



STB23NM60ND-STF23NM60ND STI23NM60ND-STP/W23NM60ND

N-channel 600 V - 0.150 Ω - 20 A - D²/I²PAK - TO-220/FP - TO-247
FDmesh™ II Power MOSFET (with fast diode)

Preliminary Data

Features

| Type | V _{DSS} (@T _{jmax}) | R _{DS(on)} max | I _D |
|-------------|-------------------------------------------|-------------------------|---------------------|
| STB23NM60ND | 650 V | < 0.180 Ω | 20 A |
| STI23NM60ND | 650 V | < 0.180 Ω | 20 A |
| STF23NM60ND | 650 V | < 0.180 Ω | 20 A ⁽¹⁾ |
| STP23NM60ND | 650 V | < 0.180 Ω | 20 A |
| STW23NM60ND | 650 V | < 0.180 Ω | 20 A |

1. Limited by wire bonding

- The worldwide best R_{DS(on)} * area amongst the fast recovery diode devices
- 100% avalanche tested
- Low input capacitance and gate charge
- Low gate input resistance
- High dv/dt and avalanche capabilities

Application

- Switching applications

Description

The FDmesh™ II series belongs to the second generation of MDmesh™ technology. This revolutionary Power MOSFET associates a new vertical structure to the company's strip layout and 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.

Table 1. Device summary

| Order codes | Marking | Package | Packaging |
|-------------|----------|--------------------|-------------|
| STB23NM60ND | 23NM60ND | D ² PAK | Tape & reel |
| STI23NM60ND | 23NM60ND | I ² PAK | Tube |
| STF23NM60ND | 23NM60ND | TO-220FP | Tube |
| STP23NM60ND | 23NM60ND | TO-220 | Tube |
| STW23NM60ND | 23NM60ND | TO-247 | Tube |

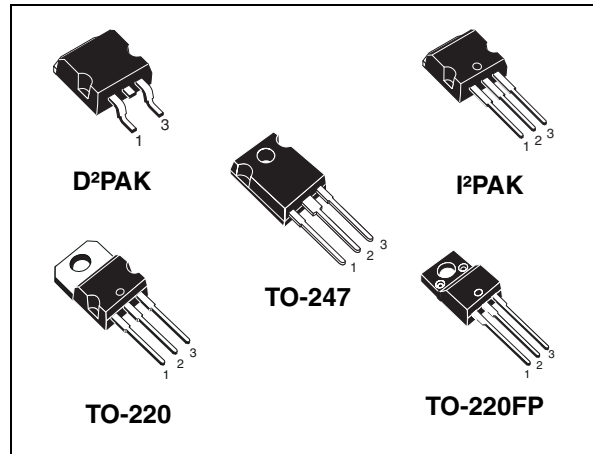
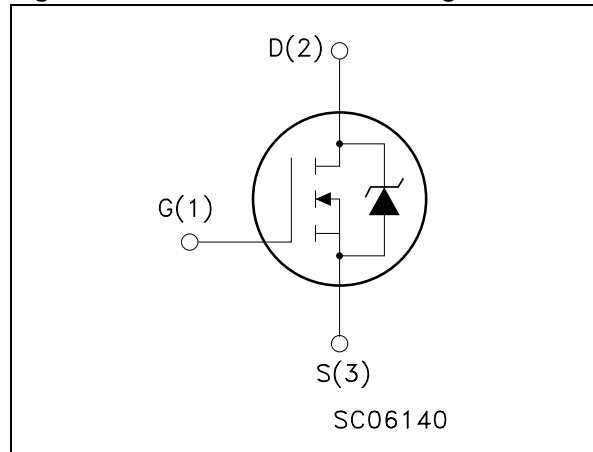


Figure 1. Internal schematic diagram



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| 4 | Package mechanical data | 7 |
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1 Electrical ratings

