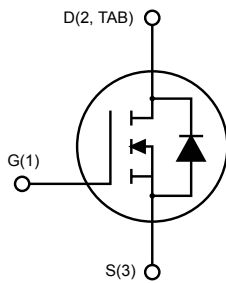
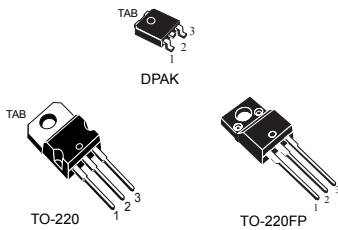


N-channel 600 V, 0.63 Ω typ., 6.5 A MDmesh™ II Power MOSFETs in DPAK, TO-220FP and TO-220 packages



AM01475v1_noZen

Features

| Order code | V_{DS} | $R_{DS(on)}$ max. | I_D | Package |
|------------|----------|-------------------|-------|----------|
| STD9NM60N | 600 V | 0.745 Ω | 6.5 A | DPAK |
| STF9NM60N | | | | TO-220FP |
| STP9NM60N | | | | TO-220 |

- 100% avalanche tested
- Low input capacitance and gate charge
- Low gate input resistance

Applications

- Switching applications

Description

These devices are N-channel Power MOSFETs developed using the second generation of MDmesh™ technology. These revolutionary Power MOSFETs associate a vertical structure to the company's strip layout to yield one of the world's lowest on-resistance and gate charge. They are therefore suitable for the most demanding high-efficiency converters.

Product status link

[STD9NM60N](#)
[STF9NM60N](#)
[STP9NM60N](#)

1 Electrical ratings

Table 1. Absolute maximum ratings

| Symbol | Parameter | Value | | Unit |
|----------------|---|--------------|--------------------|------|
| | | DPAK, TO-220 | TO-220FP | |
| V_{DS} | Drain-source voltage | 600 | | V |
| V_{GS} | Gate-source voltage | ±25 | | V |
| I_D | Drain current (continuous) at $T_C = 25\text{ °C}$ | 6.5 | 6.5 ⁽¹⁾ | A |
| I_D | Drain current (continuous) at $T_C = 100\text{ °C}$ | 4 | 4 ⁽¹⁾ | A |
| $I_{DM}^{(2)}$ | Drain current (pulsed) | 26 | 26 ⁽¹⁾ | A |
| P_{TOT} | Total dissipation at $T_C = 25\text{ °C}$ | 70 | 25 | W |
| $dv/dt^{(3)}$ | Peak diode recovery voltage slope | 15 | | V/ns |
| V_{ISO} | Insulation withstand voltage (RMS) from all three leads to external heat sink ($t = 1\text{ s}$; $T_C = 25\text{ °C}$) | 2.5 | | kV |
| T_j | Operating junction temperature range | -55 to 150 | | °C |
| T_{stg} | Storage temperature range | | | |

- Limited by maximum junction temperature.
- Pulse width limited by safe operating area.
- $I_{SD} \leq 6.5\text{ A}$, $di/dt \leq 400\text{ A}/\mu\text{s}$, $V_{DD} = 80\% V_{(BR)DSS}$.

Table 2. Thermal data

| Symbol | Parameter | Value | | | Unit |
|---------------------|-------------------------------------|-------|--------|----------|------|
| | | DPAK | TO-220 | TO-220FP | |
| $R_{thj-case}$ | Thermal resistance junction-case | 1.79 | | 5 | °C/W |
| $R_{thj-amb}$ | Thermal resistance junction-ambient | 62.5 | | | |
| $R_{thj-pcb}^{(1)}$ | Thermal resistance junction-pcb | 50 | | | |

- When mounted on 1inch² FR-4, 2 Oz copper board.

Table 3. Avalanche characteristics

| Symbol | Parameter | Value | Unit |
|----------|--|-------|------|
| I_{AR} | Avalanche current, repetitive or not-repetitive (pulse width limited by $T_j\text{ Max}$) | 2.5 | A |
| E_{AS} | Single pulse avalanche energy (starting $T_j = 25\text{ °C}$, $I_D = I_{AR}$, $V_{DD} = 50\text{ V}$) | 115 | mJ |

2 Electrical characteristics

($T_{CASE} = 25\text{ °C}$ unless otherwise specified)

Table 4. On/off states

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---------------|-----------------------------------|--|------|------|-------|---------------|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage | $I_D = 1\text{ mA}$, $V_{GS} = 0\text{ V}$ | 600 | | | V |
| I_{DSS} | Zero gate voltage drain current | $V_{GS} = 0\text{ V}$, $V_{DS} = 600\text{ V}$ | | | 1 | μA |
| | | $V_{GS} = 0\text{ V}$, $V_{DS} = 600\text{ V}$, $T_C = 125\text{ °C}$ ⁽¹⁾ | | | 100 | μA |
| I_{GSS} | Gate body leakage current | $V_{DS} = 0\text{ V}$, $V_{GS} = \pm 20\text{ V}$ | | | 100 | nA |
| $V_{GS(th)}$ | Gate threshold voltage | $V_{DS} = V_{GS}$, $I_D = 250\text{ }\mu\text{A}$ | 2 | 3 | 4 | V |
| $R_{DS(on)}$ | Static drain-source on resistance | $V_{GS} = 10\text{ V}$, $I_D = 3.25\text{ A}$ | | 0.63 | 0.745 | Ω |

1. Defined by design, not subject to production test.

Table 5. Dynamic

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|----------------------------|-------------------------------|---|------|------|------|---------------|
| C_{iss} | Input capacitance | $V_{DS} = 50\text{ V}$, $f = 1\text{ MHz}$, $V_{GS} = 0\text{ V}$ | - | 452 | - | μF |
| C_{oss} | Output capacitance | | | 30 | | |
| C_{rss} | Reverse transfer capacitance | | | 1.45 | | |
| $C_{oss\text{ eq.}}^{(1)}$ | Equivalent output capacitance | $V_{DS} = 0\text{ to }480\text{ V}$, $V_{GS} = 0\text{ V}$ | - | 79 | - | μF |
| R_g | Gate input resistance | $f = 1\text{ MHz}$, $I_D = 0\text{ A}$ | - | 4.8 | - | Ω |
| Q_g | Total gate charge | $V_{DD} = 480\text{ V}$, $I_D = 6.5\text{ A}$, $V_{GS} = 0\text{ to }10\text{ V}$ (see Figure 17. Test circuit for gate charge behavior) | - | 17.4 | - | nC |
| Q_{gs} | Gate-source charge | | | 3 | | |
| Q_{gd} | Gate-drain charge | | | 9.7 | | |

