# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

| Symbol | Parameter | Value | | Unit |
|---|---|---|---|---|
| | | $D^2PAK$, TO-220 | TO-220FP | |
| $V_{DS}$ | Drain-source voltage | 400 | | V |
| $V_{GS}$ | Gate-source voltage | ±30 | | V |
| $I_D$ | Drain current (continuous) at $T_C$ = 25 °C | 9 | 9 (1) | A |
| $I_D$ | Drain current (continuous) at $T_C$ = 100 °C | 5.67 | 5.67 (1) | A |
| $I_{DM}$ (2) | Drain current (pulsed) | 36 | 36 (1) | A |
| $P_{TOT}$ | Total dissipation at $T_C$ = 25 °C | 110 | 30 | W |
| ESD | Gate-source human body model (C = 100 pF, R = 1.5 kΩ) | 3.5 | | kV |
| dv/dt (3) | Peak diode recovery voltage slope | 4.5 | | 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. *$I_{SD}$ ≤ 9 A, di/dt ≤ 200 A/µs, $V_{DD}$ = 80% $V_{(BR)DSS}$, $T_j$ ≤ $T_{JMAX}$.*

**Table 2. Thermal data**

| Symbol | Parameter | Value | | | Unit |
|---|---|---|---|---|---|
| | | $D^2PAK$ | TO-220 | TO-220FP | |
| $R_{thj\text{-}case}$ | Thermal resistance junction-case | 1.14 | | 4.17 | °C/W |
| $R_{thj\text{-}amb}$ | Thermal resistance junction-ambient | | 62.5 | | °C/W |
| $R_{thj\text{-}pcb}$ (1) | Thermal resistance junction-pcb | 50 | | | °C/W |

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

**Table 3. Avalanche characteristics**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $I_{AR}$ | Avalanche current, repetitive or not-repetitive (pulse width limited by $T_j$ Max) | 9 | A |
| $E_{AS}$ | Single pulse avalanche energy (starting $T_j$ = 25 °C, $I_D$ = $I_{AR}$, $V_{DD}$ = 50 V) | 190 | mJ |


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# 2 Electrical characteristics

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

**Table 4. On/off states**

| Symbol | Parameter | Test condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{(BR)DSS}$ | Drain-source Breakdown voltage | $I_D$ = 1 mA, $V_{GS}$ = 0 V | 400 | | | V |
| $I_{DSS}$ | Zero gate voltage drain current | $V_{GS}$ = 0 V, $V_{DS}$ = 400 V | | | 1 | µA |
| | | $V_{GS}$ = 0 V, $V_{DS}$ = 400 V, $T_C$ = 125 °C(1) | | | 50 | µA |
| $I_{GSS}$ | Gate body leakage current | $V_{DS}$ = 0 V, $V_{GS}$ = ±20 V | | | ±10 | µA |
| $V_{GS(th)}$ | Gate threshold voltage | $V_{DS}$ = $V_{GS}$, $I_D$ = 100 µA | 3 | 3.75 | 4.5 | V |
| $R_{DS(on)}$ | Static drain-source on resistance | $V_{GS}$ = 10 V, $I_D$ = 4.5 A | | 0.47 | 0.55 | Ω |

1. *Defined by design, not subject to production test.*

**Table 5. Dynamic**

| Symbol | Parameter | Test condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $C_{iss}$ | Input capacitance | $V_{DS}$ = 25 V, f = 1 MHz, $V_{GS}$ = 0 V | - | 930 | - | pF |
| $C_{oss}$ | Output capacitance | | | 140 | | |
| $C_{rss}$ | Reverse transfer capacitance | | | 30 | | |
| $C_{oss\ eq.}$ (1) | Equivalent output capacitance | $V_{DS}$ = 0 to 320 V, $V_{GS}$ = 0 V | - | 78 | - | pF |
| $Q_g$ | Total gate charge | $V_{DD}$ = 320 V, $I_D$ = 9 A, $V_{GS}$ = 0 to 10 V (see Figure 16. Test circuit for gate charge behavior) | - | 32 | - | nC |
| $Q_{gs}$ | Gate-source charge | | | 6 | | |
| $Q_{gd}$ | Gate-drain charge | | | 18.5 | | |

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 condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $t_{d(on)}$ | Turn-on delay time | $V_{DD}$ = 200 V, $I_D$ = 4.5 A, $R_G$ = 4.7 Ω, $V_{GS}$ = 10 V (see Figure 15. Test circuit for resistive load switching times and Figure 20. Switching time waveform) | - | 20 | - | ns |
| $t_r$ | Rise time | | | 20 | | |
| $t_{d(off)}$ | Turn-off delay time | | | 40 | | |
| $t_f$ | Fall time | | | 18 | | |
| $t_{r(Voff)}$ | Off-voltage rise time | $V_{DD}$ = 320 V, $I_D$ = 9 A, $R_G$ = 4.7 Ω, $V_{GS}$ = 10 V (see Figure 17. Test circuit for inductive load switching and diode recovery times) | | 15 | | |
| $t_f$ | Fall time | | | 17 | | |
| $t_c$ | Cross-over time | | | 30 | | |


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**Table 7. Source drain diode**

| Symbol | Parameter | Test condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $I_{SD}$ | Source-drain current | | - | | 9 | A |
| $I_{SDM}$ (1) | Source-drain current (pulsed) | | | | 36 | |
| $V_{SD}$ (2) | Forward on voltage | $I_{SD}$ = 9 A, $V_{GS}$ = 0 V | - | | 1.6 | V |
| $t_{rr}$ | Reverse recovery time | $I_{SD}$ = 9 A, di/dt = 100 A/µs, $V_{DD}$ = 45 V, $T_j$ = 150 °C (see Figure 17. Test circuit for inductive load switching and diode recovery times) | - | 225 | | ns |
| $Q_{rr}$ | Reverse recovery charge | | | 1.6 | | µC |
| $I_{RRM}$ | Reverse recovery current | | | 14 | | A |

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

**Table 8. Gate-source Zener diode**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{(BR)GSO}$ | Gate-source breakdown voltage | $I_{GS}$ = ±1 mA, $I_D$ = 0 A | ±30 | - | - | V |

The built-in back-to-back Zener diodes are specifically designed to enhance the ESD performance of the device. The Zener voltage facilitates efficient and cost-effective device integrity protection, thus eliminating the need for additional external componentry.