Table 2. Absolute maximum ratings

| Symbol | Parameter | Value | | Unit |
|--------------------------------|-----------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|---------------------|------|
| | | D ² PAK/I ² PAK TO-220/TO-247 | TO-220FP | |
| V _{DS} | Drain-source voltage (V _{GS} =0) | 600 | | V |
| V _{GS} | Gate-source voltage | ± 25 | | V |
| I _D | Drain current (continuous) at T _C = 25 °C | 20 | 20 ⁽¹⁾ | A |
| I _D | Drain current (continuous) at T _C = 100 °C | 12.6 | 12.6 ⁽¹⁾ | A |
| I _{DM} ⁽²⁾ | Drain current (pulsed) | 80 | 80 ⁽¹⁾ | A |
| P _{TOT} | Total dissipation at T _C = 25 °C | 150 | 35 | W |
| dv/dt ⁽³⁾ | Peak diode recovery voltage slope | 40 | | V/ns |
| V _{ISO} | Insulation withstand voltage (RMS) from all three leads to external heat sink (t = 1 s; T _C = 25 °C) | -- | 2500 | V |
| T _{stg} | Storage temperature | -55 to 150 | | °C |
| T _j | Max. operating junction temperature | 150 | | °C |

1. Limited only by maximum temperature allowed
2. Pulse width limited by safe operating area
3. I_{SD} ≤ 20 A, di/dt ≤ 600 A/μs, V_{DD} = 80% V_{(BR)DSS}

Table 3. Thermal data

| Symbol | Parameter | D ² PAK/I ² PAK TO-220 | TO-247 | TO-220FP | Unit |
|-----------------------|-------------------------------------------------|-------------------------------------------------|--------|----------|------|
| R _{thj-case} | Thermal resistance junction-case max | 0.83 | | 3.6 | °C/W |
| R _{thj-amb} | Thermal resistance junction-amb max | 62.5 | 50 | 62.5 | °C/W |
| T _l | Maximum lead temperature for soldering purposes | 300 | | | °C |

Table 4. Avalanche characteristics

| Symbol | Parameter | Max value | Unit |
|-----------------|----------------------------------------------------------------------------------------------------------------------------|-----------|------|
| I _{AS} | Avalanche current, repetitive or not-repetitive (pulse width limited by T _j max) | 9 | A |
| E _{AS} | Single pulse avalanche energy (starting T _j = 25 °C, I _D = I _{AS} , V _{DD} = 50 V) | 700 | mJ |

2 Electrical characteristics

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

Table 5. On/off states

| 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 |
| $dv/dt^{(1)}$ | Drain-source voltage slope | $V_{DD} = 480 \text{ V}, I_D = 20 \text{ A}, V_{GS} = 10 \text{ V}$ | 30 | | | V/ns |
| I_{DSS} | Zero gate voltage drain current ($V_{GS} = 0$) | $V_{DS} = \text{Max rating}, V_{DS} = \text{Max rating}, @ 125^{\circ}C$ | | | 1 100 | μA μA |
| I_{GSS} | Gate body leakage current ($V_{DS} = 0$) | $V_{GS} = \pm 20 \text{ V}$ | | | 100 | nA |
| $V_{GS(th)}$ | Gate threshold voltage | $V_{DS} = V_{GS}, I_D = 250 \mu\text{A}$ | 3 | 4 | 5 | V |
| $R_{DS(on)}$ | Static drain-source on resistance | $V_{GS} = 10 \text{ V}, I_D = 10 \text{ A}$ | | 0.150 | 0.180 | Ω |

