t_{rr} Q_{rr} I_{RRM} | Reverse recovery time Reverse recovery charge Reverse recovery current | $I_{SD} = 11A$, $V_{DD} = 50V$ $di/dt = 100A/\mu s$, $T_j = 150^\circ C$ (see Figure 19) | | 260 1600 13 | | ns nC A |

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

2.1 Electrical characteristics (curves)

Figure 1. Safe operating area

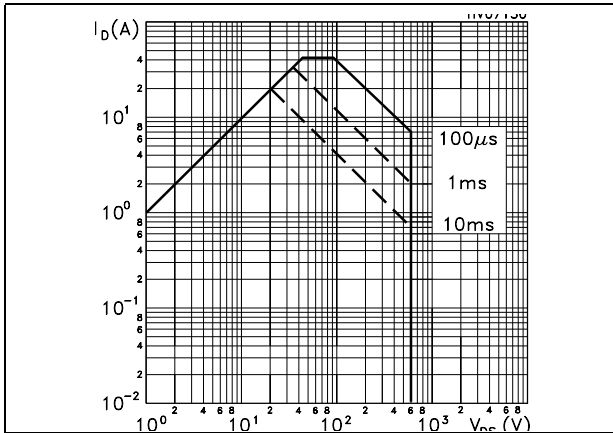


Figure 2. Thermal impedance

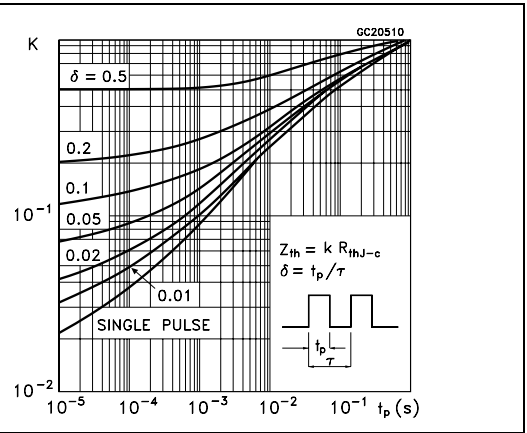


