# STB10N60M2, STD10N60M2, STP10N60M2, STU10N60M2

## N-channel 600 V, 0.55 Ω typ., 7.5 A MDmesh™ M2 Power MOSFETs in D²PAK, DPAK, TO-220 and IPAK packages

Datasheet - production data

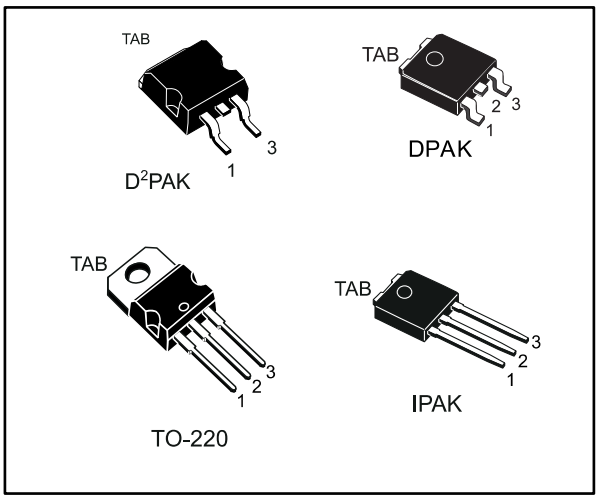
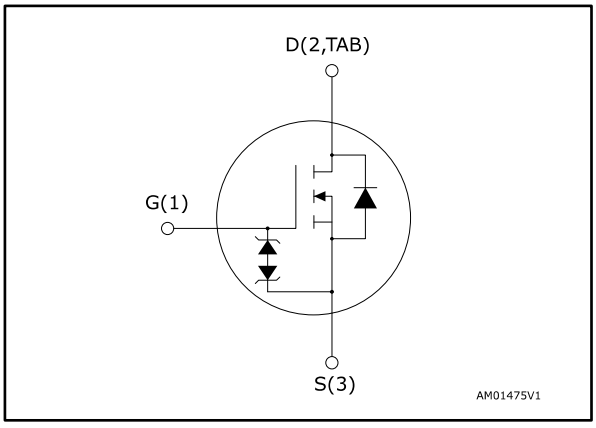



**Figure 1: Internal schematic diagram**




## Features

| Order code | $V_{DS}@T_{Jmax.}$ | $R_{DS(on)}$ max. | $I_D$ |
|---|---|---|---|
| STB10N60M2 | 650 V | 0.60 Ω | 7.5 A |
| STD10N60M2 | | | |
| STP10N60M2 | | | |
| STU10N60M2 | | | |

- 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.

**Table 1: Device summary**

| Order code | Marking | Package | Packing |
|---|---|---|---|
| STB10N60M2 | 10N60M2 | D²PAK | Tape and reel |
| STD10N60M2 | | DPAK | |
| STP10N60M2 | | TO-220 | Tube |
| STU10N60M2 | | IPAK | |

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# 1 Electrical ratings

**Table 2: Absolute maximum ratings**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{GS}$ | Gate-source voltage | ±25 | V |
| $I_D$ | Drain current (continuous) at $T_{case}$ = 25 °C | 7.5 | A |
| | Drain current (continuous) at $T_{case}$ = 100 °C | 4.9 | |
| $I_{DM}$(1) | Drain current (pulsed) | 30 | A |
| $P_{TOT}$ | Total dissipation at $T_{case}$ = 25 °C | 85 | W |
| dv/dt(2) | Peak diode recovery voltage slope | 15 | V/ns |
| dv/dt(3) | MOSFET dv/dt ruggedness | 50 | |
| $T_{stg}$ | Storage temperature range | -55 to 150 | °C |
| $T_j$ | Operating junction temperature range | | |

**Notes:**

(1)Pulse limited by safe operating area.

(2) $I_{SD} \leq 7.5$ A, di/dt ≤ 400 A/µs; $V_{DS}$ peak < $V_{(BR)DSS}$, $V_{DD}$ = 400 V

(3) $V_{DS} \leq 480$ V.

**Table 3: Thermal data**

| Symbol | Parameter | Value | | | | Unit |
|---|---|---|---|---|---|---|
| | | $D^2PAK$ | DPAK | TO-220 | IPAK | |
| $R_{thj\text{-}case}$ | Thermal resistance junction-case | 1.47 | | | | °C/W |
| $R_{thj\text{-}pcb}$ | Thermal resistance junction-pcb(1) | 30 | 50 | | | |
| $R_{thj\text{-}amb}$ | Thermal resistance junction-ambient | | | 62.5 | 100 | |

**Notes:**

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

**Table 4: Avalanche characteristics**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $I_{AR}$(1) | Avalanche current, repetitive or not repetitive | 1.5 | A |
| $E_{AS}$(2) | Single pulse avalanche energy | 110 | mJ |

**Notes:**

(1) Pulse width limited by $T_{jmax}$.

(2) Starting $T_j$ = 25 °C, $I_D = I_{AR}$, $V_{DD}$ = 50 V.

# 2 Electrical characteristics

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

**Table 5: 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, $I_D$ = 3 A | | 0.55 | 0.60 | Ω |

**Notes:**

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

**Table 6: Dynamic**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $C_{iss}$ | Input capacitance | $V_{DS}$ = 100 V, f = 1 MHz, $V_{GS}$ = 0 V | - | 400 | - | pF |
| $C_{oss}$ | Output capacitance | | - | 22 | - | |
| $C_{rss}$ | Reverse transfer capacitance | | - | 0.84 | - | |
| $C_{oss\ eq.}$(1) | Equivalent output capacitance | $V_{DS}$ = 0 to 480 V, $V_{GS}$ = 0 V | - | 83 | - | pF |
| $R_G$ | Intrinsic gate resistance | f = 1 MHz, $I_D$ = 0 A | - | 6.4 | - | Ω |
| $Q_g$ | Total gate charge | $V_{DD}$ = 480 V, $I_D$ = 7.5 A, $V_{GS}$ = 0 to 10 V (see *Figure 17: "Test circuit for gate charge behavior"*) | - | 13.5 | - | nC |
| $Q_{gs}$ | Gate-source charge | | - | 2.1 | - | |
| $Q_{gd}$ | Gate-drain charge | | - | 7.2 | - | |

**Notes:**

(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 7: Switching times**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $t_{d(on)}$ | Turn-on delay time | $V_{DD}$ = 300 V, $I_D$ = 3.75 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"*) | - | 8.8 | - | ns |
| $t_r$ | Rise time | | - | 8 | - | |
| $t_{d(off)}$ | Turn-off delay time | | - | 32.5 | - | |
| $t_f$ | Fall time | | - | 13.2 | - | |

**Table 8: Source-drain diode**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $I_{SD}$ | Source-drain current | | - | | 7.5 | A |
| $I_{SDM}$(1) | Source-drain current (pulsed) | | - | | 30 | A |
| $V_{SD}$(2) | Forward on voltage | $V_{GS}$ = 0 V, $I_{SD}$ = 7.5 A | - | | 1.6 | V |
| $t_{rr}$ | Reverse recovery time | $I_{SD}$ = 7.5 A, di/dt = 100 A/µs, $V_{DD}$ = 60 V (see *Figure 18: "Test circuit for inductive load switching and diode recovery times"*) | - | 270 | | ns |
| $Q_{rr}$ | Reverse recovery charge | | - | 2 | | µC |
| $I_{RRM}$ | Reverse recovery current | | - | 14.4 | | A |
| $t_{rr}$ | Reverse recovery time | $I_{SD}$ = 7.5 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 | | - | 2.8 | | µC |
| $I_{RRM}$ | Reverse recovery current | | - | 15 | | A |

