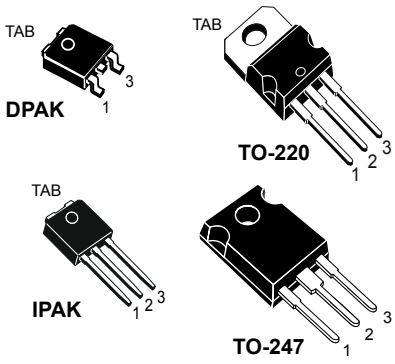
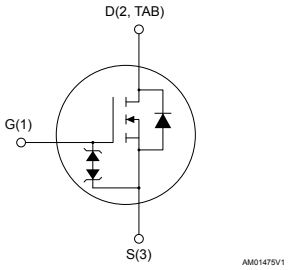
# STD6N95K5, STP6N95K5
# STU6N95K5, STW6N95K5

Datasheet

## N-channel 950 V, 1 Ω typ., 9 A MDmesh™ K5 Power MOSFETs in DPAK, TO-220, IPAK and TO-247 packages




| Product status link |
|---|
| STD6N95K5 |
| STP6N95K5 |
| STU6N95K5 |
| STW6N95K5 |

## Features

| Order codes | $V_{DS}$ | $R_{DS(on)}$ max. | $I_D$ | $P_{TOT}$ |
|---|---|---|---|---|
| STD6N95K5 | 950 V | 1.25 Ω | 9 A | 90 W |
| STP6N95K5 | | | | |
| STU6N95K5 | | | | |
| STW6N95K5 | | | | |

- DPAK 950 V worldwide best $R_{DS(on)}$
- Worldwide best FOM (figure of merit)
- Ultra low gate charge
- 100% avalanche tested
- Zener-protected

## Applications

- Switching applications

## Description

These very high voltage N-channel Power MOSFETs are designed using MDmesh™ K5 technology based on an innovative proprietary vertical structure. The result is a dramatic reduction in on-resistance and ultra-low gate charge for applications requiring superior power density and high efficiency.

# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{GS}$ | Gate- source voltage | ± 30 | V |
| $I_D$ | Drain current (continuous) at $T_C$ = 25 °C | 9 | A |
| $I_D$ | Drain current (continuous) at $T_C$ = 100 °C | 6 | A |
| $I_{DM}$ (1) | Drain current (pulsed) | 24 | A |
| $P_{TOT}$ | Total dissipation at $T_C$ = 25 °C | 90 | W |
| $I_{AR}$ (2) | Max current during repetitive or single pulse avalanche | 3 | A |
| $E_{AS}$ | Single pulse avalanche energy (starting $T_J$ = 25 °C, $I_D$=$I_{AS}$, $V_{DD}$= 50 V) | 90 | mJ |
| dv/dt (3) | Peak diode recovery voltage slope | 4.5 | V/ns |
| dv/dt (4) | MOSFET dv/dt ruggedness | 50 | V/ns |
| $T_j$ | Operating junction temperature range | - 55 to 150 | °C |
| $T_{stg}$ | Storage temperature range | | |

1. *Pulse width limited by safe operating area.*
2. *Pulse width limited by $T_{Jmax}$.*
3. *$I_{SD}$ ≤ 9 A, di/dt ≤ 100 A/µs, $V_{DS(peak)}$ ≤ $V_{(BR)DSS}$*
4. *$V_{DS}$ ≤ 760 V*

**Table 2. Thermal data**

| Symbol | Parameter | Value | | | Unit |
|---|---|---|---|---|---|
| | | TO-220, IPAK | DPAK | TO-247 | |
| $R_{thj\text{-}case}$ | Thermal resistance junction-case | 1.39 | | | °C/W |
| $R_{thj\text{-}amb}$ | Thermal resistance junction-amb | 62.5 | | 50 | °C/W |
| $R_{thj\text{-}pcb}$ (1) | Thermal resistance junction-pcb | | 50 | | °C/W |