Figure 3. Safe operating area for TO-220FP

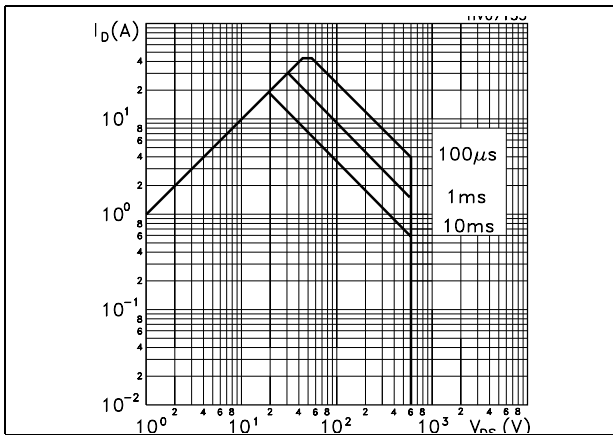


Figure 4. Thermal impedance for TO-220FP

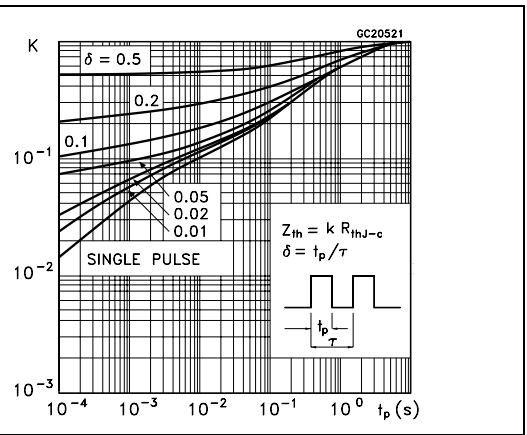


Figure 5. Output characteristics

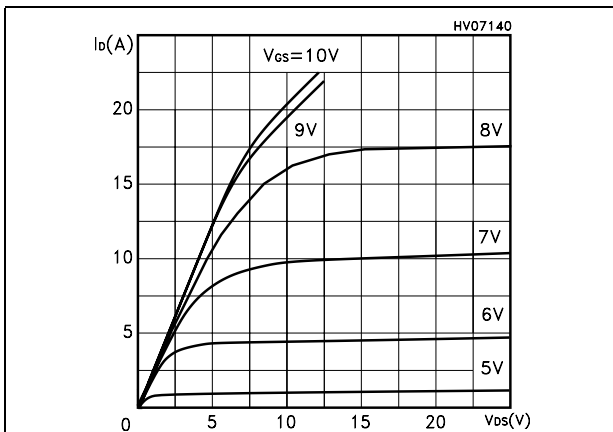


Figure 6. Transfer characteristics

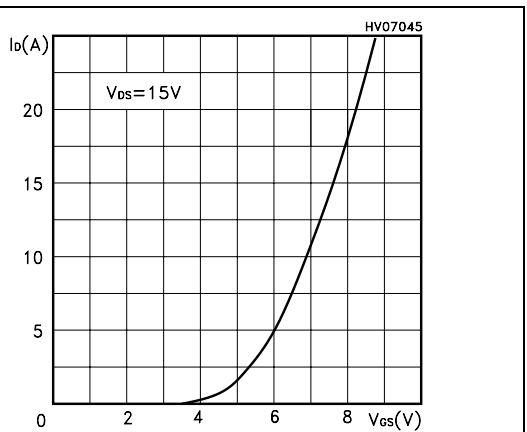


Figure 7. Transconductance

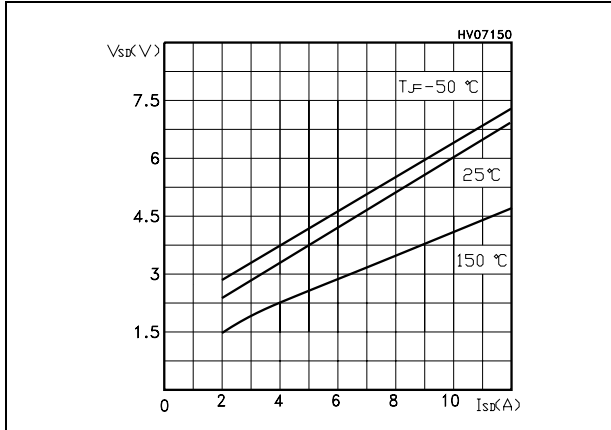


Figure 8. Static drain-source on resistance

