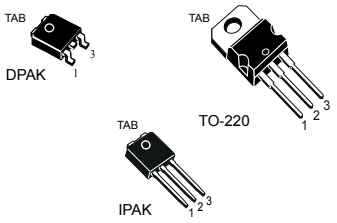
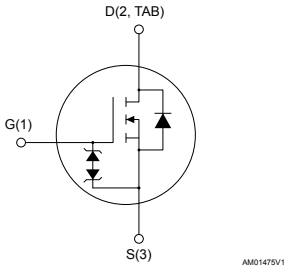
# STD7N60M2, STP7N60M2, STU7N60M2

Datasheet

## N-channel 600 V, 0.86 Ω typ., 5 A, MDmesh™ M2 Power MOSFETs in DPAK, TO-220 and IPAK packages




## Features

| Order codes | $V_{DS}$ @ $T_{Jmax}$ | $R_{DS(on)}$ max. | $I_D$ |
|---|---|---|---|
| STD7N60M2 | 650 V | 0.95 Ω | 5 A |
| STP7N60M2 | | | |
| STU7N60M2 | | | |

- Extremely low gate charge
- Excellent output capacitance ($C_{OSS}$) profile
- 100% avalanche tested
- Zener-protected

## Applications

- Switching applications

## Description

These devices are N-channel Power MOSFETs developed using MDmesh™ M2 technology. Thanks to their strip layout and improved vertical structure, these devices exhibit low on-resistance and optimized switching characteristics, rendering them suitable for the most demanding high efficiency converters.

| Product status link |
|---|
| STD7N60M2 |
| STP7N60M2 |
| STU7N60M2 |

| Product summary | |
|---|---|
| **Order code** | **STD7N60M2** |
| **Marking** | 7N60M2 |
| **Package** | DPAK |
| **Packing** | Tape and reel |
| **Order code** | **STP7N60M2** |
| **Marking** | 7N60M2 |
| **Package** | TO-220 |
| **Packing** | Tube |
| **Order code** | **STU7N60M2** |
| **Marking** | 7N60M2 |
| **Package** | IPAK |
| **Packing** | Tube |

# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{GS}$ | Gate-source voltage | ±25 | V |
| $I_D$ (1) | Drain current (continuous) at $T_{case}$ = 25 °C | 5 | A |
| | Drain current (continuous) at $T_{case}$ = 100 °C | 3.5 | |
| $I_{DM}$ (2) | Drain current (pulsed) | 20 | A |
| $P_{TOT}$ | Total dissipation at $T_{case}$ = 25 °C | 60 | W |
| dv/dt (3) | Peak diode recovery voltage slope | 15 | V/ns |
| dv/dt (4) | MOSFET dv/dt ruggedness | 50 | |
| $T_{stg}$ | Storage temperature range | -55 to 150 | °C |
| $T_j$ | Operating junction temperature range | | |

1. *Limited by maximum junction temperature.*
2. *Pulse width limited by safe operating area.*
3. *$I_{SD}$ ≤ 5 A, di/dt ≤ 400 A/µs; $V_{DS\ peak}$ < $V_{(BR)DSS}$, $V_{DD}$=400 V*
4. *$V_{DS}$ ≤ 480 V*

**Table 2. Thermal data**

| Symbol | Parameter | Value | | | Unit |
|---|---|---|---|---|---|
| | | DPAK | TO-220 | IPAK | |
| $R_{thj\text{-}case}$ | Thermal resistance junction-case | | 2.08 | | °C/W |
| $R_{thj\text{-}pcb}$ (1) | Thermal resistance junction-pcb | 50 | | | °C/W |
| $R_{thj\text{-}amb}$ | Thermal resistance junction-ambient | | 62.5 | 100 | °C/W |

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

**Table 3. Avalanche characteristics**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $I_{AR}$ | Avalanche current, repetitive or non-repetitive (pulse width limited by $T_{Jmax}$) | 1.5 | A |
| $E_{AS}$ | Single pulse avalanche energy (starting $T_j$ = 25 °C, $I_D$ = $I_{AR}$, $V_{DD}$ = 50 V) | 99 | mJ |

# 2 Electrical characteristics

($T_{case}$ = 25 °C unless otherwise specified)

**Table 4. Static**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage | $V_{GS}$ = 0 V, $I_D$ = 1 mA | 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, $T_{case}$ = 125 °C (1) | | | 100 | |
| $I_{GSS}$ | Gate-body leakage current | $V_{DS}$ = 0 V, $V_{GS}$ = ±25 V | | | ±10 | µA |
| $V_{GS(th)}$ | 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, $I_D$ = 2.5 A | | 0.86 | 0.95 | 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 | $V_{DS}$ = 100 V, f = 1 MHz, $V_{GS}$ = 0 V | - | 271 | - | pF |
| $C_{oss}$ | Output capacitance | | - | 15.7 | - | |
| $C_{rss}$ | Reverse transfer capacitance | | - | 0.68 | - | |
| $C_{oss\ eq.}$ (1) | Equivalent output capacitance | $V_{DS}$ = 0 to 480 V, $V_{GS}$ = 0 V | - | 75.5 | - | pF |
| $R_G$ | Intrinsic gate resistance | f = 1 MHz, $I_D$ = 0 A | - | 7.2 | - | Ω |
| $Q_g$ | Total gate charge | $V_{DD}$ = 480 V, $I_D$ = 5 A, $V_{GS}$ = 0 to 10 V (see Figure 17. Test circuit for gate charge behavior) | - | 8.8 | - | nC |
| $Q_{gs}$ | Gate-source charge | | - | 1.8 | - | |
| $Q_{gd}$ | Gate-drain charge | | - | 4.3 | - | |

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 | $V_{DD}$ = 300 V, $I_D$ = 2.5 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) | - | 7.6 | - | ns |
| $t_r$ | Rise time | | - | 7.2 | - | |
| $t_{d(off)}$ | Turn-off delay time | | - | 19.3 | - | |
| $t_f$ | Fall time | | - | 15.9 | - | |

**Table 7. Source-drain diode**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $I_{SD}$ | Source-drain current | | - | | 5 | A |
| $I_{SDM}$ (1) | Source-drain current (pulsed) | | - | | 20 | A |
| $V_{SD}$ (2) | Forward on voltage | $V_{GS}$ = 0 V, $I_{SD}$ = 5 A | - | | 1.6 | V |
| $t_{rr}$ | Reverse recovery time | $I_{SD}$ = 5 A, di/dt = 100 A/µs, $V_{DD}$ = 60 V (see Figure 18. Test circuit for inductive load switching and diode recovery times ) | - | 275 | | ns |
| $Q_{rr}$ | Reverse recovery charge | | - | 1.55 | | µC |
| $I_{RRM}$ | Reverse recovery current | | - | 11 | | A |
| $t_{rr}$ | Reverse recovery time | $I_{SD}$ = 5 A, di/dt = 100 A/µs, $V_{DD}$ = 60 V, $T_j$ = 150 °C (see Figure 18. Test circuit for inductive load switching and diode recovery times ) | - | 376 | | ns |
| $Q_{rr}$ | Reverse recovery charge | | - | 2.1 | | µC |
| $I_{RRM}$ | Reverse recovery current | | - | 11 | | A |