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

# 2 Electrical characteristics

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

**Table 3. On/off states**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage | $V_{GS}$= 0 V, $I_D$ = 1 mA | 950 | | | V |
| $I_{DSS}$ | Zero gate voltage drain current | $V_{GS}$ = 0 V, $V_{DS}$ = 950 V | | | 1 | µA |
| | | $V_{GS}$ = 0 V, $V_{DS}$ = 950 V, Tc=125 °C(1) | | | 50 | µA |
| $I_{GSS}$ | Gate body leakage current | $V_{DS}$ = 0, $V_{GS}$ = ± 20 V | | | ±10 | µA |
| $V_{GS(th)}$ | Gate threshold voltage | $V_{DS}$ = $V_{GS}$, $I_D$ = 100 µA | 3 | 4 | 5 | V |
| $R_{DS(on)}$ | Static drain-source on-resistance | $V_{GS}$ = 10 V, $I_D$= 3 A | | 1 | 1.25 | Ω |

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

**Table 4. Dynamic**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $C_{iss}$ | Input capacitance | $V_{GS}$=0 V, $V_{DS}$ =100 V, f=1 MHz | - | 450 | - | pF |
| $C_{oss}$ | Output capacitance | | - | 30 | - | pF |
| $C_{rss}$ | Reverse transfer capacitance | | - | 1.6 | - | pF |
| $C_{o(tr)}$ (1) | Equivalent capacitance time related | $V_{GS}$ = 0 V, $V_{DS}$ = 0 to 760 V | - | 45 | - | pF |
| $C_{o(er)}$ (2) | Equivalent capacitance energy related | | - | 19 | - | pF |
| $R_G$ | Intrinsic gate resistance | f = 1 MHz, $I_D$=0 A | - | 7 | - | Ω |
| $Q_g$ | Total gate charge | $V_{DD}$ = 760 V, $I_D$ = 6 A, $V_{GS}$ = 0 to 10 V, (see Figure 17. Test circuit for gate charge behavior) | - | 13 | - | nC |
| $Q_{gs}$ | Gate-source charge | | - | 3 | - | nC |
| $Q_{gd}$ | Gate-drain charge | | - | 7 | - | nC |

1. *$C_{o(tr)}$ is a constant capacitance value that gives the same charging time as $C_{oss}$ while $V_{DS}$ is rising from 0 to 80% $V_{DSS}$.*
2. *$C_{o(er)}$ is a constant capacitance value that gives the same stored energy as $C_{oss}$ while $V_{DS}$ is rising from 0 to 80% $V_{DSS}$.*

**Table 5. Switching times**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $t_{d(on)}$ | Turn-on delay time | $V_{DD}$ = 475 V, $I_D$ = 3 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) | - | 12 | - | ns |
| $t_r$ | Rise time | | - | 12 | - | ns |
| $t_{d(off)}$ | Turn-off delay time | | - | 33 | - | ns |
| $t_f$ | Fall time | | - | 21 | - | ns |

**Table 6. Source drain diode**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $I_{SD}$ | Source-drain current | | - | | 9 | A |
| $I_{SDM}$ (1) | Source-drain current (pulsed) | | - | | 24 | A |
| $V_{SD}$ (2) | Forward on voltage | $I_{SD}$= 6 A, $V_{GS}$=0 V | - | | 1.6 | V |
| $t_{rr}$ | Reverse recovery time | $I_{SD}$= 6 A, $V_{DD}$= 60 V | - | 372 | | ns |
| $Q_{rr}$ | Reverse recovery charge | di/dt = 100 A/µs, | - | 4 | | µC |
| $I_{RRM}$ | Reverse recovery current | (see Figure 18. Test circuit for inductive load switching and diode recovery times) | - | 22 | | A |
| $t_{rr}$ | Reverse recovery time | $I_{SD}$= 6 A,$V_{DD}$= 60 V | - | 522 | | ns |
| $Q_{rr}$ | Reverse recovery charge | di/dt=100 A/µs, Tj=150 °C | - | 5 | | µC |
| $I_{RRM}$ | Reverse recovery current | (see Figure 18. Test circuit for inductive load switching and diode recovery times) | - | 20 | | A |