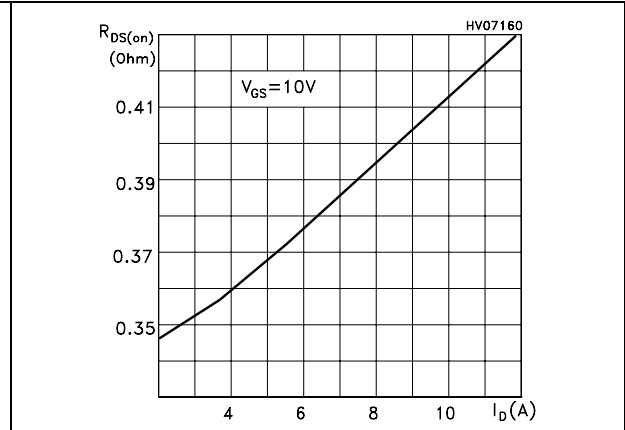


Figure 9. Gate charge vs gate-source voltage Figure 10. Capacitance variations

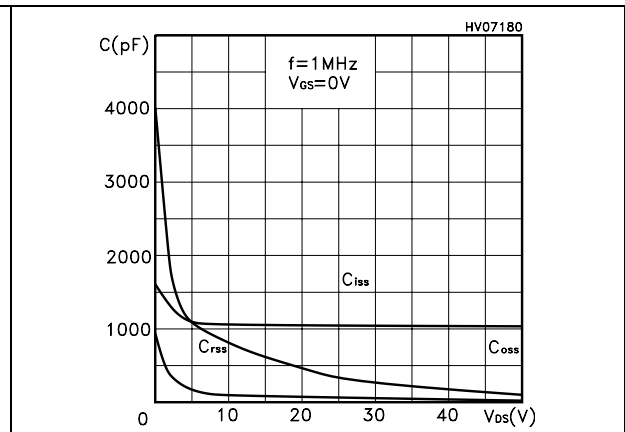
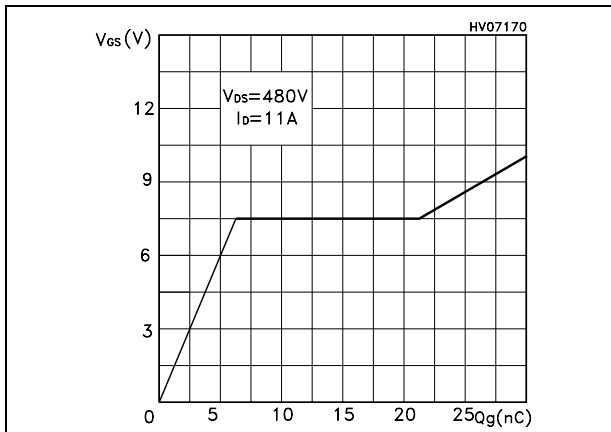


Figure 11. Normalized gate threshold voltage vs temperature

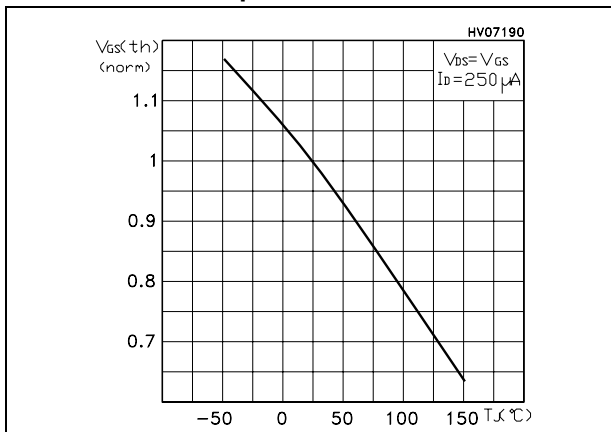


Figure 12. Normalized on resistance vs temperature

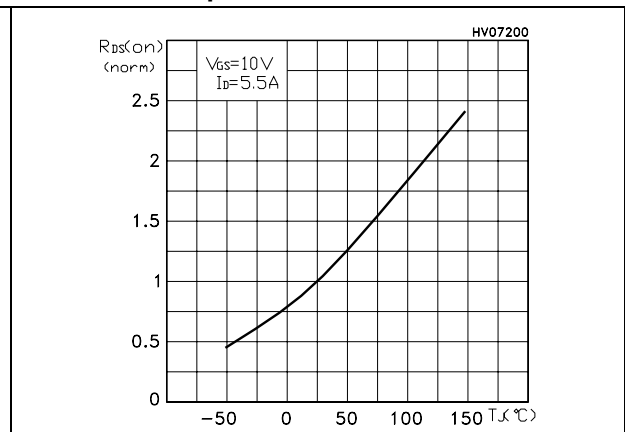
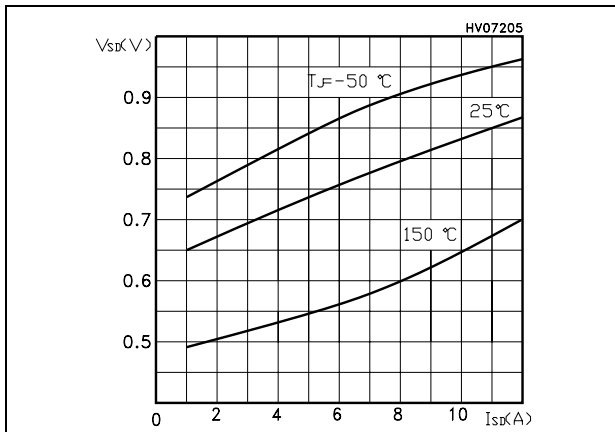


