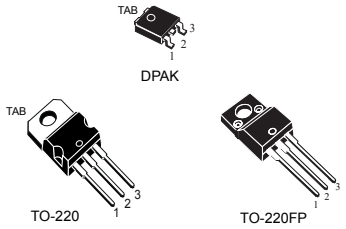
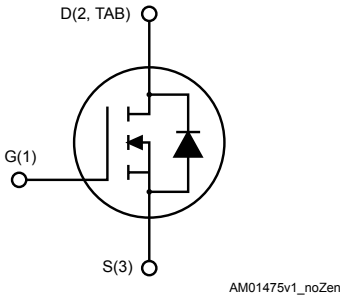
# THE DATASHEET OF

# STD9NM60N

Datasheet

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




## 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 °C | 6.5 | 6.5 (1) | A |
| $I_D$ | Drain current (continuous) at $T_C$ = 100 °C | 4 | 4 (1) | A |
| $I_{DM}$ (2) | Drain current (pulsed) | 26 | 26 (1) | A |
| $P_{TOT}$ | Total dissipation at $T_C$ = 25 °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 s; $T_c$ = 25 °C) | | 2.5 | kV |
| $T_j$ | Operating junction temperature range | -55 to 150 | | °C |
| $T_{stg}$ | Storage temperature range | | | |

1. *Limited by maximum junction temperature.*
2. *Pulse width limited by safe operating area.*
3. *$I_{SD}$ ≤ 6.5 A, di/dt ≤ 400 A/µs,, $V_{DD}$ = 80% $V_{(BR)DSS}$.*

**Table 2. Thermal data**

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

1. *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 $T_j$ Max) | 2.5 | A |
| $E_{AS}$ | Single pulse avalanche energy (starting $T_j$ = 25 °C, $I_D$ = $I_{AR}$, $V_{DD}$ = 50 V) | 115 | mJ |

# 2 Electrical characteristics

($T_{CASE}$ = 25 °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 mA, $V_{GS}$ = 0 V | 600 | | | V |
| $I_{DSS}$ | Zero gate voltage drain current | $V_{GS}$ = 0 V, $V_{DS}$ = 600 V | | | 1 | µA |
| | | $V_{GS}$ = 0 V, $V_{DS}$ = 600 V, $T_C$ = 125 °C (1) | | | 100 | µA |
| $I_{GSS}$ | Gate body leakage current | $V_{DS}$ = 0 V, $V_{GS}$ = ±20 V | | | 100 | nA |
| $V_{GS(th)}$ | Gate threshold voltage | $V_{DS}$ = $V_{GS}$, $I_D$ = 250 µA | 2 | 3 | 4 | V |
| $R_{DS(on)}$ | Static drain-source on resistance | $V_{GS}$ = 10 V, $I_D$ = 3.25 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 V, f = 1 MHz, $V_{GS}$ = 0 V | - | 452 | - | pF |
| $C_{oss}$ | Output capacitance | | | 30 | | |
| $C_{rss}$ | Reverse transfer capacitance | | | 1.45 | | |
| $C_{oss\ eq.}$ (1) | Equivalent output capacitance | $V_{DS}$ = 0 to 480 V, $V_{GS}$ = 0 V | - | 79 | - | pF |
| $R_g$ | Gate input resistance | f = 1 MHz, $I_D$ = 0 A | - | 4.8 | - | Ω |
| $Q_g$ | Total gate charge | $V_{DD}$ = 480 V, $I_D$ = 6.5 A, $V_{GS}$ = 0 to 10 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. *$C_{oss\ eq.}$ 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 V, $I_D$ = 6.5 A, $R_G$ = 4.7 Ω, $V_{GS}$ = 10 V (see Figure 16. Test circuit for resistive load switching times and Figure 21. Switching time waveform) | - | 28 | - | ns |
| $t_r$ | Rise time | | | 23 | | |
| $t_{d(off)}$ | Turn-off delay time | | | 52.5 | | |
| $t_f$ | 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 A, $V_{GS}$ = 0 V | - | | 1.6 | V |
| $t_{rr}$ | Reverse recovery time | $I_{SD}$ = 6.5 A, di/dt = 100 A/µs | - | 264 | | ns |
| $Q_{rr}$ | Reverse recovery charge | $V_{DD}$ = 60 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 A, di/dt = 100 A/µs | - | 324 | | ns |
| $Q_{rr}$ | Reverse recovery charge | $V_{DD}$ = 60 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**