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

**Table 7. Gate-source Zener diode**

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

## 2.1 Electrical characteristics (curves)

**Figure 1. Safe operating area for DPAK and IPAK**

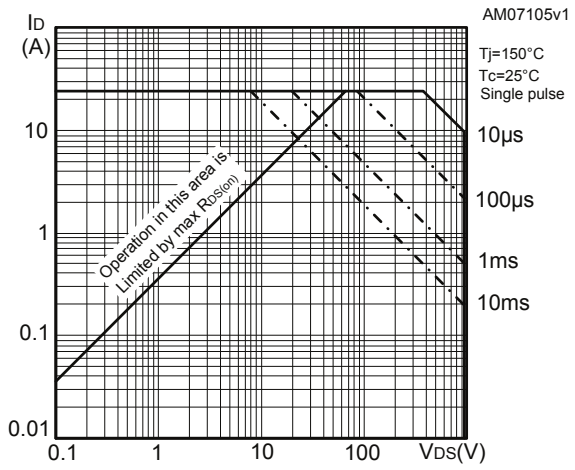



**Figure 2. Thermal impedance for DPAK and IPAK**

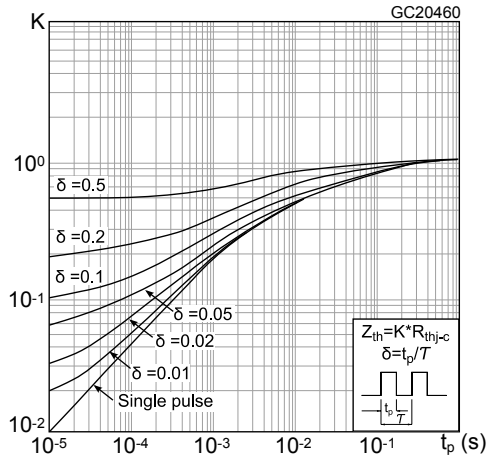



**Figure 3. Safe operating area for TO-220 and TO-247**

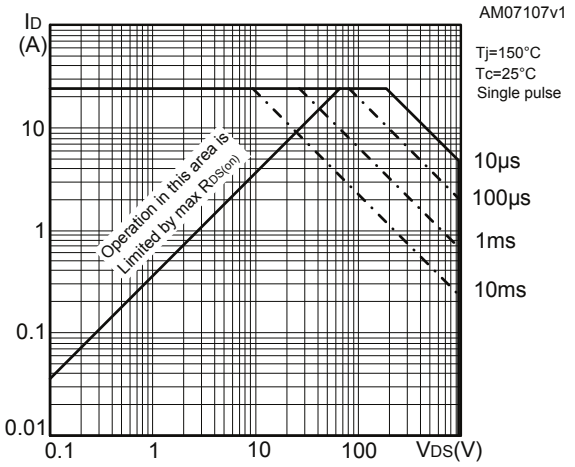



**Figure 4. Thermal impedance for TO-220 and TO-247**

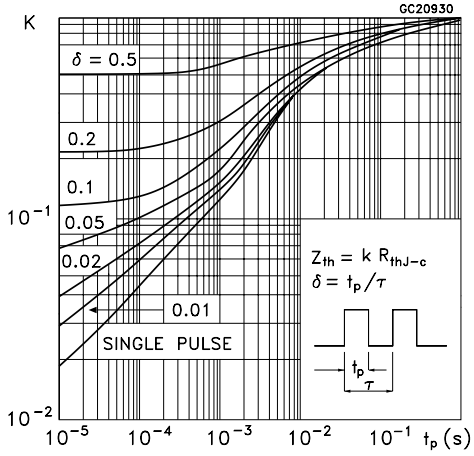