Figure 13. Source-drain diode forward characteristics



3 Test circuit

Figure 14. Switching times test circuit for resistive load

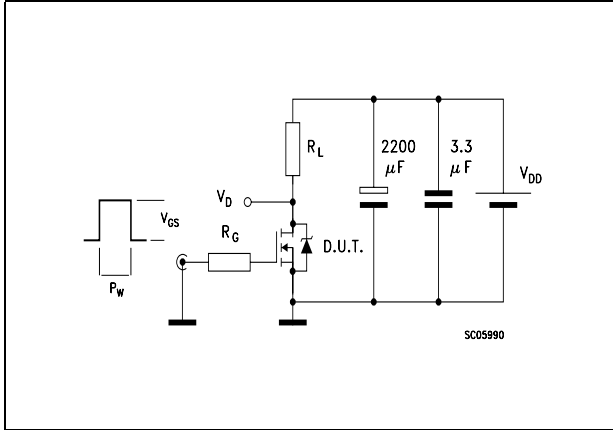


Figure 15. Gate charge test circuit

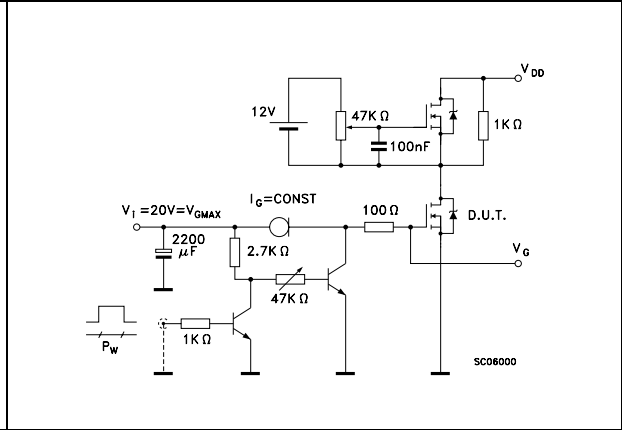


Figure 16. Test circuit for inductive load switching and diode recovery times



Figure 17. Unclamped Inductive load test circuit

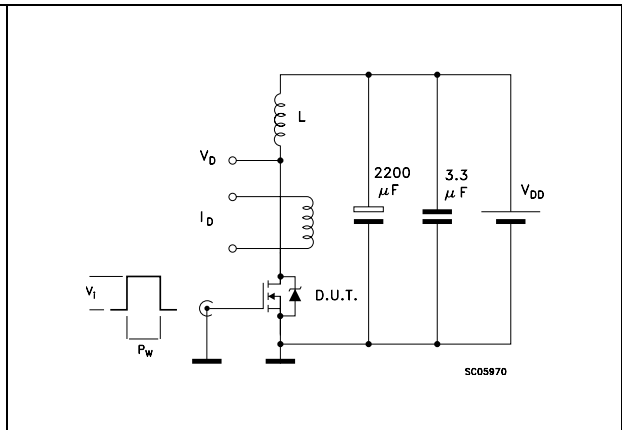
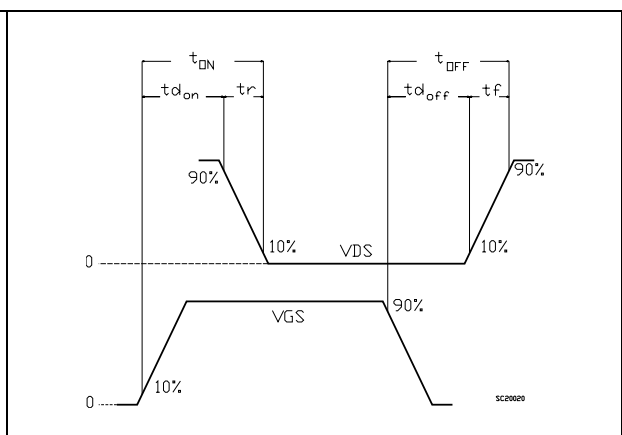