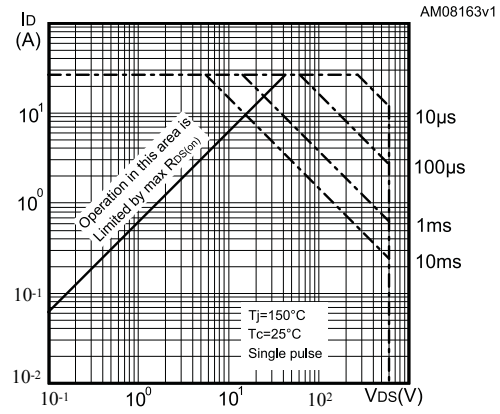



**Figure 2. Thermal impedance for DPAK**

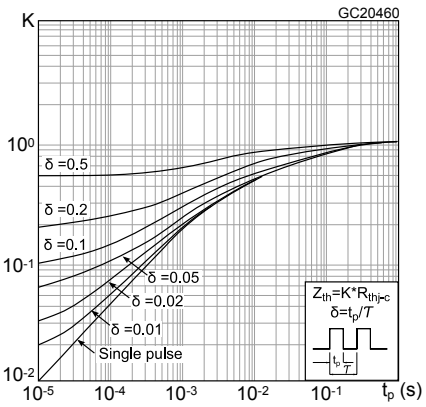



**Figure 3. Safe operating area for TO-220FP**

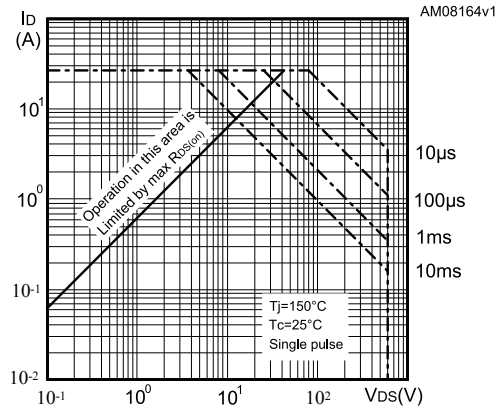



**Figure 4. Thermal impedance for TO-220FP**

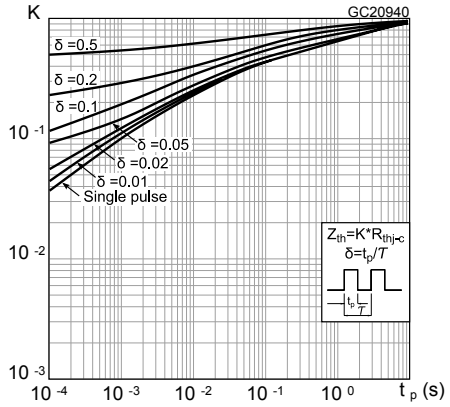



**Figure 5. Safe operating area for TO-220**

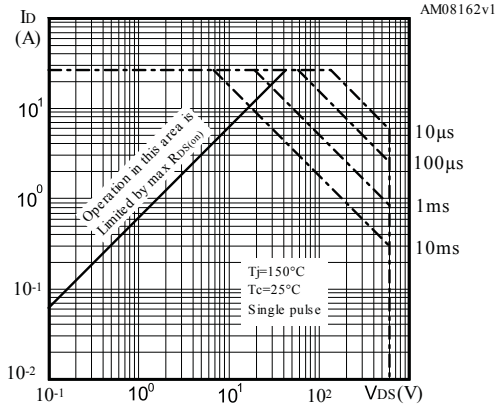



**Figure 6. Thermal impedance for TO-220**

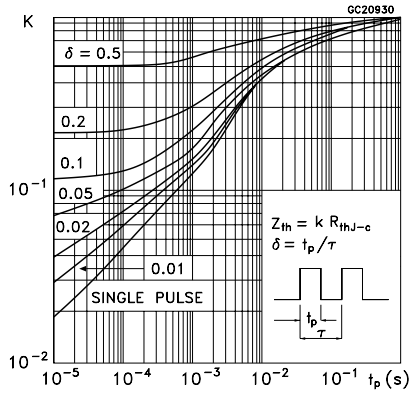


**Figure 7. Output characterisics**

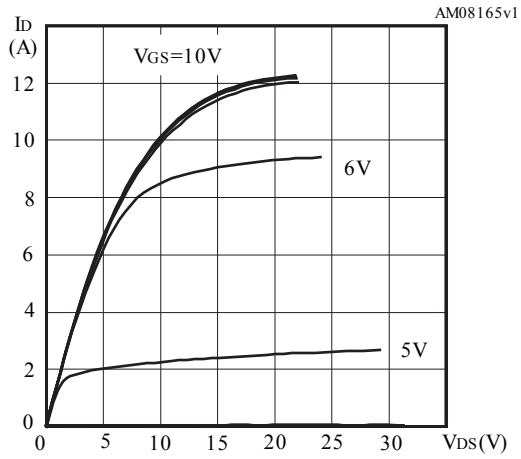



**Figure 8. Transfer characteristics**

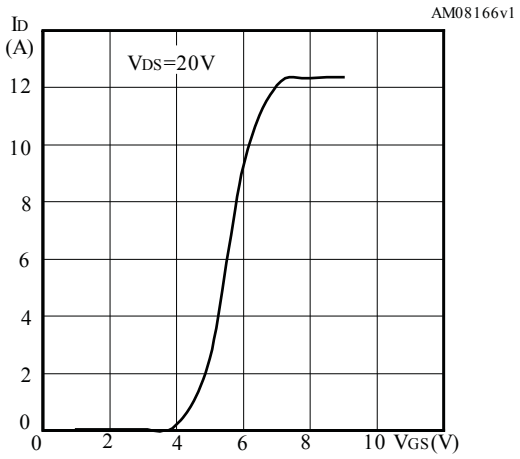



