# THE DATASHEET OF

# STB33N60DM2

# STB33N60DM2, STP33N60DM2, STW33N60DM2

## N-channel 600 V, 0.110 Ω typ., 24 A MDmesh™ DM2 Power MOSFET in D²PAK, TO-220 and TO-247 packages

Datasheet - production data

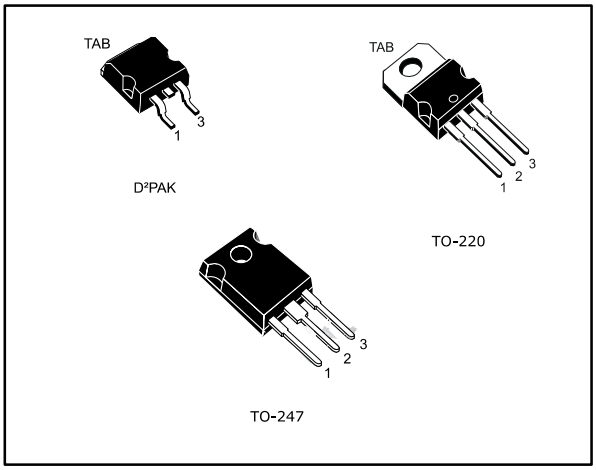
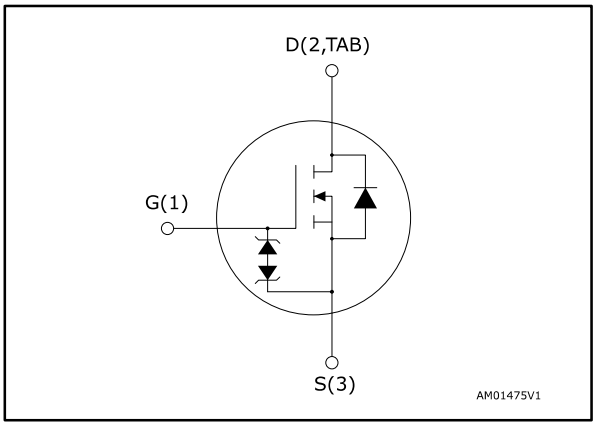



**Figure 1: Internal schematic diagram**




## Features

| Order code | $V_{DS}$ @ $T_{Jmax.}$ | $R_{DS(on)}$ max. | $I_D$ |
|---|---|---|---|
| STB33N60DM2 | 650 V | 0.130 Ω | 24 A |
| STP33N60DM2 | 650 V | 0.130 Ω | 24 A |
| STW33N60DM2 | 650 V | 0.130 Ω | 24 A |

- Fast-recovery body diode
- Extremely low gate charge and input capacitance
- Low on-resistance
- 100% avalanche tested
- Extremely high dv/dt ruggedness
- Zener-protected

## Applications

- Switching applications

## Description

These high voltage N-channel Power MOSFETs are part of the MDmesh™ DM2 fast recovery diode series. They offer very low recovery charge ($Q_{rr}$) and time ($t_{rr}$) combined with low $R_{DS(on)}$, rendering them suitable for the most demanding high efficiency converters and ideal for bridge topologies and ZVS phase-shift converters.

**Table 1: Device summary**

| Order code | Marking | Package | Packing |
|---|---|---|---|
| STB33N60DM2 | 33N60DM2 | D²PAK | Tape and reel |
| STP33N60DM2 | 33N60DM2 | TO-220 | Tube |
| STW33N60DM2 | 33N60DM2 | TO-247 | Tube |

# Contents

# 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 | 24 | A |
| | Drain current (continuous) at $T_{case}$ = 100 °C | 15.5 | |
| $I_{DM}$(1) | Drain current (pulsed) | 96 | A |
| $P_{TOT}$ | Total dissipation at $T_{case}$ = 25 °C | 190 | W |
| dv/dt(2) | Peak diode recovery voltage slope | 50 | V/ns |
| dv/dt(3) | MOSFET dv/dt ruggedness | 50 | |
| $T_{stg}$ | Storage temperature | -55 to 150 | °C |
| $T_j$ | Operating junction temperature | | |

**Notes:**

(1) Pulse width is limited by safe operating area.

(2) $I_{SD} \leq 24$ A, di/dt=900 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 |
|---|---|---|---|---|---|
| | | D²PAK | TO-220 | TO-247 | |
| $R_{thj\text{-}case}$ | Thermal resistance junction-case | 0.66 | | | °C/W |
| $R_{thj\text{-}pcb}$ | Thermal resistance junction-pcb(1) | 30 | | | |
| $R_{thj\text{-}amb}$ | Thermal resistance junction-ambient | | 62.5 | 50 | |

**Notes:**

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

**Table 4: Avalanche characteristics**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $I_{AR}$ | Avalanche current, repetitive or not repetitive (Pulse width limited by $T_{jmax}$) | 5.5 | A |
| $E_{AS}$ | Single pulse avalanche energy (starting $T_j$ = 25 °C, $I_D = I_{AR}$, $V_{DD}$ = 50 V) | 570 | mJ |

# 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 | | | 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 | 3 | 4 | 5 | V |
| $R_{DS(on)}$ | Static drain-source on-resistance | $V_{GS}$ = 10 V, $I_D$ = 12 A | | 0.110 | 0.130 | Ω |

