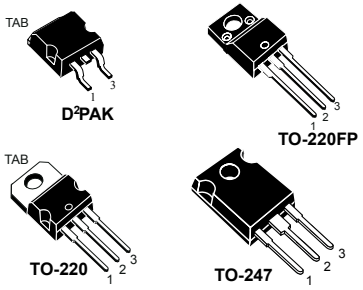
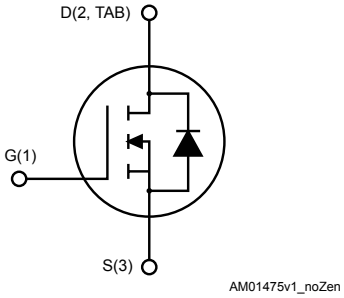
# STB31N65M5, STF31N65M5
# STP31N65M5, STW31N65M5

Datasheet

## N-channel 650 V, 0.124 Ω, 22 A, MDmesh M5 Power MOSFETs in D²PAK, TO-220FP, TO-220 and TO-247 packages




## Features

| Order code | $V_{DS}$ @ $T_{JMAX}$ | $R_{DS(on)}$ max. | $I_D$ | Package |
|---|---|---|---|---|
| STB31N65M5 | 710 V | 0.148 Ω | 22 A | D²PAK |
| STF31N65M5 | | | | TO-220FP |
| STP31N65M5 | | | | TO-220 |
| STW31N65M5 | | | | TO-247 |

- Extremely low $R_{DS(on)}$
- Low gate charge and input capacitance
- Excellent switching performance
- 100% avalanche tested

## Applications

- Switching applications

## Description

These devices are N-channel Power MOSFETs based on the MDmesh M5 innovative vertical process technology combined with the well-known PowerMESH horizontal layout. The resulting products offer extremely low on-resistance, making them particularly suitable for applications requiring high power and superior efficiency.

STPOWER

| Product status link |
|---|
| STB31N65M5 |
| STF31N65M5 |
| STP31N65M5 |
| STW31N65M5 |

# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

| Symbol | Parameter | Value | | Unit |
|---|---|---|---|---|
| | | D²PAK, TO-220, TO-247 | TO-220FP | |
| $V_{GS}$ | Gate-source voltage | ±25 | | V |
| $I_D$ | Drain current (continuous) at $T_C$ = 25 °C | 22 | 22 (1) | A |
| $I_D$ | Drain current (continuous) at $T_C$ = 100 °C | 13.9 | 13.9 (1) | A |
| $I_{DM}$ (2) | Drain current (pulsed) | 88 | 88 (1) | A |
| $P_{TOT}$ | Total power dissipation at $T_C$ = 25 °C | 150 | 30 | W |
| $V_{ISO}$ | Insulation withstand voltage (RMS) from all three leads to external heat-sink (t = 1 s, $T_C$ = 25 °C) | | 2500 | V |
| dv/dt (3) | Peak diode recovery voltage slope | 15 | | V/ns |
| dv/dt (4) | MOSFET dv/dt ruggedness | 50 | | |
| $T_j$ | Operating junction temperature range | -55 to 150 | | °C |
| $T_{stg}$ | Storage temperature range | | | |

1. *Limited by package.*
2. *Limited by maximum junction temperature.*
3. *$I_{SD}$ ≤ 22 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 |
|---|---|---|---|---|---|---|
| | | D²PAK | TO-220 | TO-220FP | TO-247 | |
| $R_{thj\text{-}case}$ | Thermal resistance junction-case | 0.83 | | 4.17 | 0.83 | °C/W |
| $R_{thj\text{-}amb}$ | Thermal resistance junction-ambient | | 62.5 | | 50 | °C/W |
| $R_{thj\text{-}pcb}$ (1) | Thermal resistance junction-pcb | 30 | | | | °C/W |

1. *When mounted on FR-4 board of 1 inch², 2 oz Cu.*

**Table 3. Avalanche characteristics**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $I_{AR}$ | Avalanche current, repetitive or not repetitive (pulse width limited by $T_{jmax}$) | 5 | A |
| $E_{AS}$ | Single pulse avalanche energy (starting $T_j$ = 25 °C, $I_D$ = $I_{AR}$, $V_{DD}$ = 50 V) | 410 | mJ |

# 2 Electrical characteristics

$T_C$ = 25 °C unless otherwise specified

**Table 4. On/off-state**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage | $V_{GS}$ = 0 V, $I_D$ = 1 mA | 650 | | | V |
| $I_{DSS}$ | Zero gate voltage drain current | $V_{GS}$ = 0 V, $V_{DS}$ = 650 V | | | 1 | µA |
| | | $V_{GS}$ = 0 V, $V_{DS}$ = 650 V, $T_C$ = 125 °C (1) | | | 100 | µA |
| $I_{GSS}$ | Gate body leakage current | $V_{DS}$ = 0 V, $V_{GS}$ = ±25 V | | | ±100 | nA |
| $V_{GS(th)}$ | 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, $I_D$ = 11 A | | 0.124 | 0.148 | 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 | - | 1865 | - | pF |
| $C_{oss}$ | Output capacitance | | - | 45 | - | pF |
| $C_{rss}$ | Reverse transfer capacitance | | - | 4.2 | - | pF |
| $C_{o(tr)}$ (1) | Equivalent capacitance time related | $V_{GS}$ = 0 V, $V_{DS}$ = 0 to 520 V | - | 146 | - | pF |
| $C_{o(er)}$ (2) | Equivalent capacitance energy related | | - | 43 | - | pF |
| $R_g$ | Intrinsic gate resistance | f = 1 MHz | - | 2.8 | - | Ω |
| $Q_g$ | Total gate charge | $V_{DD}$ = 520 V, $I_D$ = 11 A $V_{GS}$= 0 to 10 V (see Figure 18. Test circuit for gate charge behavior) | - | 45 | - | nC |
| $Q_{gs}$ | Gate-source charge | | - | 11.5 | - | nC |
| $Q_{gd}$ | Gate-drain charge | | - | 20 | - | nC |

1. *$C_{o(tr)}$ is defined as a constant equivalent capacitance giving the same charging time as $C_{oss}$ when $V_{DS}$ increases from 0 to 80% $V_{DSS}$.*
2. *$C_{o(er)}$ is defined as a constant equivalent capacitance giving the same stored energy 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 |
|---|---|---|---|---|---|---|
| $t_{d(v)}$ | Voltage delay time | $V_{DD}$= 400 V, $I_D$ = 14 A, $R_G$ = 4.7 Ω $V_{GS}$ = 10 V (see Figure 19. Test circuit for inductive load switching and diode recovery times and Figure 22. Switching time waveform) | - | 46 | - | ns |
| $t_{r(v)}$ | Voltage rise time | | - | 8 | - | ns |
| $t_{f(i)}$ | Current fall time | | - | 8.5 | - | ns |
| $t_{c(off)}$ | Crossing time | | - | 11 | - | ns |