**Figure 9. Gate charge vs gate-source voltage**

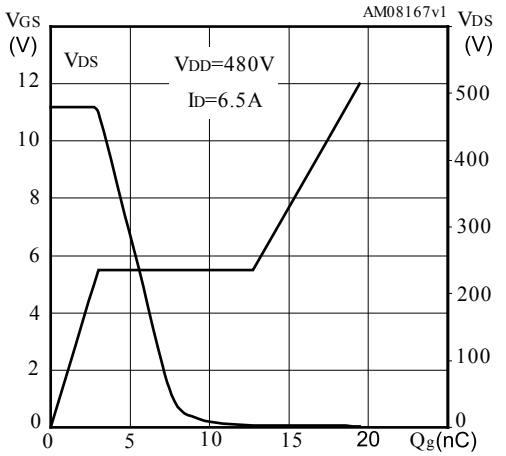



**Figure 10. Static drain-source on resistance**

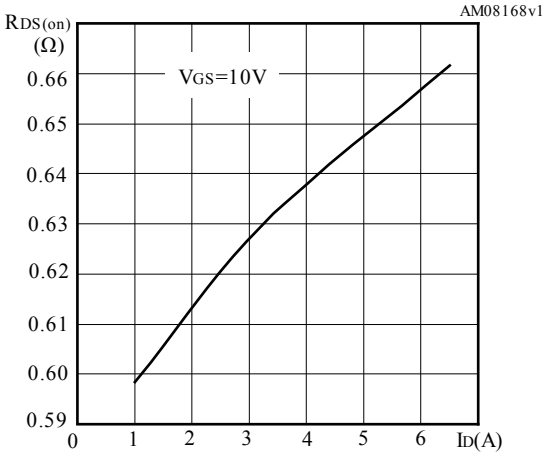



**Figure 11. Capacitance variations**

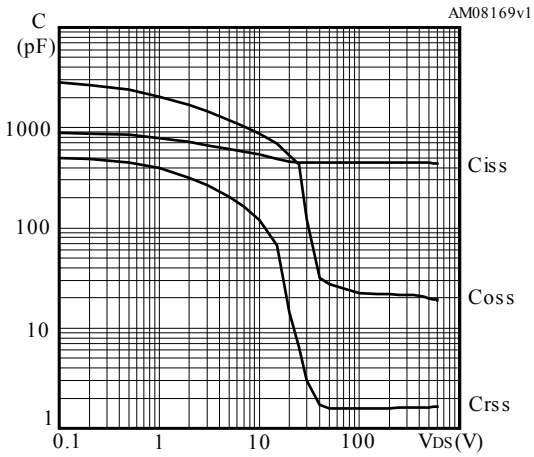



**Figure 12. Output capacitance stored energy**

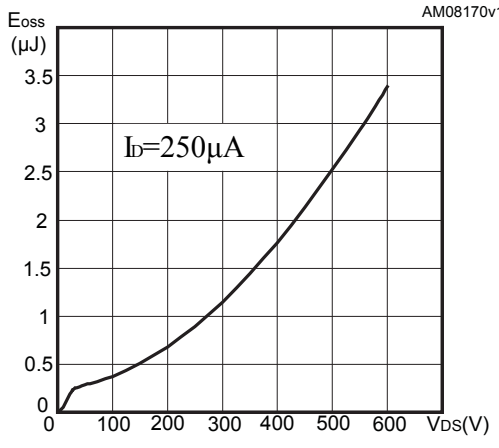


**Figure 13. Normalized gate threshold voltage vs temperature**

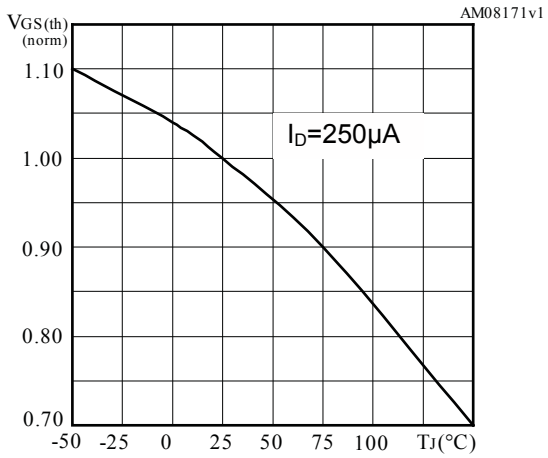



**Figure 14. Normalized on resistance vs temperature**

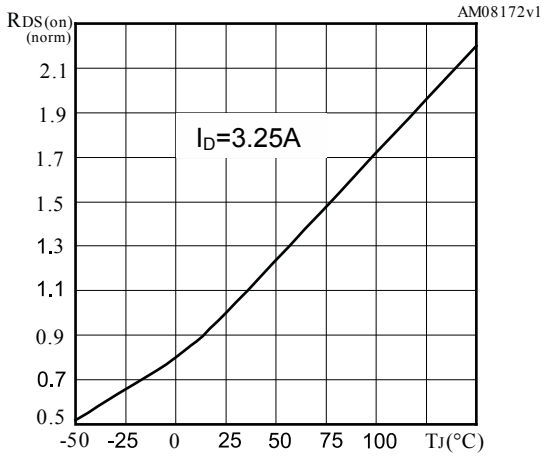
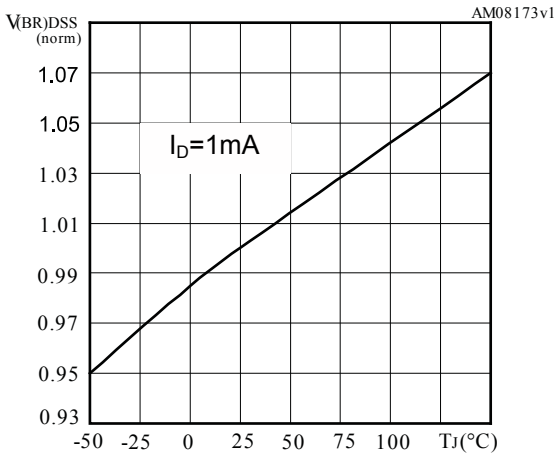