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

## 2.1 Electrical characteristics (curves)

**Figure 2. Safe operating area for DPAK and IPAK**

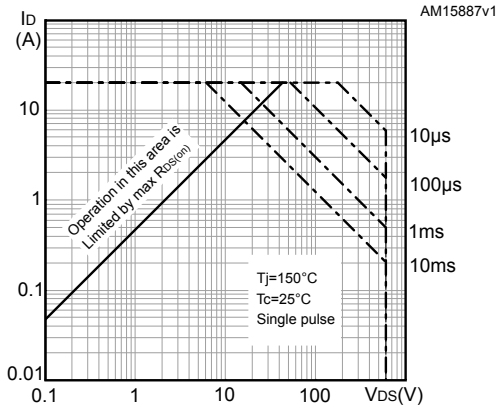



**Figure 3. Thermal impedance for DPAK and IPAK**

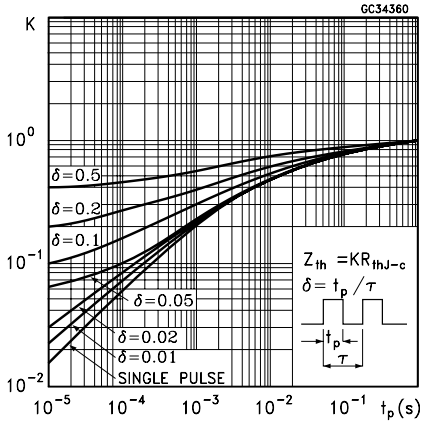



**Figure 4. Safe operating area for TO-220**

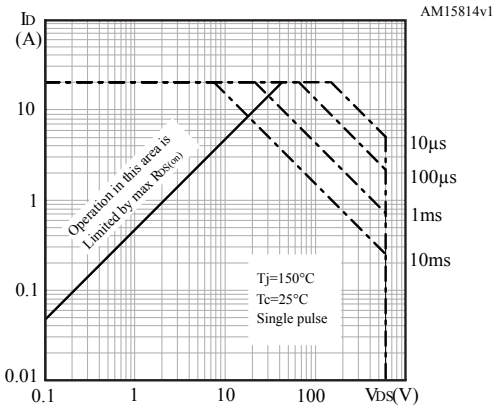



**Figure 5. Thermal impedance for TO-220**

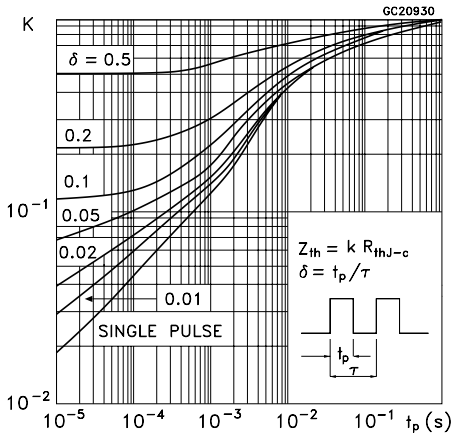



**Figure 6. Output characteristics**

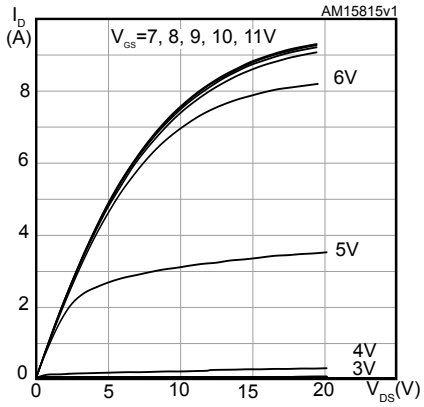



**Figure 7. Transfer characteristics**

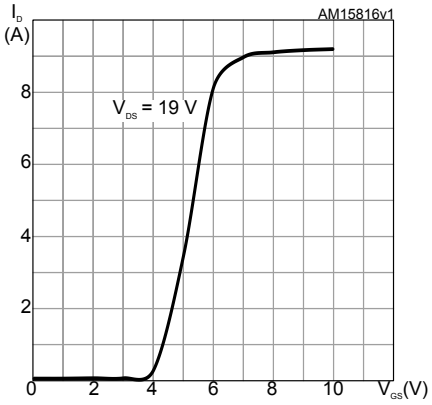


**Figure 8. Gate charge vs gate-source voltage**

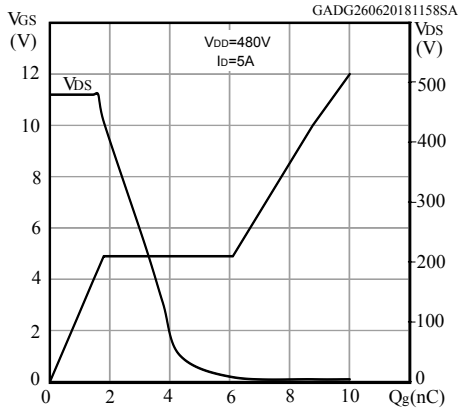



**Figure 9. Static drain-source on-resistance**

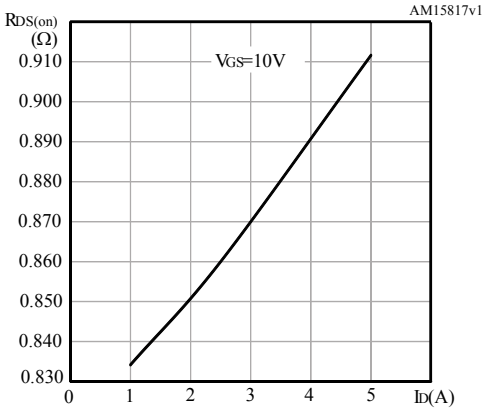



**Figure 10. Capacitance variations**

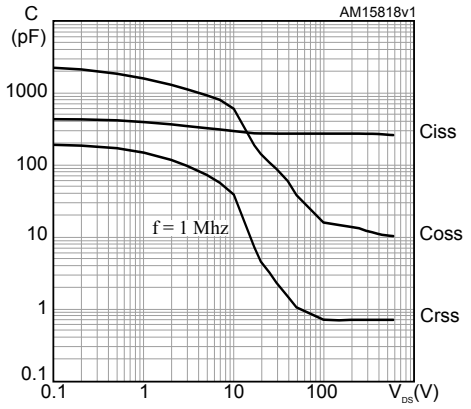



**Figure 11. Output capacitance stored energy**

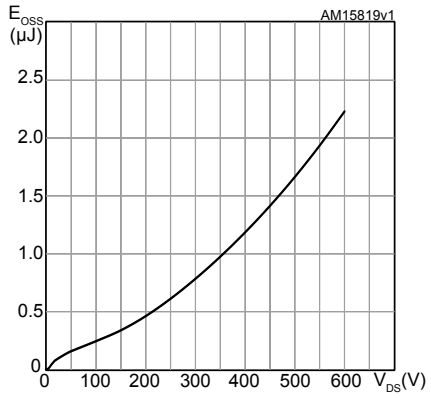