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## 2.1 Electrical characteristics curves

**Figure 1. Safe operating area for TO-220, D²PAK**

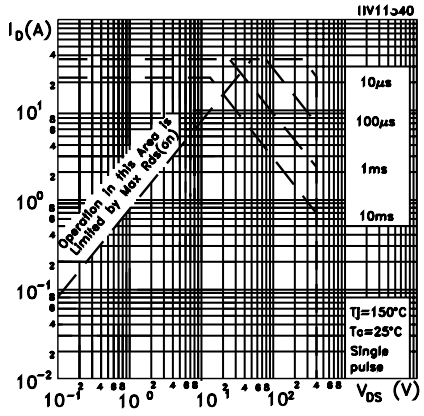


**Figure 2. Thermal impedance for TO-220, D²PAK**

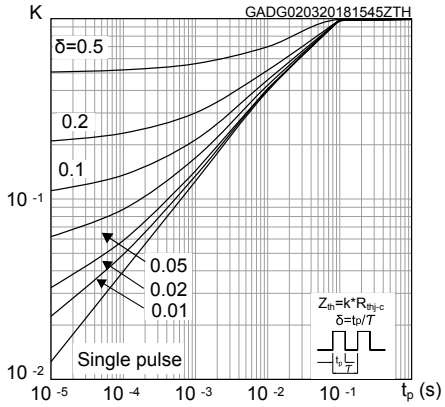


**Figure 3. Safe operating area for TO-220FP**

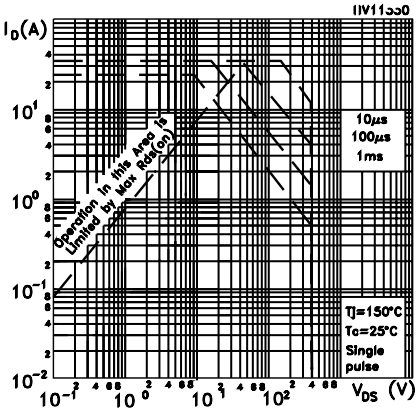


**Figure 4. Thermal impedance for TO-220FP**

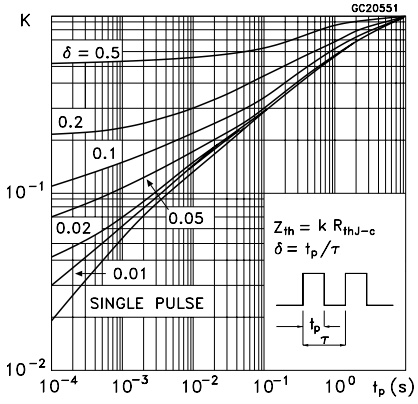


**Figure 5. Output characterisics**

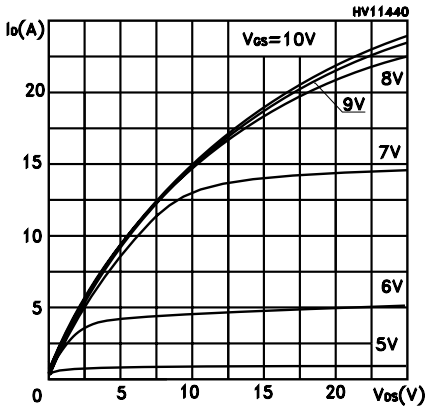


**Figure 6. Transfer characteristics**

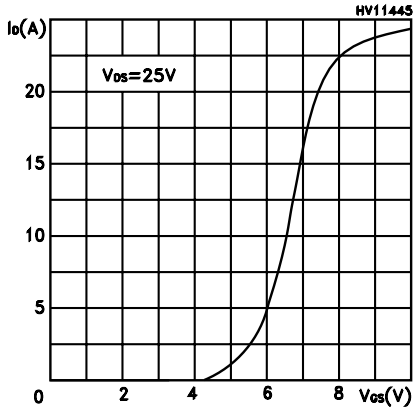



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Figure 7. Static drain-source on resistance