**Figure 15. Normalized $V_{(BR)DSS}$ vs temperature**



# 3 Test circuits

**Figure 16. Test circuit for resistive load switching times**

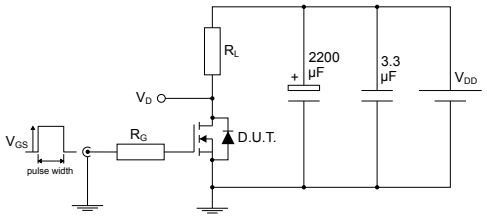



**Figure 17. Test circuit for gate charge behavior**

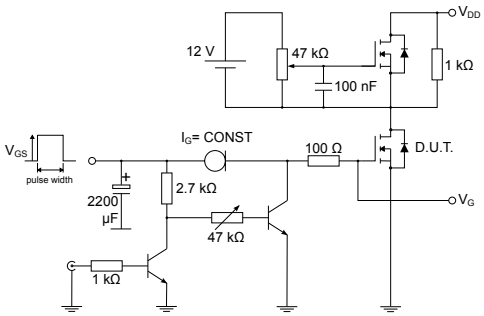



**Figure 18. Test circuit for inductive load switching and diode recovery times**

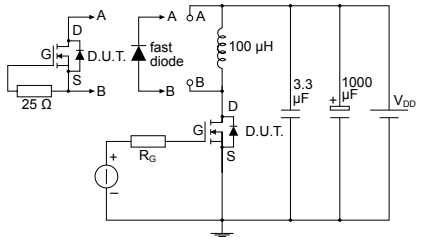



**Figure 19. Unclamped inductive load test circuit**

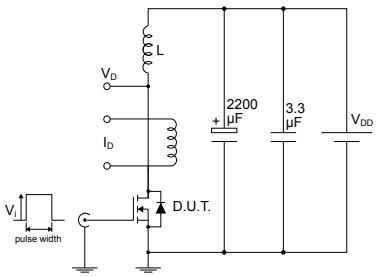



**Figure 20. Unclamped inductive waveform**

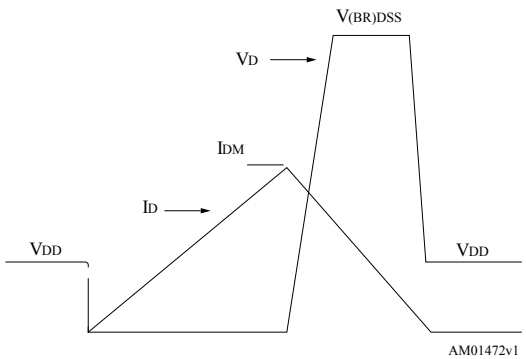
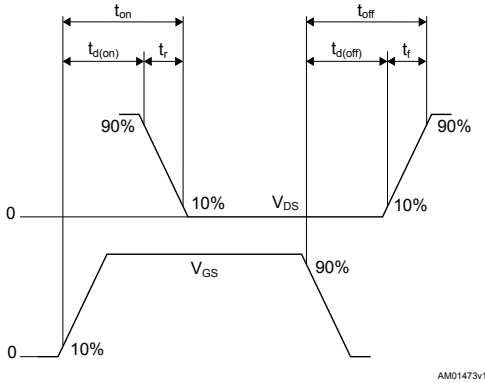