**Table 7. Source-drain diode**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $I_{SD}$ | Source-drain current | | - | | 22 | A |
| $I_{SDM}$ (1) | Source-drain current (pulsed) | | - | | 88 | A |
| $V_{SD}$ (2) | Forward on voltage | $I_{SD}$ = 22 A, $V_{GS}$ = 0 V | - | | 1.5 | V |
| $t_{rr}$ | Reverse recovery time | $I_{SD}$ = 22 A, di/dt = 100 A/µs, $V_{DD}$ = 100 V (see Figure 19. Test circuit for inductive load switching and diode recovery times) | - | 336 | | ns |
| $Q_{rr}$ | Reverse recovery charge | | - | 5 | | µC |
| $I_{RRM}$ | Reverse recovery current | | - | 30 | | A |
| $t_{rr}$ | Reverse recovery time | $I_{SD}$ = 22 A, di/dt = 100 A/µs, $V_{DD}$= 100 V, $T_j$= 150 °C ( see Figure 19. Test circuit for inductive load switching and diode recovery times) | - | 406 | | ns |
| $Q_{rr}$ | Reverse recovery charge | | - | 6 | | µC |
| $I_{RRM}$ | Reverse recovery current | | - | 31 | | 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 D²PAK, TO-220 and TO-247**