1. Characteristic value at turn off on inductive load

Table 6. Dynamic

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|-------------------------------------|-------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|------|------------------|------|----------------|
| $g_{fs}^{(1)}$ | Forward transconductance | $V_{DS} = 15 \text{ V}, I_D = 10 \text{ A}$ | | 17 | | S |
| C_{iss} C_{oss} C_{rss} | Input capacitance Output capacitance Reverse transfer capacitance | $V_{DS} = 50 \text{ V}, f = 1 \text{ MHz}, V_{GS} = 0$ | | 2050 140 8 | | pF pF pF |
| $C_{oss \text{ eq.}}^{(2)}$ | Equivalent output capacitance | $V_{GS} = 0, V_{DS} = 0 \text{ to } 480 \text{ V}$ | | 260 | | pF |
| R_g | Gate input resistance | $f = 1 \text{ MHz}$ Gate DC Bias=0 Test signal level=20 mV open drain | | 4 | | Ω |
| Q_g Q_{gs} Q_{gd} | Total gate charge Gate-source charge Gate-drain charge | $V_{DD} = 480 \text{ V}, I_D = 20 \text{ A}$ $V_{GS} = 10 \text{ V}$ (see Figure 3) | | 60 10 30 | | nC nC nC |

1. Pulsed: pulse duration = 300 μs , duty cycle 1.5%

2. $C_{oss \text{ eq.}}$ 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}

Table 7. Switching times

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|--------------|---------------------|--------------------------------------------------------------------------------------------------------------------------|------|------|------|------|
| $t_{d(on)}$ | Turn-on delay time | $V_{DD} = 300\text{ V}$, $I_D = 10\text{ A}$, $R_G = 4.7\ \Omega$, $V_{GS} = 10\text{ V}$ <i>(see Figure 2)</i> | | 25 | | ns |
| t_r | Rise time | | | 45 | | ns |
| $t_{d(off)}$ | Turn-off delay time | | | 90 | | ns |
| t_f | Fall time | | | 36 | | ns |

Table 8. Source drain diode

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|-----------------|-------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|---------------|
| I_{SD} | Source-drain current | | | | 20 | A |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) | | | | 80 | A |
| $V_{SD}^{(2)}$ | Forward on voltage | $I_{SD} = 20\text{ A}$, $V_{GS}=0$ | | | 1.3 | V |
| t_{rr} | Reverse recovery time | $I_{SD} = 20\text{ A}$, $di/dt = 100\text{ A}/\mu\text{s}$, $V_{DD} = 100\text{ V}$ <i>(see Figure 4)</i> | | 140 | | ns |
| Q_{rr} | Reverse recovery charge | | | 0.85 | | μC |
| I_{RRM} | Reverse recovery current | | | 12 | | A |
| t_{rr} | Reverse recovery time | $V_{DD} = 100\text{ V}$ $di/dt = 100\text{ A}/\mu\text{s}$, $I_{SD} = 20\text{ A}$ $T_j = 150\text{ }^\circ\text{C}$ <i>(see Figure 4)</i> | | TBD | | ns |
| Q_{rr} | Reverse recovery charge | | | TBD | | μC |
| I_{RRM} | Reverse recovery current | | | TBD | | A |