**Figure 21. Switching time waveform**



# 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**

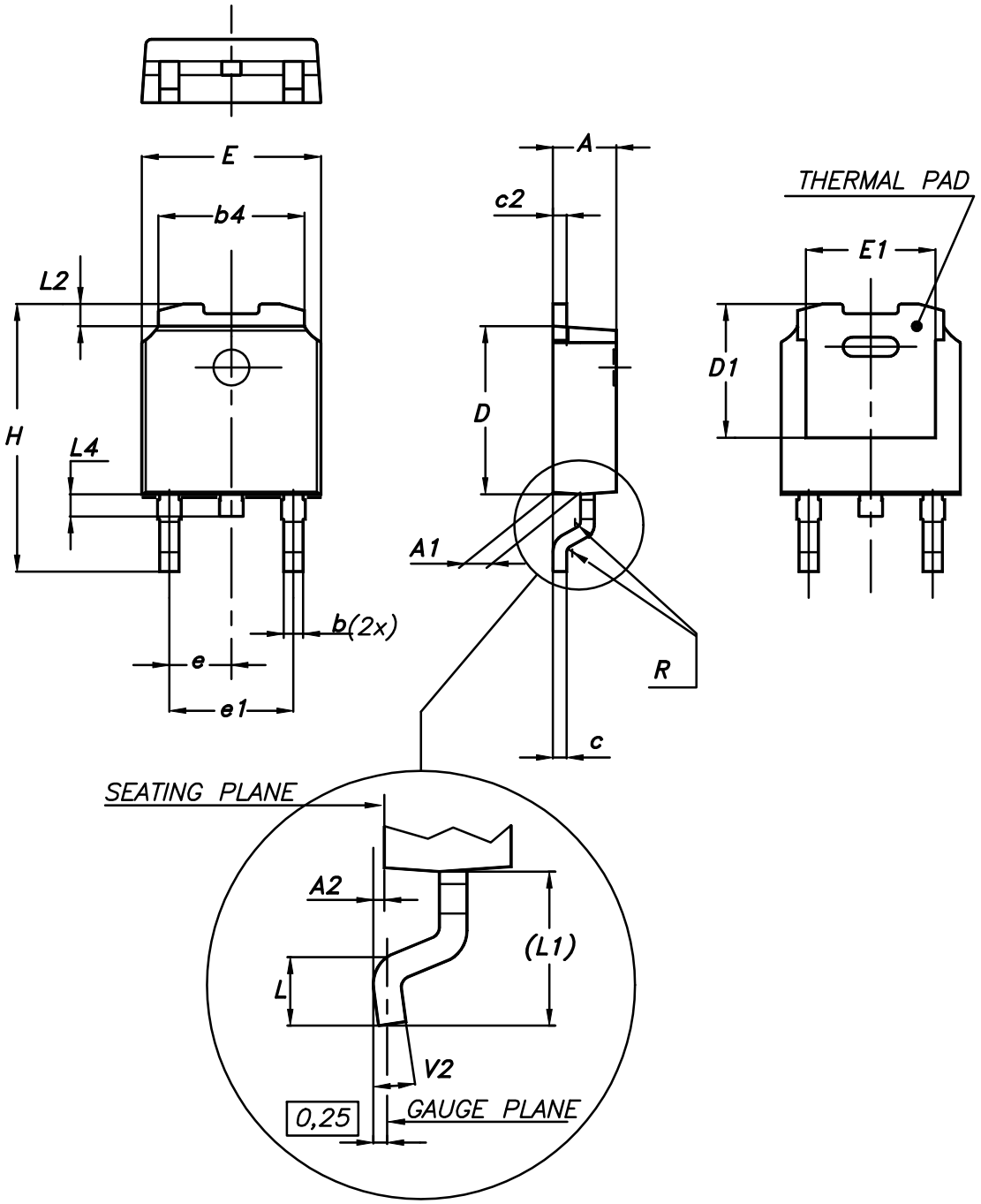


Table 8. **DPAK (TO-252) type A mechanical data**