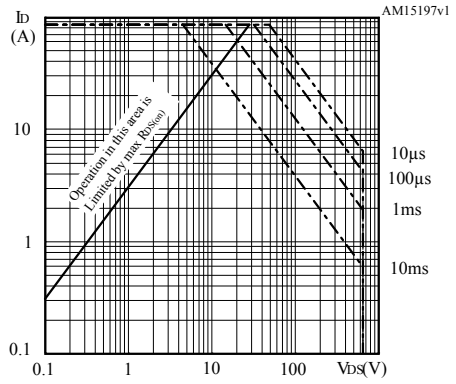



**Figure 2. Thermal impedance for D²PAK, TO-220 and TO-247**

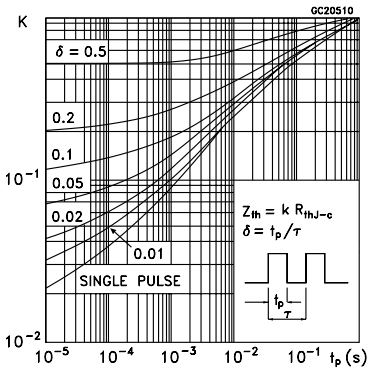



**Figure 3. Safe operating area for TO-220FP**

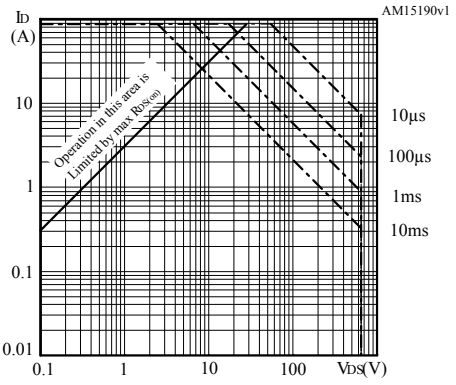



**Figure 4. Thermal impedance for TO-220FP**

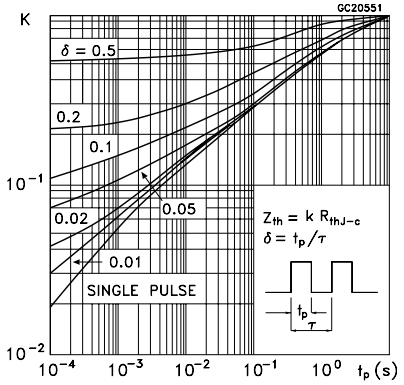



**Figure 5. Output characteristics**

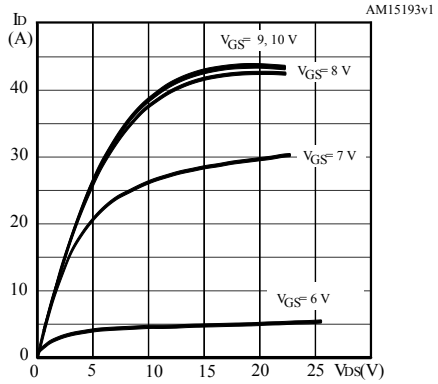



**Figure 6. Transfer characteristics**

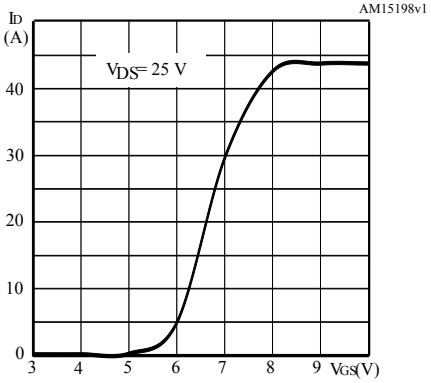


**Figure 7. Gate charge vs gate-source voltage**

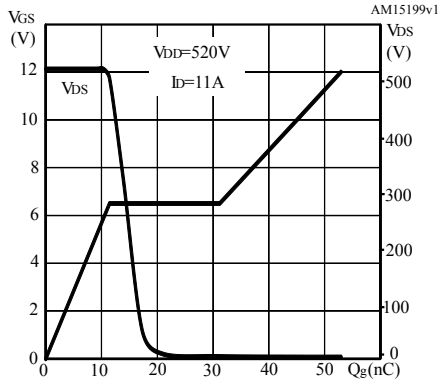



**Figure 8. Static drain-source on-resistance**

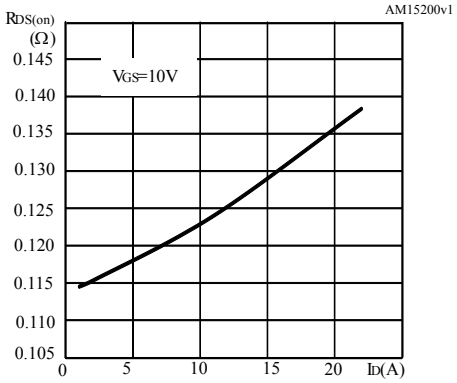



**Figure 9. Capacitance variations**

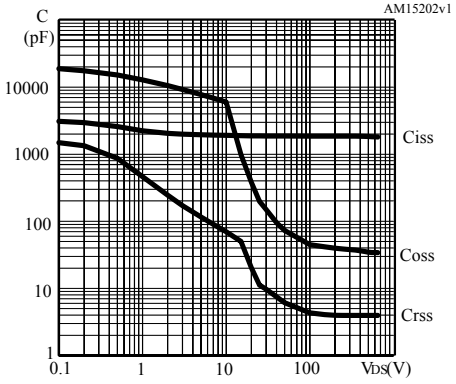



**Figure 10. Output capacitance stored energy**

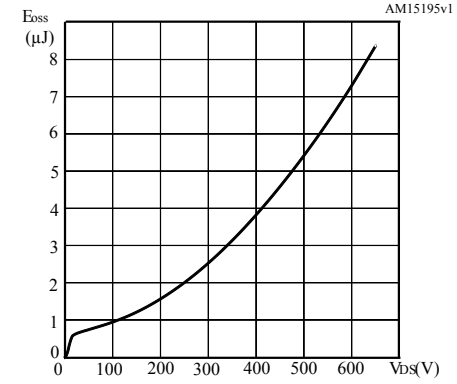



**Figure 11. Normalized gate threshold voltage vs temperature**

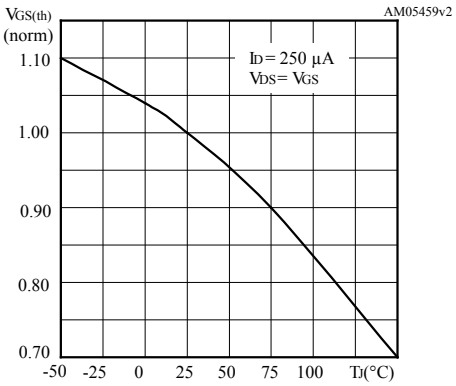



**Figure 12. Normalized on-resistance vs temperature**

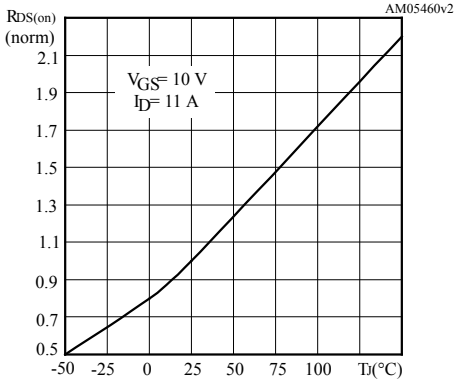


**Figure 13. Source-drain diode forward characteristics**

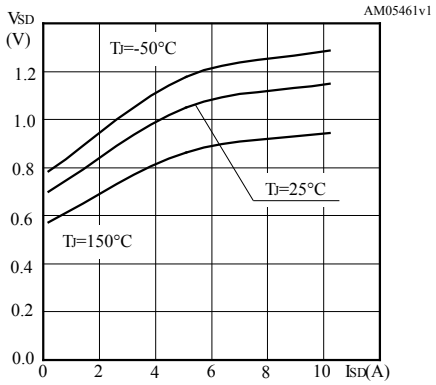



**Figure 14. Normalized $V_{(BR)DSS}$ vs temperature**

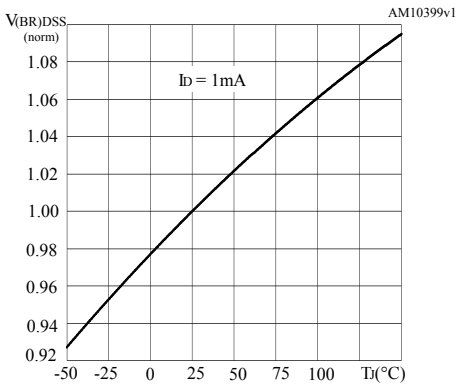
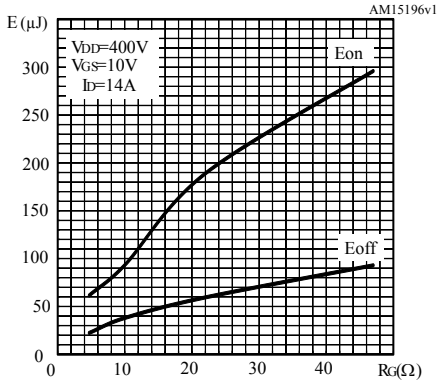



**Figure 15. Switching energy vs gate resistance**




*Note: $E_{on}$ including reverse recovery of a SiC diode.*

# 3 Test circuits

**Figure 17. Test circuit for resistive load switching times**

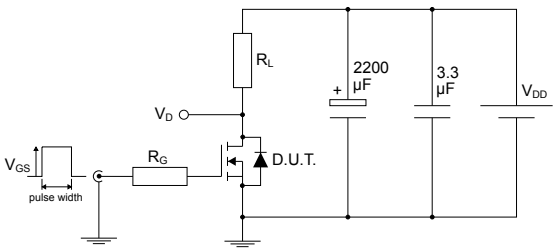



**Figure 18. Test circuit for gate charge behavior**

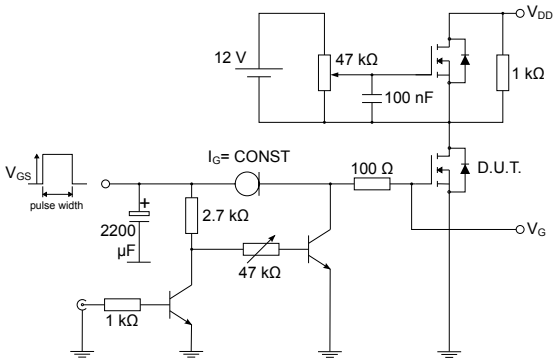



**Figure 19. Test circuit for inductive load switching and diode recovery times**

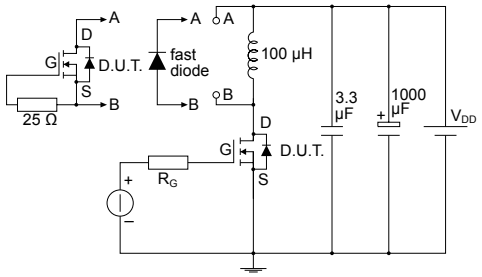



**Figure 20. Unclamped inductive load test circuit**

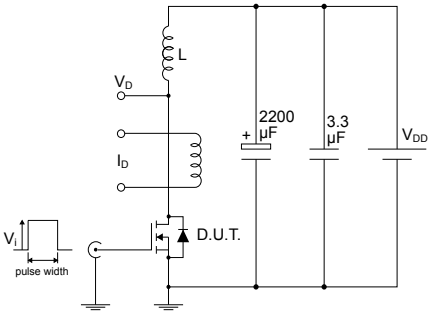



**Figure 21. Unclamped inductive waveform**

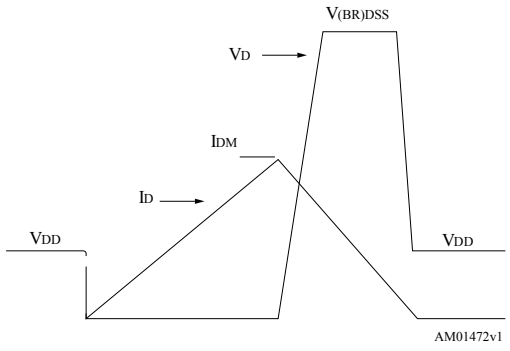
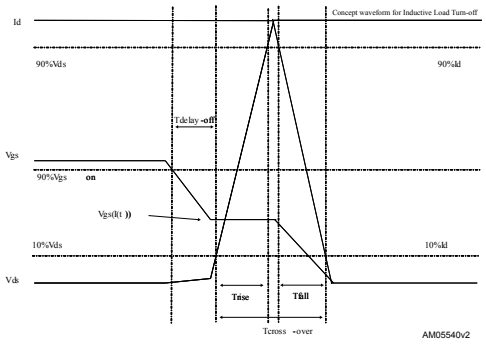