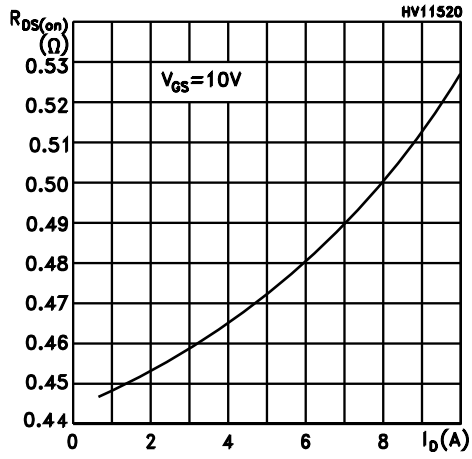


Figure 8. Gate charge vs gate-source voltage

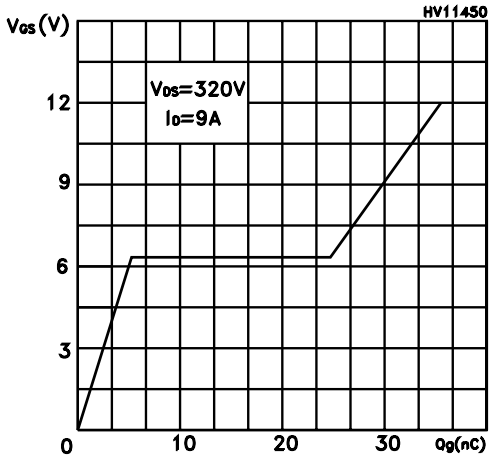


Figure 9. Capacitance variations

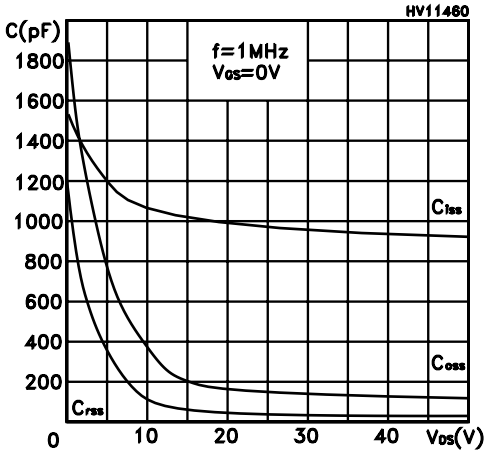


Figure 10. Normalized gate threshold voltage vs temperature

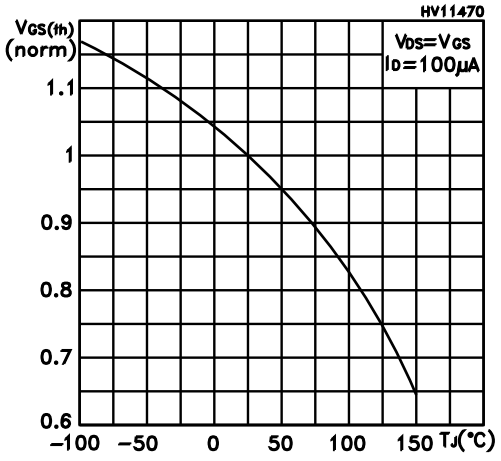


Figure 11. Normalized on resistance vs temperature

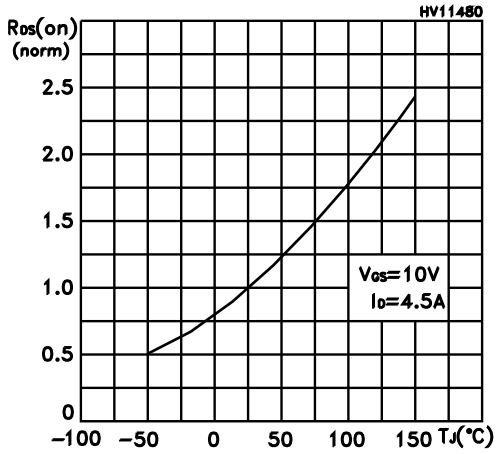


Figure 12. Source-drain diode forward characteristics

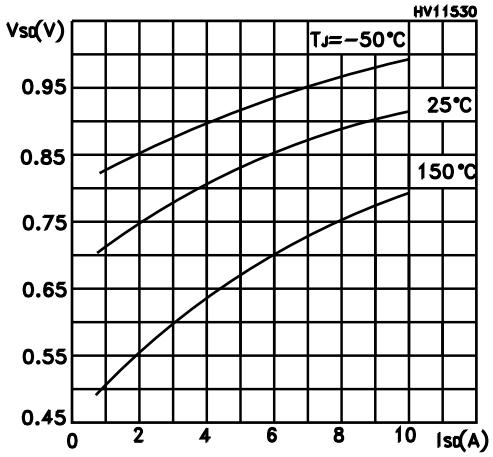



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Figure 13. Normalized $V_{(BR)DSS}$ vs temperature

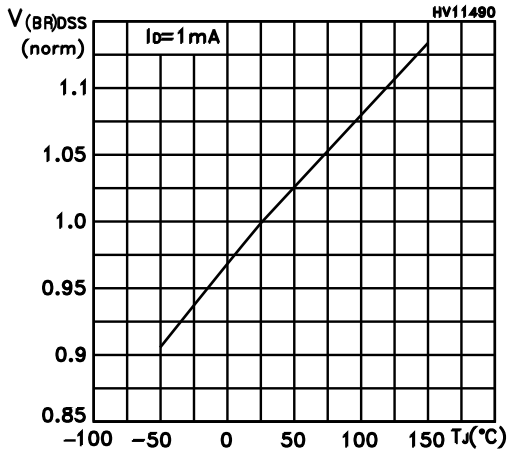
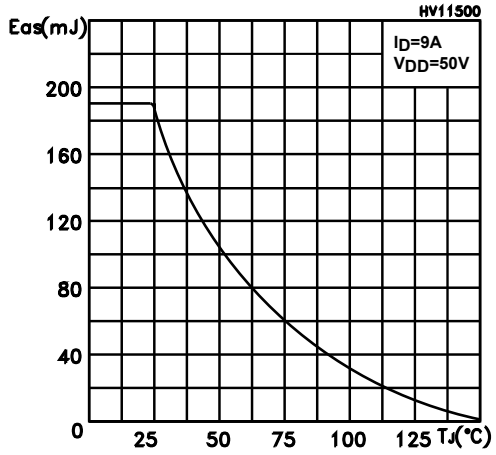