1. $C_{oss\text{ eq.}}$ 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 6. Switching times

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|--------------|---------------------|---|------|------|------|------|
| $t_{d(on)}$ | Turn-on delay time | $V_{DD} = 480\text{ V}$, $I_D = 6.5\text{ A}$, $R_G = 4.7\text{ }\Omega$, $V_{GS} = 10\text{ V}$ | - | 28 | - | ns |
| t_r | Rise time | | | 23 | | |
| $t_{d(off)}$ | Turn-off delay time | (see Figure 16. Test circuit for resistive load switching times and Figure 21. Switching time waveform) | - | 52.5 | - | ns |
| t_f | Fall time | | | 26.7 | | |

Table 7. Source drain diode

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|-----------------|-------------------------------|--|------|------|------|---------------|
| I_{SD} | Source-drain current | | | | 6.5 | A |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) | | - | | 26 | |
| $V_{SD}^{(2)}$ | Forward on voltage | $I_{SD} = 6.5 \text{ A}$, $V_{GS} = 0 \text{ V}$ | - | | 1.6 | V |
| t_{rr} | Reverse recovery time | $I_{SD} = 6.5 \text{ A}$, $di/dt = 100 \text{ A}/\mu\text{s}$ | | 264 | | ns |
| Q_{rr} | Reverse recovery charge | $V_{DD} = 60 \text{ V}$ (see Figure 18. Test circuit for inductive load switching and diode recovery times) | - | 1.9 | | μC |
| I_{RRM} | Reverse recovery current | | | 14.6 | | A |
| t_{rr} | Reverse recovery time | $I_{SD} = 6.5 \text{ A}$, $di/dt = 100 \text{ A}/\mu\text{s}$ | | 324 | | ns |
| Q_{rr} | Reverse recovery charge | $V_{DD} = 60 \text{ V}$ (see Figure 18. Test circuit for inductive load switching and diode recovery times) | - | 2.3 | | μC |
| I_{RRM} | Reverse recovery current | | | 14.2 | | A |

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

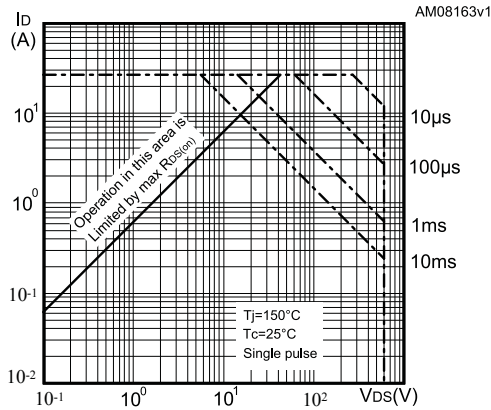
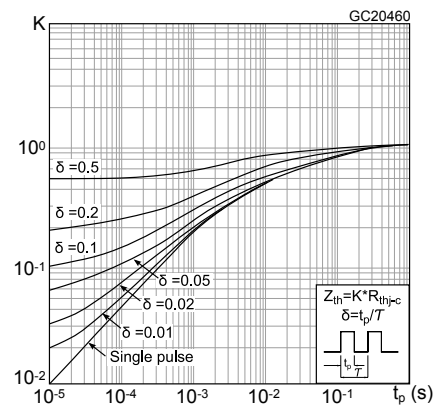
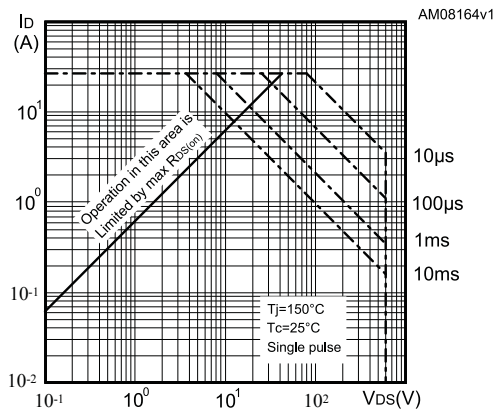
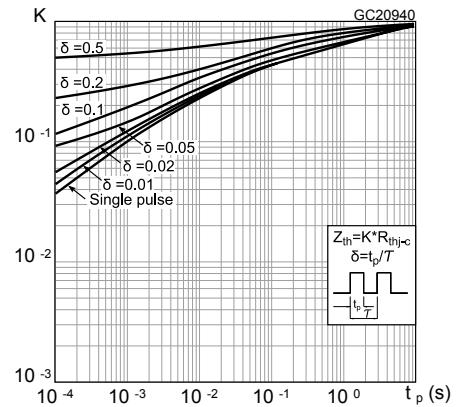
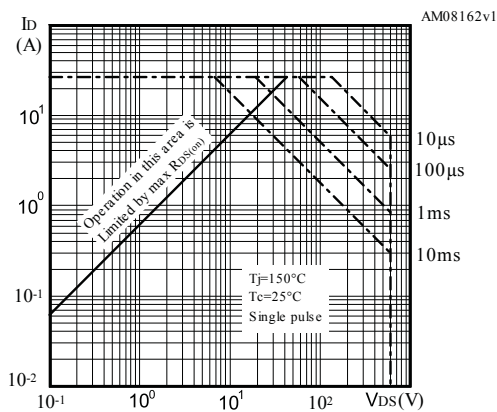
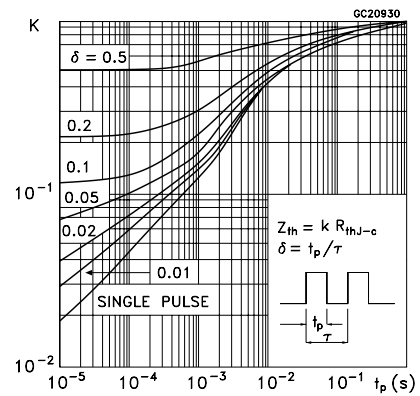
2.1 Electrical characteristics curves
Figure 1. Safe operating area for DPAK