**Figure 12. Normalized gate threshold voltage vs temperature**

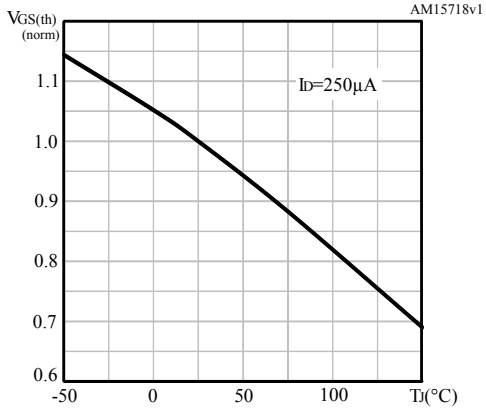



**Figure 13. Normalized on-resistance vs temperature**

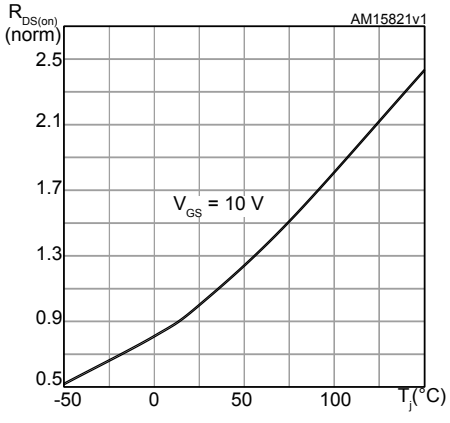


**Figure 14. Source-drain diode forward characteristics**

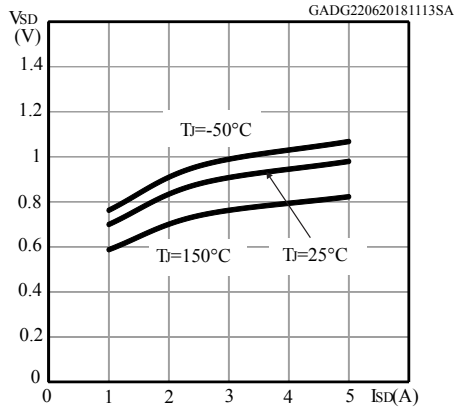
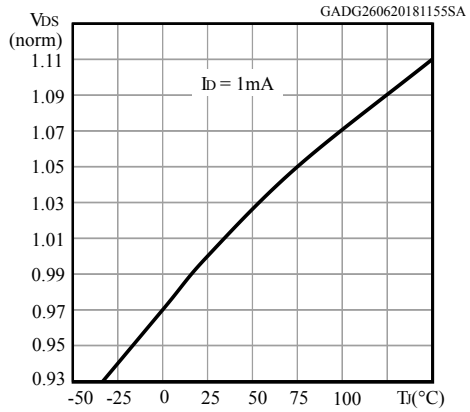



**Figure 15. Normalized $V_{(BR)DSS}$ vs temperature**



# 3 Test circuits

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

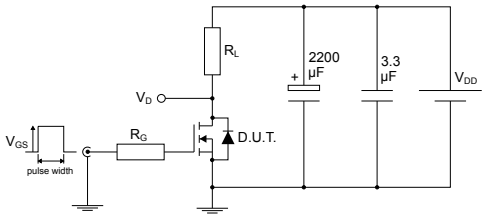



**Figure 17. Test circuit for gate charge behavior**

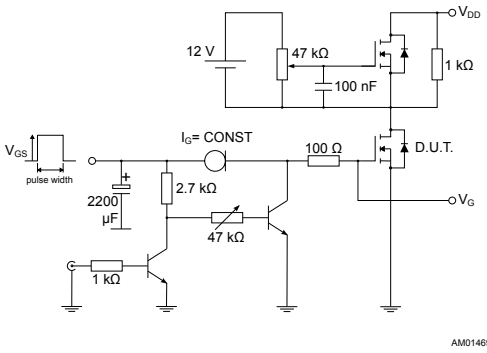



**Figure 18. Test circuit for inductive load switching and diode recovery times**

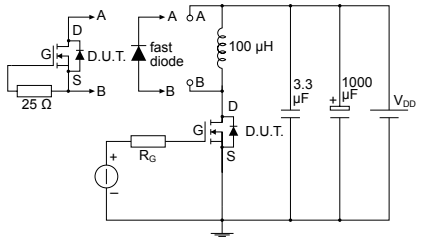



**Figure 19. Unclamped inductive load test circuit**

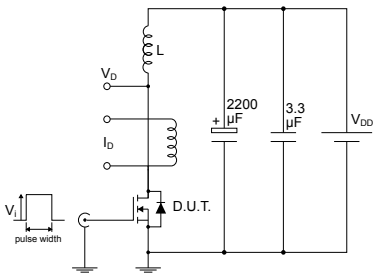



**Figure 20. Unclamped inductive waveform**

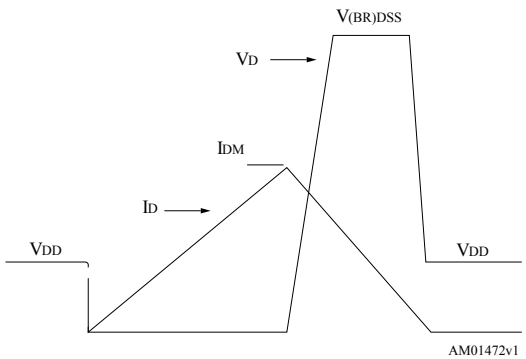
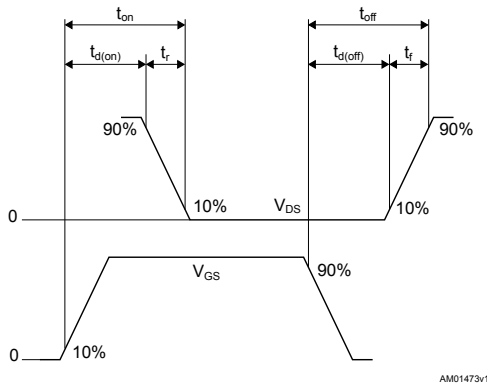