Figure 14. Maximum avalanche energy vs temperature





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# 3 Test circuits

**Figure 15. Test circuit for resistive load switching times**

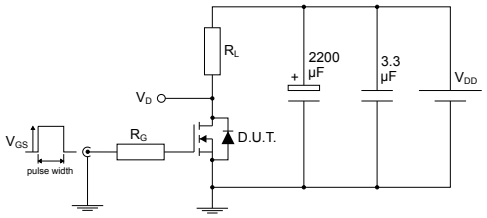



**Figure 16. Test circuit for gate charge behavior**

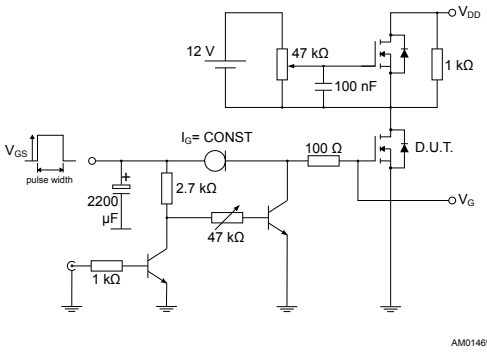



**Figure 17. Test circuit for inductive load switching and diode recovery times**

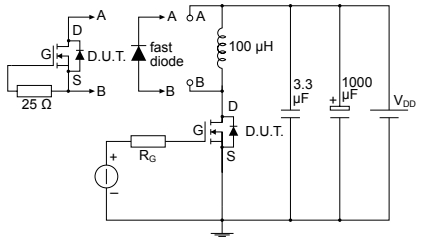



**Figure 18. Unclamped inductive load test circuit**

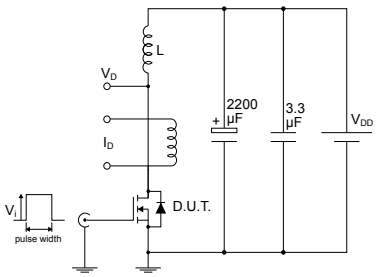



**Figure 19. Unclamped inductive waveform**

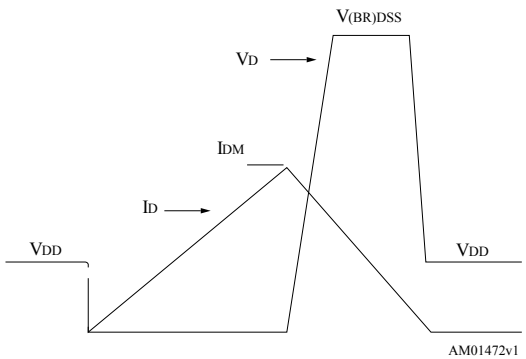
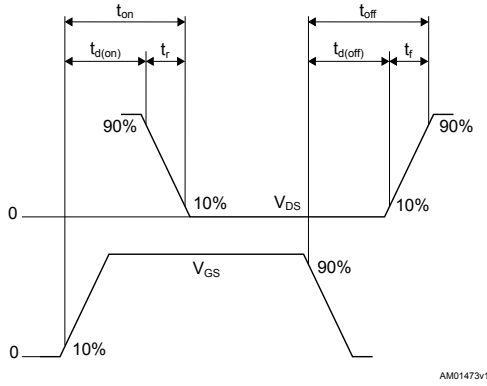



**Figure 20. Switching time waveform**





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# 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.


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## 4.1 D²PAK (TO-263) type A package information

Figure 21. D²PAK (TO-263) type A package outline

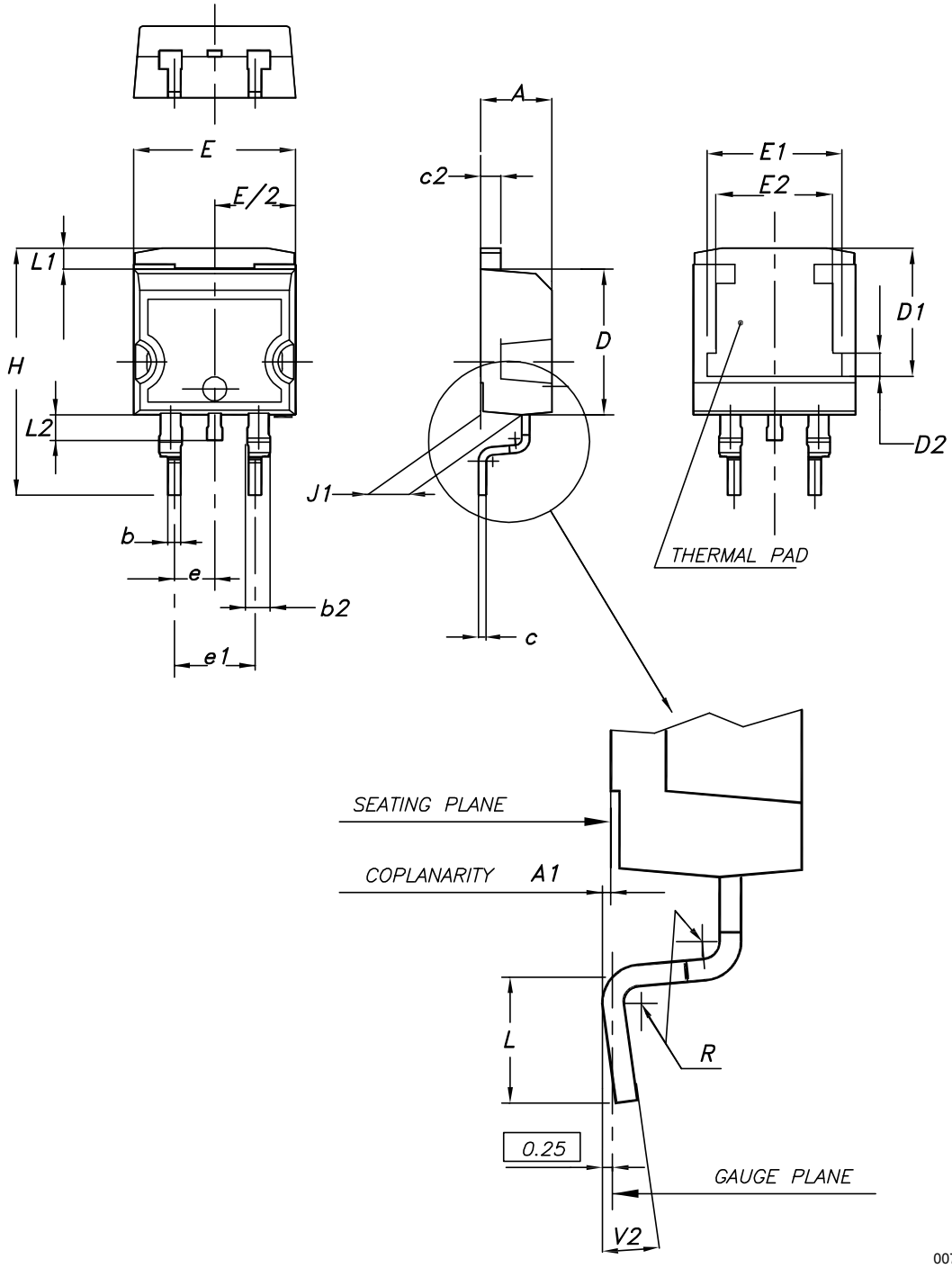



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Table 9. D²PAK (TO-263) type A package mechanical data

| 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 | 8.30 | 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° |


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## 4.2 D²PAK (TO-263) type B package information