Figure 2. Thermal impedance for DPAK

Figure 3. Safe operating area for TO-220FP

Figure 4. Thermal impedance for TO-220FP

Figure 5. Safe operating area for TO-220

Figure 6. Thermal impedance for TO-220


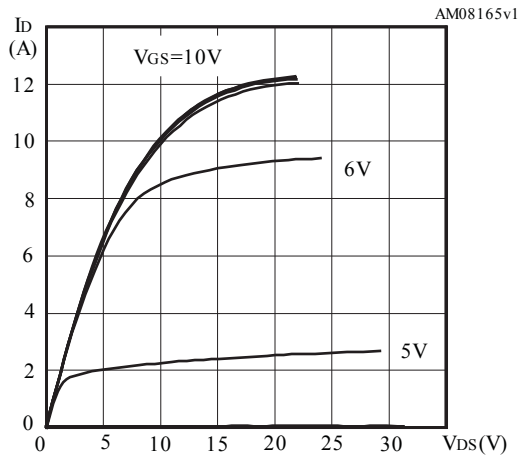
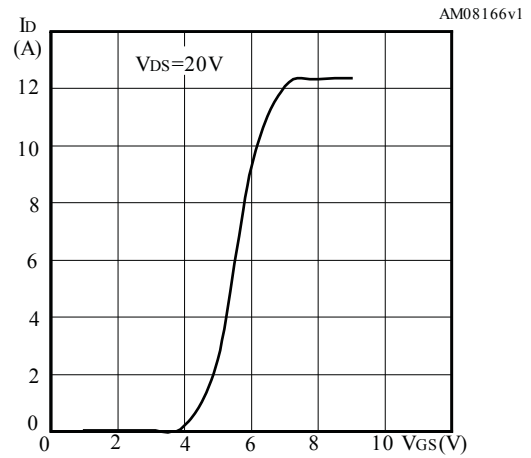
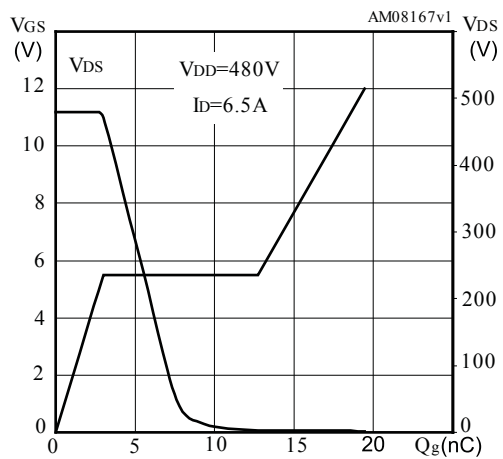
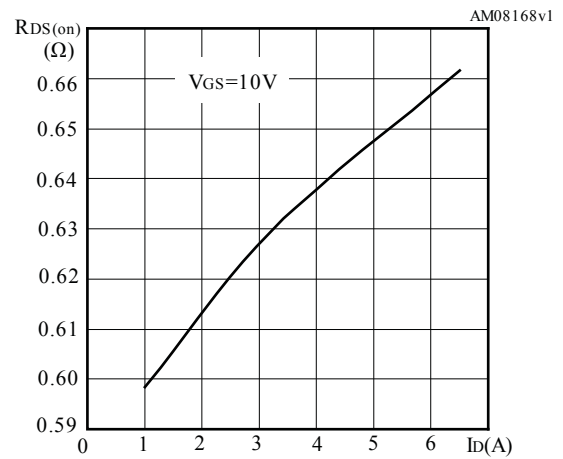
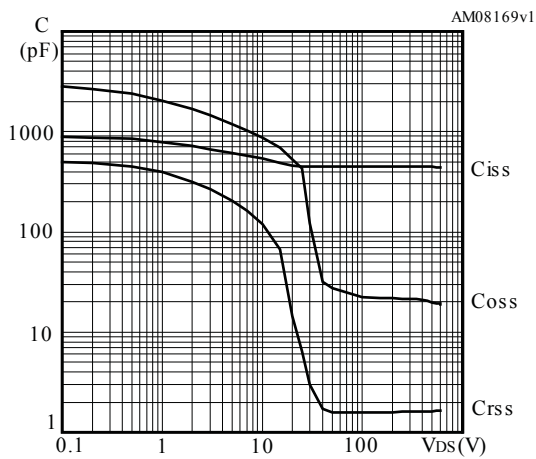
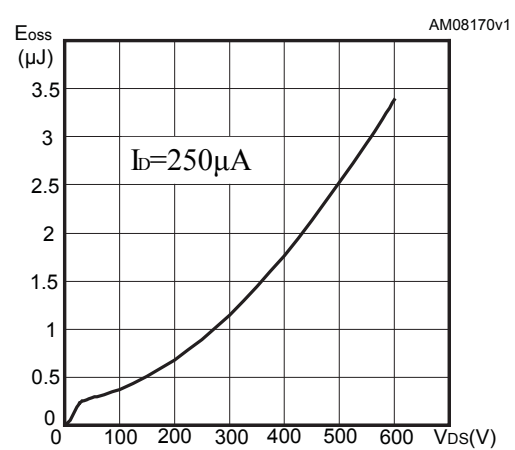
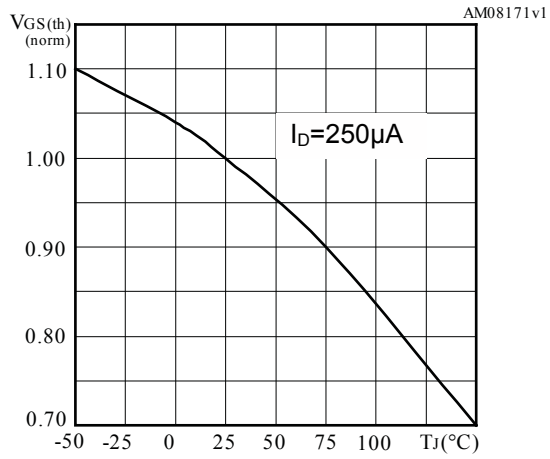
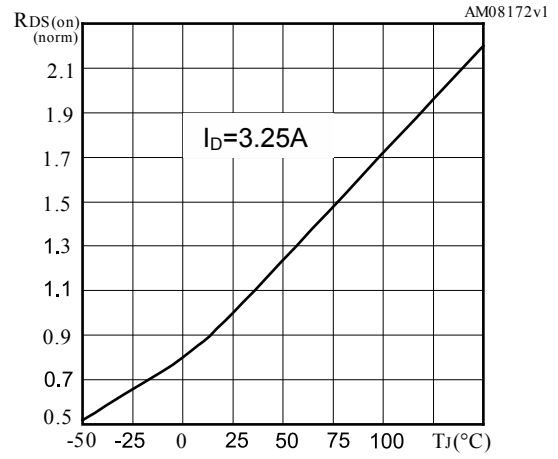
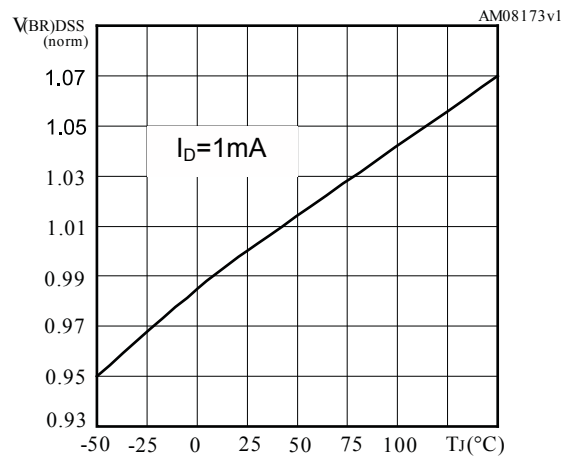
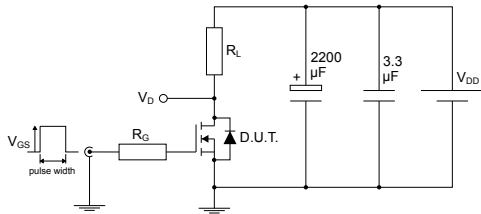
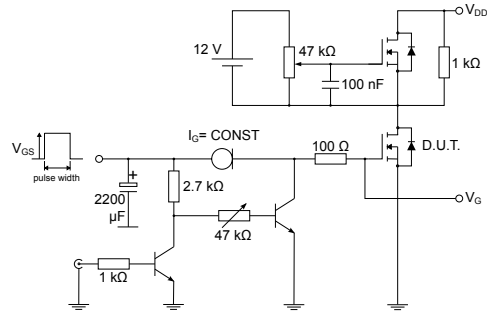
Figure 7. Output characteristics