**Figure 21. Switching time waveform**



# 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**

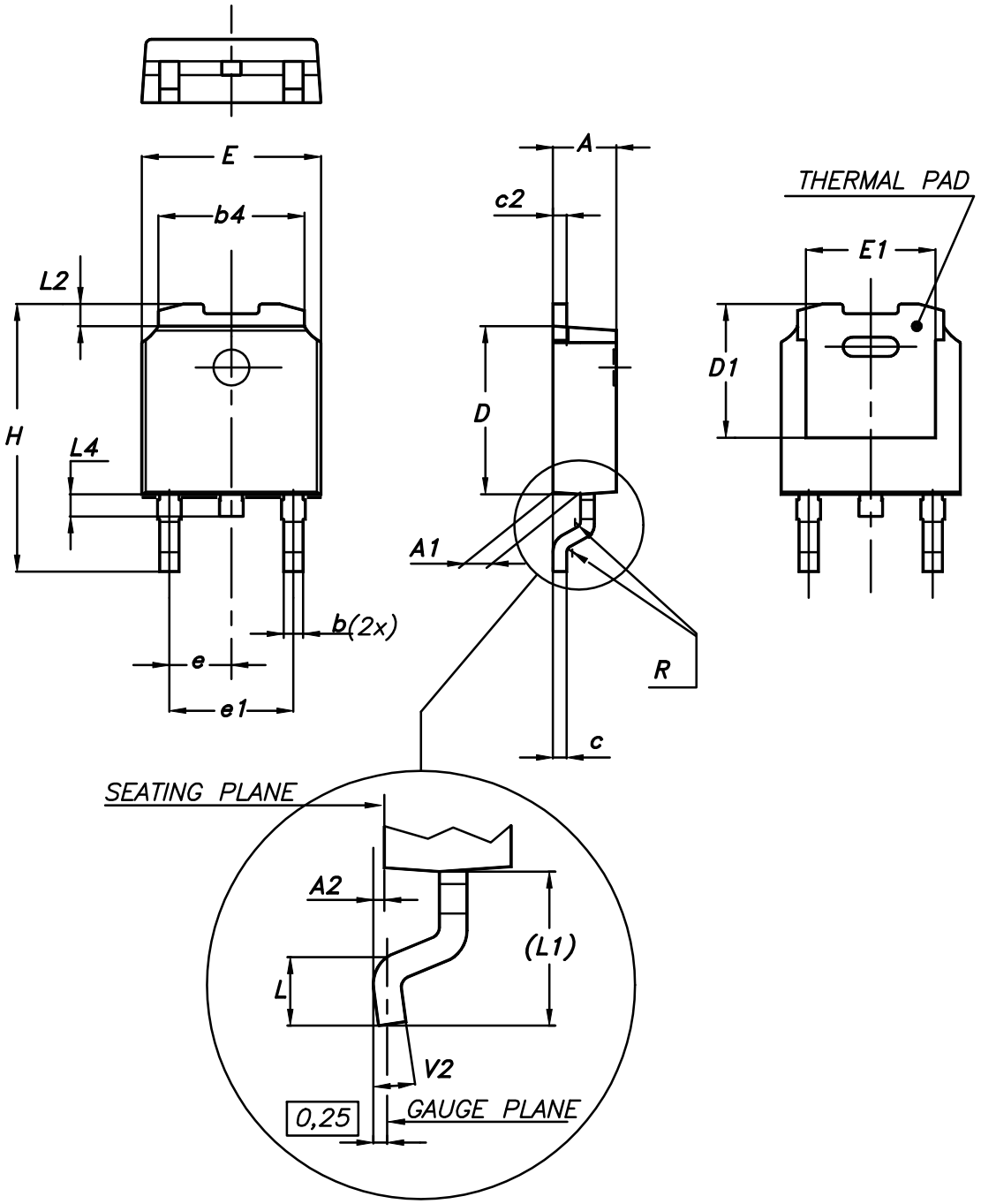



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Table 8. **DPAK (TO-252) type A mechanical data**