**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 | - | 1870 | - | pF |
| $C_{oss}$ | Output capacitance | | - | 87 | - | |
| $C_{rss}$ | Reverse transfer capacitance | | - | 2 | - | |
| $C_{oss\ eq.}$ (1) | Equivalent output capacitance | $V_{DD}$ = 480 V, $V_{GS}$ = 0 V | - | 157 | - | pF |
| $R_G$ | Intrinsic gate resistance | f = 1 MHz, $I_D$= 0 A | - | 4.5 | - | Ω |
| $Q_g$ | Total gate charge | $V_{DD}$ = 480 V, $I_D$ = 24 A, $V_{GS}$ = 10 V (see *Figure 19: "Test circuit for gate charge behavior"* and *Figure 23: "Switching time waveform"*) | - | 43 | - | nC |
| $Q_{gs}$ | Gate-source charge | | - | 9.8 | - | |
| $Q_{gd}$ | Gate-drain charge | | - | 21 | - | |

**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, $I_D$ = 12 A, $R_G$ = 4.7 Ω, $V_{GS}$ = 10 V (see *Figure 18: "Test circuit for resistive load switching times"* and ) | - | 17 | - | ns |
| $t_r$ | Rise time | | - | 8 | - | |
| $t_{d(off)}$ | Turn-off delay time | | - | 62 | - | |
| $t_f$ | Fall time | | - | 9 | - | |

**Table 8: Source-drain diode**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $I_{SD}$ | Source-drain current | | - | | 24 | A |
| $I_{SDM}$(1) | Source-drain current (pulsed) | | - | | 96 | A |
| $V_{SD}$(2) | Forward on voltage | $V_{GS}$ = 0 V, $I_{SD}$ = 24 A | - | | 1.6 | V |
| $t_{rr}$ | Reverse recovery time | $I_{SD}$ = 24 A, di/dt = 100 A/µs, $V_{DD}$ = 60 V (see *Figure 20: "Test circuit for inductive load switching and diode recovery times"*) | - | 150 | | ns |
| $Q_{rr}$ | Reverse recovery charge | | - | 0.5 | | µC |
| $I_{RRM}$ | Reverse recovery current | | - | 8.8 | | A |
| $t_{rr}$ | Reverse recovery time | $I_{SD}$ = 24 A, di/dt = 100 A/µs, $V_{DD}$ = 60 V, $T_j$ = 150 °C (see *Figure 20: "Test circuit for inductive load switching and diode recovery times"*) | - | 316 | | ns |
| $Q_{rr}$ | Reverse recovery charge | | - | 2.85 | | µC |
| $I_{RRM}$ | Reverse recovery current | | - | 18 | | A |

**Notes:**

(1) Pulse width is limited by safe operating area.

(2) Pulse test: pulse duration = 300 µs, duty cycle 1.5%.

**Table 9: Gate-source Zener diode**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{(BR)GSO}$ | Gate-source breakdown voltage | $I_{GS}$ = ±250 µA, $I_D$ = 0 A | ±30 | - | - | V |