**Notes:**

(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**

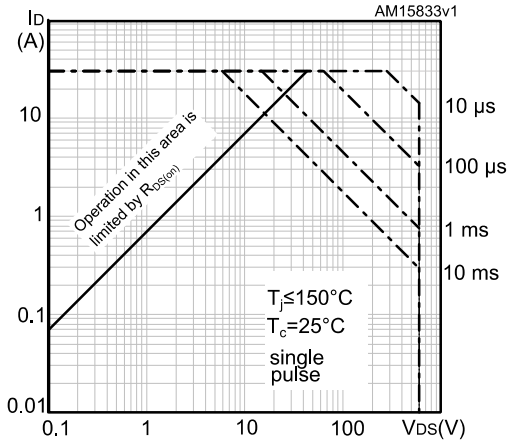



**Figure 3: Thermal impedance for DPAK and IPAK**

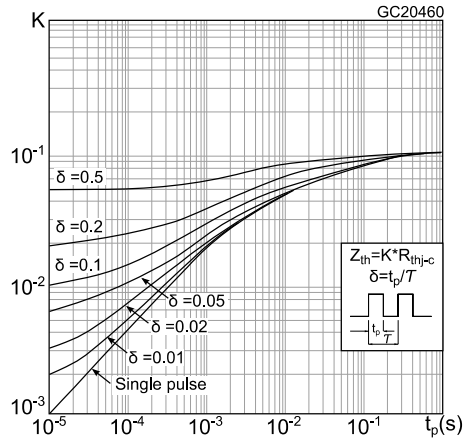



**Figure 4: Safe operating area for D²PAK and TO-220**

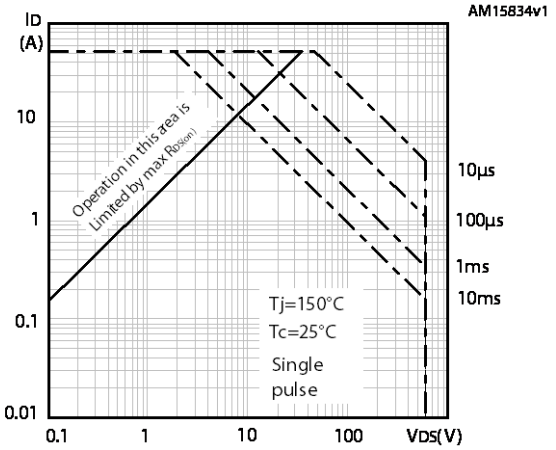



**Figure 5: Thermal impedance for D²PAK and TO-220**

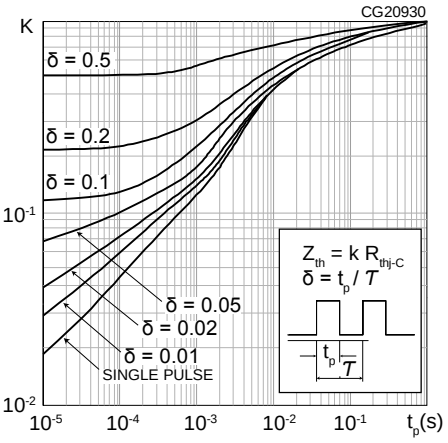



**Figure 6: Output characteristics**

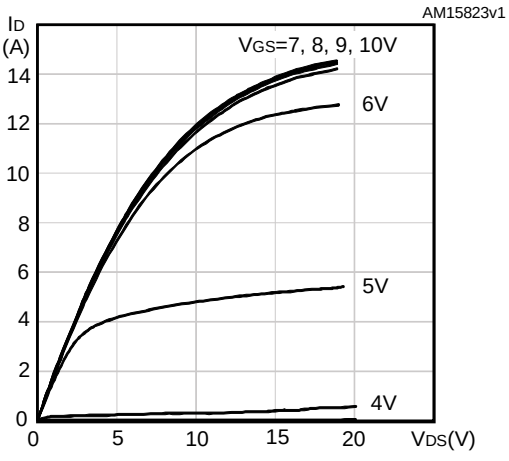



**Figure 7: Transfer characteristics**

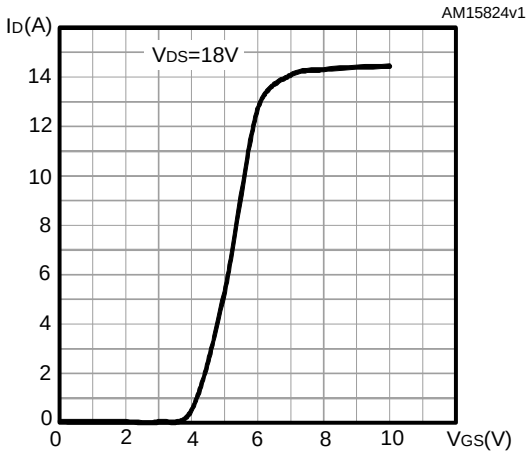


**Figure 8: Gate charge vs gate-source voltage**

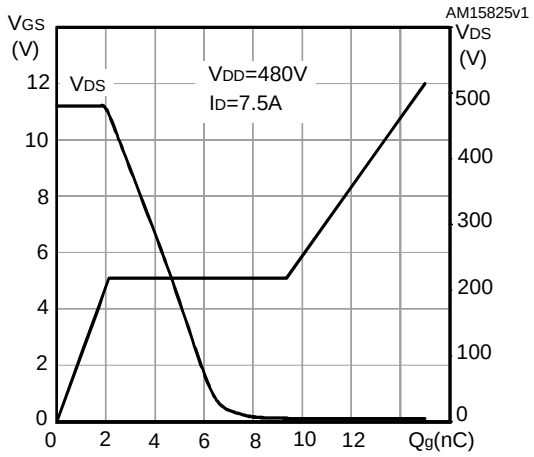



**Figure 9: Static drain-source on-resistance**

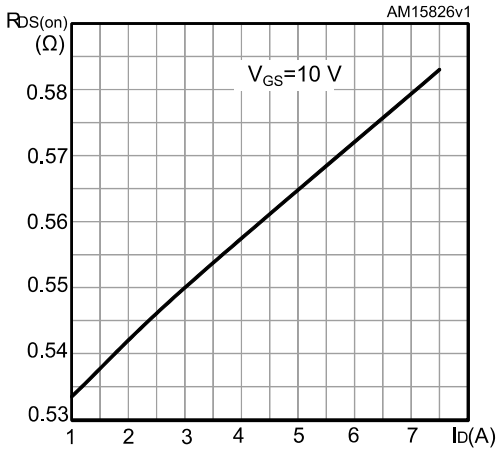



**Figure 10: Capacitance variations**

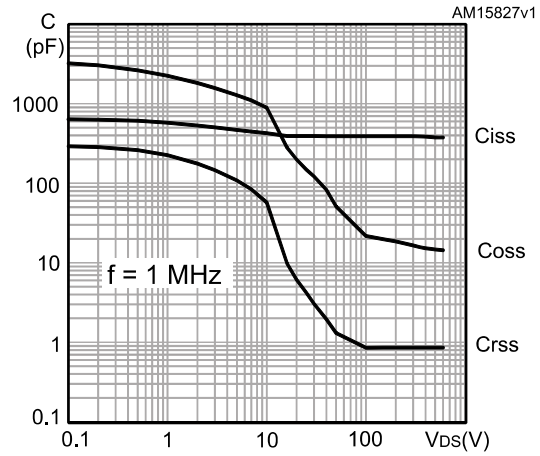



**Figure 11: Normalized gate threshold voltage vs temperature**

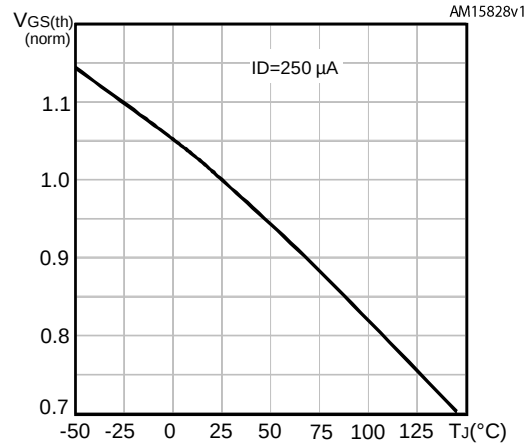