| 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 C package information

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

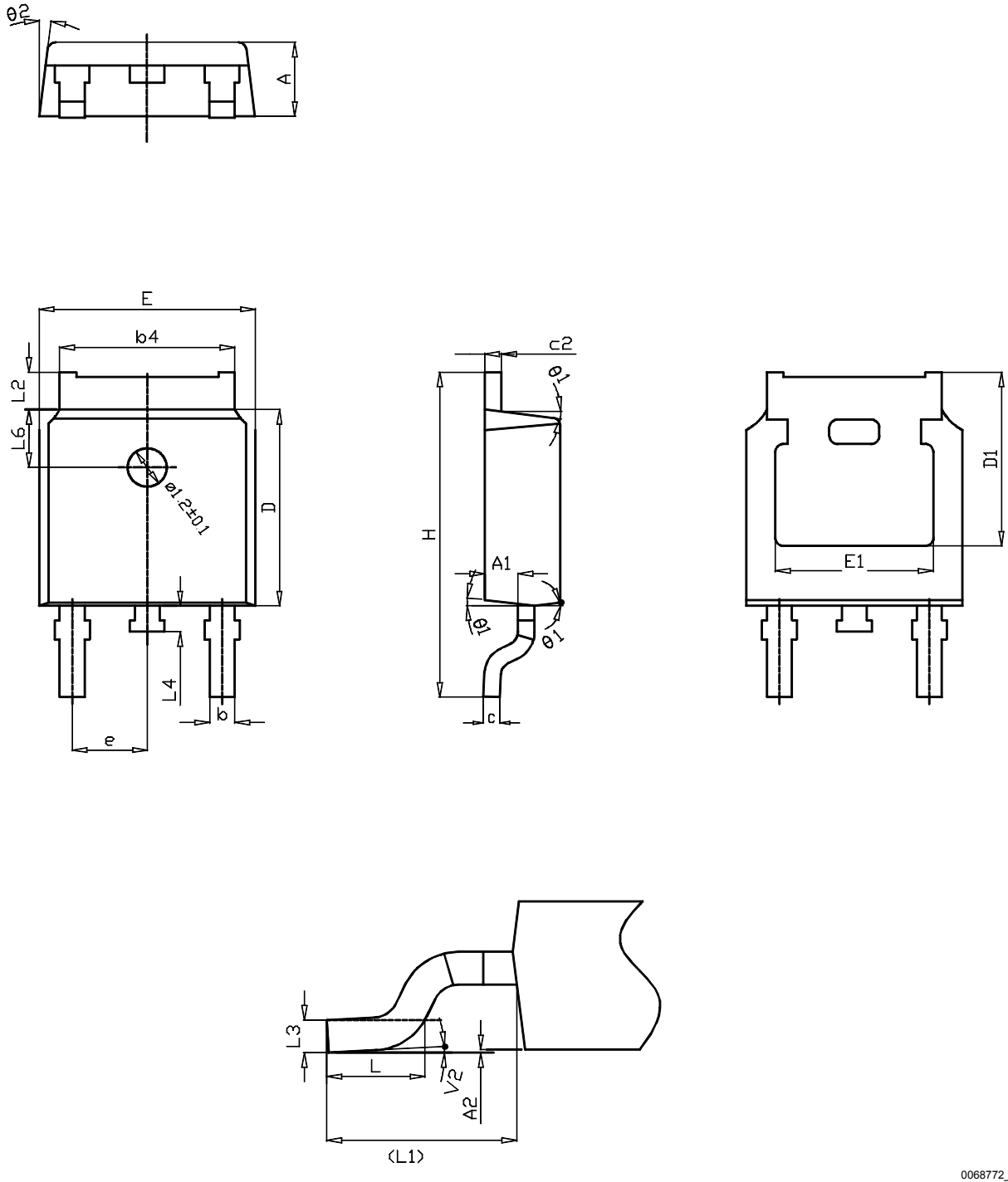

**Table 9. DPAK (TO-252) type C mechanical data**

| 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 | 5.25 | | |
| E | 6.50 | 6.60 | 6.70 |
| E1 | 4.70 | | |
| 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° |

## 4.3 DPAK (TO-252) type E package information

Figure 24. **DPAK (TO-252) type E package outline**

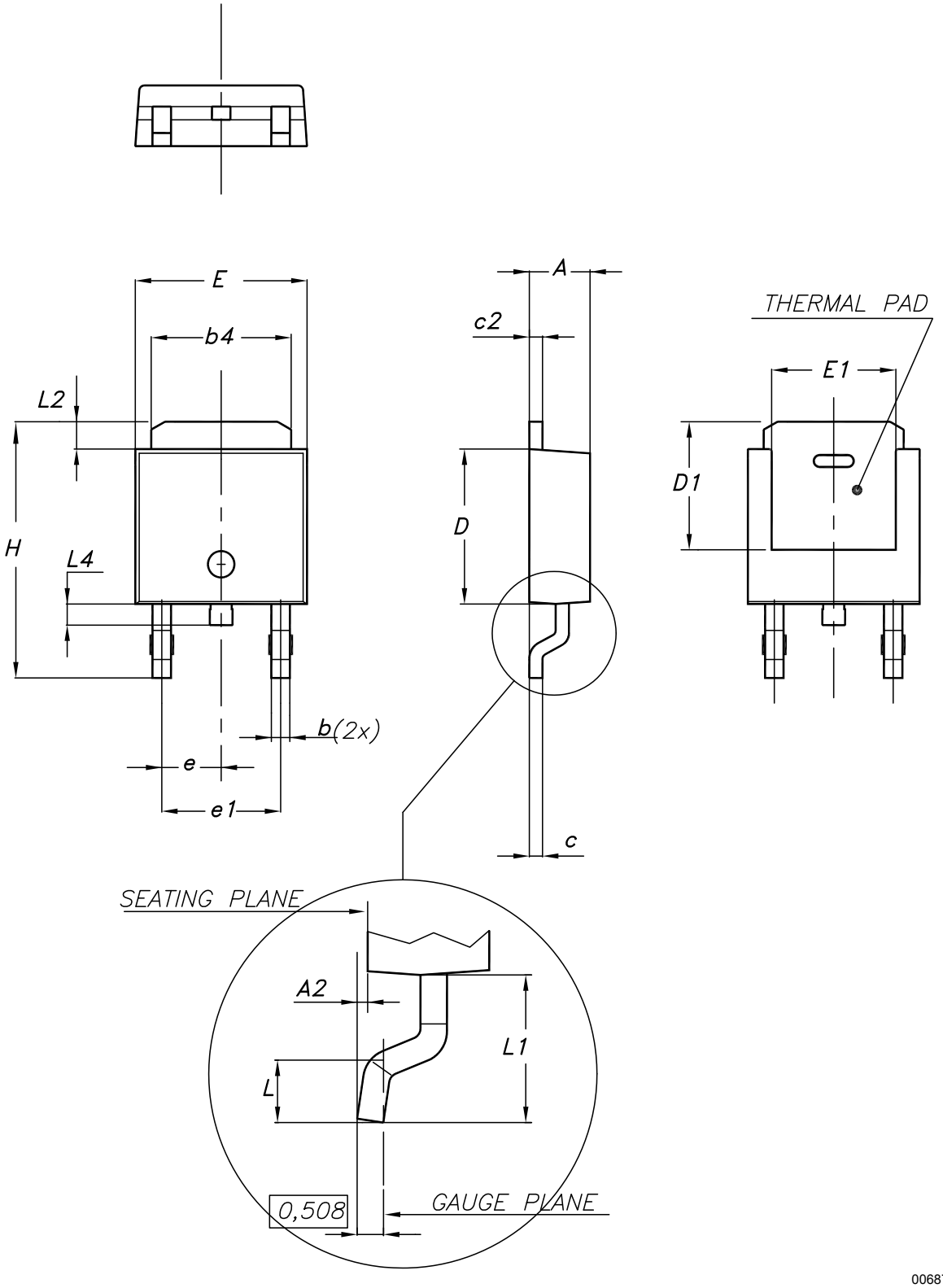


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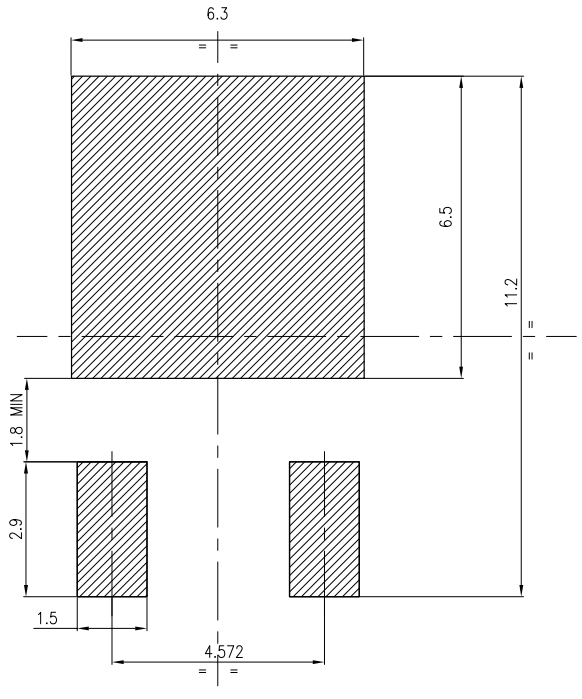
Table 10. **DPAK (TO-252) type E mechanical data**