**Figure 22. Switching time waveform**



# 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) package information

Figure 23. D²PAK (TO-263) type A package outline

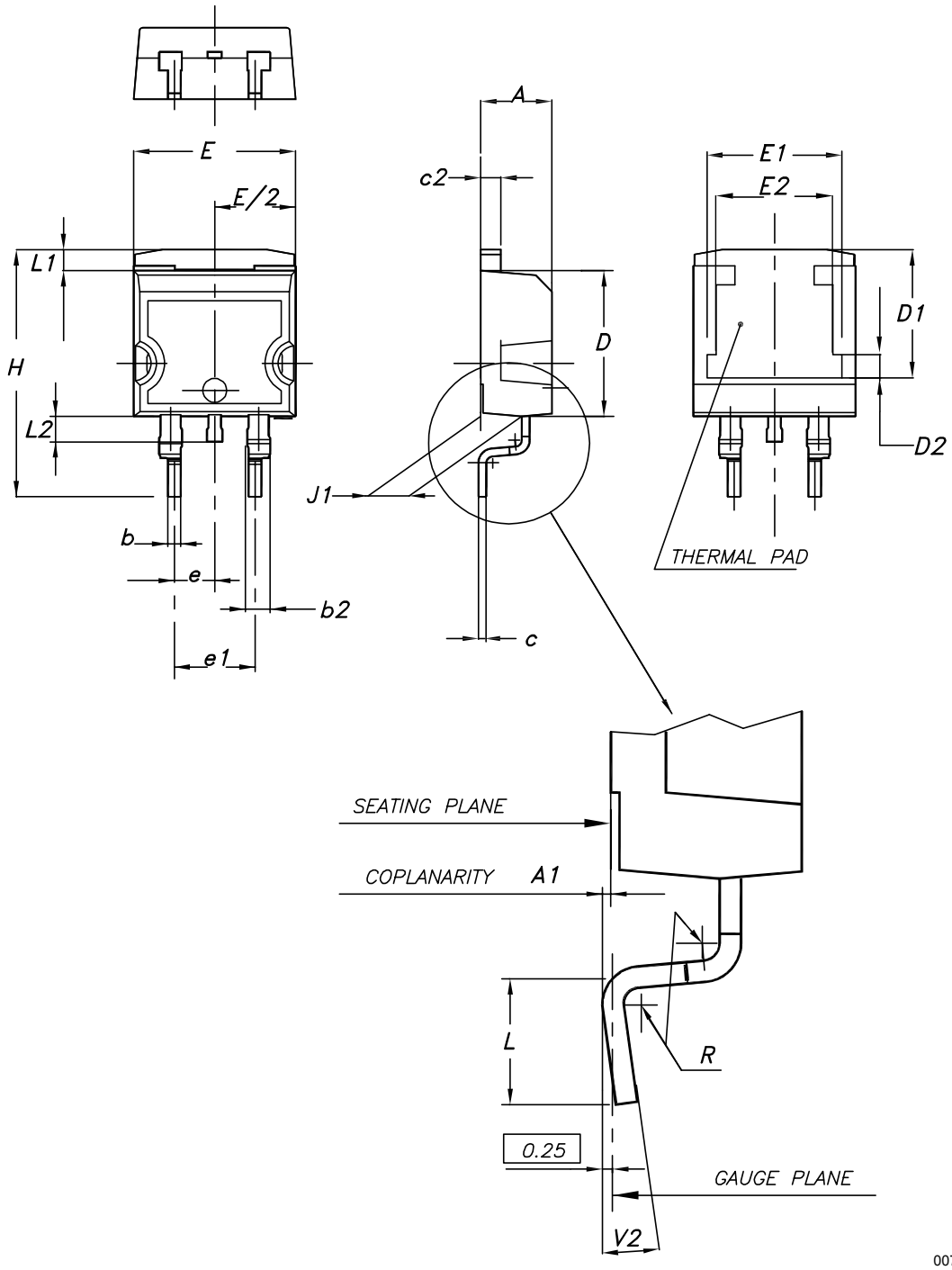


Table 8. D²PAK (TO-263) type A package mechanical data

| 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 | 8.30 | 8.50 | 8.70 |
| 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 24. **D²PAK (TO-263) type B package outline**