## 2.1 Electrical characteristics (curves)

**Figure 2: Safe operating area for D²PAK**

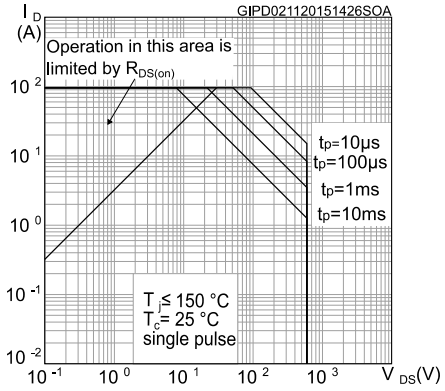



**Figure 3: Thermal impedance for D²PAK**

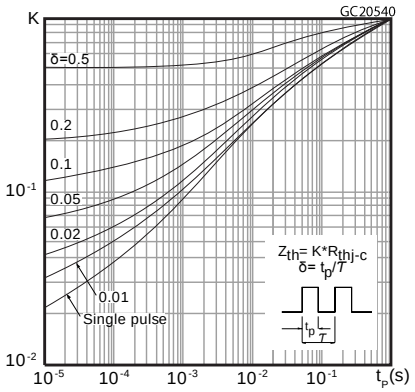



**Figure 4: Safe operating area for TO-220**

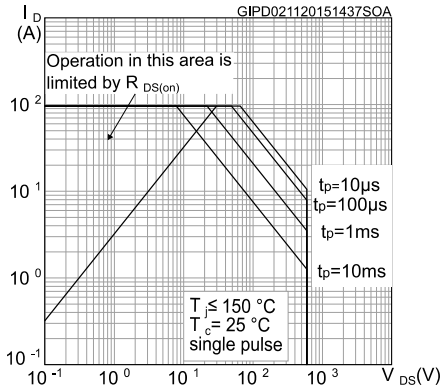



**Figure 5: Thermal impedance for TO-220**

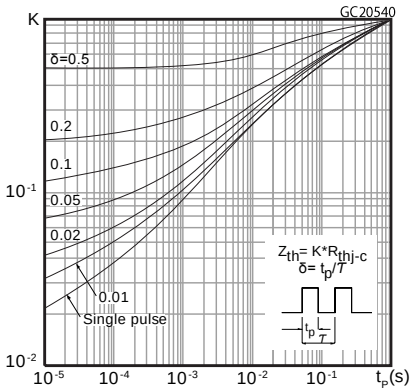



**Figure 6: Safe operating area for TO-247**

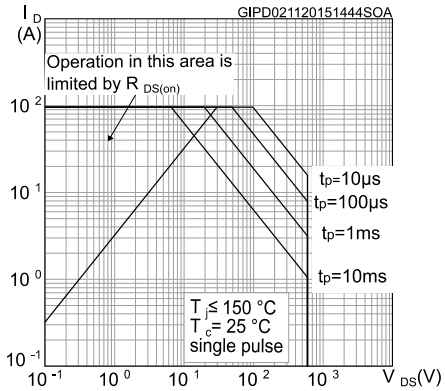



**Figure 7: Thermal impedance for TO-247**

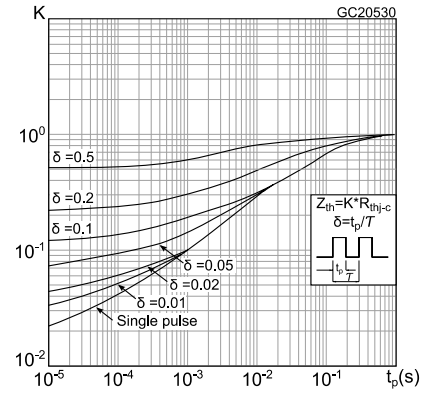


**Figure 8: Output characteristics**

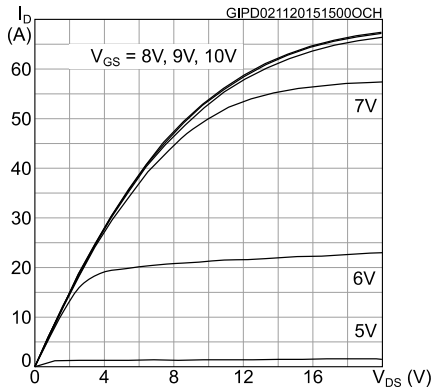



**Figure 9: Transfer characteristics**

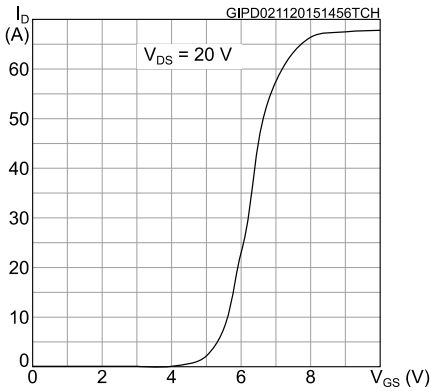



**Figure 10: Gate charge vs gate-source voltage**

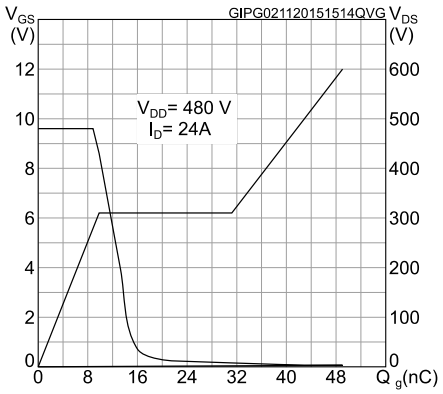



**Figure 11: Static drain-source on-resistance**

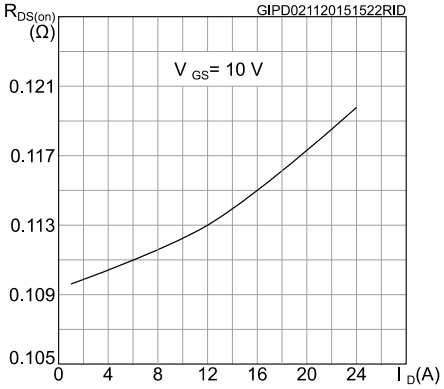



**Figure 12: Capacitance variations**

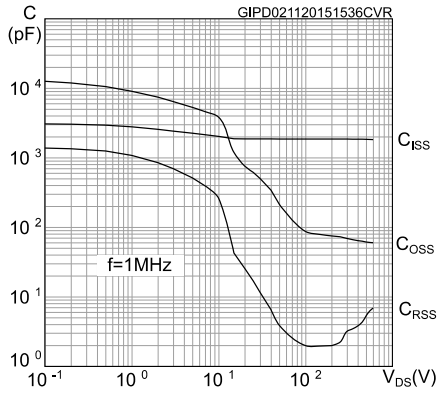