**Figure 12: Normalized on-resistance vs temperature**

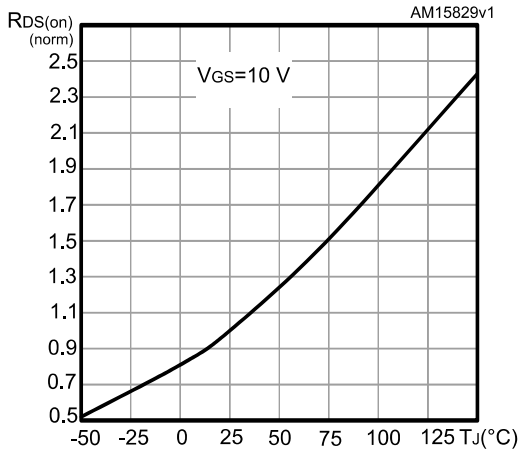



**Figure 13: Normalized $V_{(BR)DSS}$ vs temperature**

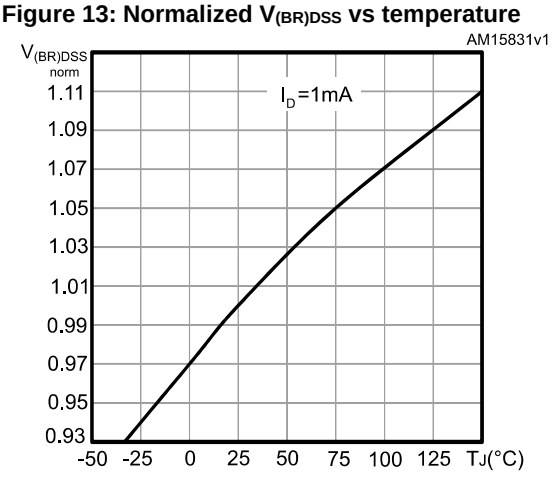


**Figure 14: Source-drain diode forward characteristics**

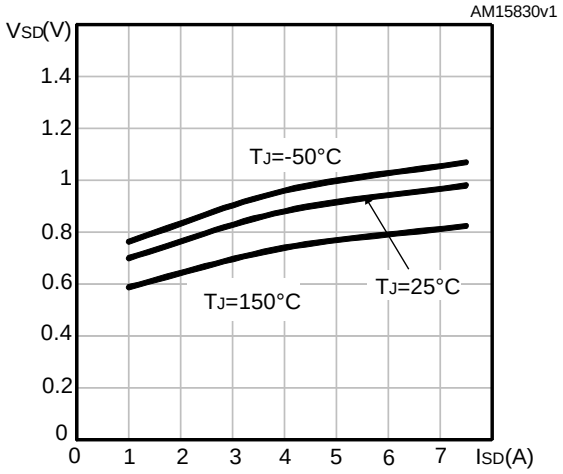
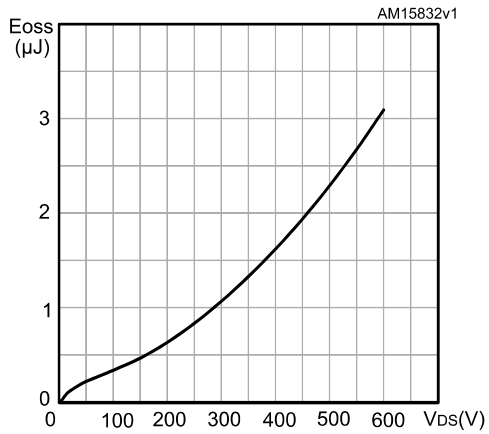



**Figure 15: Output capacitance stored energy**



# 3 Test circuits

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

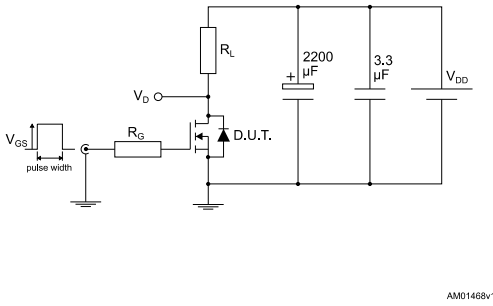



**Figure 17: Test circuit for gate charge behavior**

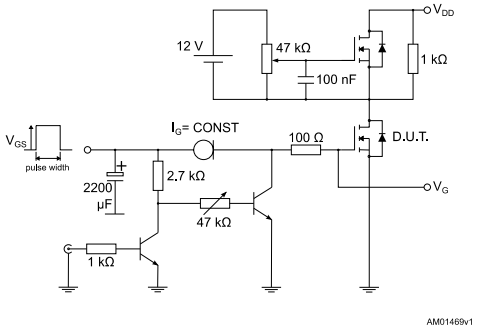



**Figure 18: Test circuit for inductive load switching and diode recovery times**

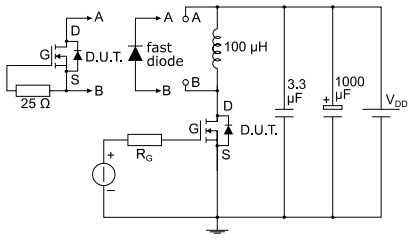



**Figure 19: Unclamped inductive load test circuit**

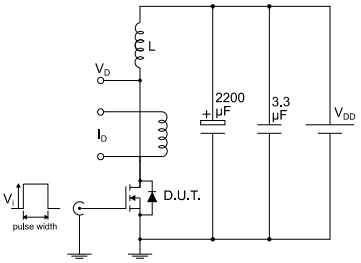



**Figure 20: Unclamped inductive waveform**

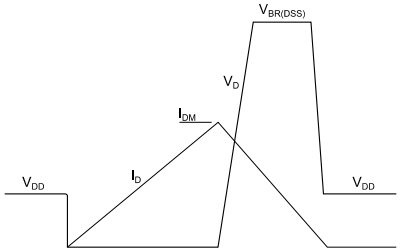
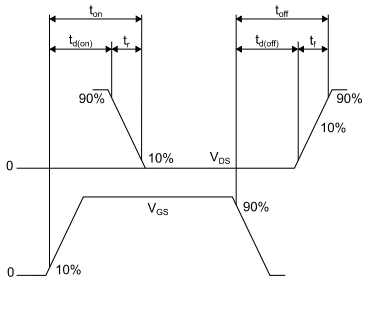