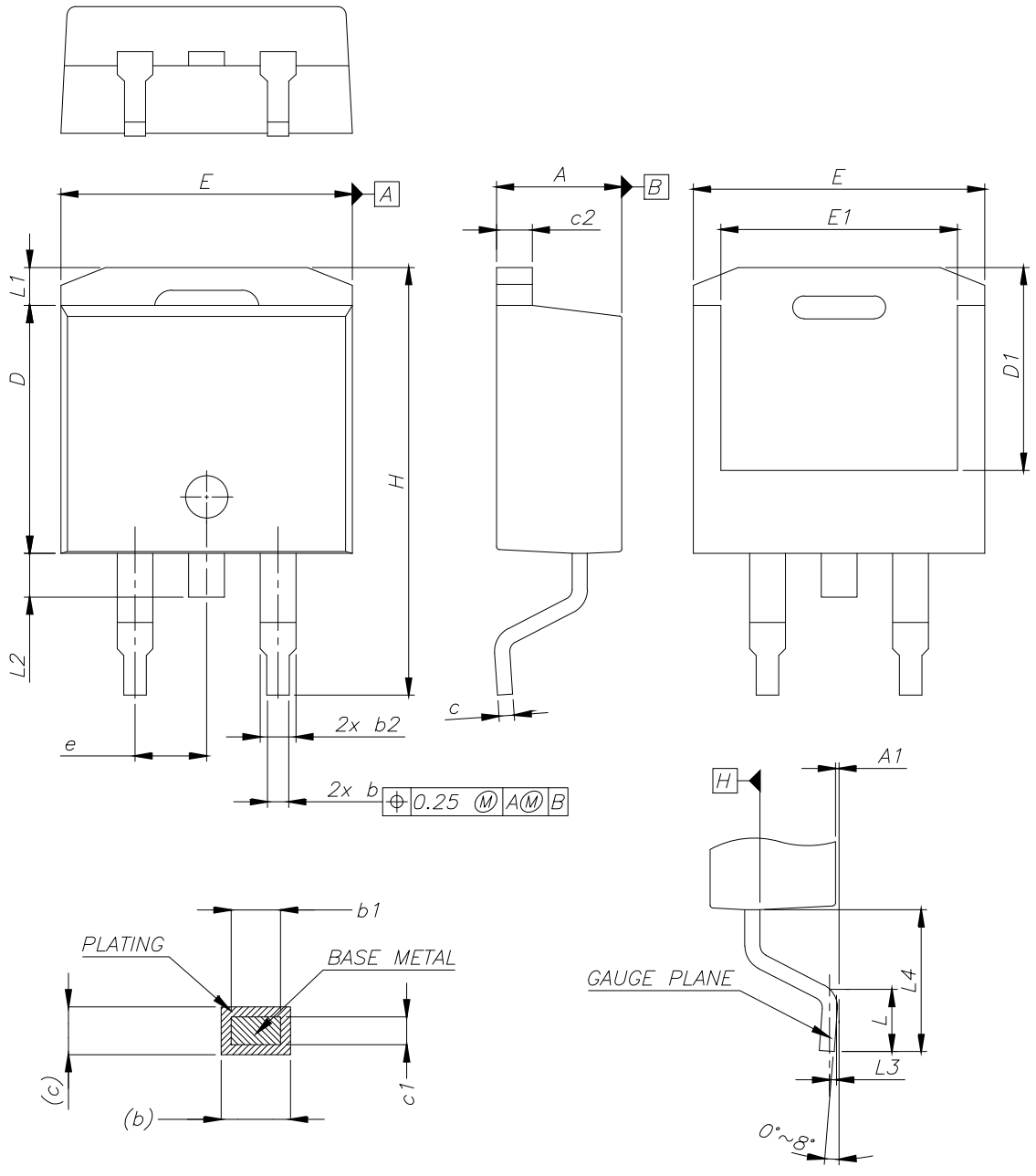



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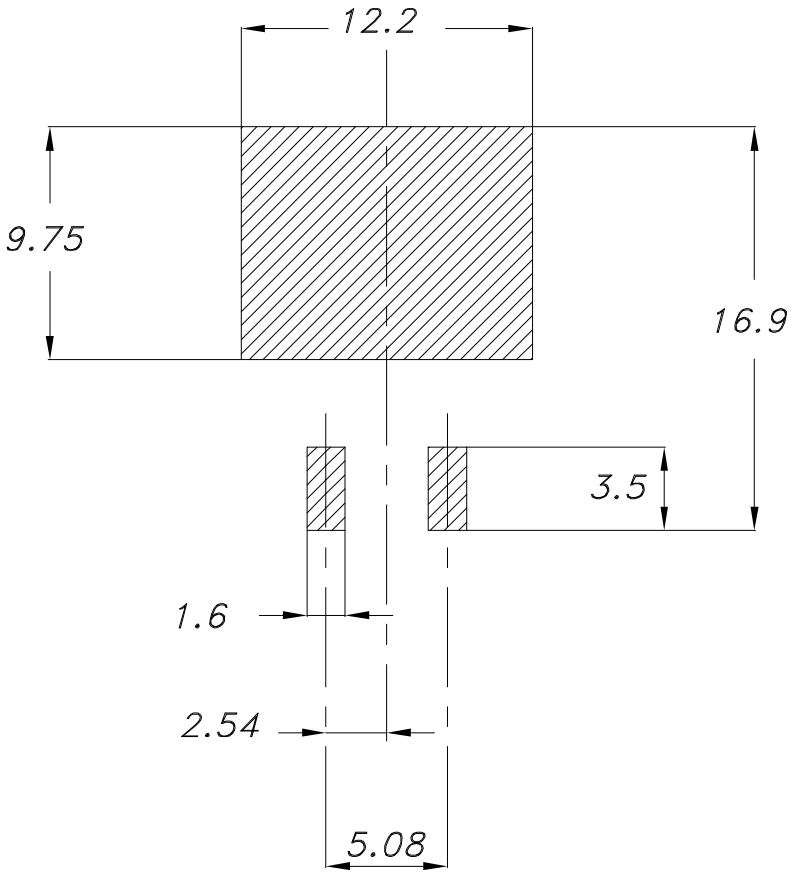
Table 9. **D²PAK (TO-263) type B mechanical data**

| Dim. | mm | | |
|---|---|---|---|
| | Min. | Typ. | Max. |
| A | 4.36 | | 4.56 |
| A1 | 0 | | 0.25 |
| b | 0.70 | | 0.90 |
| b1 | 0.51 | | 0.89 |
| b2 | 1.17 | | 1.37 |
| c | 0.38 | | 0.694 |
| c1 | 0.38 | | 0.534 |
| c2 | 1.19 | | 1.34 |
| D | 8.60 | | 9.00 |
| D1 | 6.90 | | 7.50 |
| E | 10.15 | | 10.55 |
| E1 | 8.10 | | 8.70 |
| e | | 2.54 BSC | |
| H | 15.00 | | 15.60 |
| L | 1.90 | | 2.50 |
| L1 | | | 1.65 |
| L2 | | | 1.78 |
| L3 | | 0.25 | |
| L4 | 4.78 | | 5.28 |