| 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**

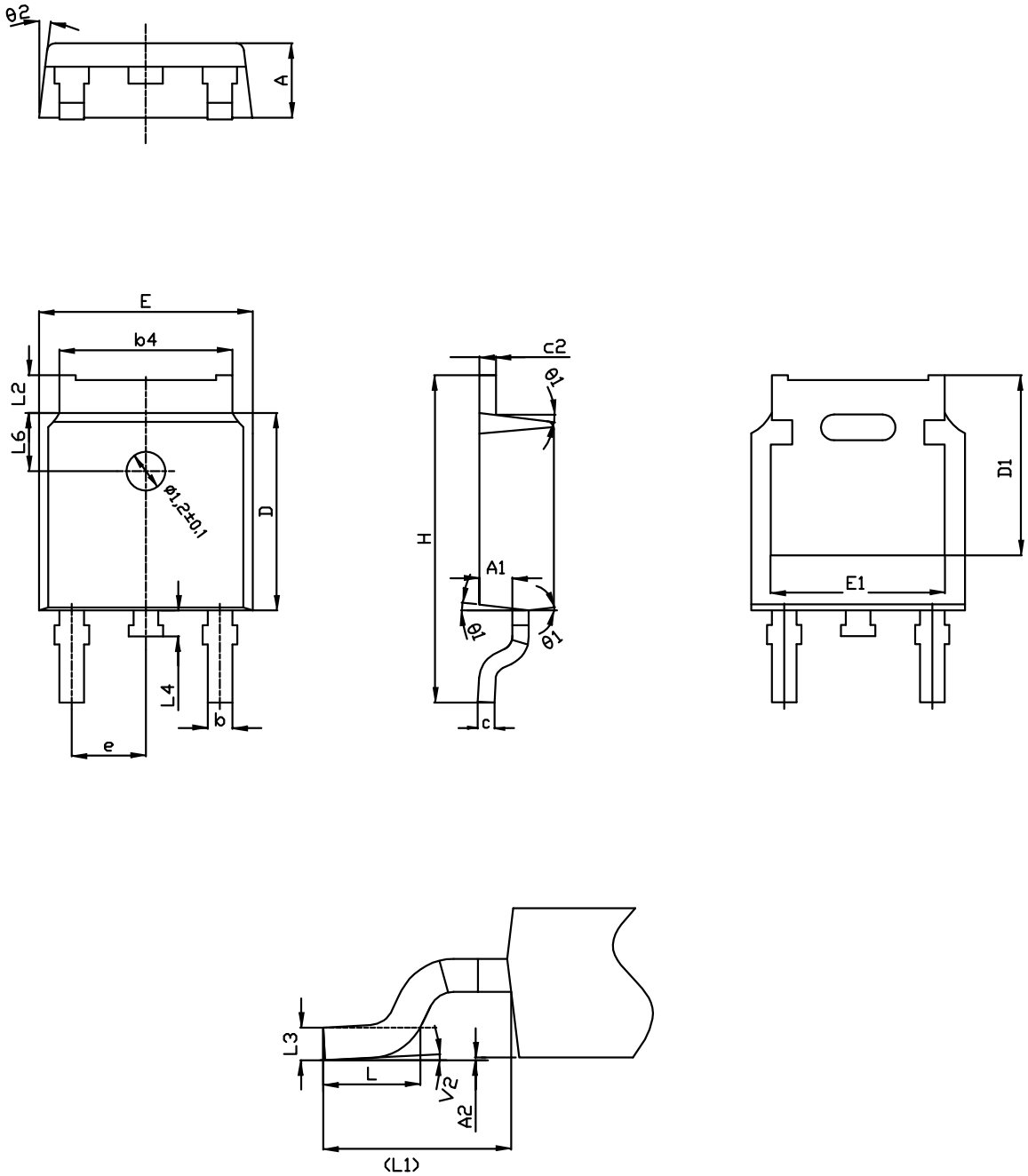



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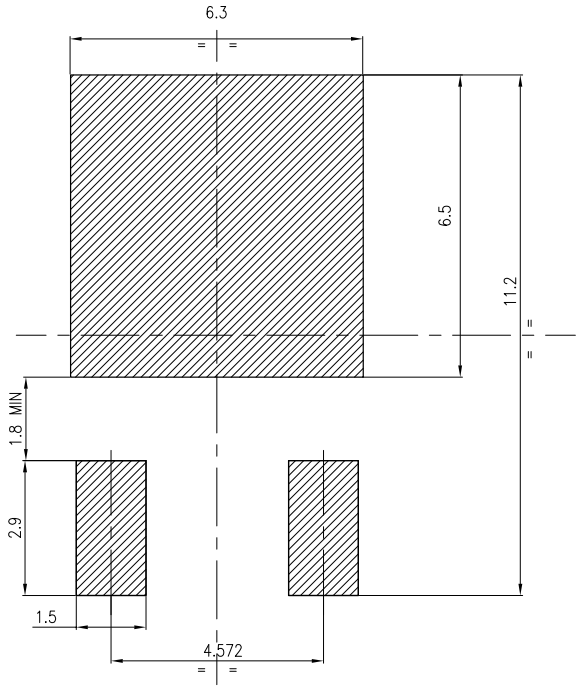
**Table 9. DPAK (TO-252) type C2 mechanical data**