**Figure 5. Output characteristics**

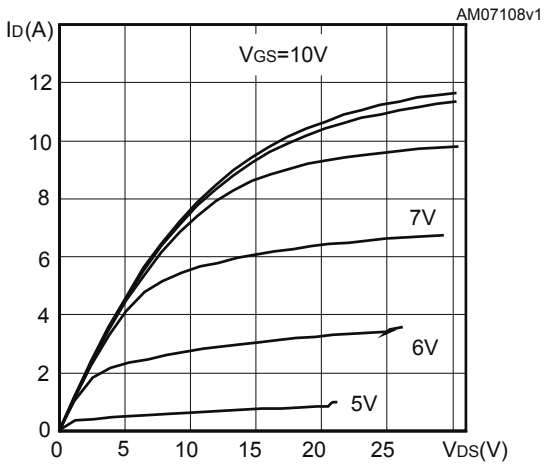



**Figure 6. Transfer characteristics**

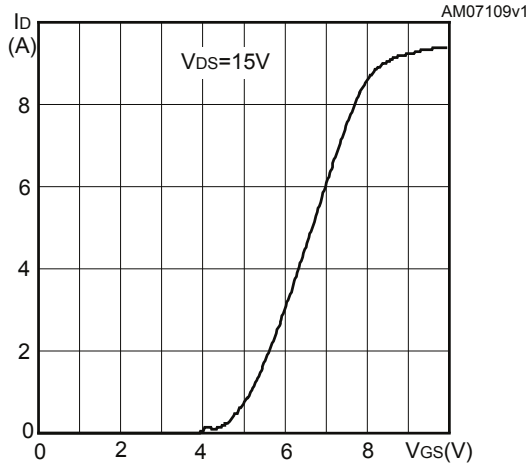


**Figure 7. Gate charge vs gate-source voltage**

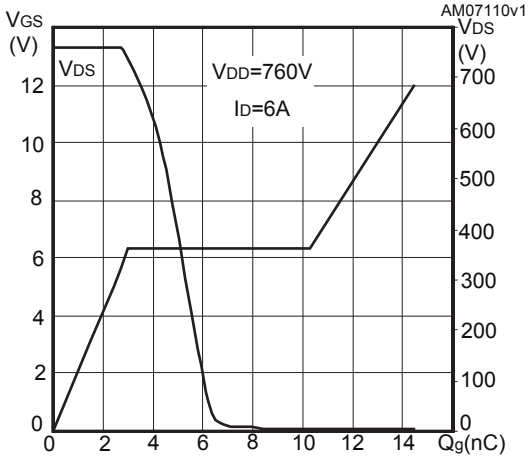



**Figure 8. Static drain-source on-resistance**

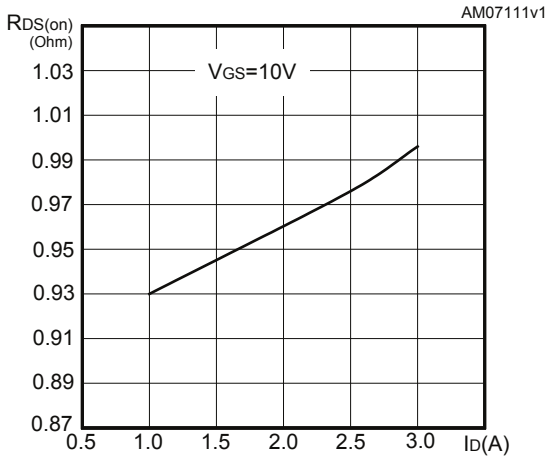



**Figure 9. Capacitance variations**

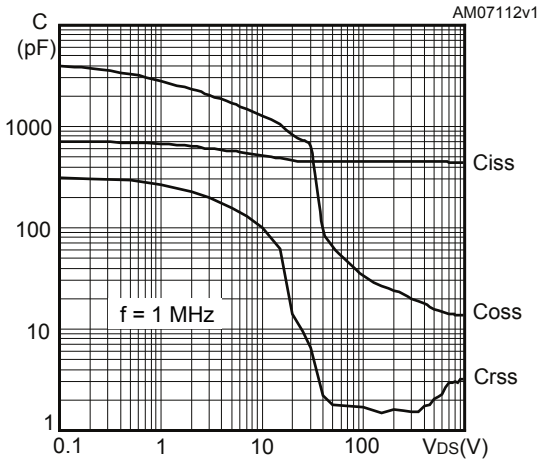



**Figure 10. Output capacitance storage energy**

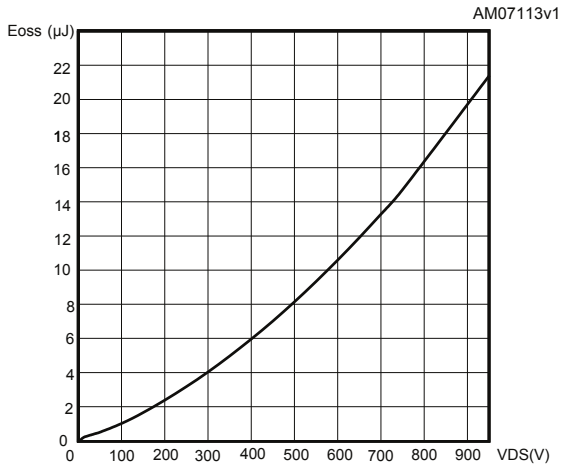