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




Footprint

## 4.2 D²PAK packing information

Figure 26. D²PAK tape outline

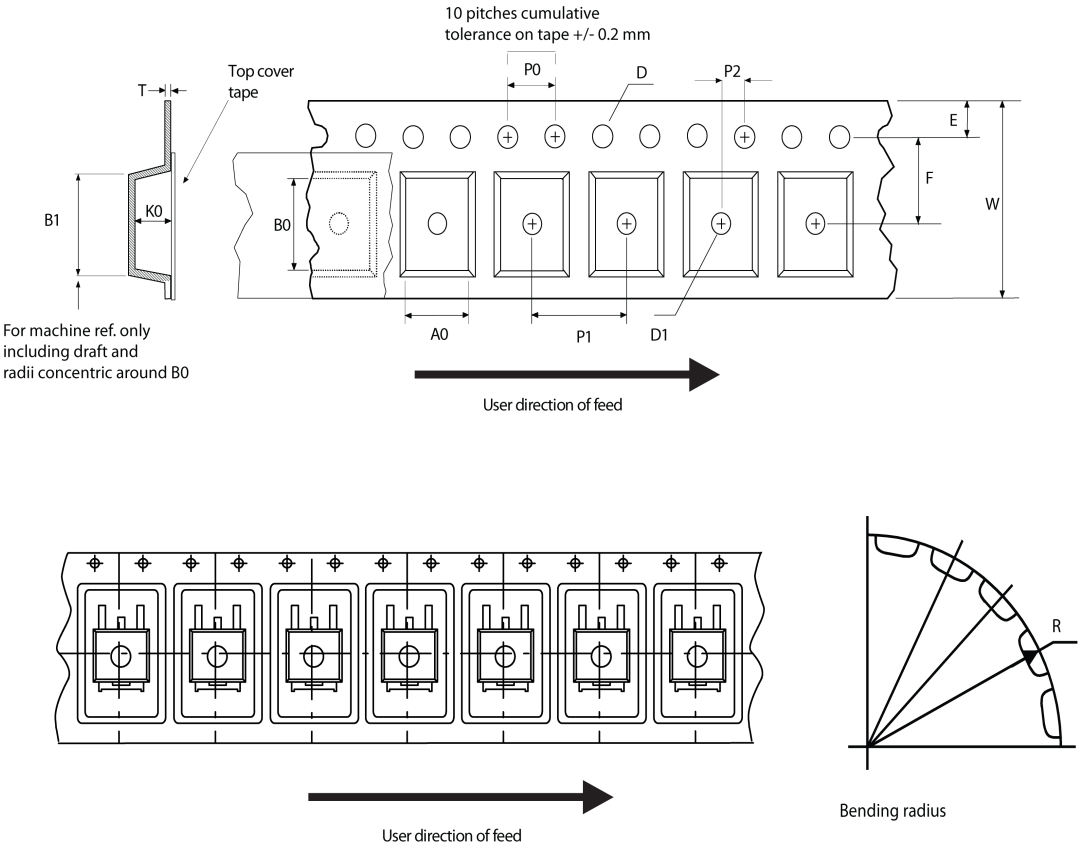


Figure 27. **D²PAK reel outline**

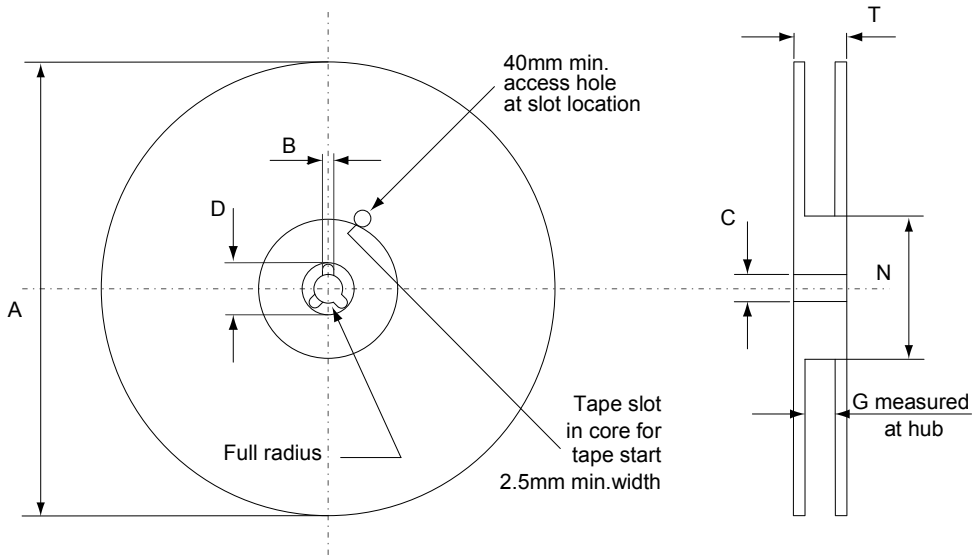



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Table 10. **D²PAK tape and reel mechanical data**

| 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 D²PAK type B packing information

Figure 28. **D²PAK type B tape outline**

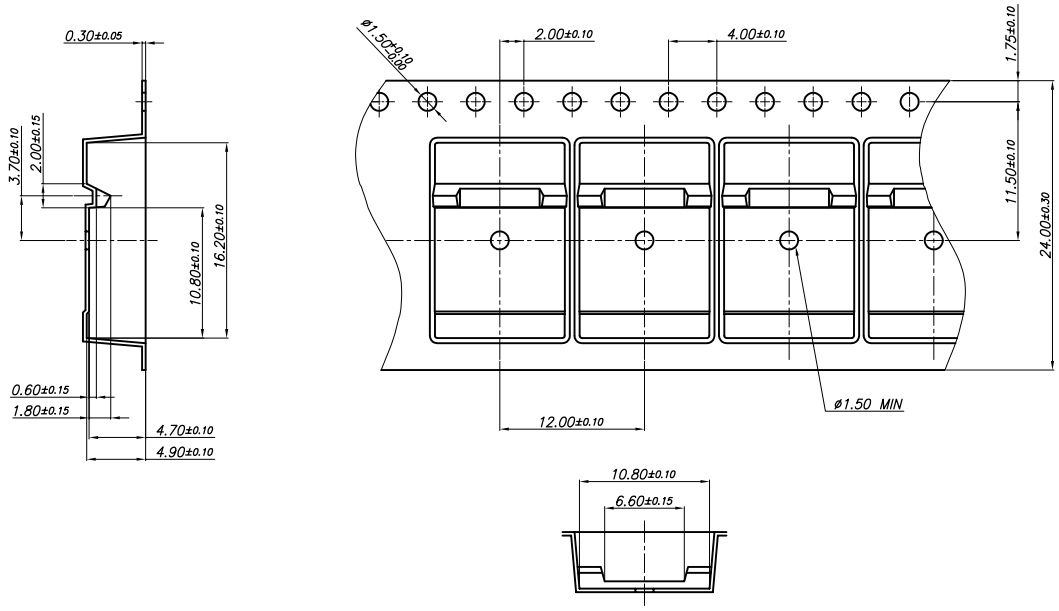


Figure 29. **D²PAK type B reel outline**

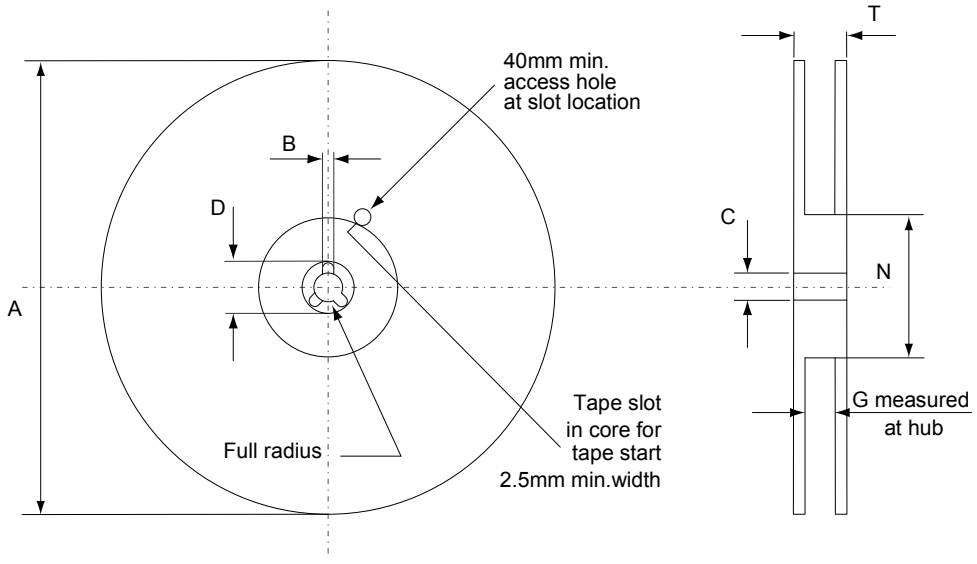


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Table 11. D²PAK type B reel mechanical data

| Dim. | mm | |
|---|---|---|
| | Min. | Max. |
| A | | 330 |
| B | 1.5 | |
| C | 12.8 | 13.2 |
| D | 20.2 | |
| G | 24.4 | 26.4 |
| N | 100 | |
| T | | 30.4 |