Figure 22. D²PAK (TO-263) type B package outline

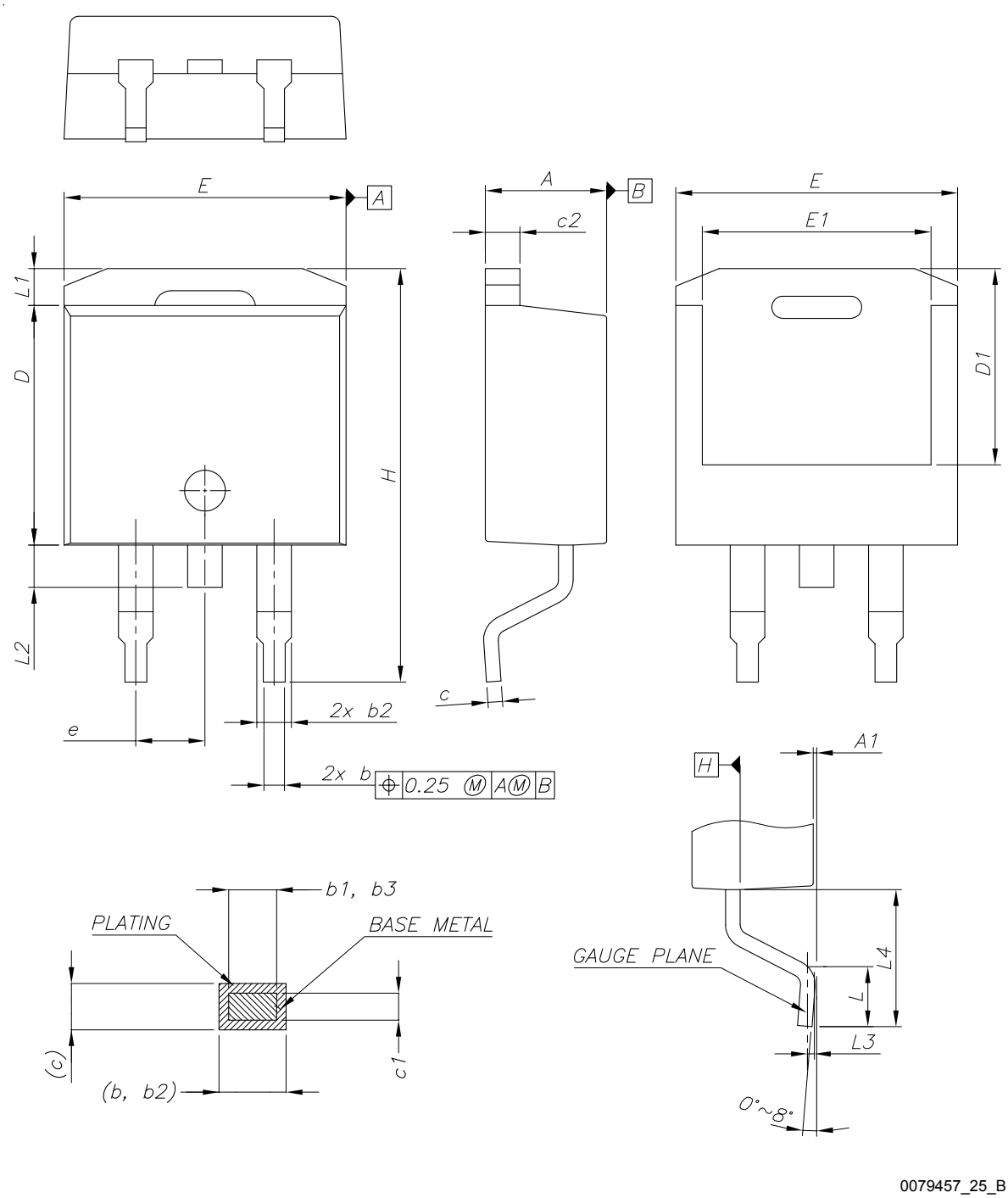


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Table 10. D²PAK (TO-263) type B mechanical data

| 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 |
| b3 | 1.36 | | 1.46 |
| 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 |


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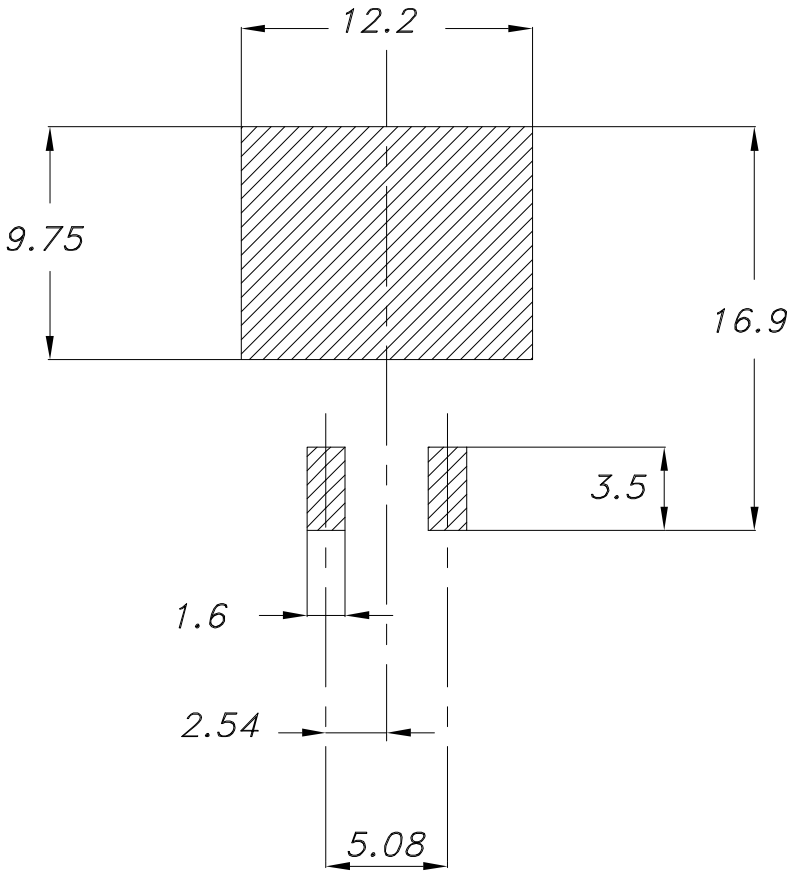
Figure 23. D²PAK (TO-263) recommended footprint (dimensions are in mm)