Figure 18. Unclamped inductive waveform



Figure 19. Switching time waveform

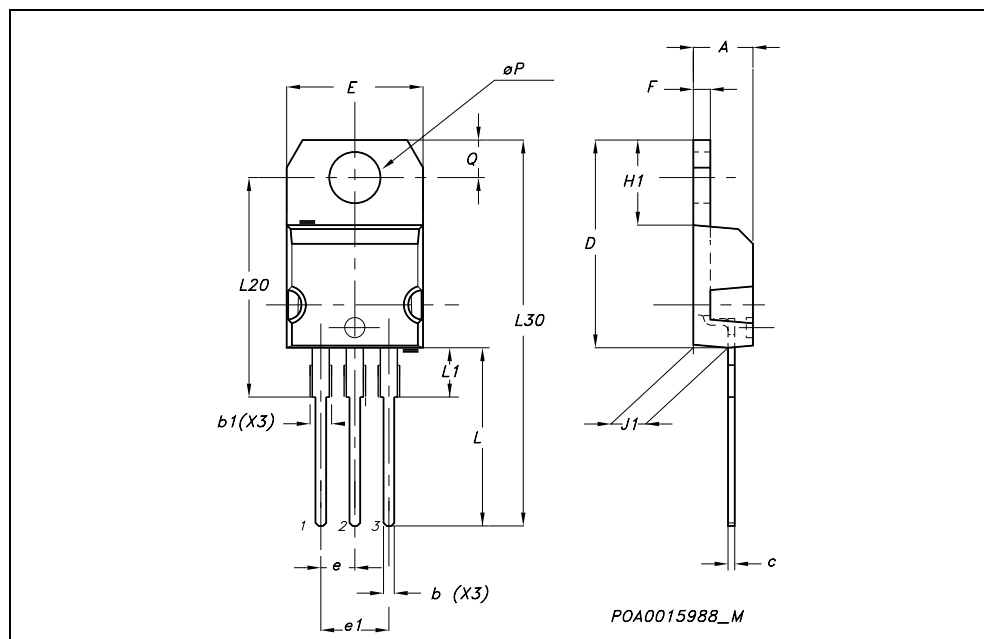


4 Package mechanical data

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

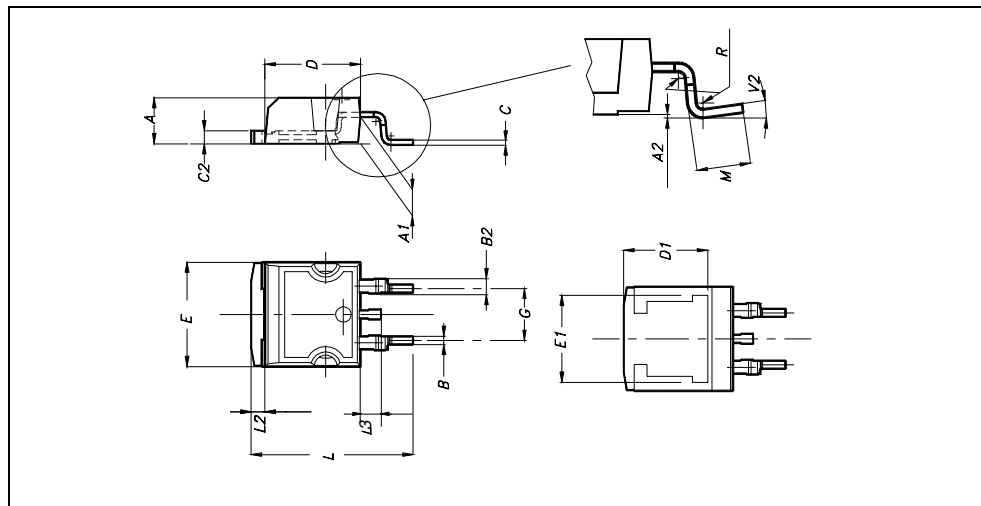
TO-220 MECHANICAL DATA

| 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 |



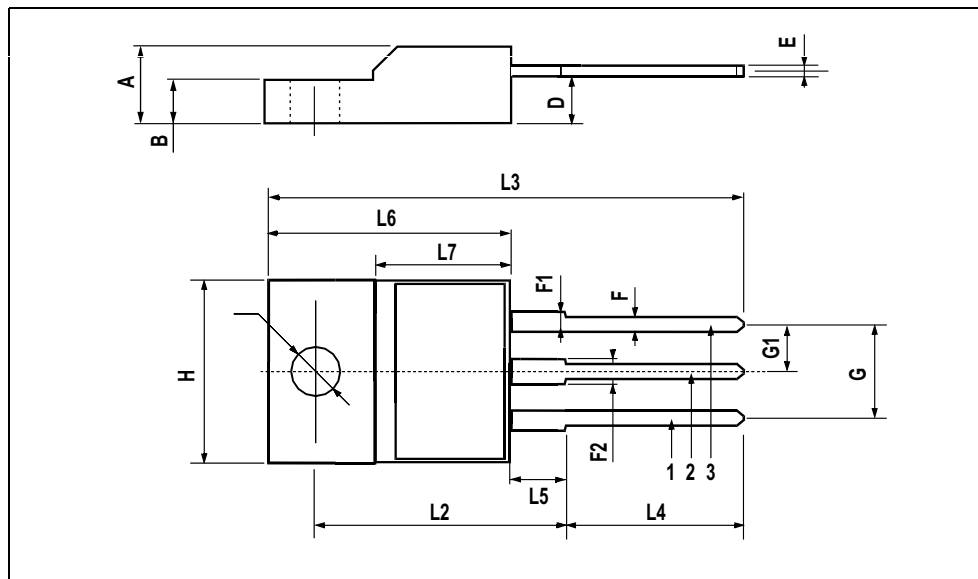
D²PAK MECHANICAL DATA

| 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° | | 4° | | | |



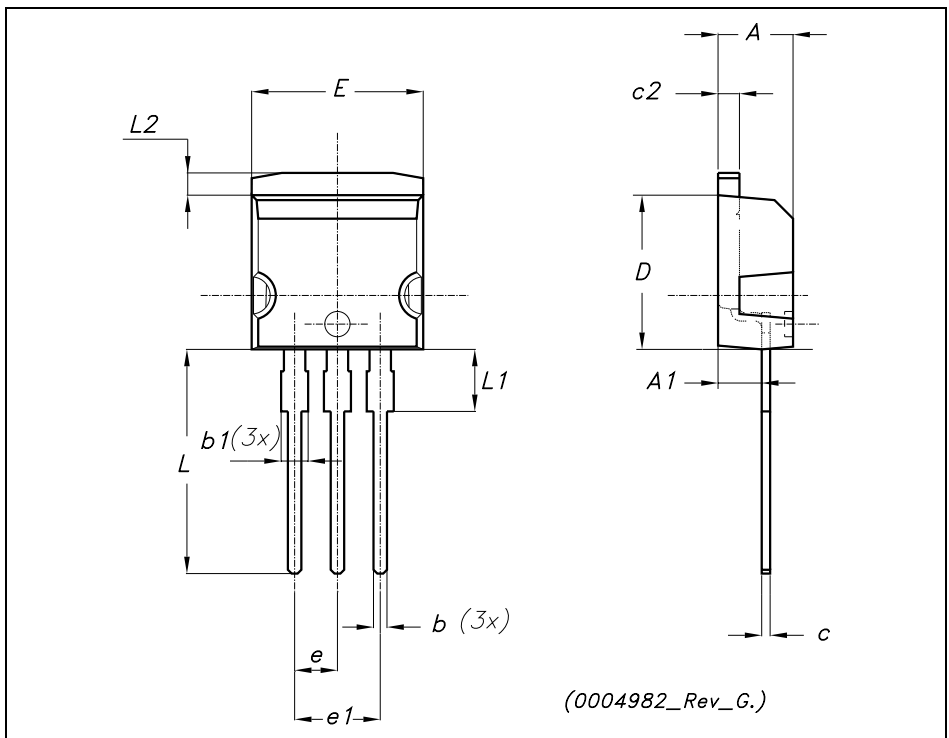
TO-220FP MECHANICAL DATA

| 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-262 (I²PAK) 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 |



5 Packaging mechanical data

D²PAK 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 |

10 pitches cumulative tolerance on tape +/- 0.2 mm

Center line of cavity

User Direction of Feed

FEED DIRECTION

TRL

Bending radius R min.

* on sales type

6 Revision history

Table 8. Revision history

| Date | Revision | Changes |
|-------------|----------|---|
| 09-Sep-2004 | 6 | Preliminary version |
| 08-May-2006 | 7 | D ² PAK package inserted |
| 22-May-2006 | 8 | Updated values Table 5: Dynamic |
| 26-Jul-2006 | 9 | New template, no content change |

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