**Figure 21: Switching time waveform**



# 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 D²PAK (TO-263) type A package information

**Figure 22: D²PAK (TO-263) type A package outline**

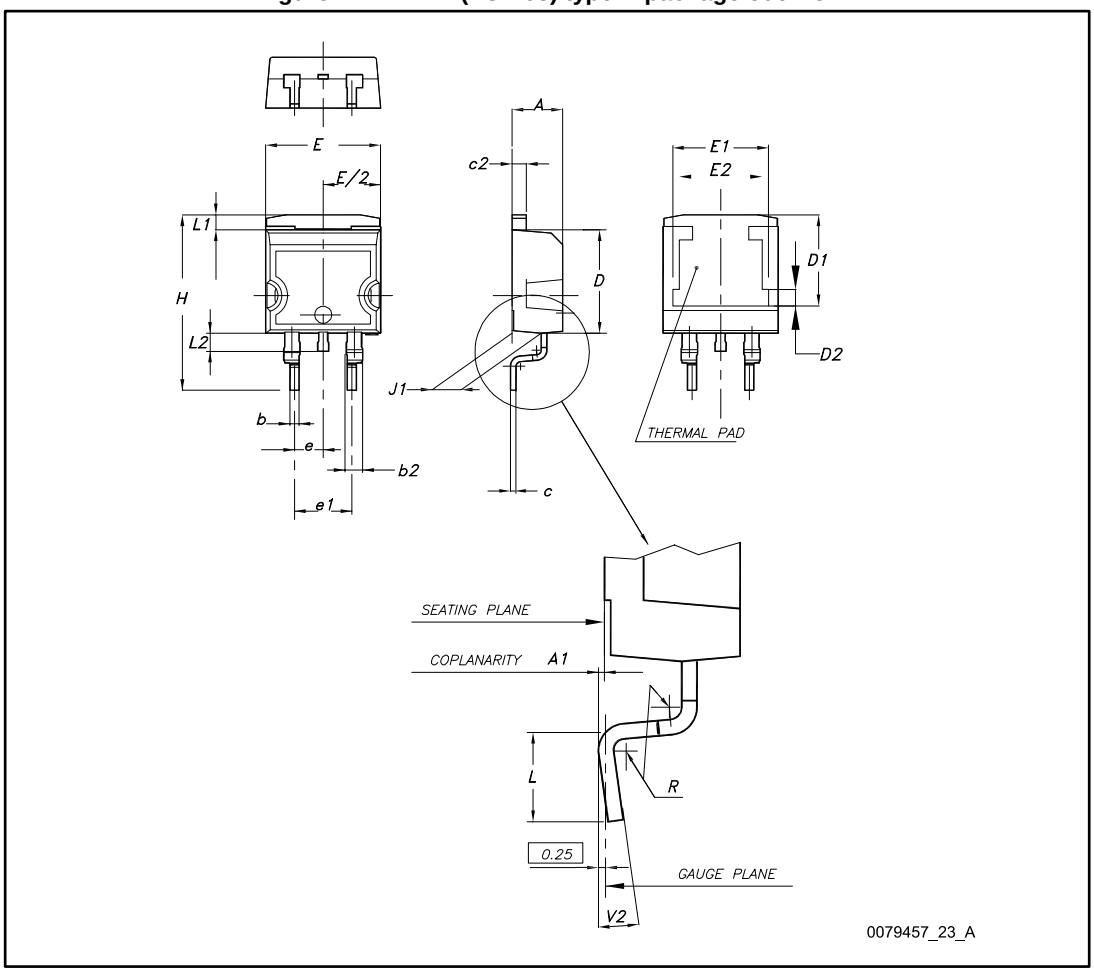
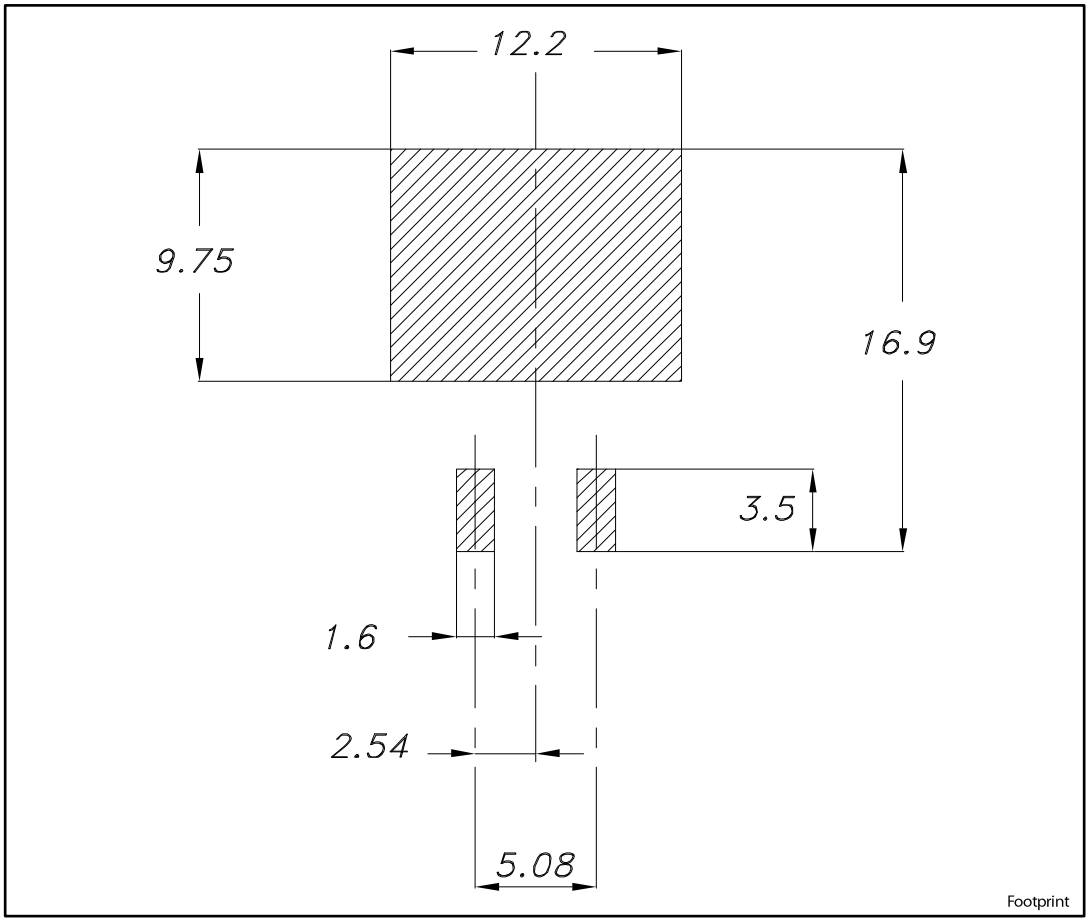


Table 9: D²PAK (TO-263) type A package mechanical data

| Dim. | mm | | |
|---|---|---|---|
| | Min. | Typ. | Max. |
| A | 4.40 | | 4.60 |
| A1 | 0.03 | | 0.23 |
| b | 0.70 | | 0.93 |
| b2 | 1.14 | | 1.70 |
| c | 0.45 | | 0.60 |
| c2 | 1.23 | | 1.36 |
| D | 8.95 | | 9.35 |
| D1 | 7.50 | 7.75 | 8.00 |
| D2 | 1.10 | 1.30 | 1.50 |
| E | 10.00 | | 10.40 |
| E1 | 8.50 | 8.70 | 8.90 |
| E2 | 6.85 | 7.05 | 7.25 |
| e | | 2.54 | |
| e1 | 4.88 | | 5.28 |
| H | 15.00 | | 15.85 |
| J1 | 2.49 | | 2.69 |
| L | 2.29 | | 2.79 |
| L1 | 1.27 | | 1.40 |
| L2 | 1.30 | | 1.75 |
| R | | 0.40 | |
| V2 | 0° | | 8° |

Figure 23: D²PAK (TO-263) type A recommended footprint (dimensions are in mm)