| Dim. | mm | | |
|---|---|---|---|
| | Min. | Typ. | Max. |
| A | 2.18 | | 2.39 |
| A2 | | | 0.13 |
| b | 0.65 | | 0.884 |
| b4 | 4.95 | | 5.46 |
| c | 0.46 | | 0.61 |
| c2 | 0.46 | | 0.60 |
| D | 5.97 | | 6.22 |
| D1 | 5.21 | | |
| E | 6.35 | | 6.73 |
| E1 | 4.32 | | |
| e | | 2.286 | |
| e1 | | 4.572 | |
| H | 9.94 | | 10.34 |
| L | 1.50 | | 1.78 |
| L1 | | 2.74 | |
| L2 | 0.89 | | 1.27 |
| L4 | | | 1.02 |

Figure 25. **DPAK (TO-252) recommended footprint (dimensions are in mm)**

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## 4.4 DPAK (TO-252) packing information

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

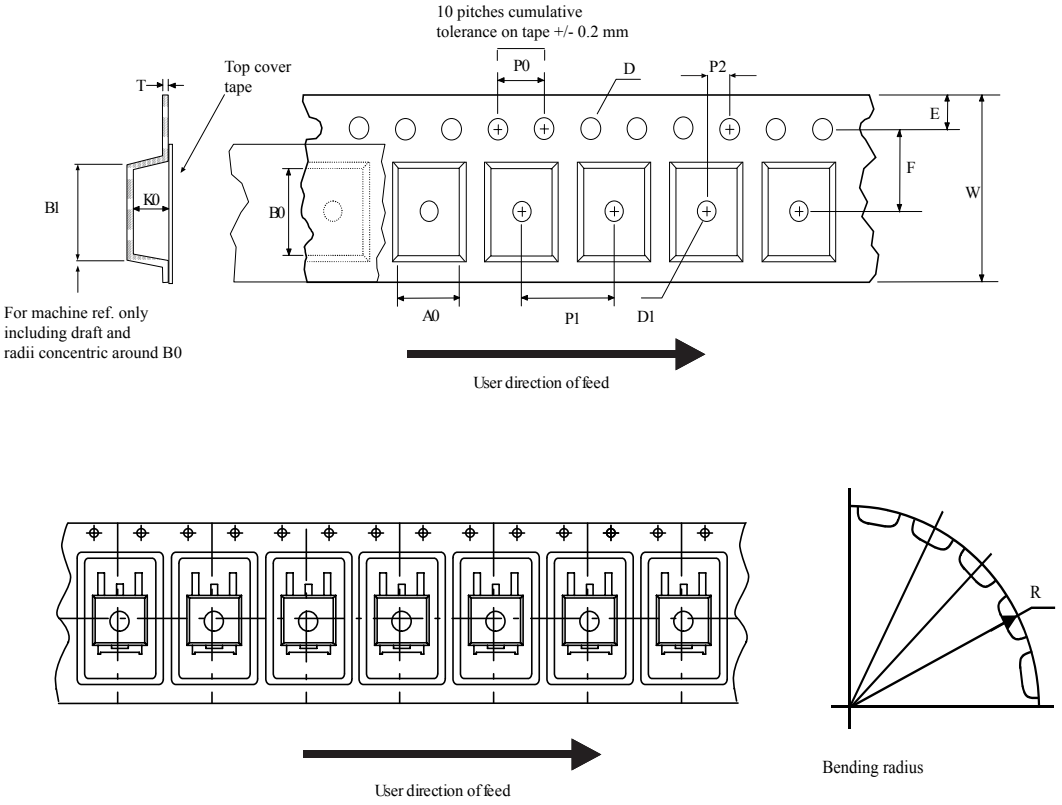

Figure 27. **DPAK (TO-252) reel outline**

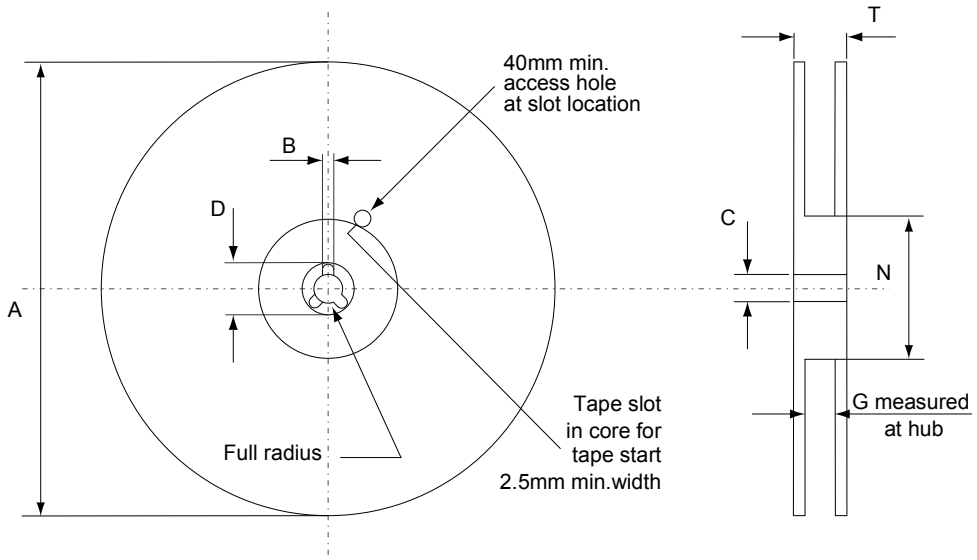


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Table 11. **DPAK (TO-252) tape and reel mechanical data**