**Figure 11. Normalized gate threshold voltage vs temperature**

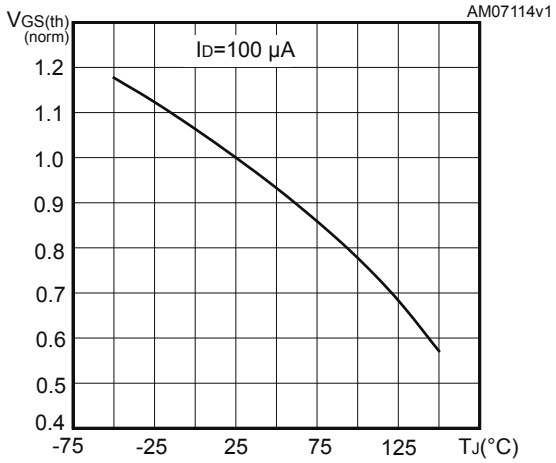



**Figure 12. Normalized on-resistance vs temperature**

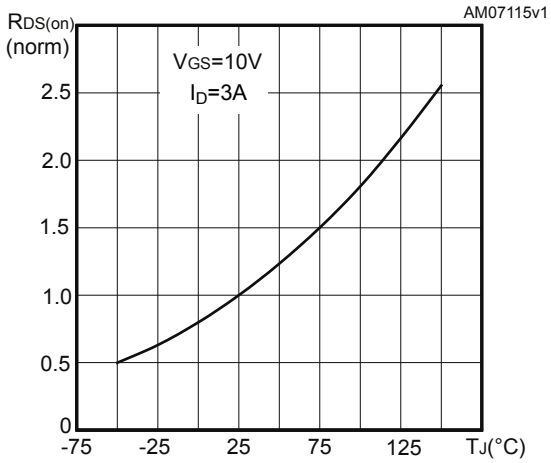


**Figure 13. Source-drain diode forward characteristics**

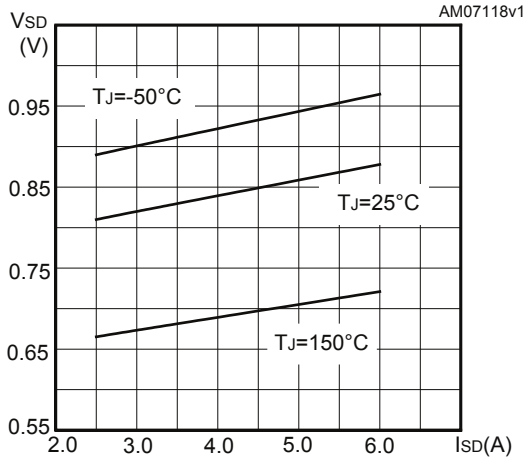



**Figure 14. Normalized $V_{(BR)DSS}$ vs temperature**

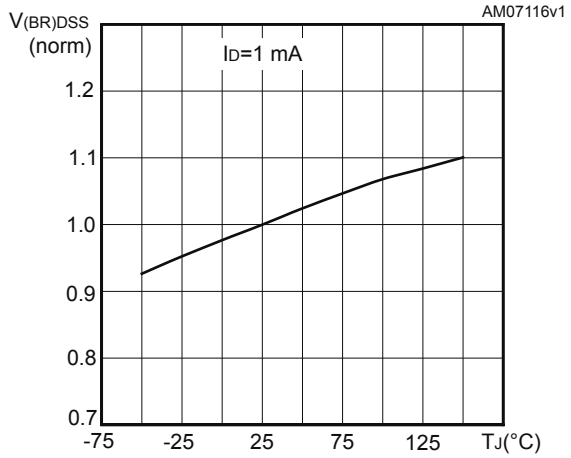
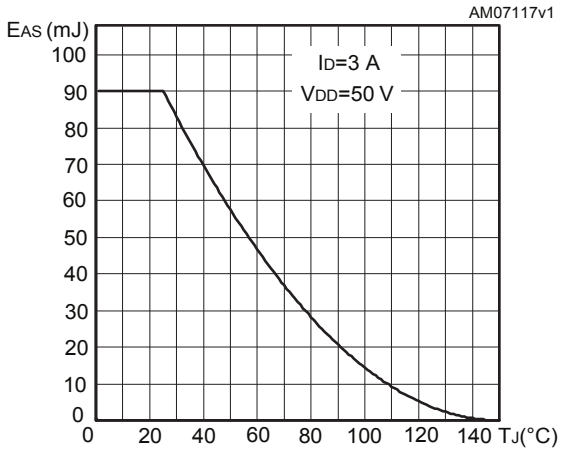



**Figure 15. Maximum avalanche energy vs starting $T_j$**



# 3 Test circuits

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