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

3 Test circuit

Figure 2. Switching times test circuit for resistive load

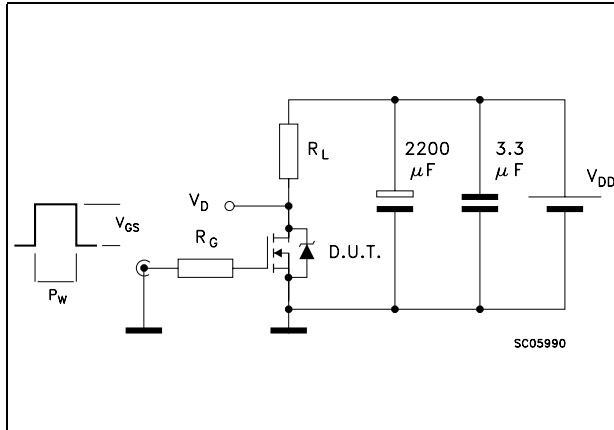


Figure 3. Gate charge test circuit

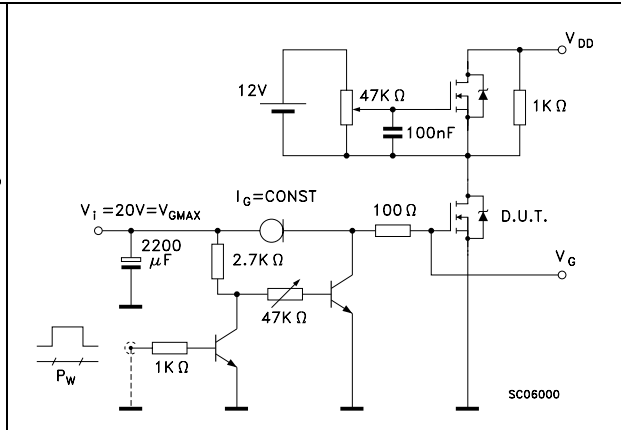


Figure 4. Test circuit for inductive load switching and diode recovery times

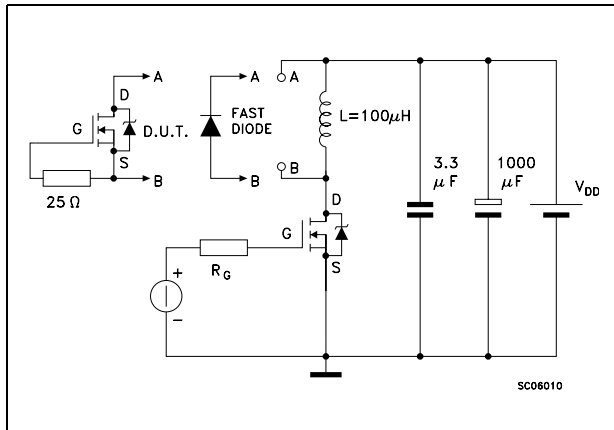


Figure 5. Unclamped inductive load test circuit

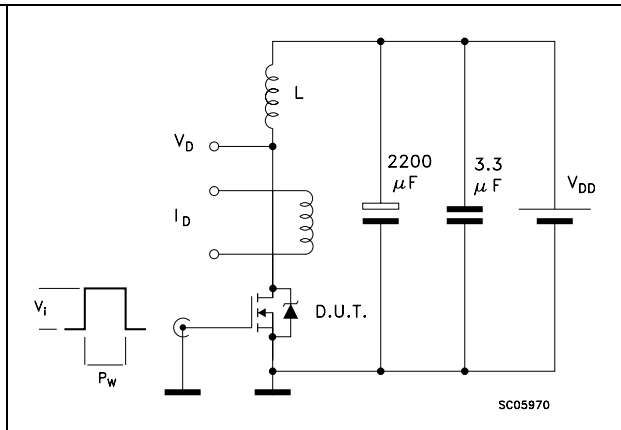


Figure 6. Unclamped inductive waveform

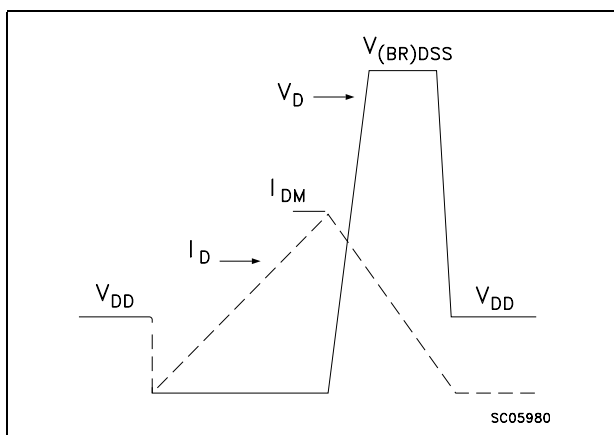
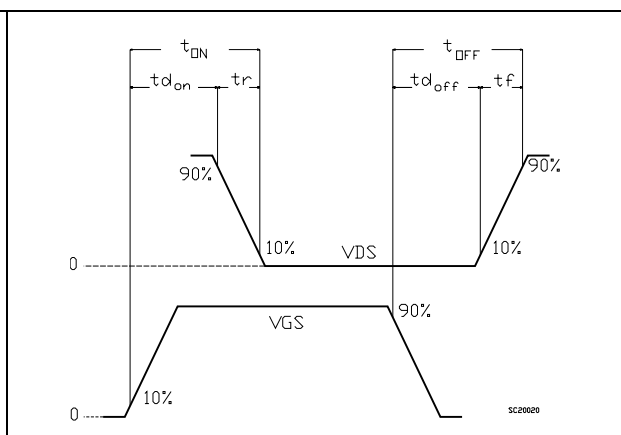