| 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 | | | |

## 4.5 TO-220 type A package information

Figure 28. **TO-220 type A package outline**

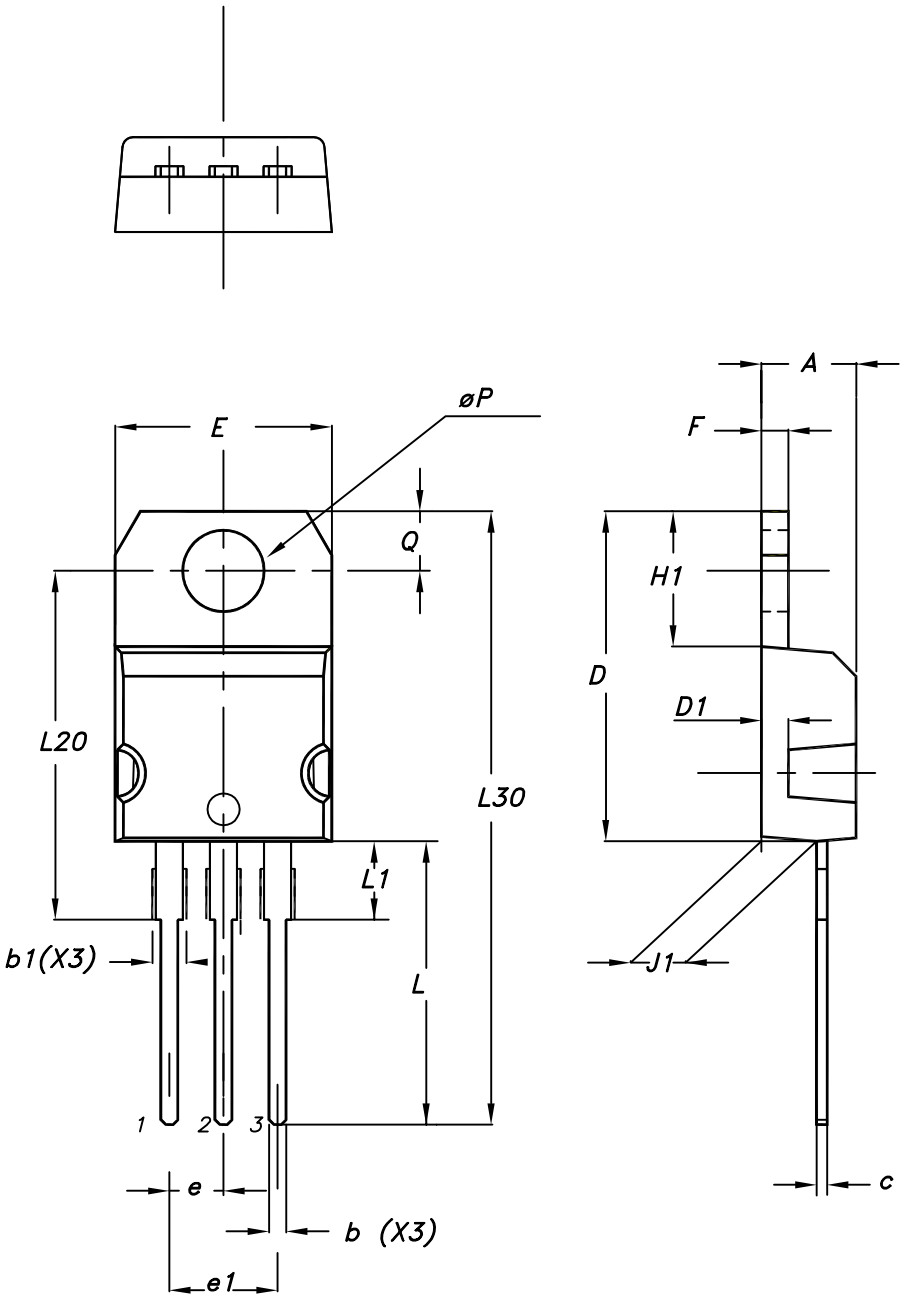


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Table 12. **TO-220 type A package mechanical data**