Figure 8. Transfer characteristics

Figure 9. Gate charge vs gate-source voltage

Figure 10. Static drain-source on resistance

Figure 11. Capacitance variations

Figure 12. Output capacitance stored energy


Figure 13. Normalized gate threshold voltage vs temperature

Figure 14. Normalized on resistance vs temperature

Figure 15. Normalized $V_{(BR)DSS}$ vs temperature


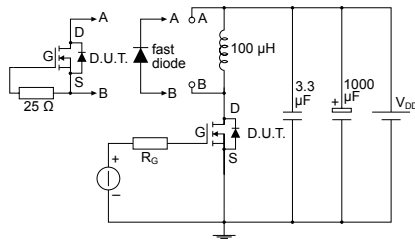
3 Test circuits

Figure 16. Test circuit for resistive load switching times


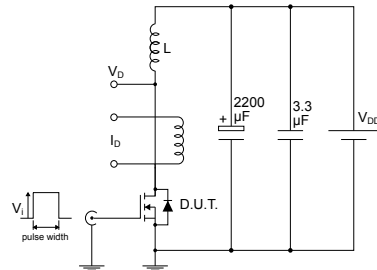
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Figure 17. Test circuit for gate charge behavior


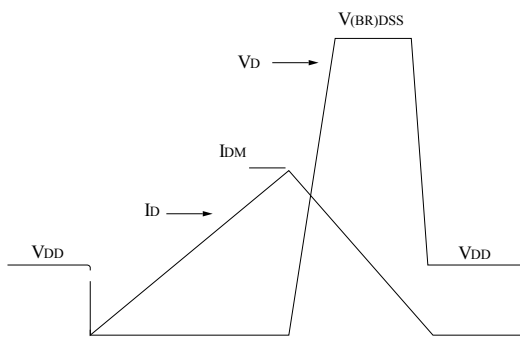
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Figure 18. Test circuit for inductive load switching and diode recovery times


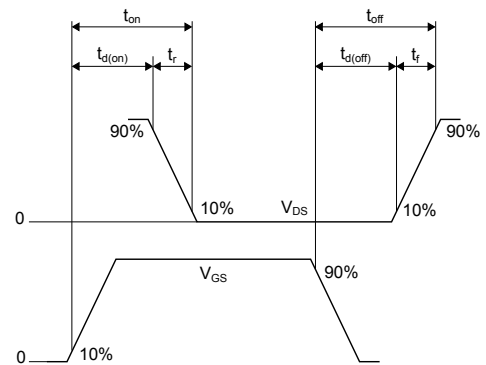
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Figure 19. Unclamped inductive load test circuit


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Figure 20. Unclamped inductive waveform


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Figure 21. Switching time waveform


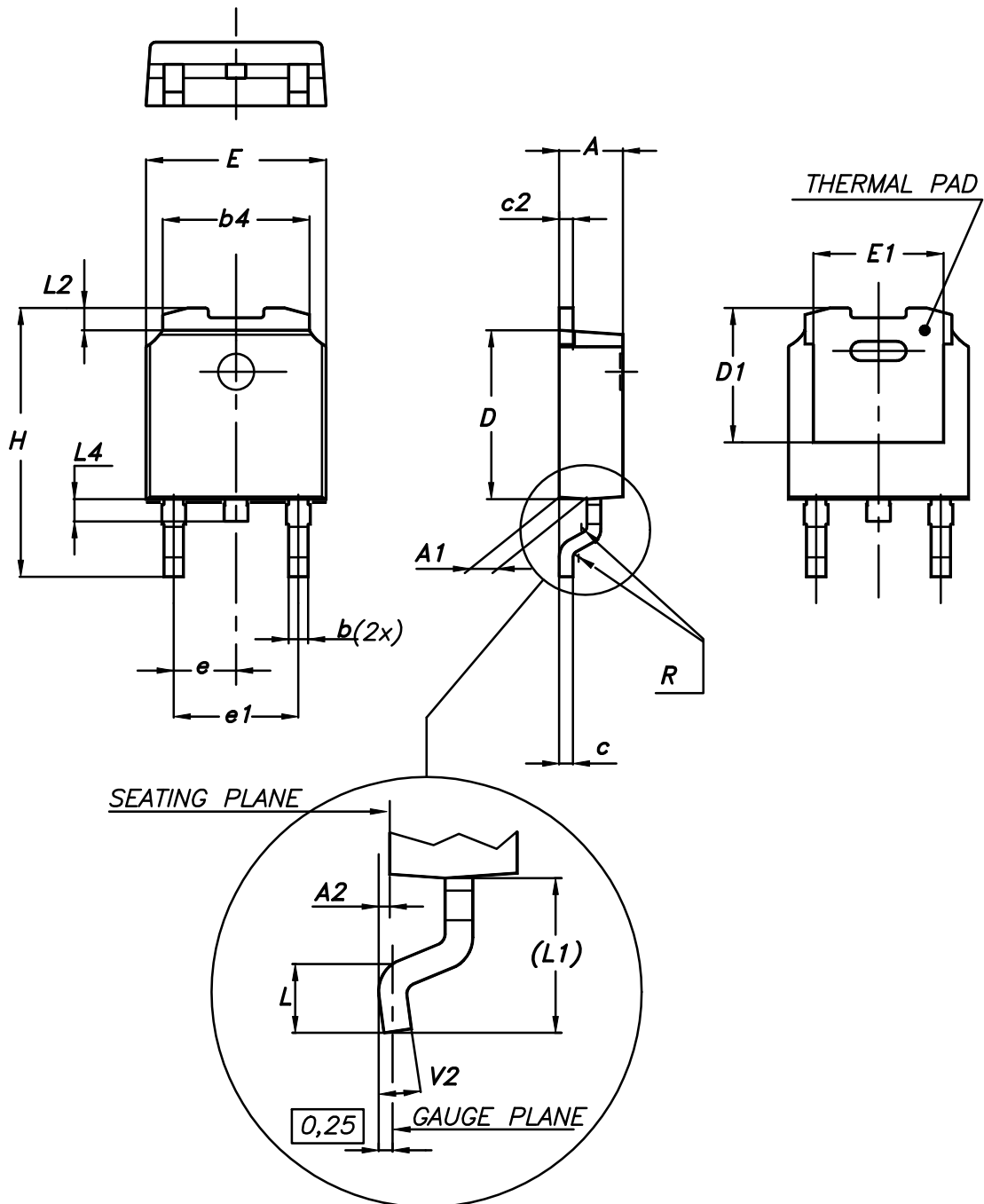
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4 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: www.st.com. ECOPACK® is an ST trademark.