**Figure 13: Normalized gate threshold voltage vs temperature**

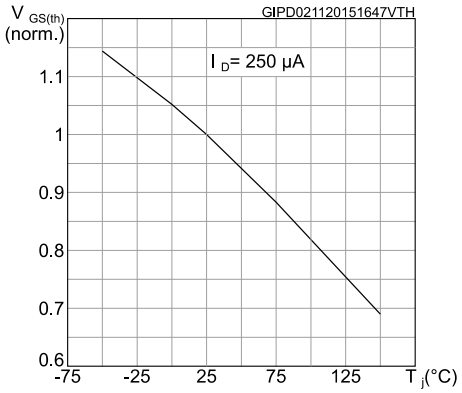


**Figure 14: Normalized on-resistance vs temperature**

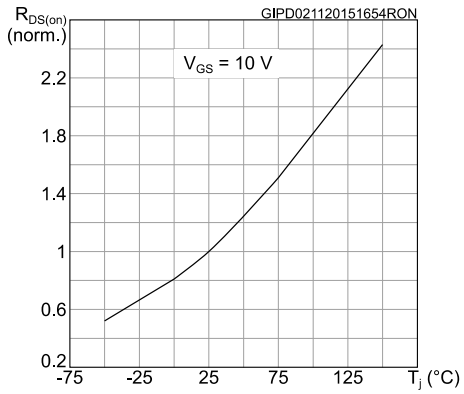



**Figure 15: Normalized V(BR)DSS vs temperature**

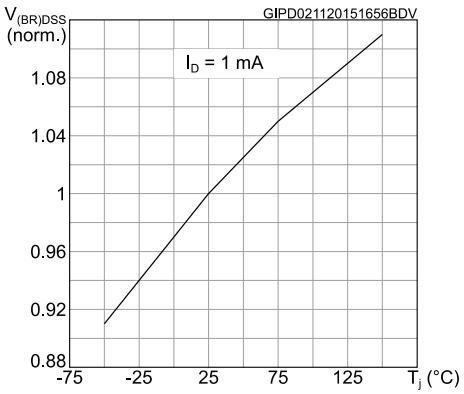



**Figure 16: Output capacitance stored energy**

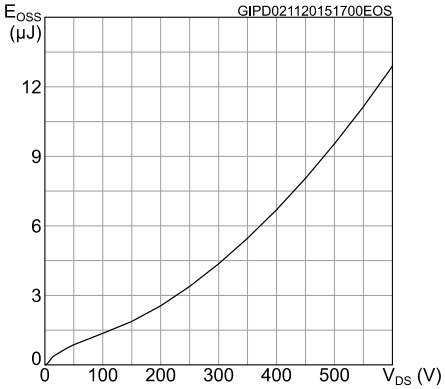
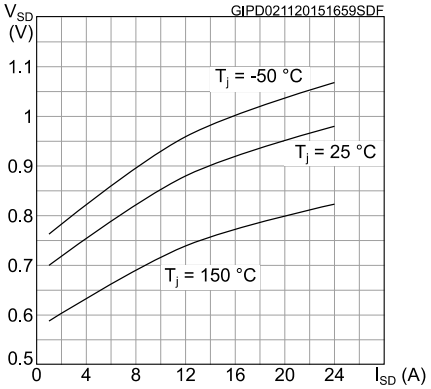



**Figure 17: Source- drain diode forward characteristics**



# 3 Test circuits

**Figure 18: Test circuit for resistive load switching times**

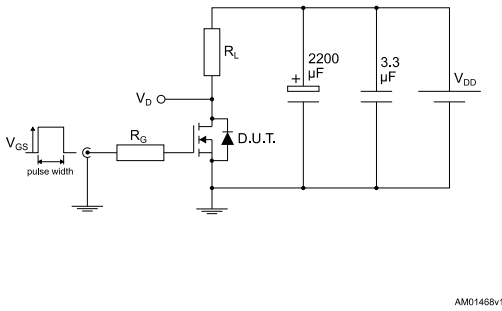



**Figure 19: Test circuit for gate charge behavior**

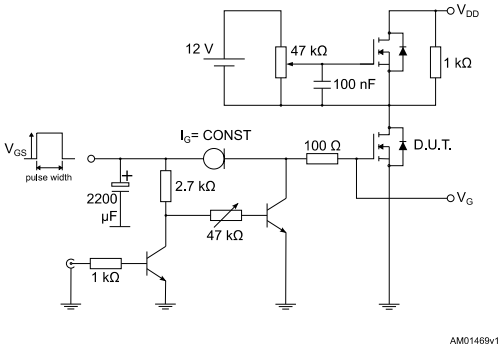



**Figure 20: Test circuit for inductive load switching and diode recovery times**

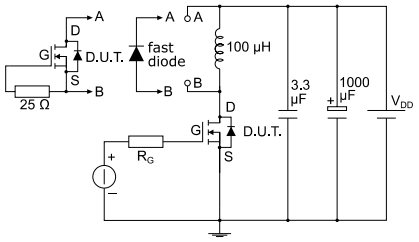



**Figure 21: Unclamped inductive load test circuit**

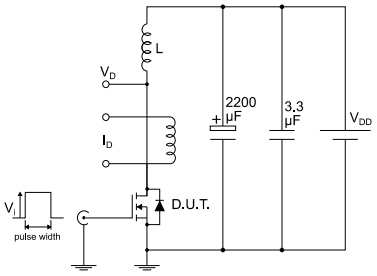



**Figure 22: Unclamped inductive waveform**

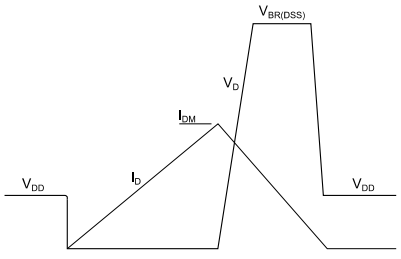
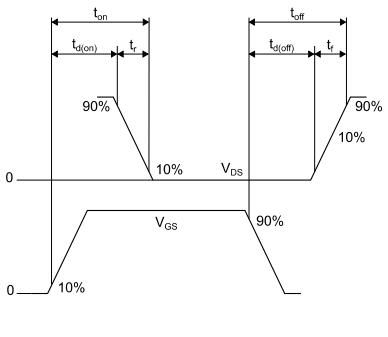