## 4.2 DPAK (TO-252) type A package information

**Figure 24: DPAK (TO-252) type A package outline**

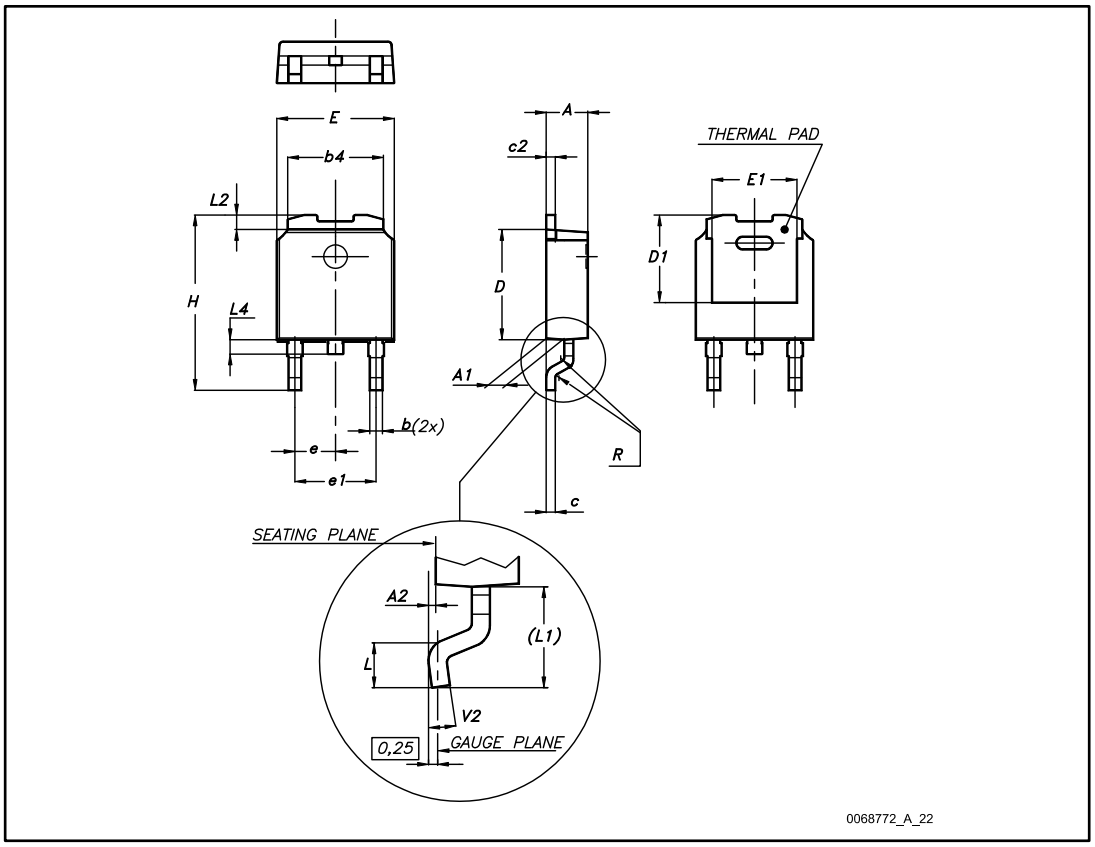


Table 10: DPAK (TO-252) type A mechanical data

| 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 | 2.16 | 2.28 | 2.40 |
| e1 | 4.40 | | 4.60 |
| 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° |