Figure 7. Switching time waveform

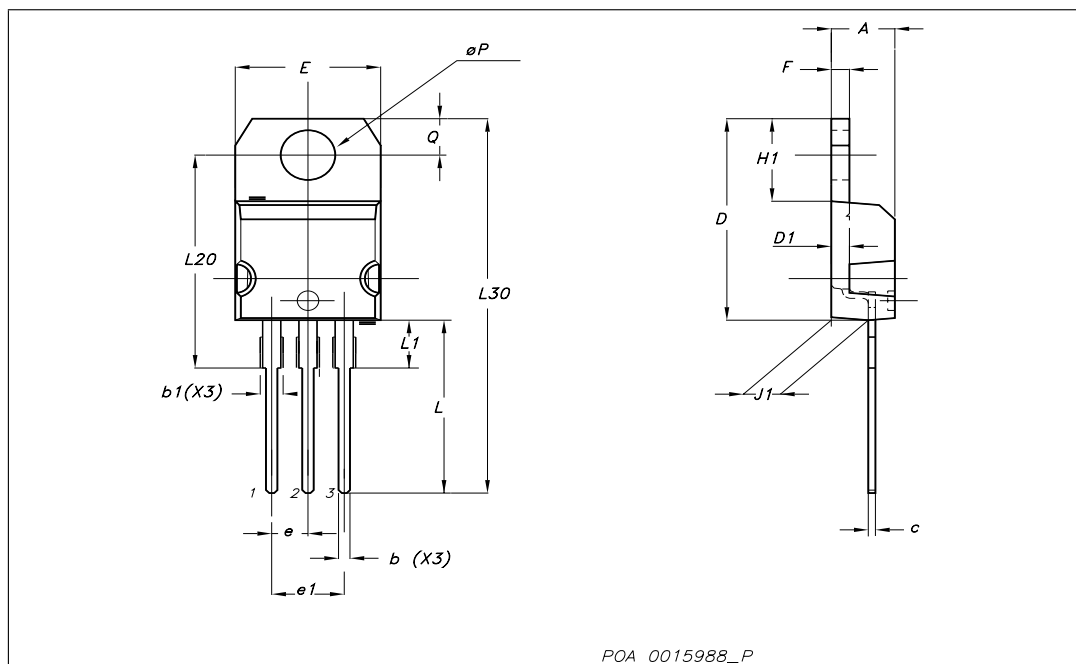


4 Package mechanical data

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

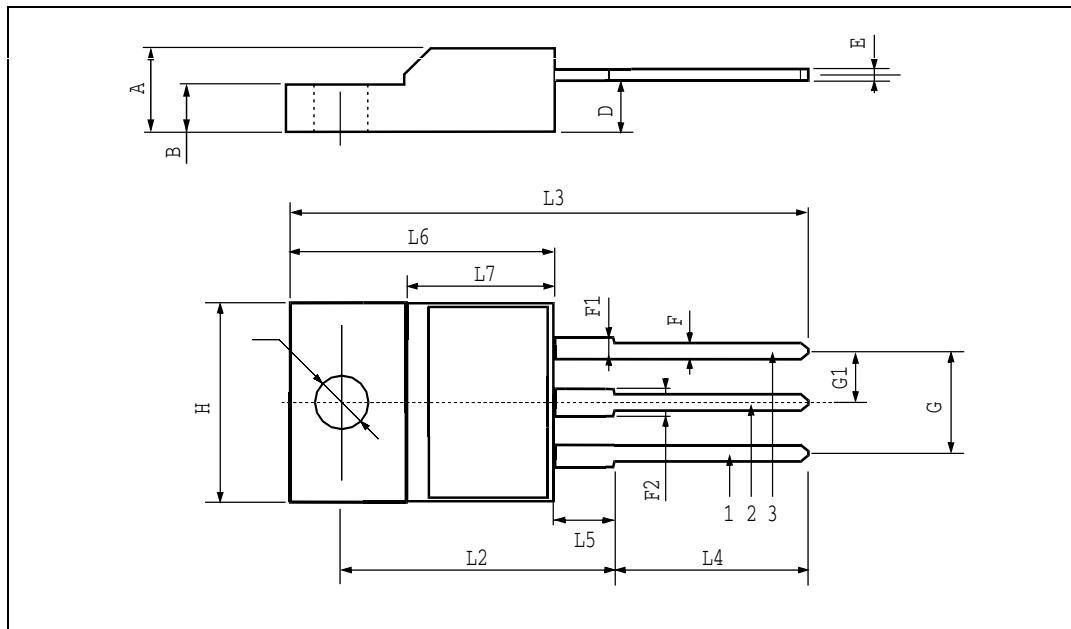
TO-220 mechanical data

| 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 | 1.14 | | 1.70 | 0.044 | | 0.066 |
| c | 0.49 | | 0.70 | 0.019 | | 0.027 |
| D | 15.25 | | 15.75 | 0.6 | | 0.62 |
| D1 | | 1.27 | | | 0.050 | |
| 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 | | 0.051 |
| 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 | |
| ∅P | 3.75 | | 3.85 | 0.147 | | 0.151 |
| Q | 2.65 | | 2.95 | 0.104 | | 0.116 |