**Figure 23: Switching time waveform**



# 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 package information

**Figure 24: D²PAK (TO-263) type A package outline**

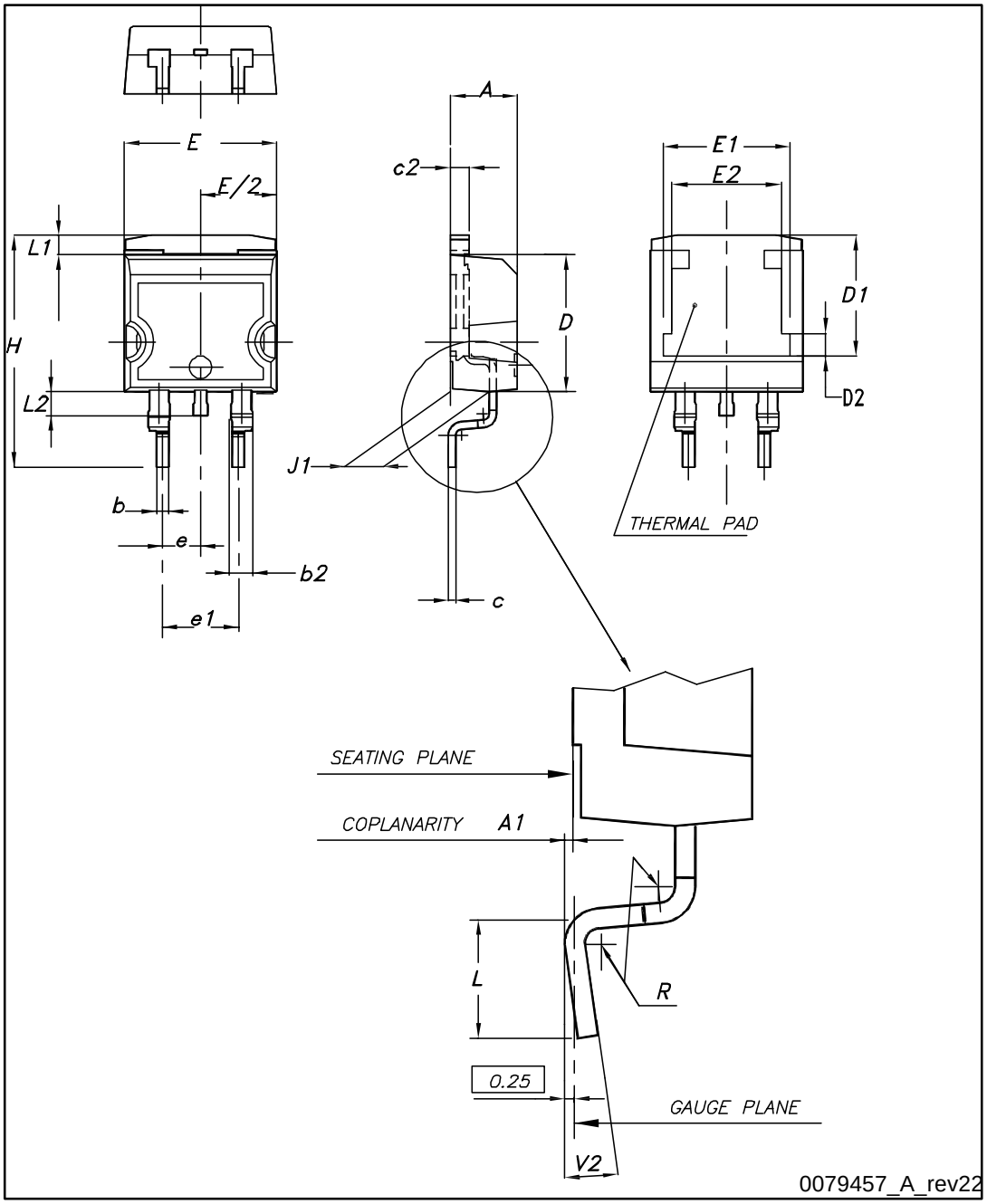
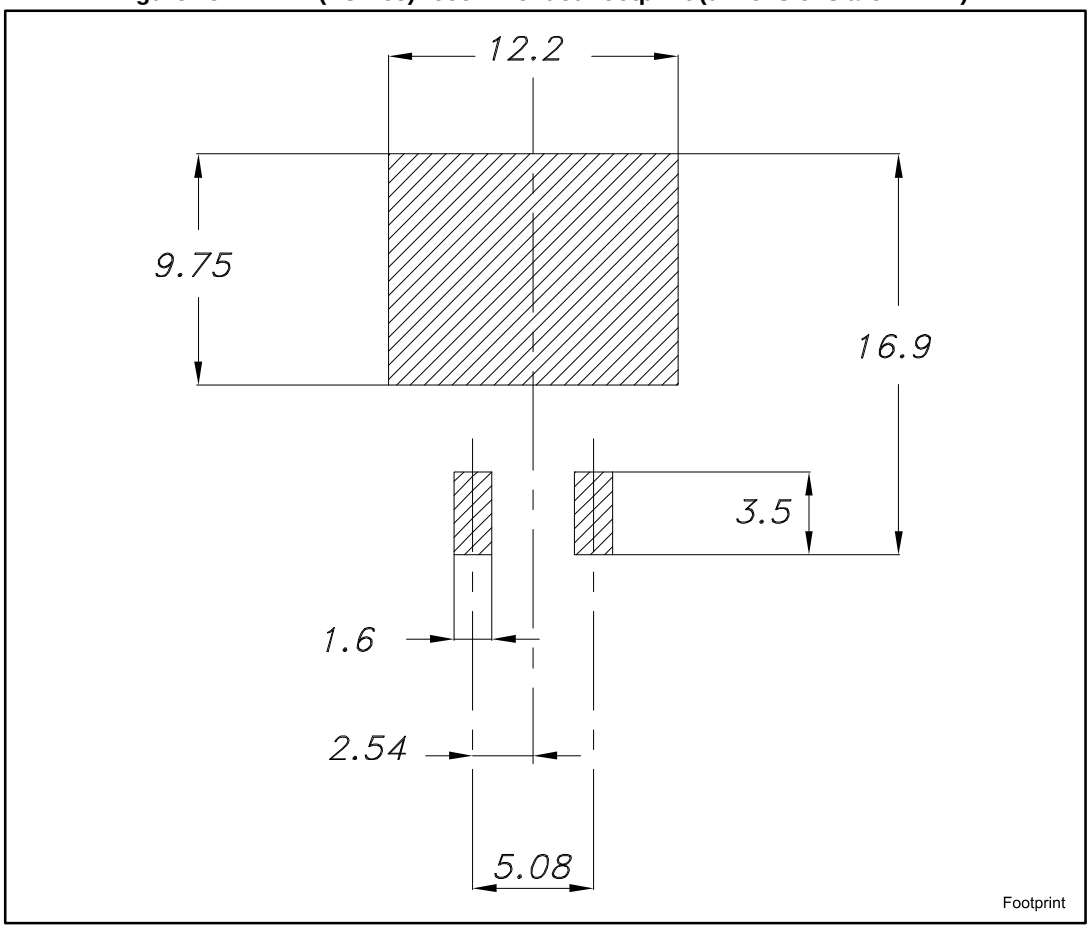