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

**Figure 25: DPAK (TO-252) type C package outline**

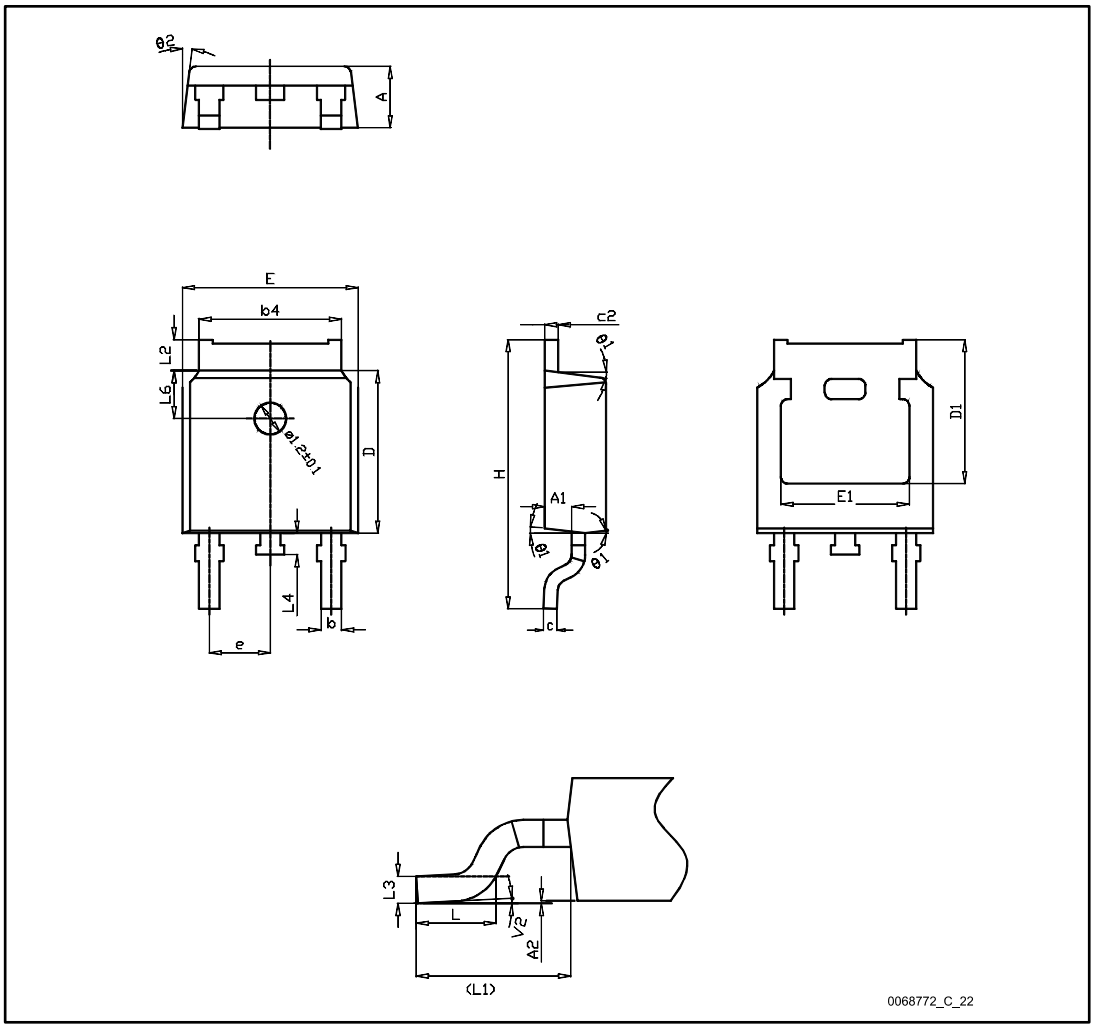


Table 11: DPAK (TO-252) type C mechanical data

| 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° |

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

**Figure 26: DPAK (TO-252) type E package outline**

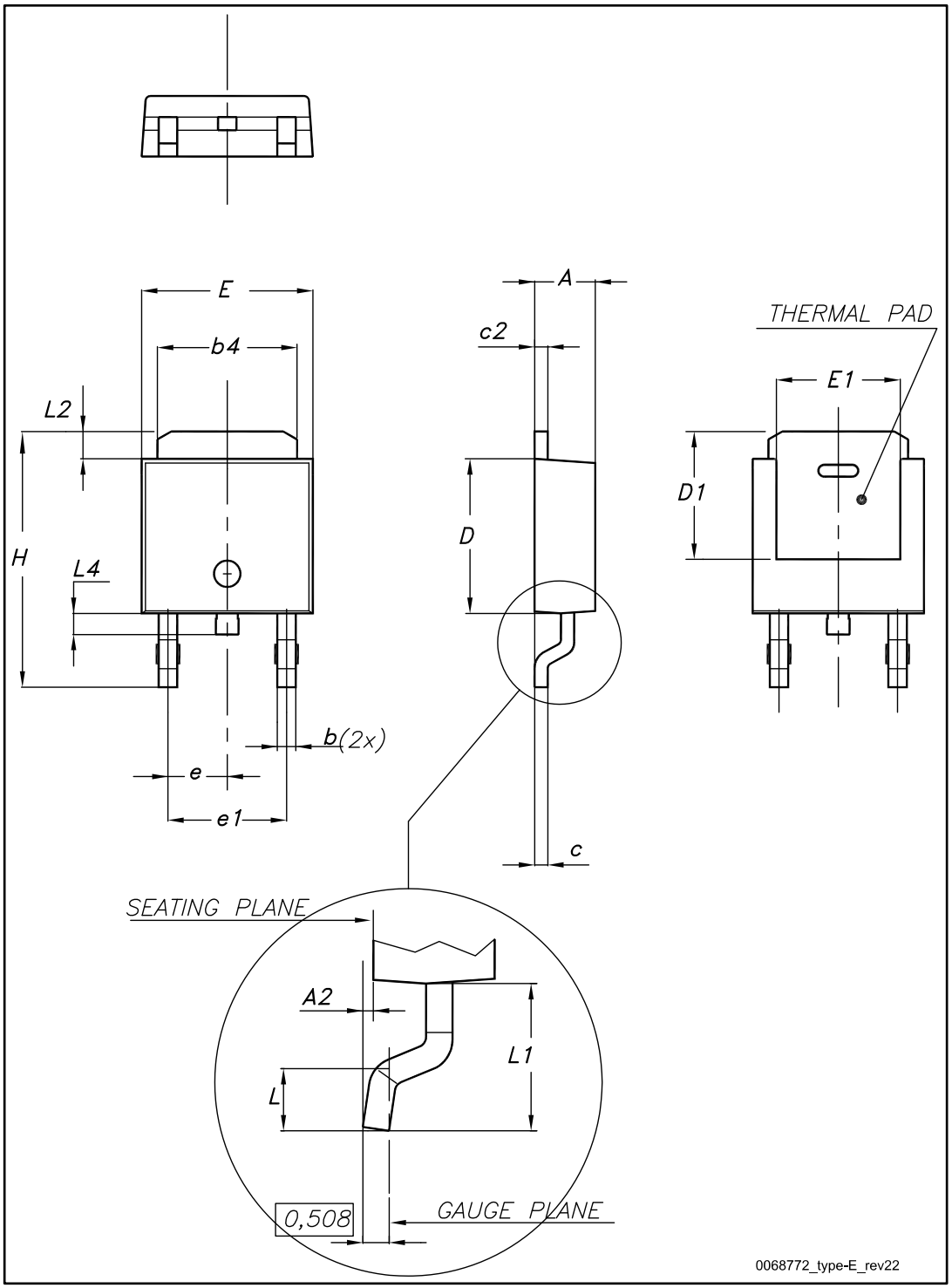
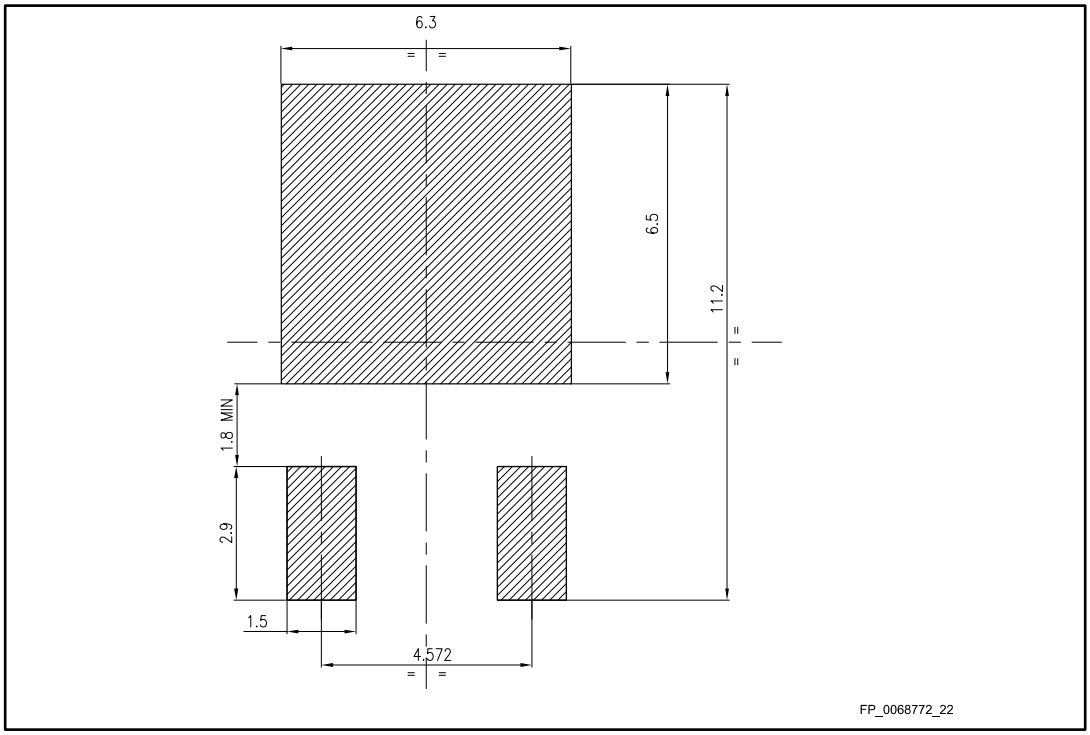


**Table 12: DPAK (TO-252) type E mechanical data**

| 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 27: DPAK (TO-252) recommended footprint (dimensions are in mm)**