| 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)**



## 4.3 DPAK (TO-252) packing information

Figure 25. **DPAK (TO-252) tape outline**

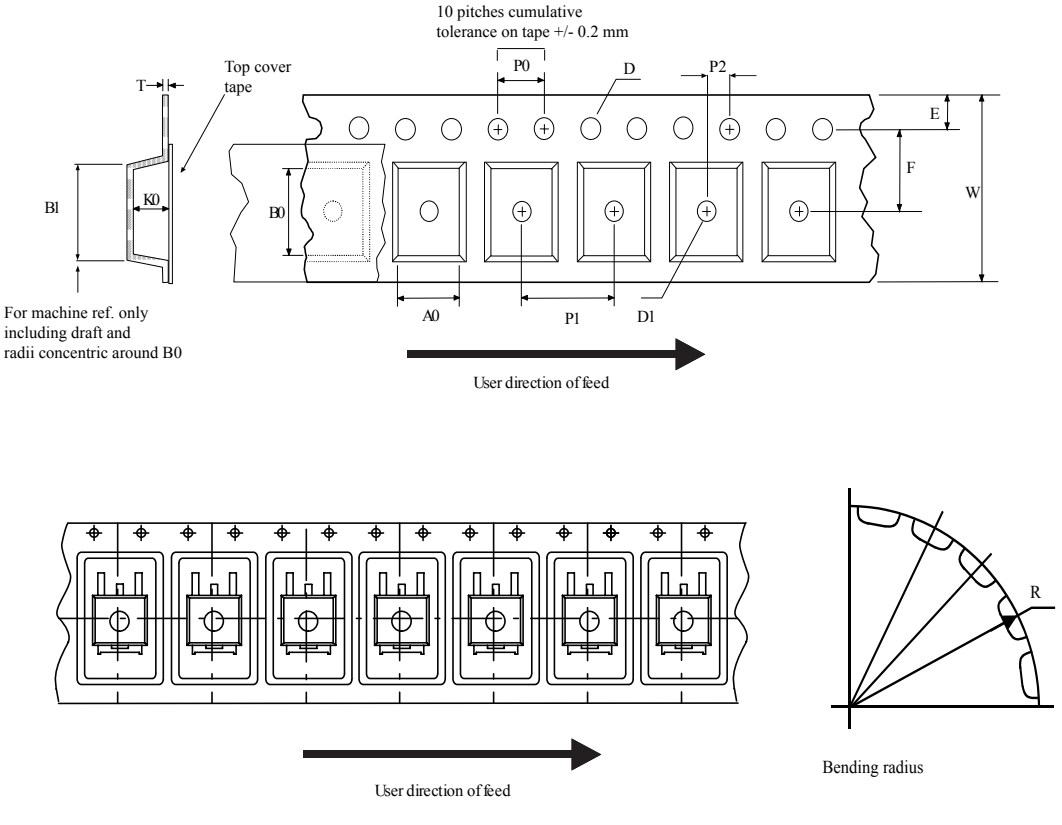


Figure 26. **DPAK (TO-252) reel outline**

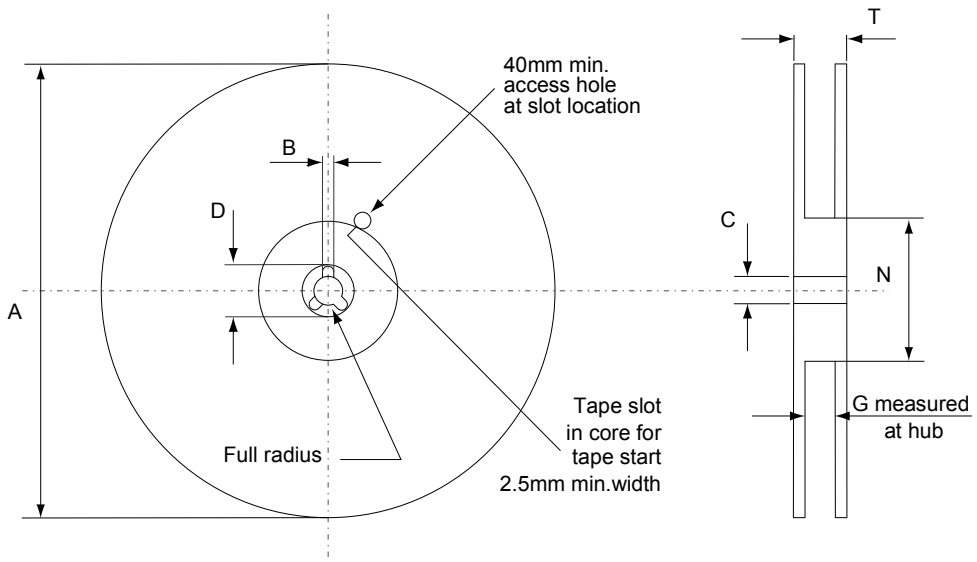



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Table 10. **DPAK (TO-252) tape and reel mechanical data**