Table 10: D²PAK (TO-263) type A package mechanical data

| 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 | | 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 | | 15.85 |
| J1 | 2.49 | | 2.69 |
| L | 2.29 | | 2.79 |
| L1 | 1.27 | | 1.40 |
| L2 | 1.30 | | 1.75 |
| R | | 0.4 | |
| V2 | 0° | | 8° |

**Figure 25: D²PAK (TO-263) recommended footprint (dimensions are in mm)**



## 4.2 D²PAK packing information

**Figure 26: Tape outline**

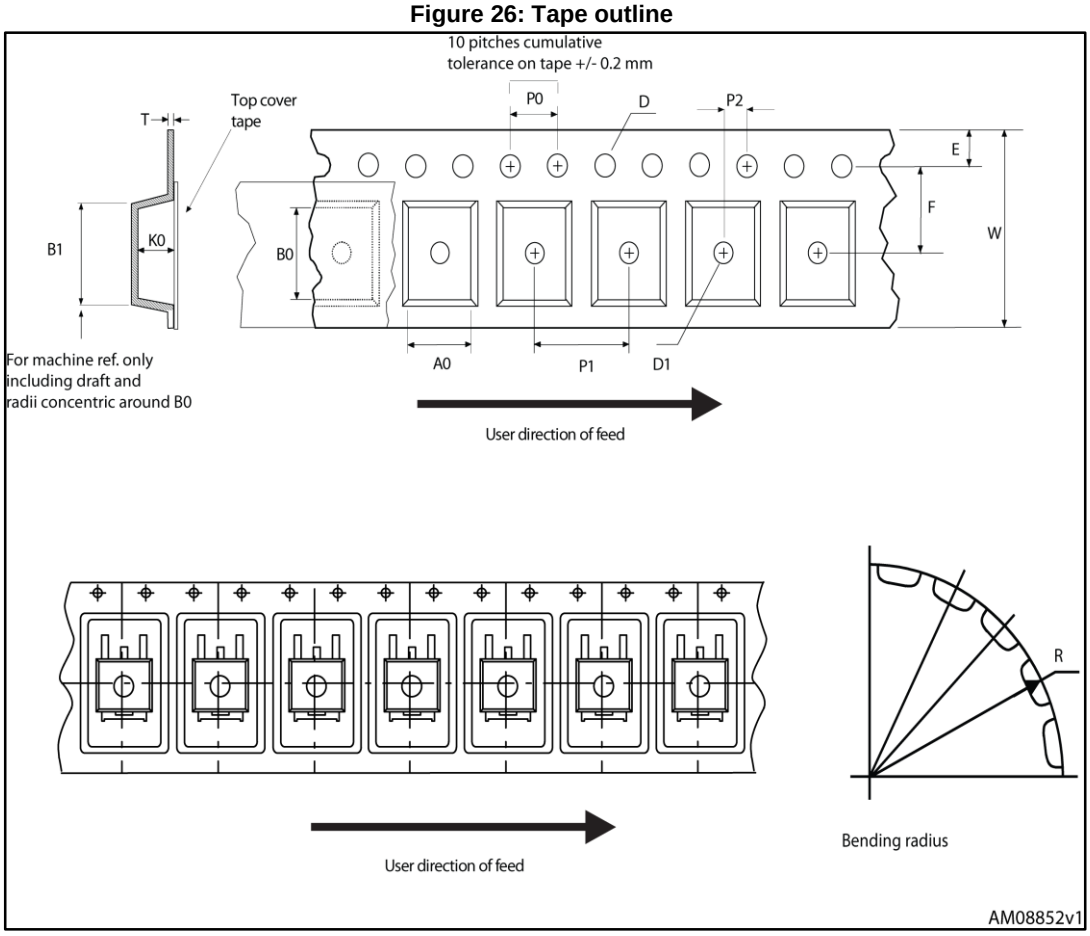


**Figure 27: Reel outline**

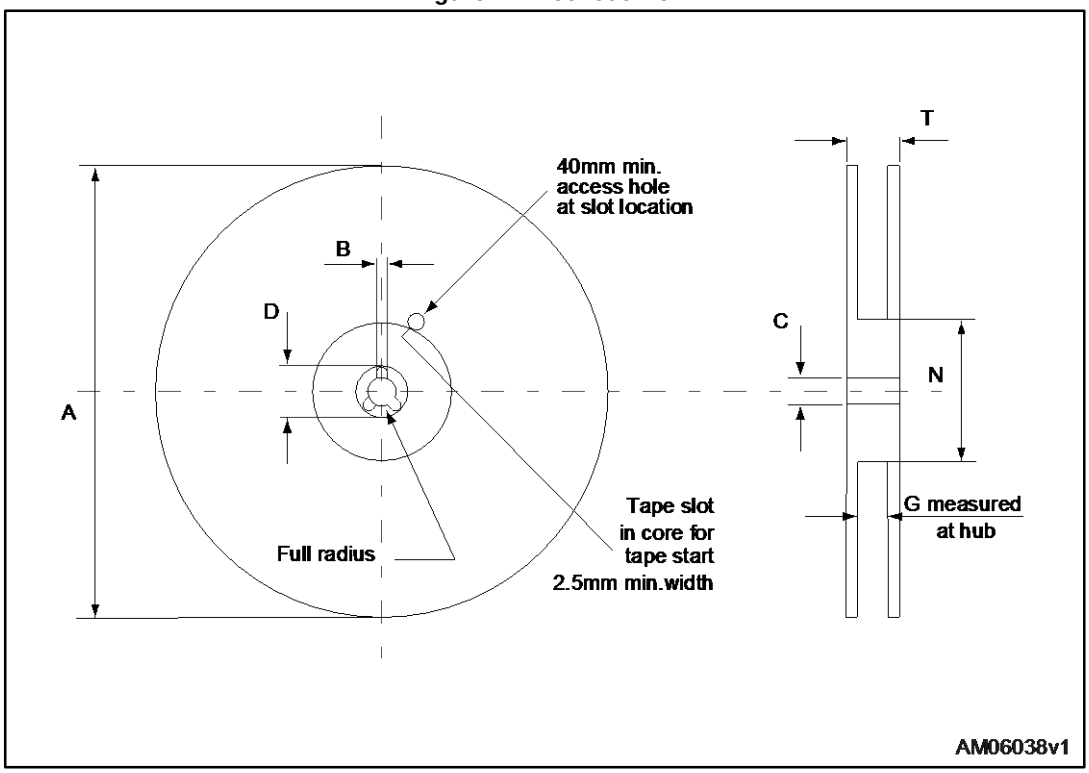