4.1 DPAK (TO-252) type A package information

Figure 22. DPAK (TO-252) type A package outline



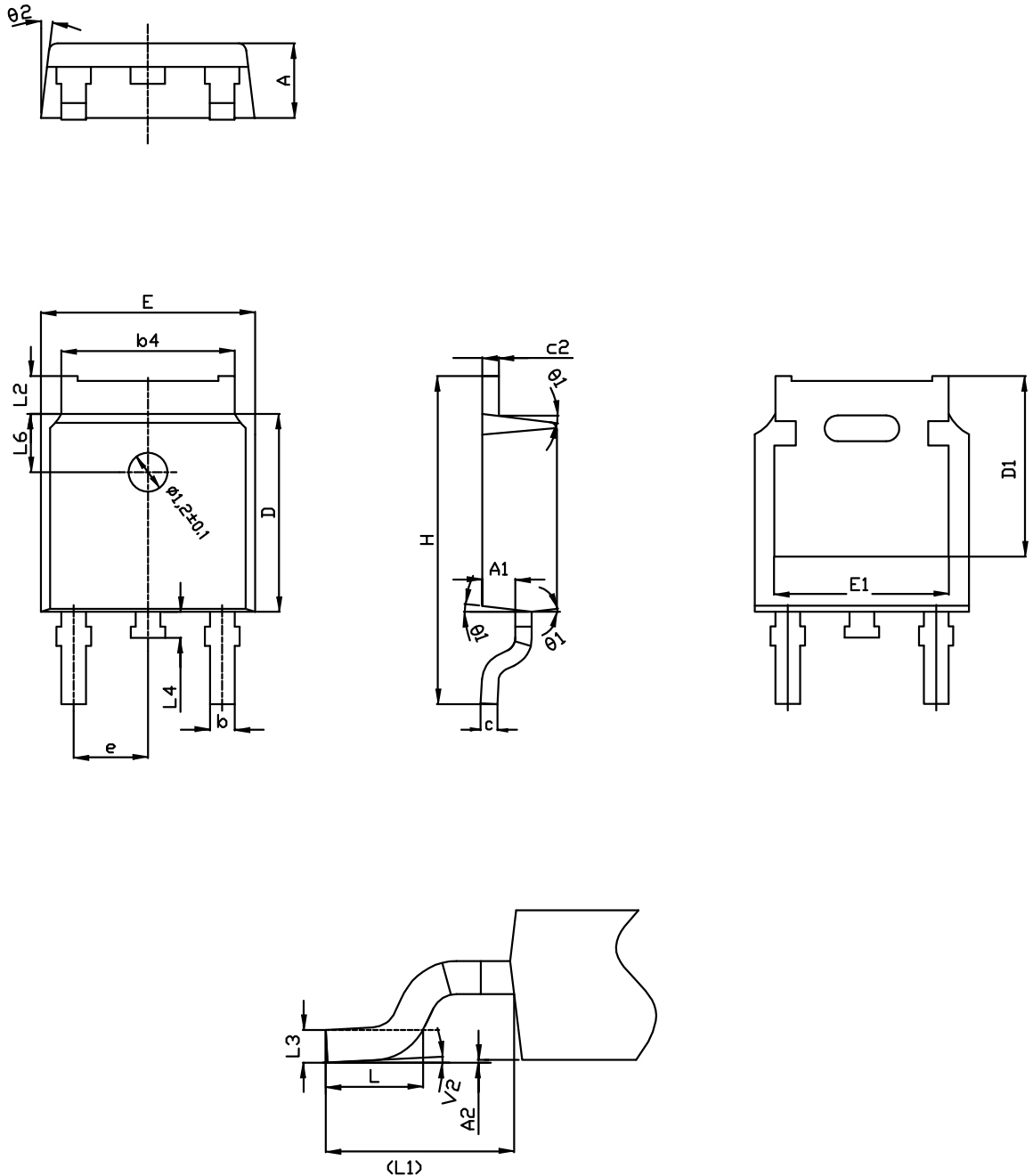
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Table 8. DPAK (TO-252) type A mechanical data

| Dim. | mm | | |
|------|-------|-------|-------|
| | Min. | Typ. | Max. |
| A | 2.20 | | 2.40 |
| A1 | 0.90 | | 1.10 |
| A2 | 0.03 | | 0.23 |
| b | 0.64 | | 0.90 |
| b4 | 5.20 | | 5.40 |
| c | 0.45 | | 0.60 |
| c2 | 0.48 | | 0.60 |
| D | 6.00 | | 6.20 |
| D1 | 4.95 | 5.10 | 5.25 |
| E | 6.40 | | 6.60 |
| E1 | 4.60 | 4.70 | 4.80 |
| e | 2.159 | 2.286 | 2.413 |
| e1 | 4.445 | 4.572 | 4.699 |
| H | 9.35 | | 10.10 |
| L | 1.00 | | 1.50 |
| (L1) | 2.60 | 2.80 | 3.00 |
| L2 | 0.65 | 0.80 | 0.95 |
| L4 | 0.60 | | 1.00 |
| R | | 0.20 | |
| V2 | 0° | | 8° |