| 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**

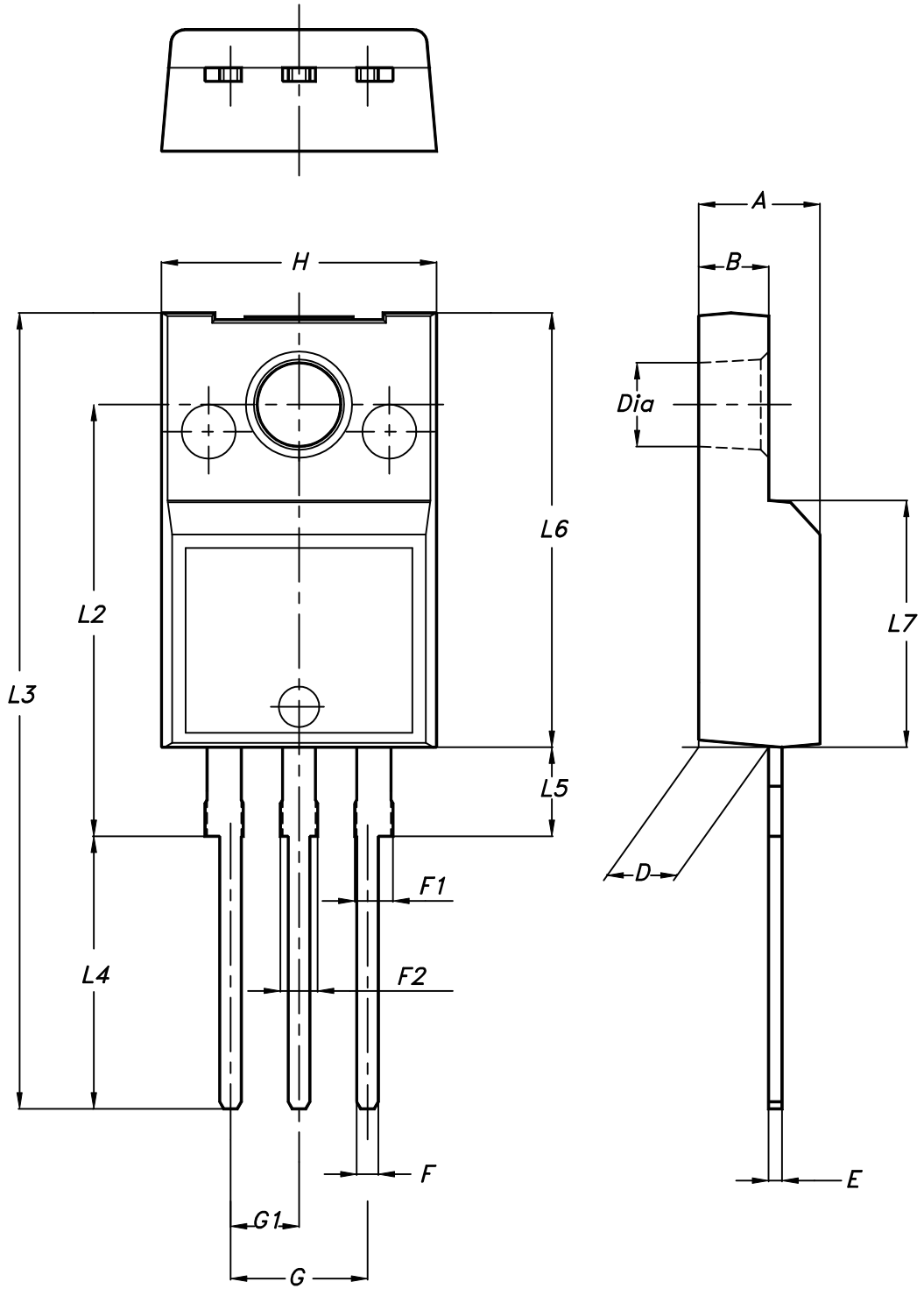

Table 11. **TO-220FP package mechanical data**

| 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**

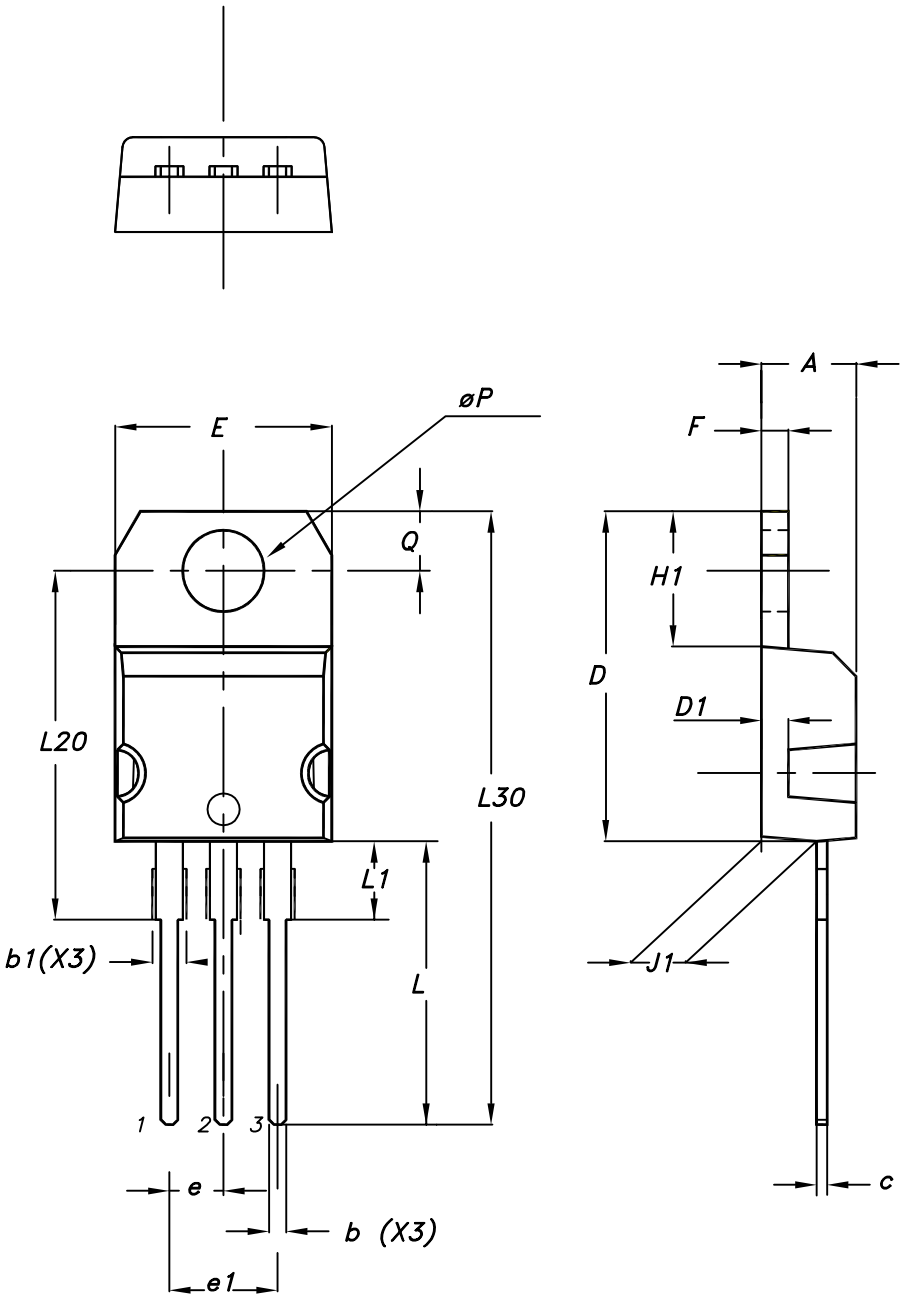


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Table 12. **TO-220 type A package mechanical data**

| 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.<br>Updated Section 4 Package information.<br>Minor text changes. |

# Contents

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