**Table 11: D²PAK tape and reel mechanical data**

| 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 | | | |

## 4.3 TO-220 type A package information

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

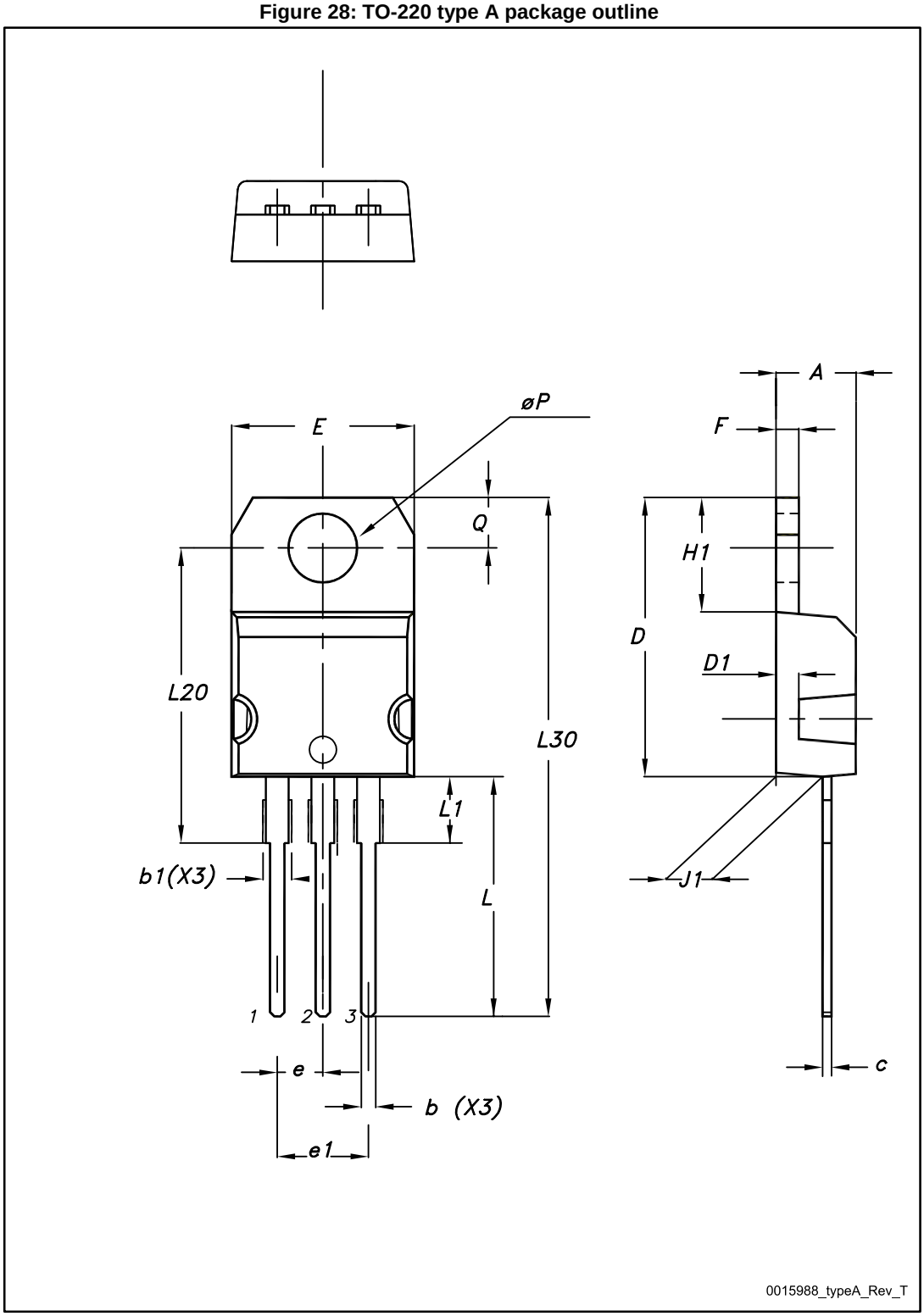


Table 12: TO-220 type A mechanical data

| Dim. | mm | | |
|---|---|---|---|
| | Min. | Typ. | Max. |
| A | 4.40 | | 4.60 |
| b | 0.61 | | 0.88 |
| b1 | 1.14 | | 1.70 |
| c | 0.48 | | 0.70 |
| D | 15.25 | | 15.75 |
| D1 | | 1.27 | |
| E | 10 | | 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 | | 14 |
| L1 | 3.50 | | 3.93 |
| L20 | | 16.40 | |
| L30 | | 28.90 | |
| øP | 3.75 | | 3.85 |
| Q | 2.65 | | 2.95 |