4.2 DPAK (TO-252) type C2 package information

Figure 23. DPAK (TO-252) type C2 package outline

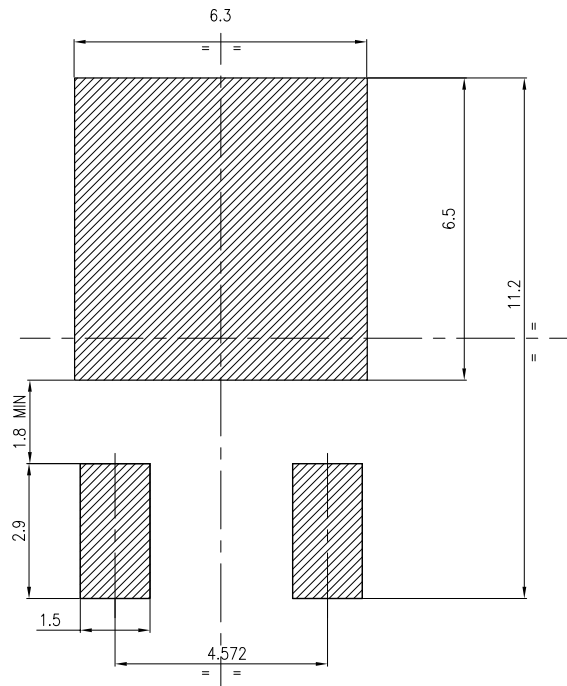


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Table 9. DPAK (TO-252) type C2 mechanical data

| Dim. | mm | | |
|------|----------|-------|-------|
| | Min. | Typ. | Max. |
| A | 2.20 | 2.30 | 2.38 |
| A1 | 0.90 | 1.01 | 1.10 |
| A2 | 0.00 | | 0.10 |
| b | 0.72 | | 0.85 |
| b4 | 5.13 | 5.33 | 5.46 |
| c | 0.47 | | 0.60 |
| c2 | 0.47 | | 0.60 |
| D | 6.00 | 6.10 | 6.20 |
| D1 | 5.10 | | 5.60 |
| E | 6.50 | 6.60 | 6.70 |
| E1 | 5.20 | | 5.50 |
| e | 2.186 | 2.286 | 2.386 |
| H | 9.80 | 10.10 | 10.40 |
| L | 1.40 | 1.50 | 1.70 |
| L1 | 2.90 REF | | |
| L2 | 0.90 | | 1.25 |
| L3 | 0.51 BSC | | |
| L4 | 0.60 | 0.80 | 1.00 |
| L6 | 1.80 BSC | | |
| θ1 | 5° | 7° | 9° |
| θ2 | 5° | 7° | 9° |
| V2 | 0° | | 8° |

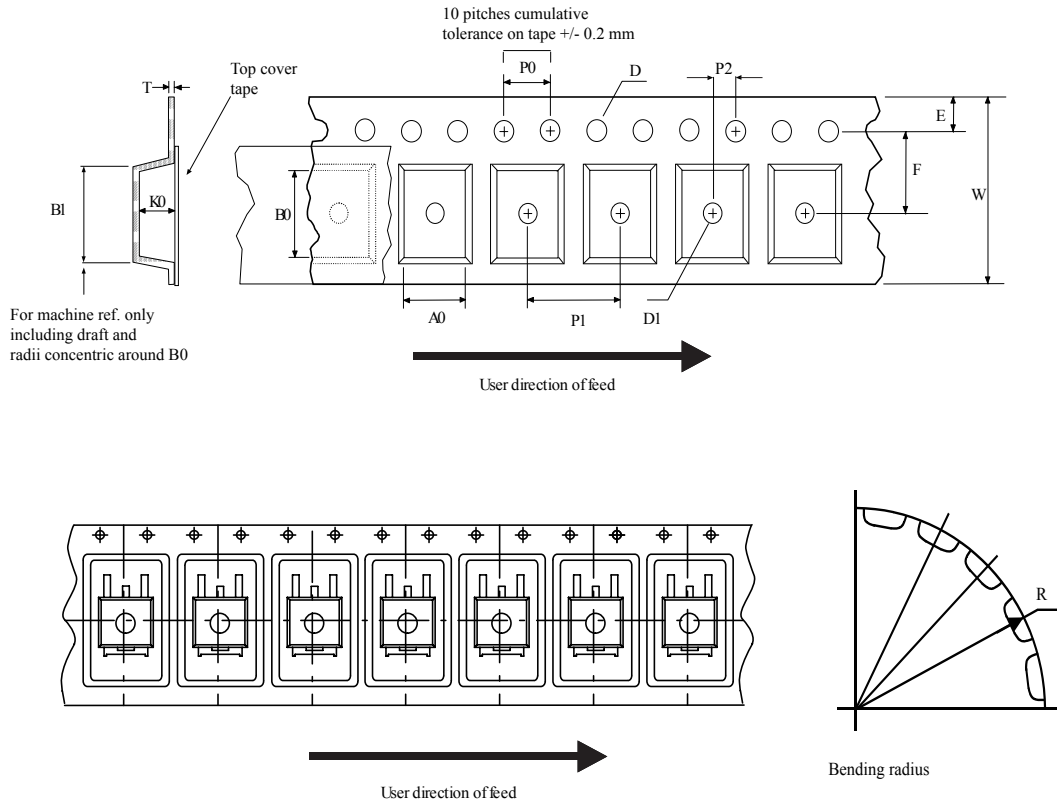
Figure 24. DPAK (TO-252) recommended footprint (dimensions are in mm)