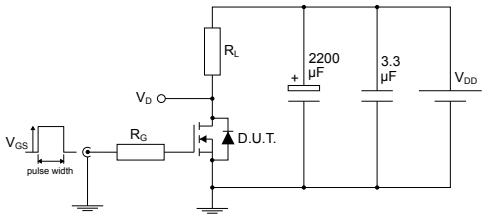



**Figure 17. Test circuit for gate charge behavior**

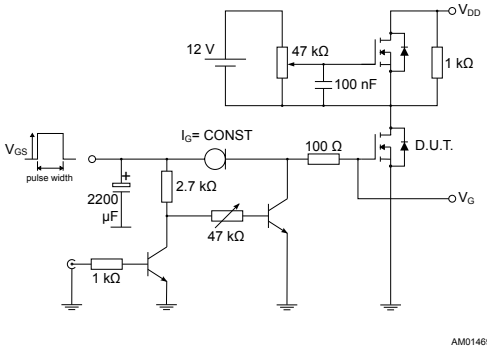



**Figure 18. Test circuit for inductive load switching and diode recovery times**

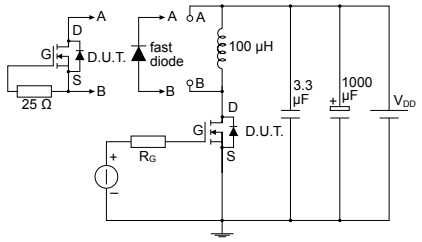



**Figure 19. Unclamped inductive load test circuit**

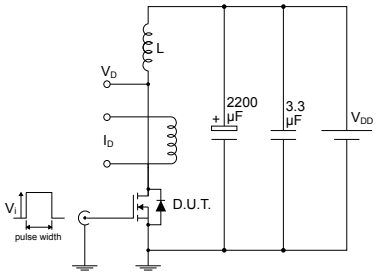



**Figure 20. Unclamped inductive waveform**

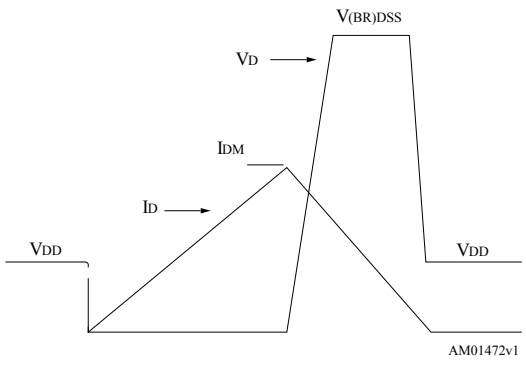
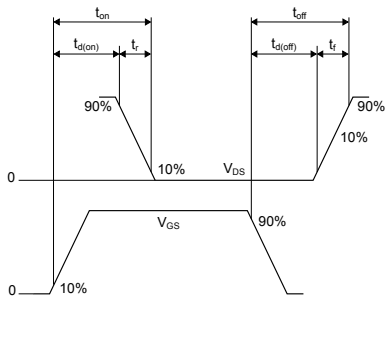