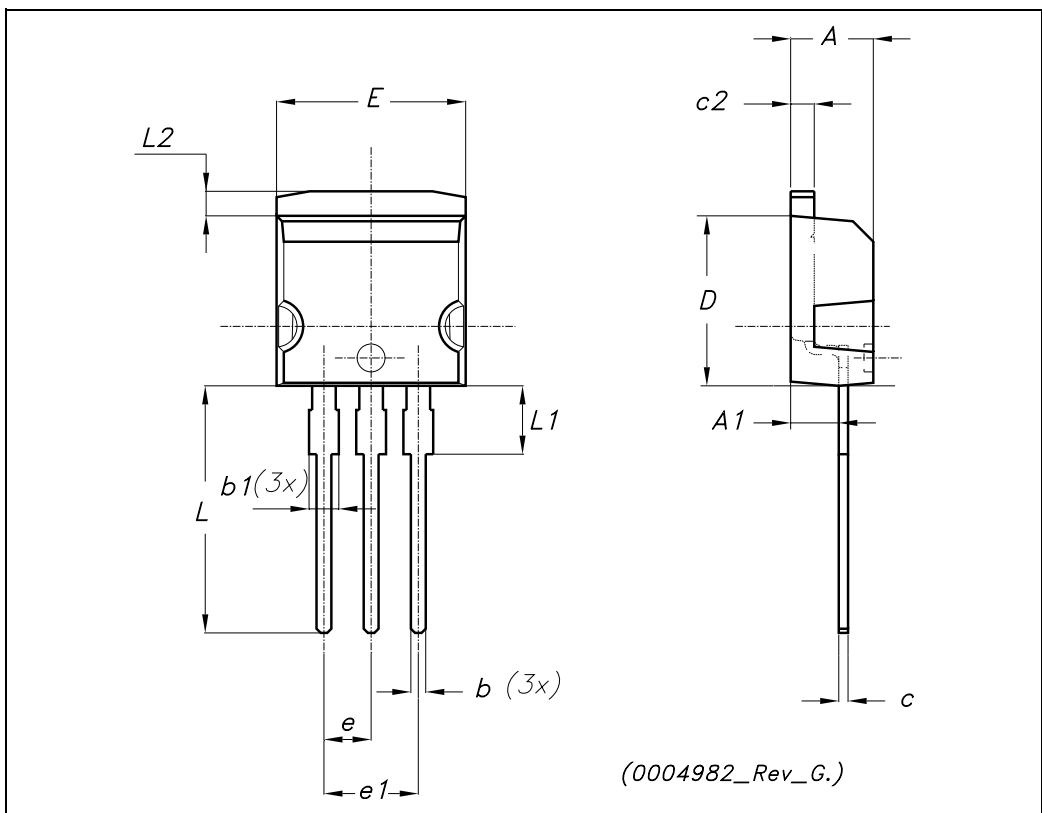
TO-220FP mechanical data

| 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 |



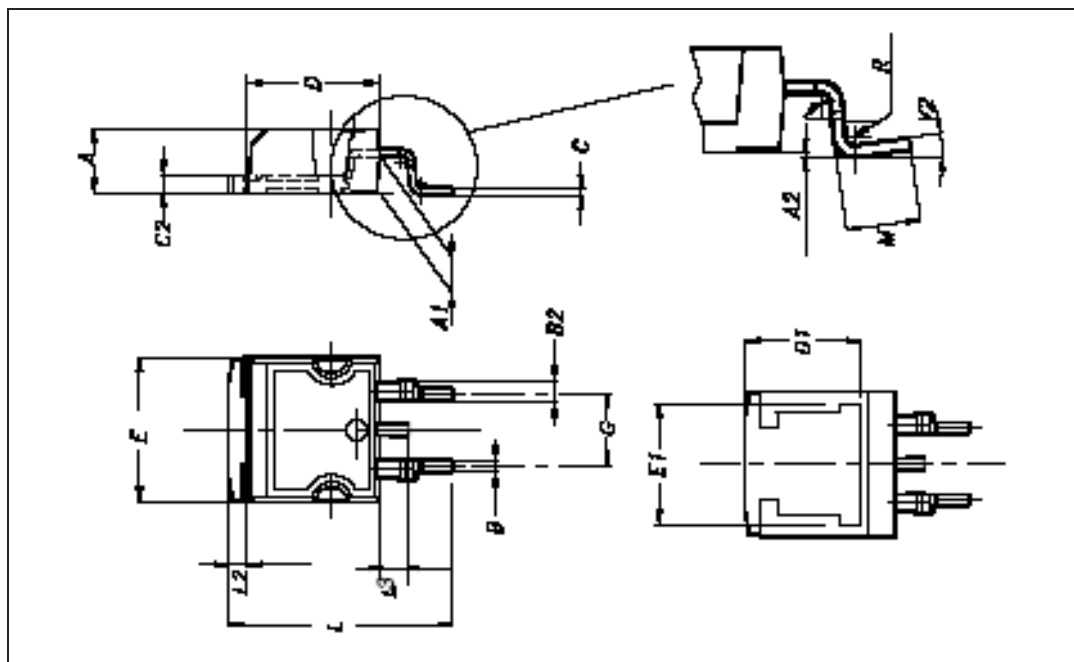
TO-262 (I²PAK) mechanical data

| 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 |



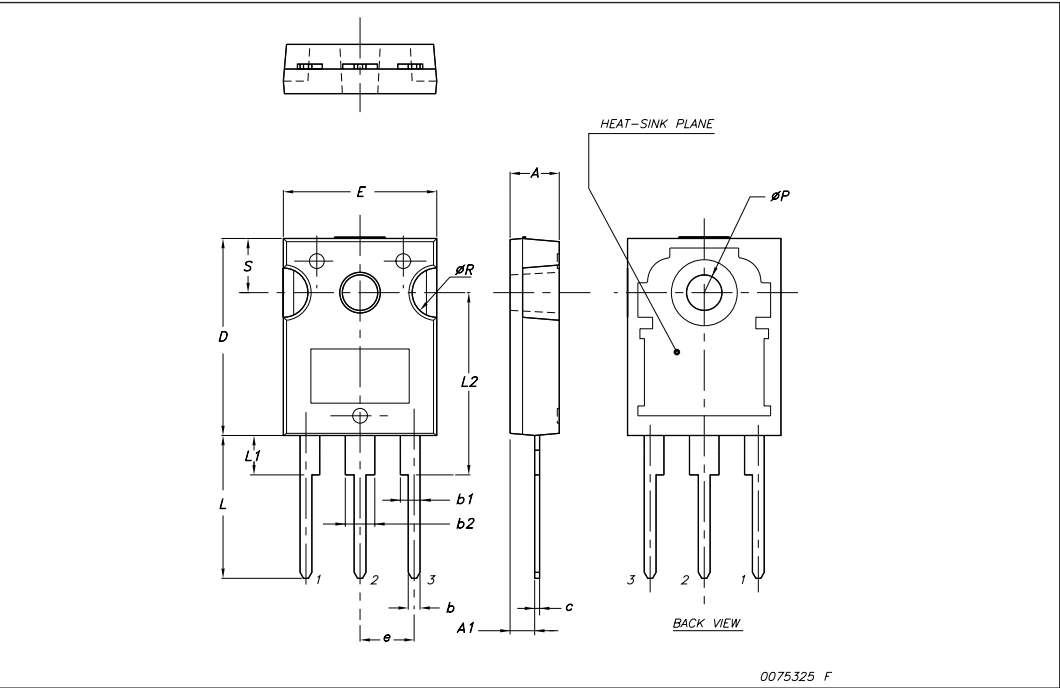
D²PAK mechanical data

| 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 | | 0.409 |
| 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 | 0.50 | | 0.55 |