## 4.4 TO-220FP package information

Figure 30. **TO-220FP package outline**

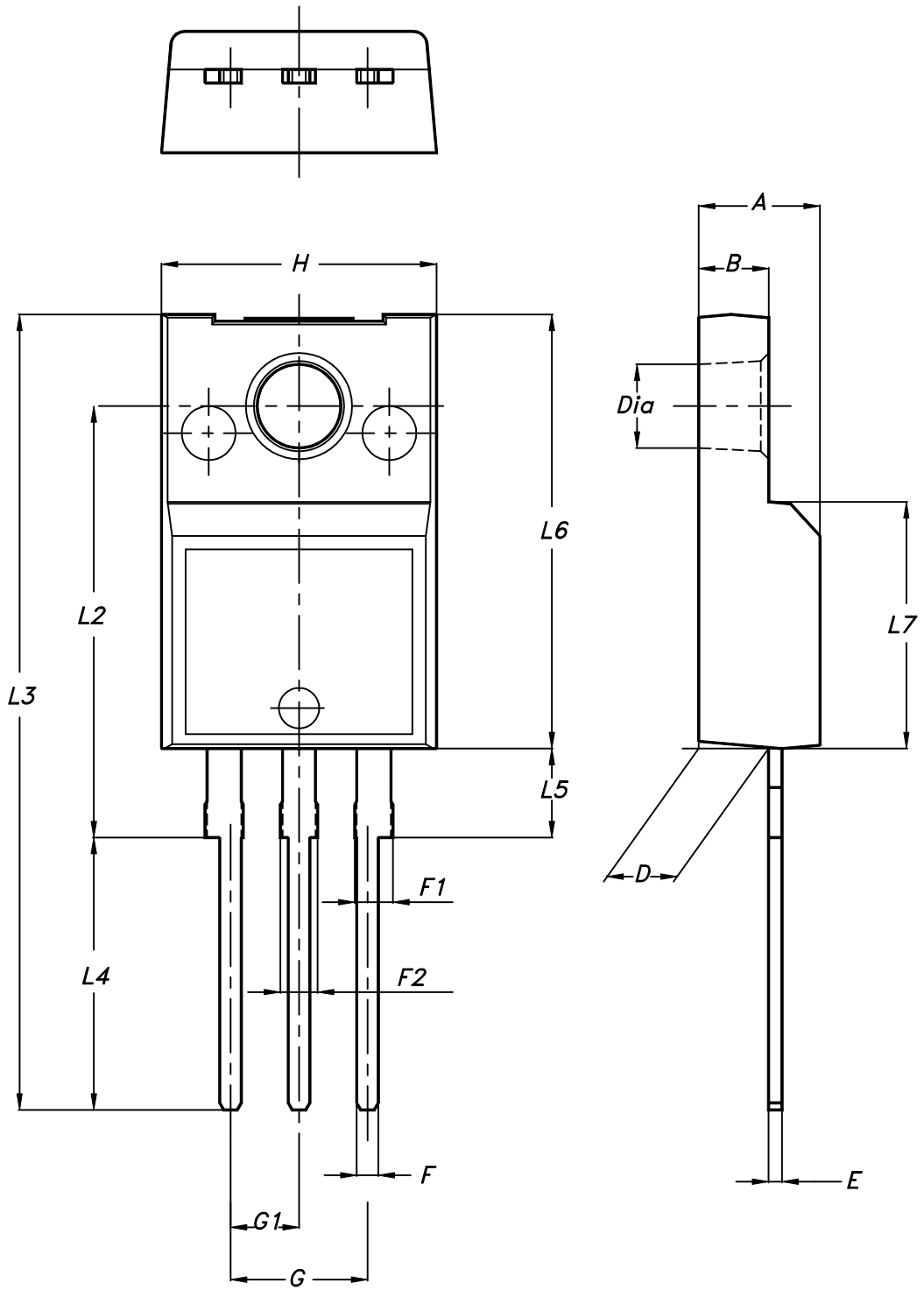

Table 12. **TO-220FP package mechanical data**

| 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 31. **TO-220 type A package outline**