## 4.5 TO-220 type A package information

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

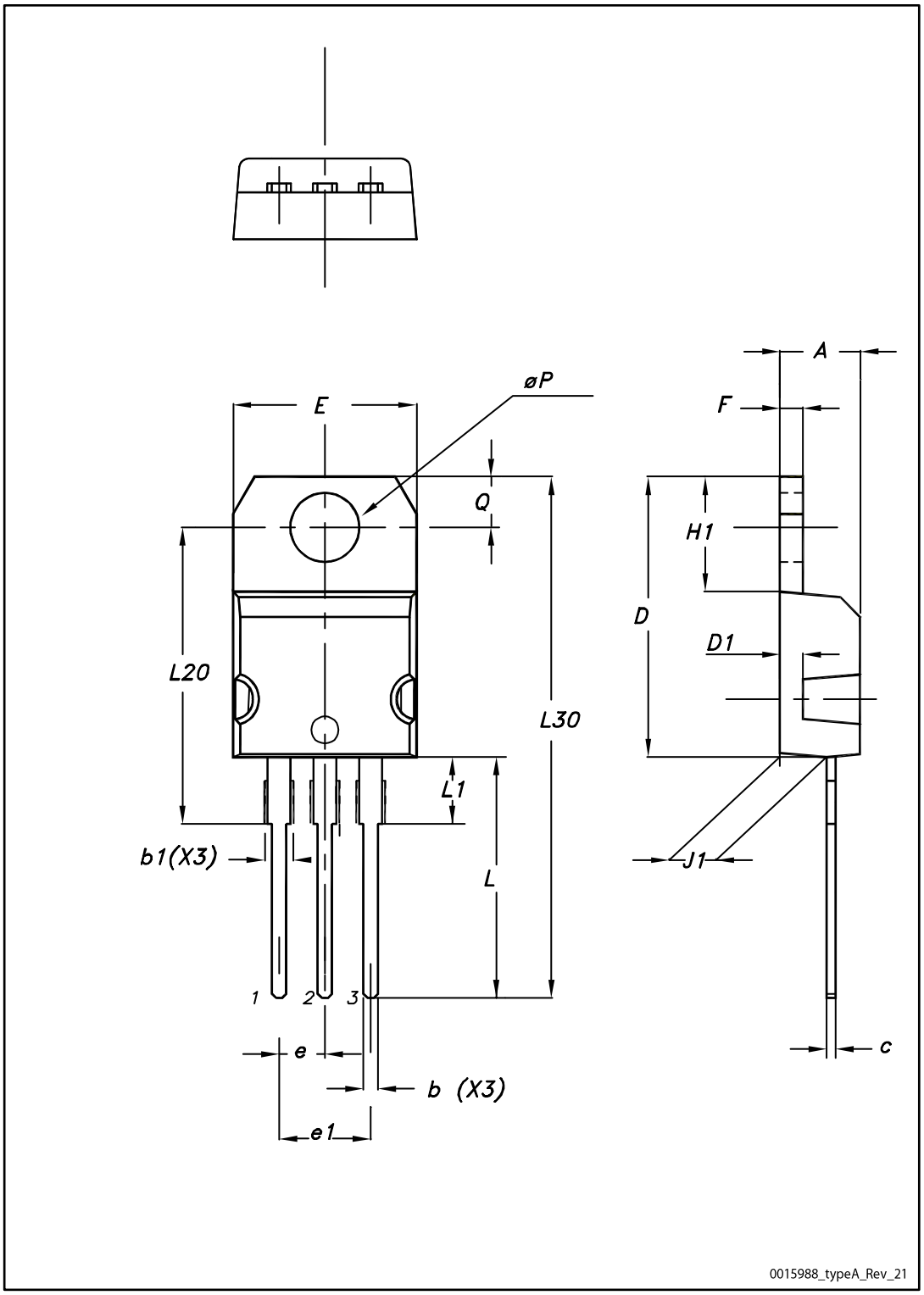


Table 13: TO-220 type A mechanical data

| 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**

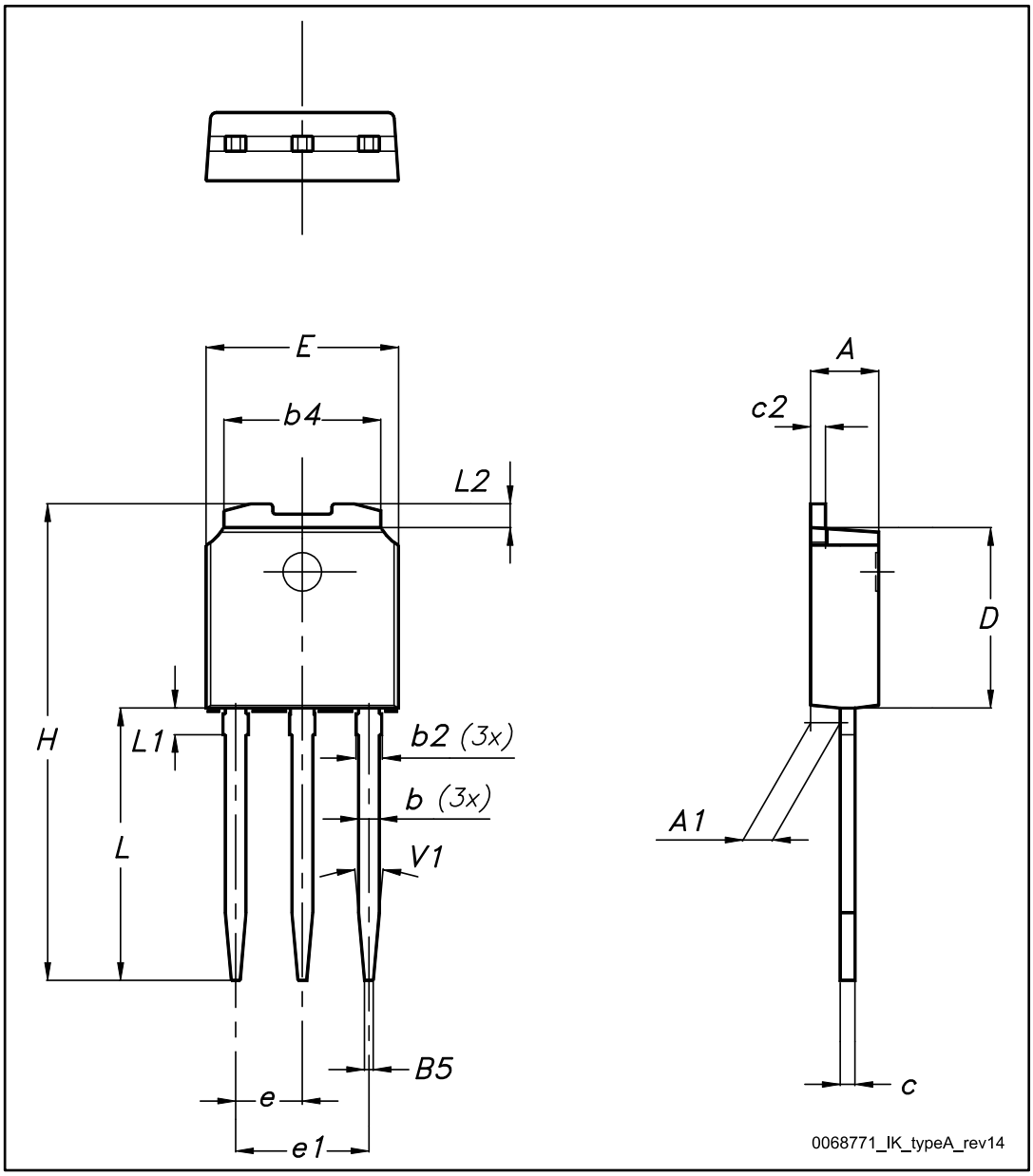


Table 14: IPAK (TO-251) type A package mechanical data

| 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**

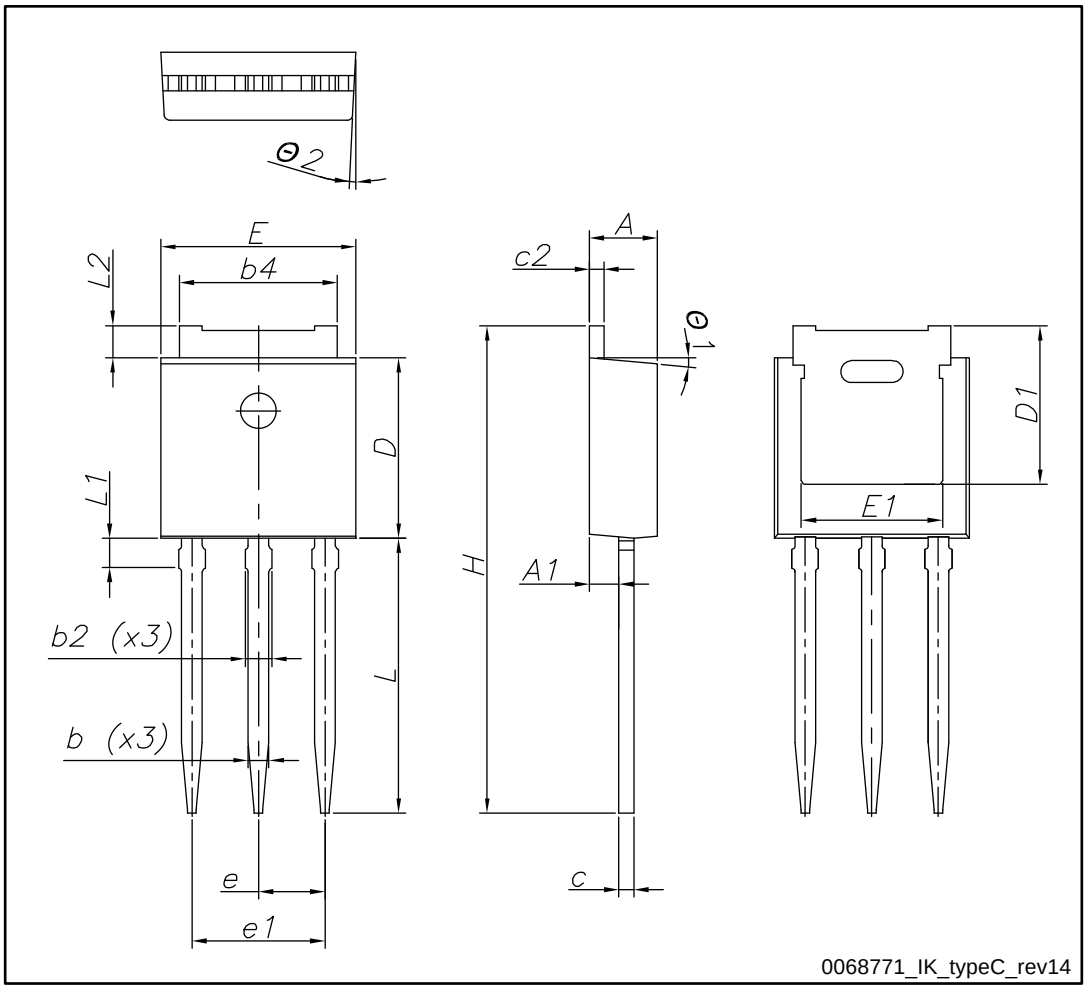


Table 15: IPAK (TO-251) type C package mechanical data

| 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° |

## 4.8 D²PAK and DPAK packing information

**Figure 31: Tape outline**

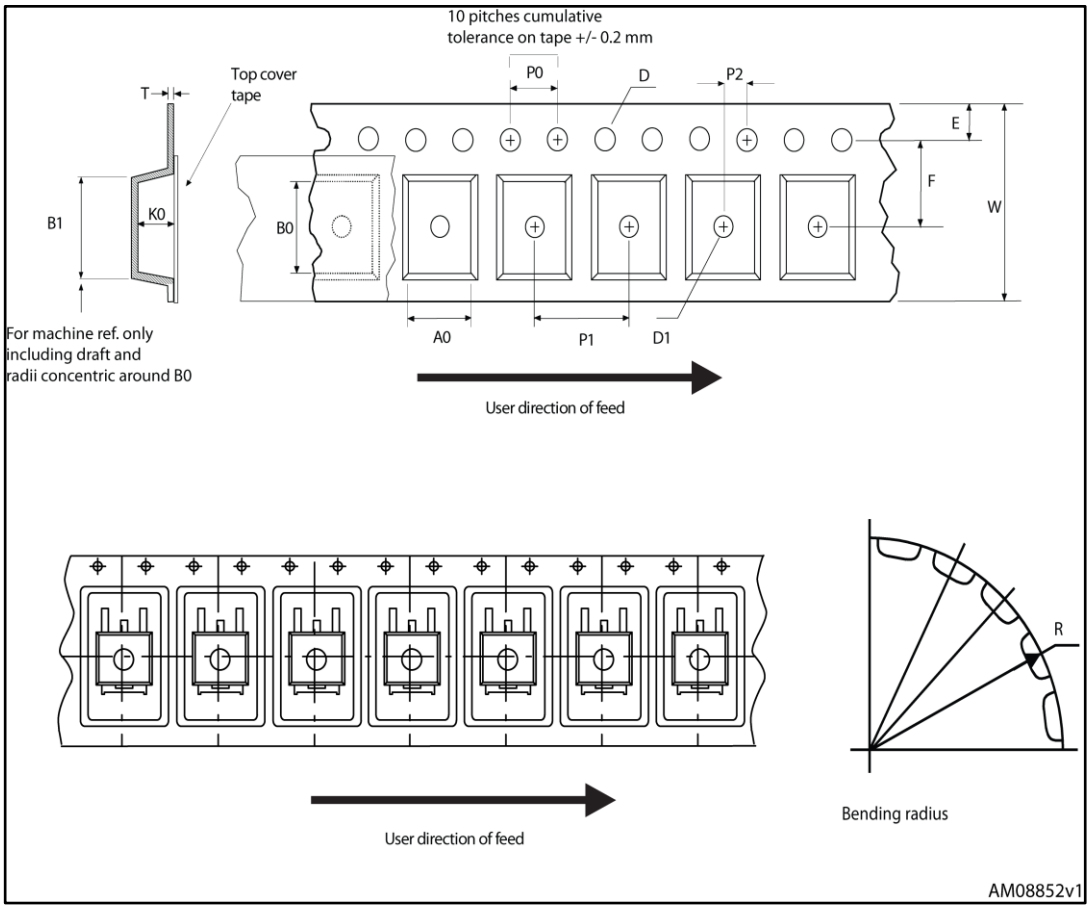


**Figure 32: Reel outline**

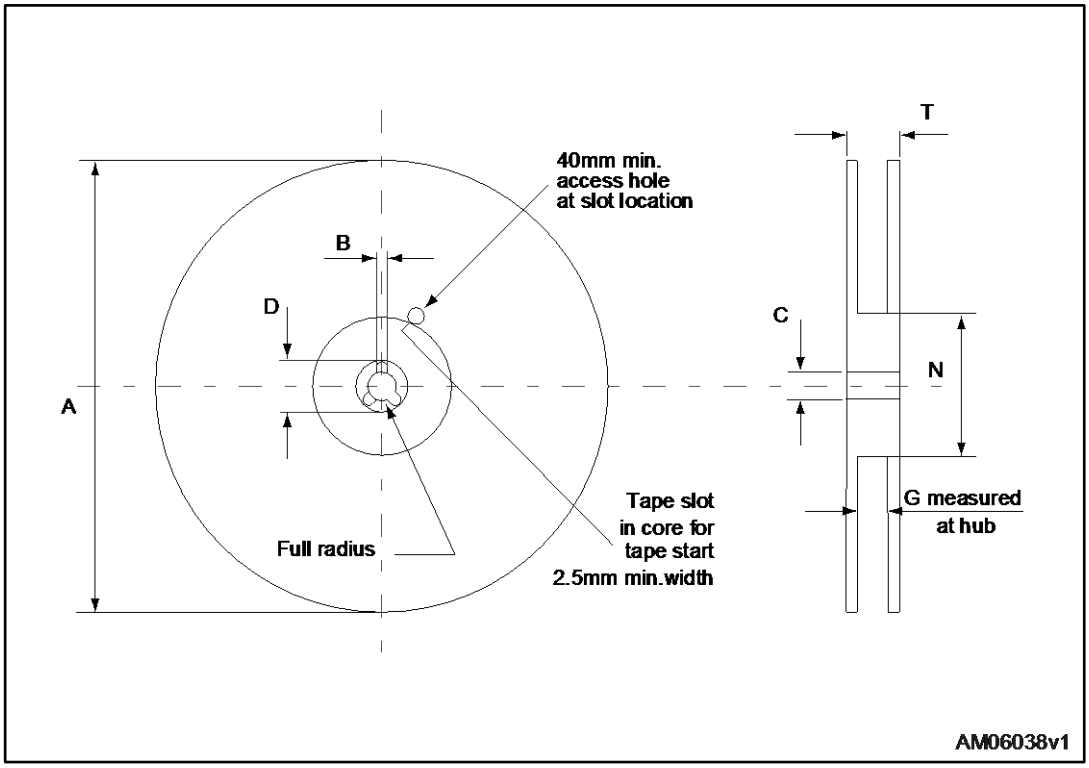



**Table 16: D²PAK tape and reel mechanical data**

| Tape | | | Reel | | |
|---|---|---|---|---|---|
| Dim. | mm | | Dim. | mm | |
| | Min. | Max. | | Min. | Max. |
| A0 | 10.5 | 10.7 | A | | 330 |
| B0 | 15.7 | 15.9 | B | 1.5 | |
| D | 1.5 | 1.6 | C | 12.8 | 13.2 |
| D1 | 1.59 | 1.61 | D | 20.2 | |
| E | 1.65 | 1.85 | G | 24.4 | 26.4 |
| F | 11.4 | 11.6 | N | 100 | |
| K0 | 4.8 | 5.0 | T | | 30.4 |
| P0 | 3.9 | 4.1 | | | |