| L3 | 1.4 | | 1.75 | 0.055 | | 0.68 |
| M | 2.4 | | 3.2 | 0.094 | | 0.126 |
| R | | 0.4 | | | 0.015 | |
| V2 | 0° | | 4° | | | |



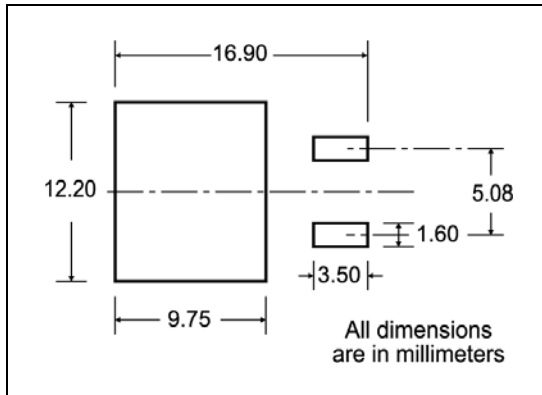
TO-247 mechanical data

| Dim. | mm. | | |
|------|-------|-------|-------|
| | Min. | Typ | Max. |
| A | 4.85 | | 5.15 |
| A1 | 2.20 | | 2.60 |
| b | 1.0 | | 1.40 |
| b1 | 2.0 | | 2.40 |
| b2 | 3.0 | | 3.40 |
| c | 0.40 | | 0.80 |
| D | 19.85 | | 20.15 |
| E | 15.45 | | 15.75 |
| e | | 5.45 | |
| L | 14.20 | | 14.80 |
| L1 | 3.70 | | 4.30 |
| L2 | | 18.50 | |
| øP | 3.55 | | 3.65 |
| øR | 4.50 | | 5.50 |
| S | | 5.50 | |



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 |

* on sales type

6 Revision history

Table 9. Document revision history

| Date | Revision | Changes |
|-------------|----------|---------------|
| 22-Jan-2008 | 1 | First release |

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