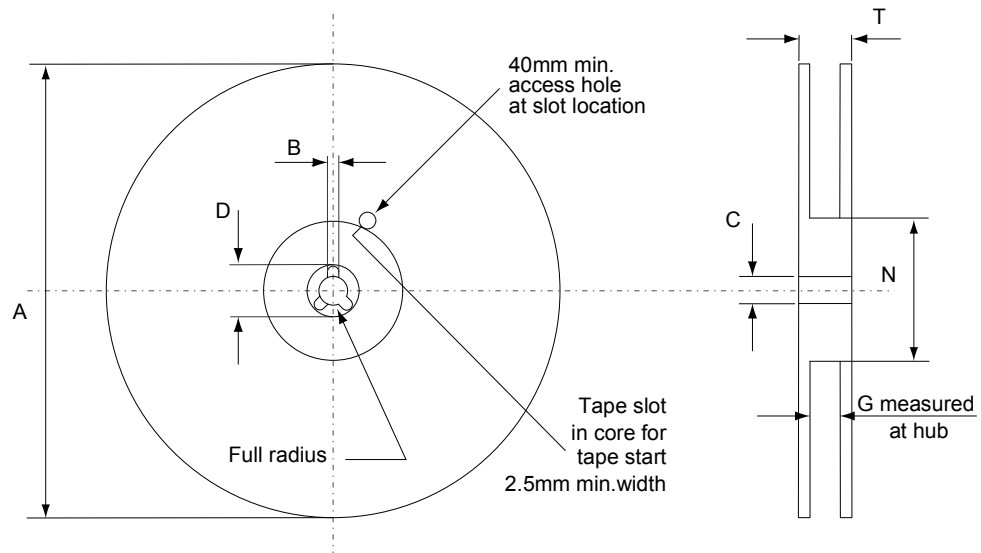
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4.3 DPAK (TO-252) packing information

Figure 25. DPAK (TO-252) tape outline



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Figure 26. DPAK (TO-252) reel outline


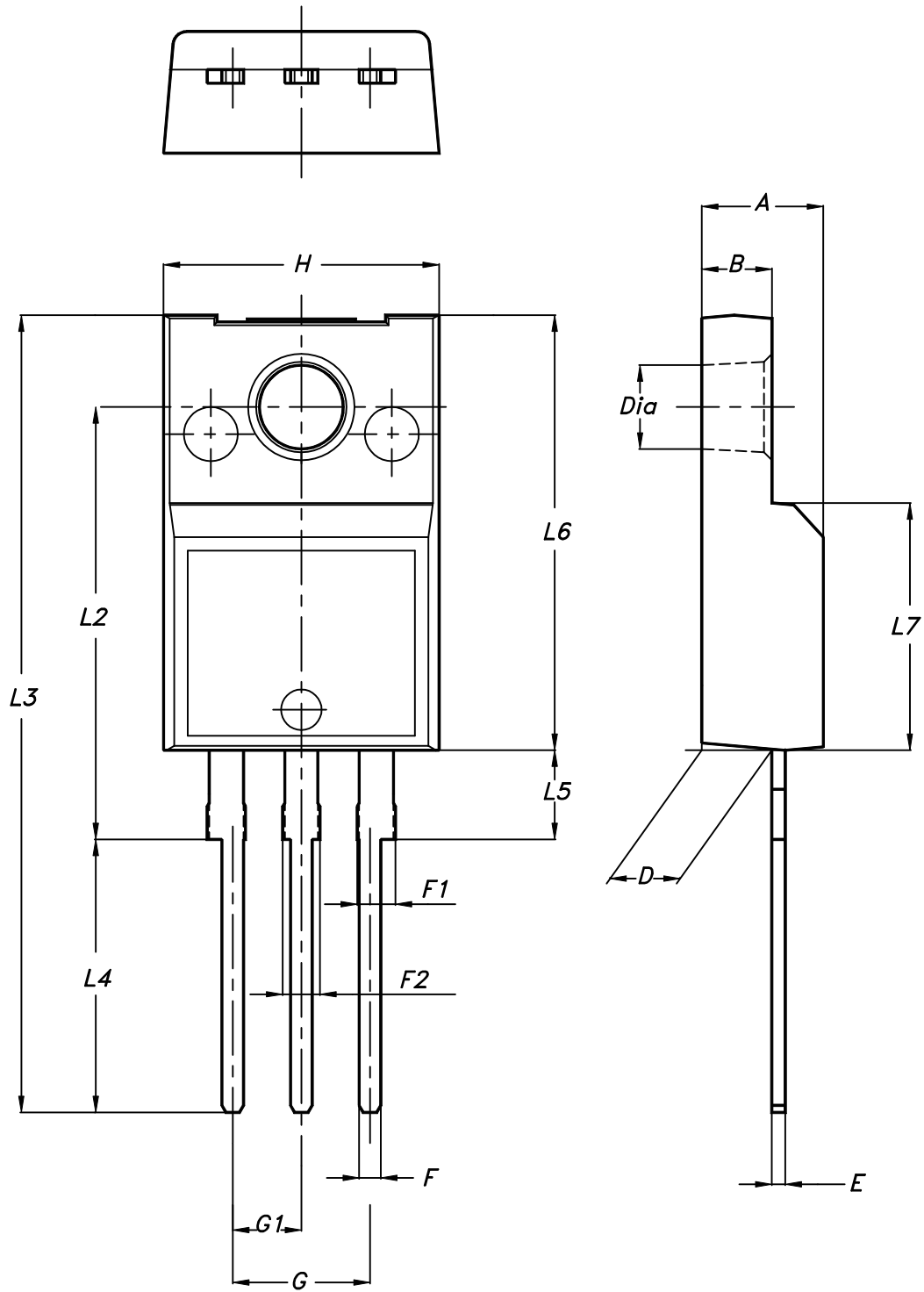
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Table 10. DPAK (TO-252) tape and reel mechanical data

| Tape | | | Reel | | |
|------|------|------|-----------|------|------|
| Dim. | mm | | Dim. | mm | |
| | Min. | Max. | | Min. | Max. |
| A0 | 6.8 | 7 | A | | 330 |
| B0 | 10.4 | 10.6 | B | 1.5 | |
| B1 | | 12.1 | C | 12.8 | 13.2 |
| D | 1.5 | 1.6 | D | 20.2 | |
| D1 | 1.5 | | G | 16.4 | 18.4 |
| E | 1.65 | 1.85 | N | 50 | |
| F | 7.4 | 7.6 | T | | 22.4 |
| K0 | 2.55 | 2.75 | | | |
| P0 | 3.9 | 4.1 | Base qty. | | 2500 |
| P1 | 7.9 | 8.1 | Bulk qty. | | 2500 |
| P2 | 1.9 | 2.1 | | | |
| R | 40 | | | | |
| T | 0.25 | 0.35 | | | |
| W | 15.7 | 16.3 | | | |