| P1 | 11.9 | 12.1 | Base quantity | | 1000 |
| P2 | 1.9 | 2.1 | Bulk quantity | | 1000 |
| R | 50 | | | | |
| T | 0.25 | 0.35 | | | |
| W | 23.7 | 24.3 | | | |

**Table 17: DPAK 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 | | | |

# 5 Revision history

**Table 18: Document revision history**

| Date | Revision | Changes |
|---|---|---|
| 29-May-2013 | 1 | First release. |
| 06-Dec-2013 | 2 | – Added: $D^2PAK$ package<br>– Modified: title and $R_{DS(on)}$ values in cover page<br>-Modified: $R_{DS(on)}$ values in *Table 5*<br>– Modified: $R_G$ value in *Table 6*<br>– Modified: *Figure 9* and $I_D$ value in *Figure 12*<br>– Added: *Table 9*, *13*, *Figure 22* and *23*<br>– Updated: *Table 10*, *11*, *Figure 24*, *25* and *26*<br>– Minor text changes |
| 13-Mar-2017 | 3 | Updated the title and the description in cover page.<br>Updated *Table 4: "Avalanche characteristics"*.<br>Updated *Section 4.2: "DPAK (TO-252) type A package information"*.<br>Added *Section 4.4: "DPAK (TO-252) type E package information"* and *Section 4.7: "IPAK (TO-251) type C package information"*.<br>Minor text changes. |

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