Footprint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## 4.3 D²PAK packing information

Figure 24. D²PAK tape outline

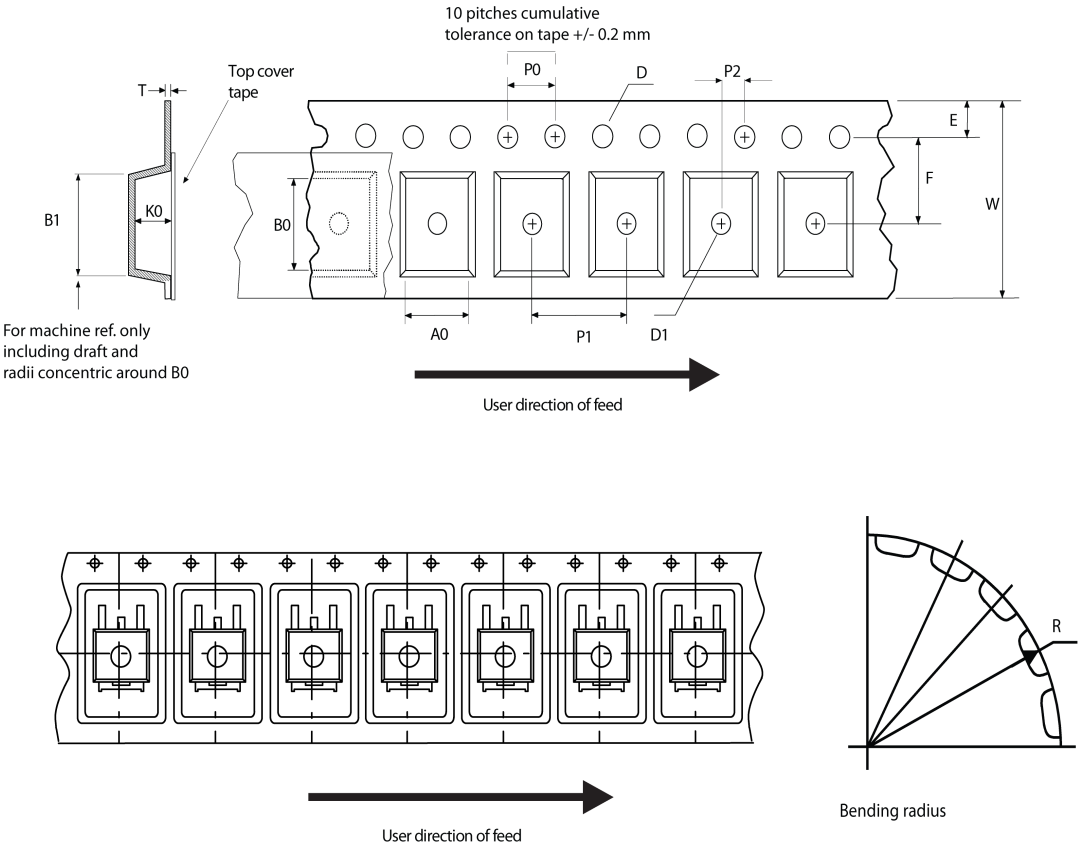



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Figure 25. **D²PAK reel outline**

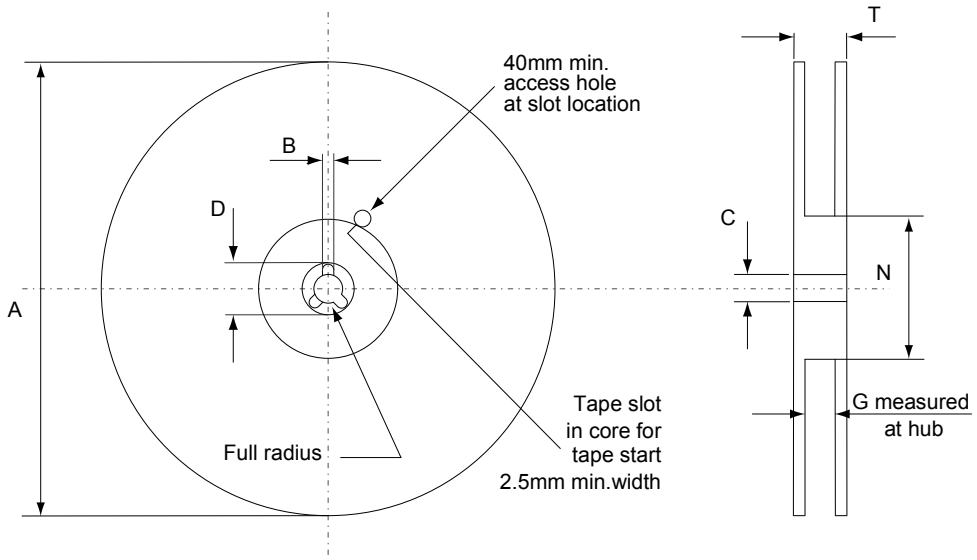


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Table 11. **D²PAK tape and reel mechanical data**

| 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 | | | |


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## 4.4 D²PAK type B packing information