## 4.4 TO-247 package information

**Figure 29: TO-247 package outline**

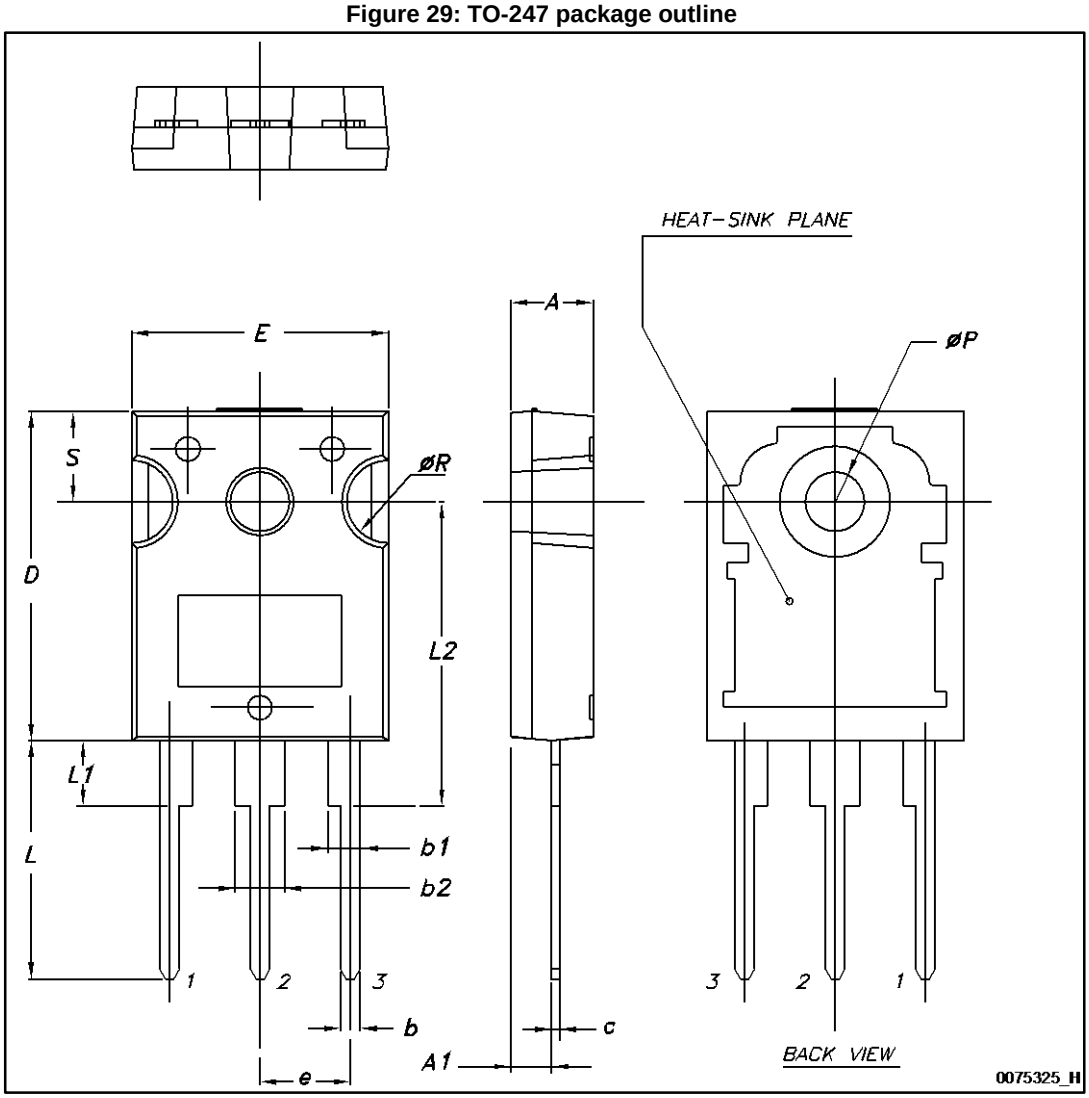


Table 13: TO-247 package mechanical data

| 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 | 5.30 | 5.45 | 5.60 |
| L | 14.20 | | 14.80 |
| L1 | 3.70 | | 4.30 |
| L2 | | 18.50 | |
| ØP | 3.55 | | 3.65 |
| ØR | 4.50 | | 5.50 |
| S | 5.30 | 5.50 | 5.70 |

# 5 Revision history

Table 14: Document revision history

| Date | Revision | Changes |
|---|---|---|
| 16-Oct-2014 | 1 | First release. |
| 02-Nov-2015 | 2 | Document status promoted from preliminary to production data.<br>Updated title and features in cover page.<br>Updated *Table 2: "Absolute maximum ratings"*, *Table 4: "Avalanche characteristics"*, *Table 5: "Static"*, *Table 6: "Dynamic"*, *Table 7: "Switching times"* and *Table 8: "Source-drain diode"*.<br>Added *Section 2.1 Electrical characteristics (curves).* |

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