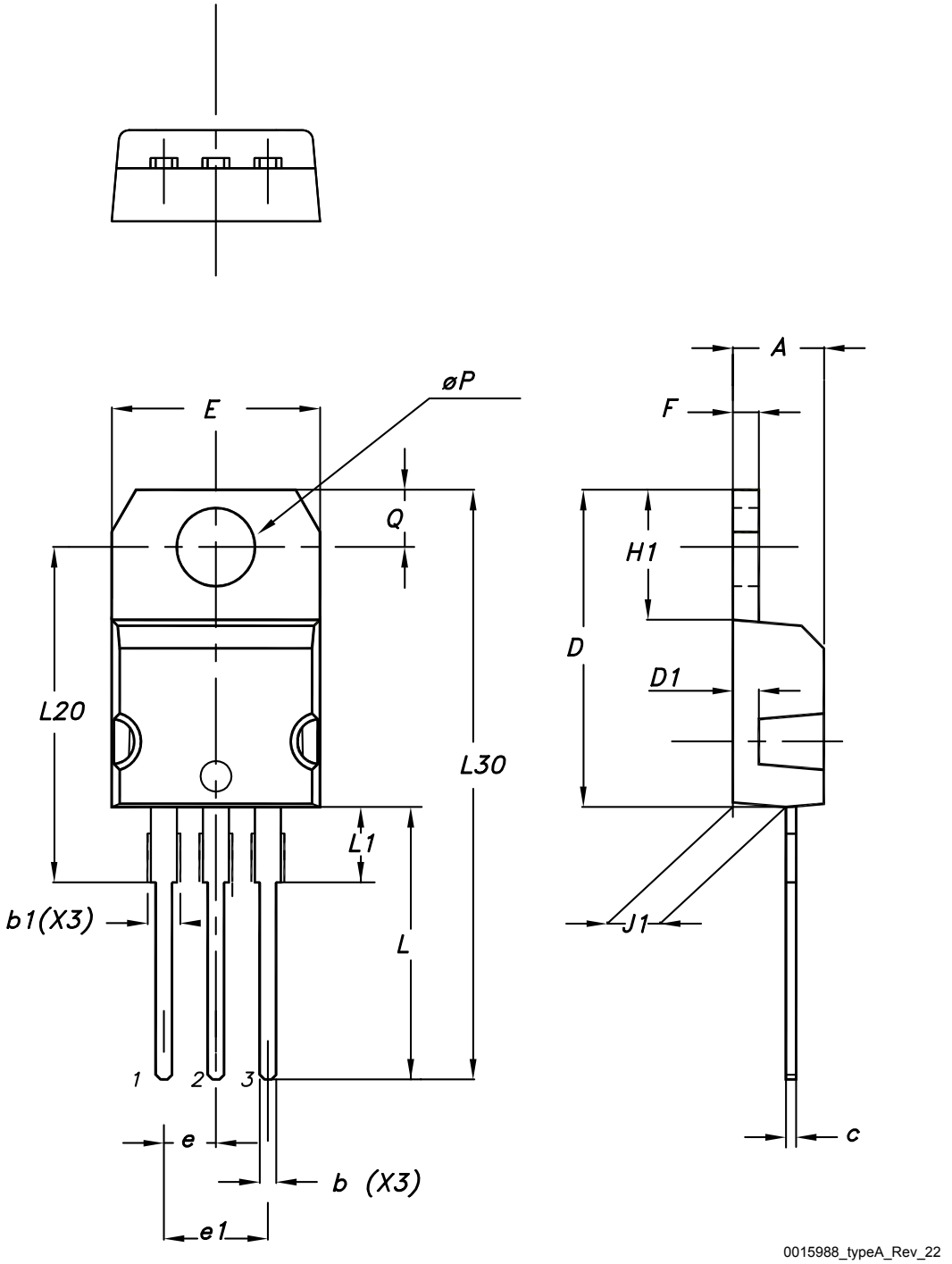


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Table 13. **TO-220 type A package mechanical data**

| 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 TO-247 package information

Figure 32. **TO-247 package outline**

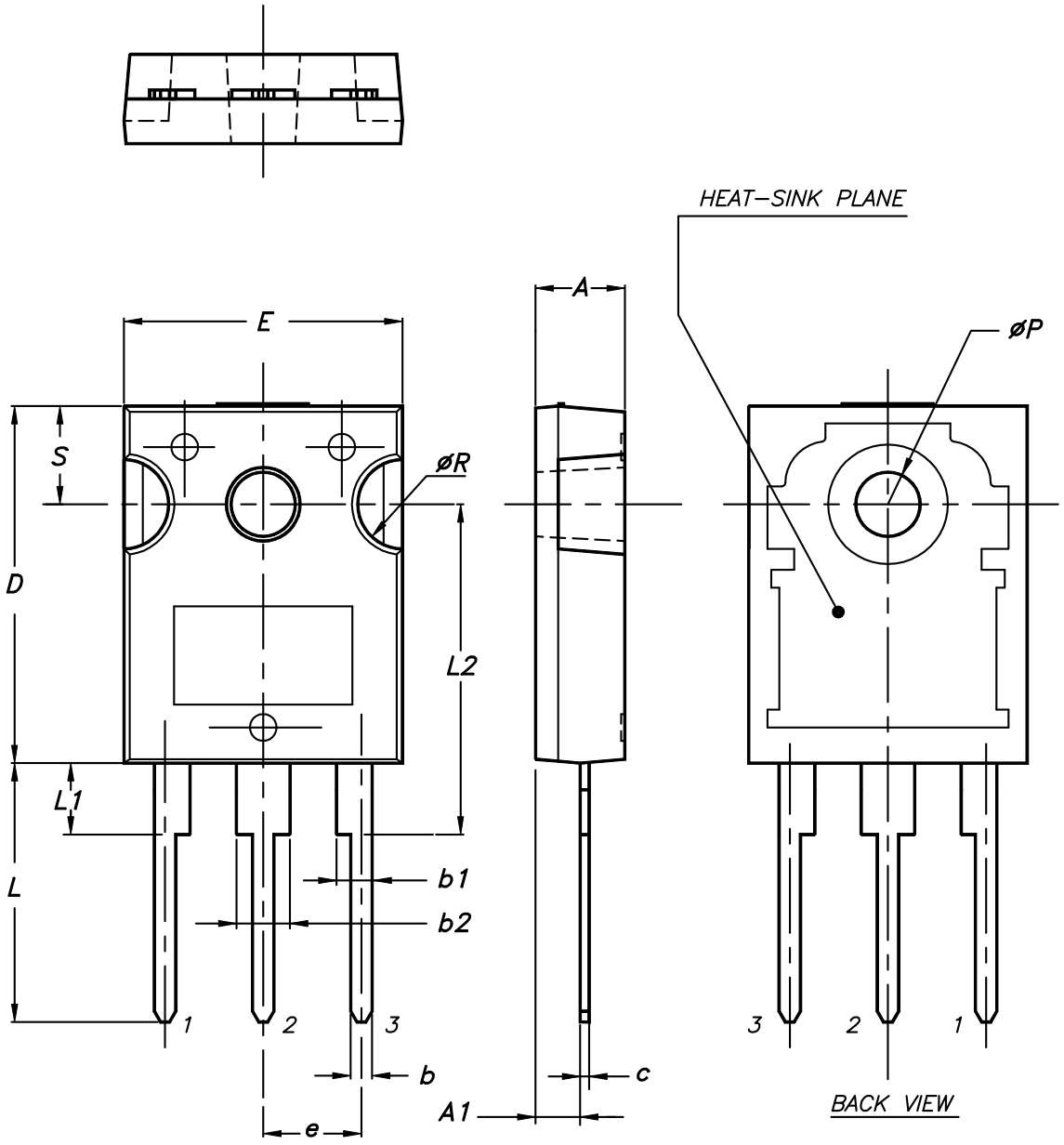


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Table 14. **TO-247 package mechanical data**

| 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 Ordering information

Table 15. **Order codes**

| Order code | Marking | Package | Packing |
|---|---|---|---|
| STB31N65M5 | 31N65M5 | $D^2PAK$ | Tape e reel |
| STF31N65M5 | | TO-220FP | Tube |
| STP31N65M5 | | TO-220 | |
| STW31N65M5 | | TO-247 | |

## Revision history

Table 16. **Document revision history**

| Date | Revision | Changes |
|---|---|---|
| 23-Feb-2012 | 1 | First release. |
| 10-Sep-2012 | 2 | – Modified *note 2* under the *Table 2*.<br>– Updated typical values in Table 4, 5 and 6.<br>– Added *Section 2.1*.<br>– Minor text changes on the cover page. |
| 05-Mar-2013 | 3 | Added dv/dt value on *Table 2: Absolute maximum ratings*. |
| 15-Apr-2019 | 4 | The part number STFI31N65M5 has been moved to a separate datasheet.<br>Removed maturity status indication from cover page. The document status is production data.<br>Updated features and description in cover page.<br>Updated Section 4 Package information.<br>Added Section 5 Ordering information.<br>Minor text changes. |

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