Figure 26. **D²PAK type B tape outline**

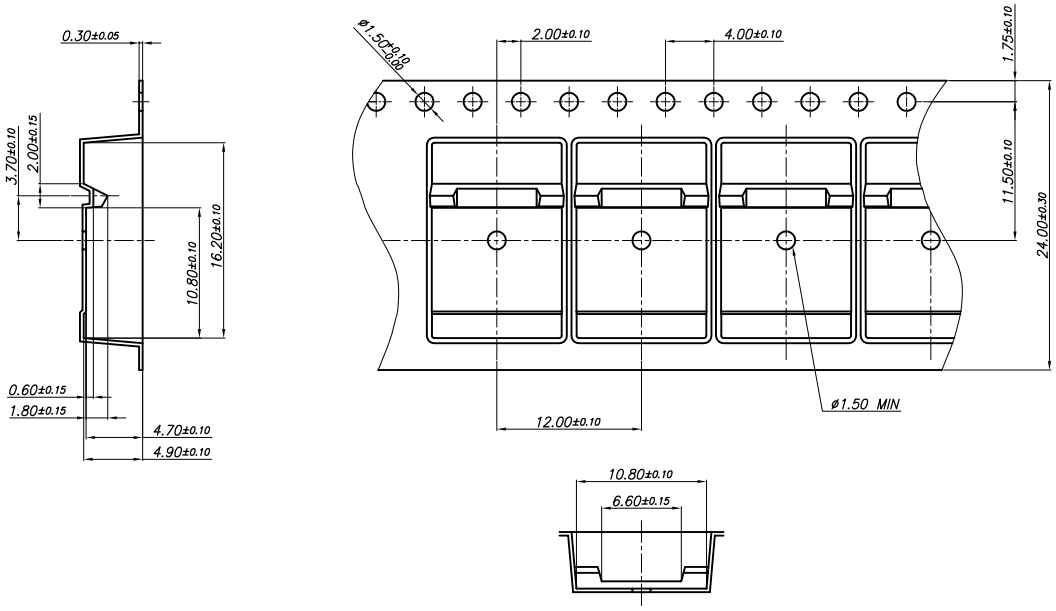


Figure 27. **D²PAK type B reel outline**

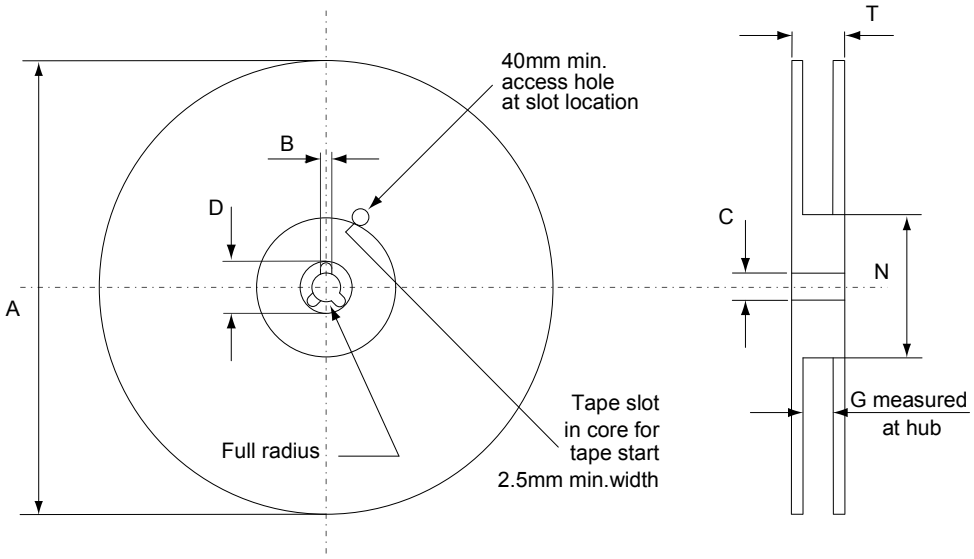


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Table 12. D²PAK type B reel mechanical data

| 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 |


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## 4.5 TO-220FP package information