| 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 |

## 4.6 IPAK (TO-251) type A package information

Figure 29. **IPAK (TO-251) type A package outline**

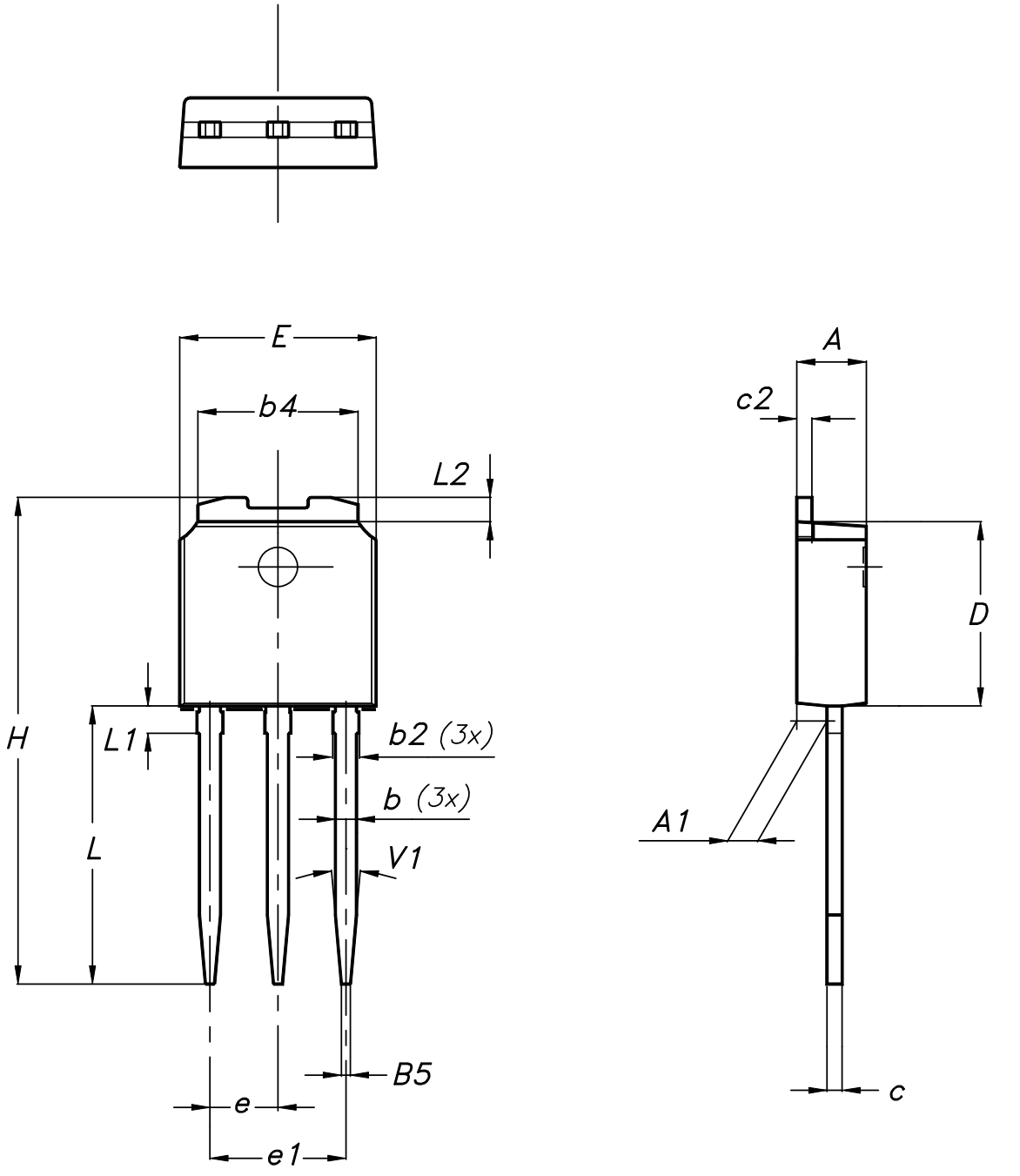
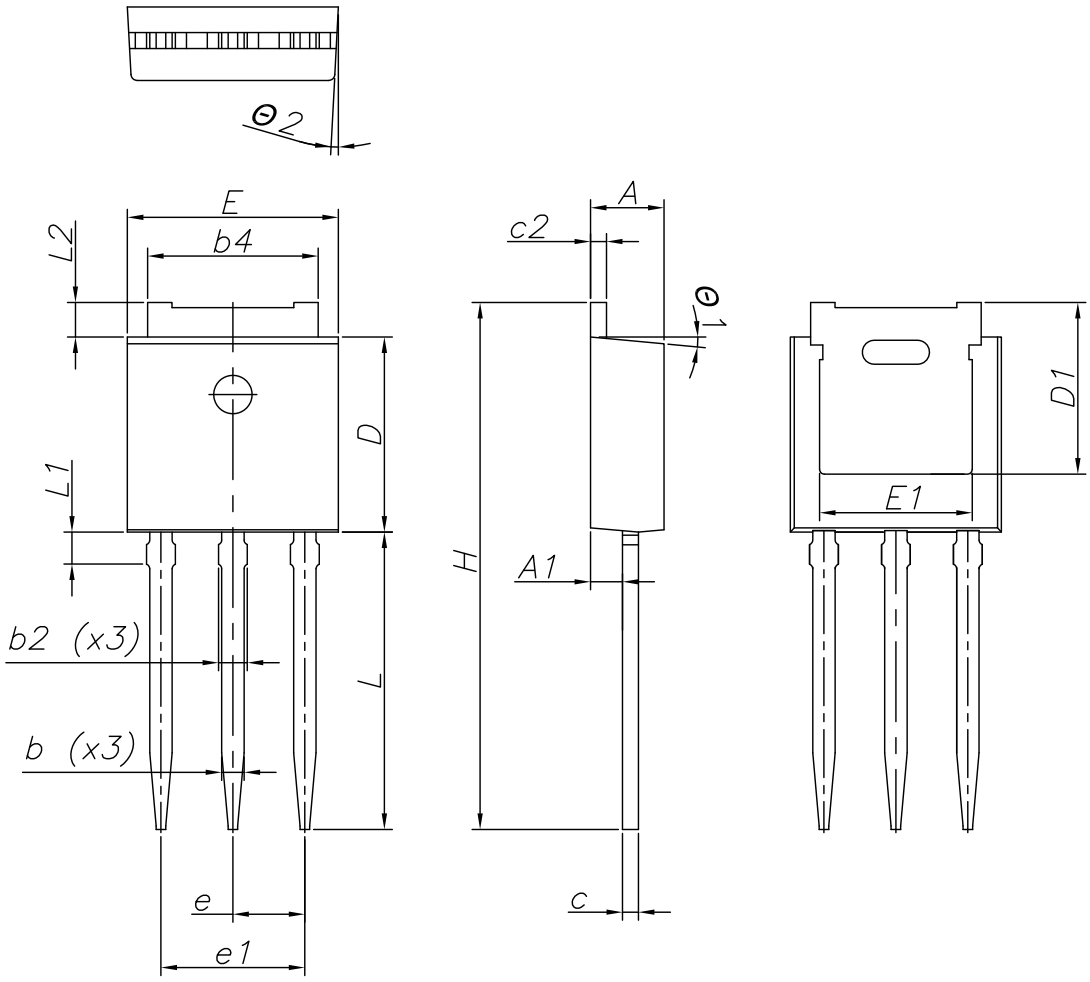


Table 13. **IPAK (TO-251) type A package mechanical data**

| Dim. | mm | | |
|---|---|---|---|
| | Min. | Typ. | Max. |
| A | 2.20 | | 2.40 |
| A1 | 0.90 | | 1.10 |
| b | 0.64 | | 0.90 |
| b2 | | | 0.95 |
| b4 | 5.20 | | 5.40 |
| B5 | | 0.30 | |
| c | 0.45 | | 0.60 |
| c2 | 0.48 | | 0.60 |
| D | 6.00 | | 6.20 |
| E | 6.40 | | 6.60 |
| e | | 2.28 | |
| e1 | 4.40 | | 4.60 |
| H | | 16.10 | |
| L | 9.00 | | 9.40 |
| L1 | 0.80 | | 1.20 |
| L2 | | 0.80 | 1.00 |
| V1 | | 10° | |

## 4.7 IPAK (TO-251) type C package information

Figure 30. **IPAK (TO-251) type C package outline**




0068771_IK_typeC_rev14

Table 14. **IPAK (TO-251) type C package mechanical data**

| Dim. | mm | | |
|---|---|---|---|
| | Min. | Typ. | Max. |
| A | 2.20 | 2.30 | 2.35 |
| A1 | 0.90 | 1.00 | 1.10 |
| b | 0.66 | | 0.79 |
| b2 | | | 0.90 |
| b4 | 5.23 | 5.33 | 5.43 |
| c | 0.46 | | 0.59 |
| c2 | 0.46 | | 0.59 |
| D | 6.00 | 6.10 | 6.20 |
| D1 | 5.20 | 5.37 | 5.55 |
| E | 6.50 | 6.60 | 6.70 |
| E1 | 4.60 | 4.78 | 4.95 |
| e | 2.20 | 2.25 | 2.30 |
| e1 | 4.40 | 4.50 | 4.60 |
| H | 16.18 | 16.48 | 16.78 |
| L | 9.00 | 9.30 | 9.60 |
| L1 | 0.80 | 1.00 | 1.20 |
| L2 | 0.90 | 1.08 | 1.25 |
| θ1 | 3° | 5° | 7° |
| θ2 | 1° | 3° | 5° |

## Revision history

Table 15. **Document revision history**

| Date | Revision | Changes |
|---|---|---|
| 06-Jun-2013 | 1 | First release. |
| 12-Jul-2018 | 2 | Removed maturity status indication from cover page. The document status is production data.<br>Added Section 4.2 DPAK (TO-252) type C package information and Section 4.3 DPAK (TO-252) type E package information.<br>Minor text changes. |

# Contents

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