4.4 TO-220FP package information

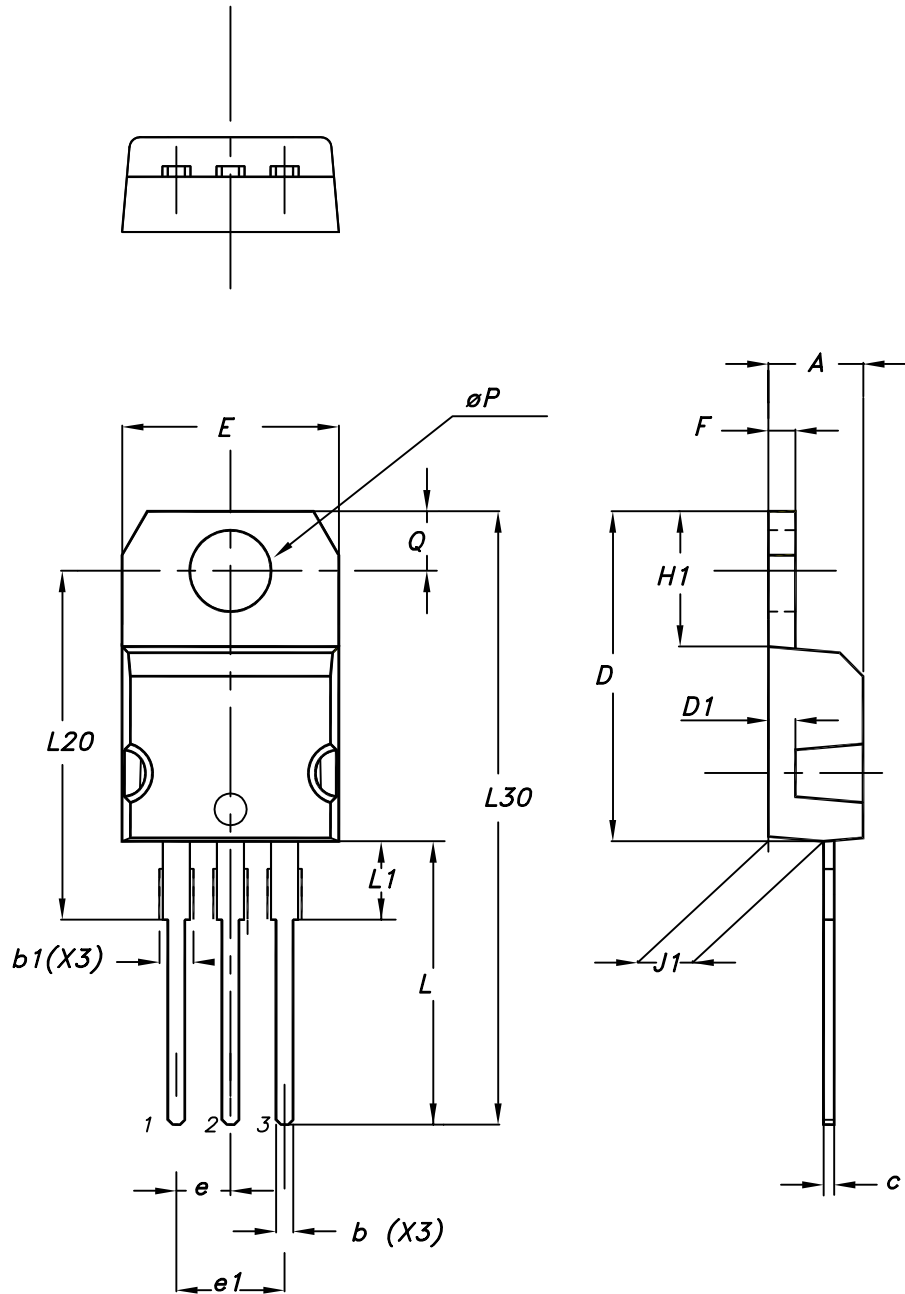
Figure 27. TO-220FP package outline



7012510_Rev_12_B

Table 11. TO-220FP package mechanical data

| Dim. | mm | | |
|------|------|------|------|
| | Min. | Typ. | Max. |
| A | 4.4 | | 4.6 |
| B | 2.5 | | 2.7 |
| D | 2.5 | | 2.75 |
| E | 0.45 | | 0.7 |
| F | 0.75 | | 1 |
| F1 | 1.15 | | 1.70 |
| F2 | 1.15 | | 1.70 |
| G | 4.95 | | 5.2 |
| G1 | 2.4 | | 2.7 |
| H | 10 | | 10.4 |
| L2 | | 16 | |
| L3 | 28.6 | | 30.6 |
| L4 | 9.8 | | 10.6 |
| L5 | 2.9 | | 3.6 |
| L6 | 15.9 | | 16.4 |
| L7 | 9 | | 9.3 |
| Dia | 3 | | 3.2 |

4.5 TO-220 type A package information
Figure 28. TO-220 type A package outline


0015988_typeA_Rev_21

Table 12. TO-220 type A package mechanical data

| Dim. | mm | | |
|------|-------|-------|-------|
| | Min. | Typ. | Max. |
| A | 4.40 | | 4.60 |
| b | 0.61 | | 0.88 |
| b1 | 1.14 | | 1.55 |
| c | 0.48 | | 0.70 |
| D | 15.25 | | 15.75 |
| D1 | | 1.27 | |
| E | 10.00 | | 10.40 |
| e | 2.40 | | 2.70 |
| e1 | 4.95 | | 5.15 |
| F | 1.23 | | 1.32 |
| H1 | 6.20 | | 6.60 |
| J1 | 2.40 | | 2.72 |
| L | 13.00 | | 14.00 |
| L1 | 3.50 | | 3.93 |
| L20 | | 16.40 | |
| L30 | | 28.90 | |
| øP | 3.75 | | 3.85 |
| Q | 2.65 | | 2.95 |

5 Ordering information

Table 13. Order codes

| Order code | Marking | Package | Packing |
|------------|---------|----------|---------------|
| STD9NM60N | 9NM60N | DPAK | Tape and reel |
| STF9NM60N | | TO-220FP | Tube |
| STP9NM60N | | TO-220 | |

Revision history

Table 14. Document revision history

| Date | Version | Changes |
|-------------|---------|---|
| 20-Oct-2010 | 1 | First release. |
| 25-Sep-2018 | 2 | Removed maturity status indication from cover page. The document status is production data. Updated Section 4 Package information . Minor text changes. |

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