Figure 28. **TO-220FP package outline**

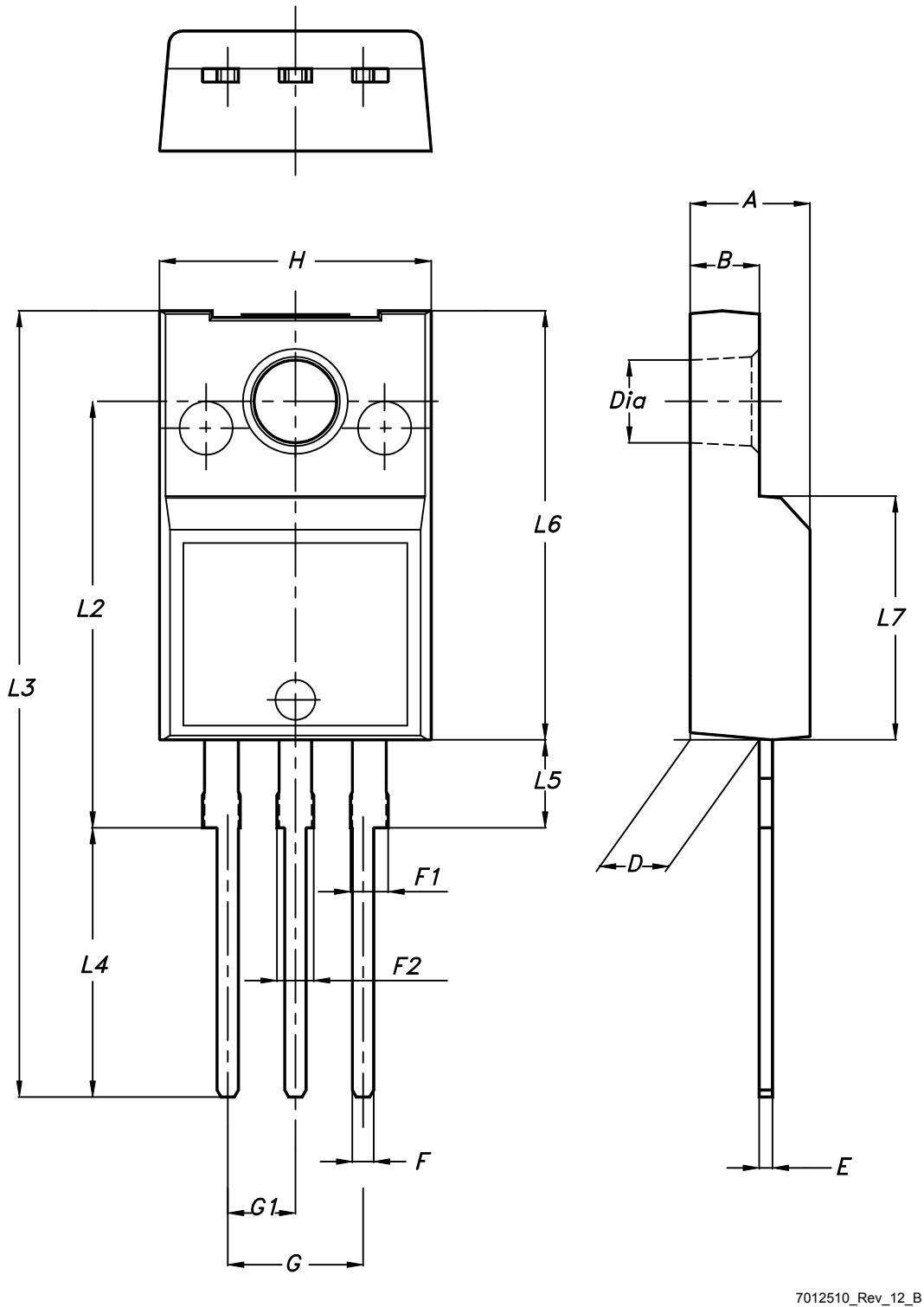



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Table 13. **TO-220FP package mechanical data**

| 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 |


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## 4.6 TO-220 type A package information

Figure 29. **TO-220 type A package outline**

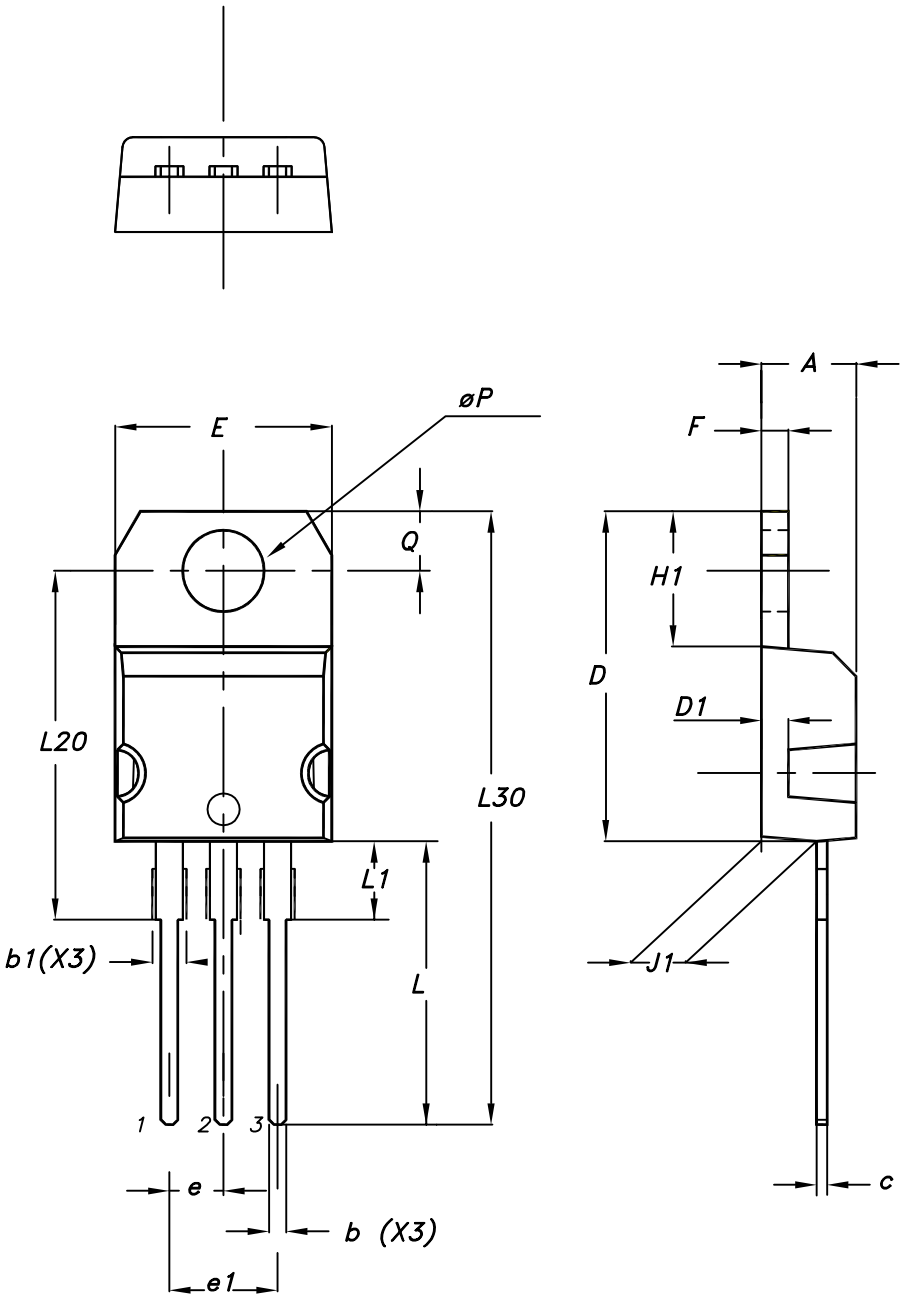


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Table 14. **TO-220 type A package mechanical data**

| 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 |


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# 5 Ordering information

Table 15. **Order codes**

| Order code | Marking | Package | Packing |
|---|---|---|---|
| STB11NK40ZT4 | B11NK40Z | $D^2PAK$ | Tape and reel |
| STP11NK40Z | P11NK40Z | TO-220 | Tube |
| STP11NK40ZFP | P11NK40ZFP | TO-220FP | |


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## Revision history

Table 16. **Document revision history**

| Date | Version | Changes |
|---|---|---|
| 23-Aug-2005 | 2 | Preliminary version |
| 28-Oct-2005 | 3 | Complete version |
| 26-Jul-2006 | 4 | New template, no content change |
| 22-Nov-2006 | 5 | Corrected unit on *Table 5.: On/off states* |
| 18-Jan-2007 | 6 | Typo mistakes on page 1 |
| 20-Apr-2009 | 7 | Updated mechanical data |
| 02-Oct-2018 | 8 | Updated Section 4 Package information.<br>Minor text changes. |


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