**Figure 21. Switching time waveform**



# 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 A2 package information

Figure 22. **DPAK (TO-252) type A2 package outline**

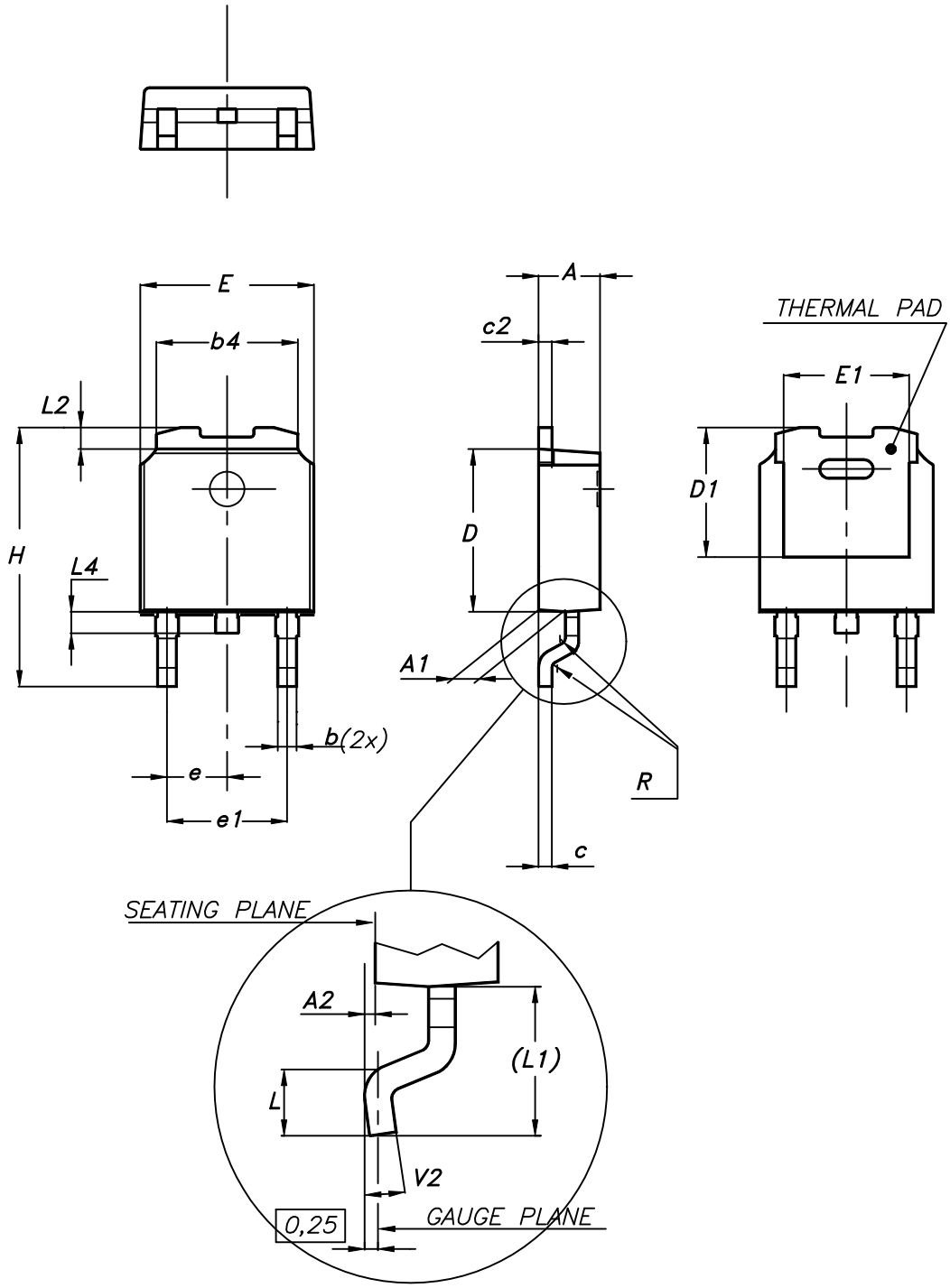
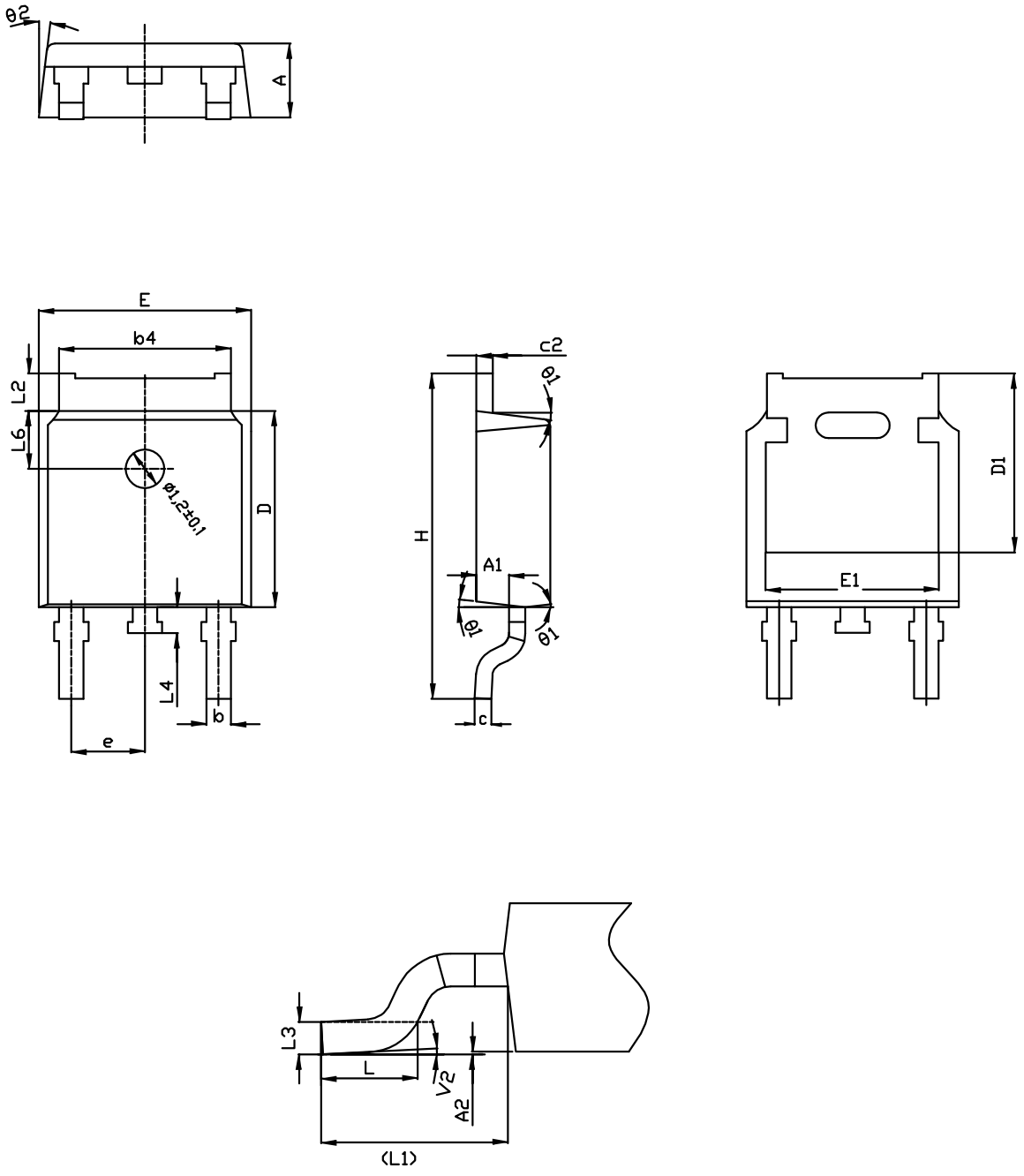


Table 8. **DPAK (TO-252) type A2 mechanical data**

| 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 | 5.10 | 5.20 | 5.30 |
| 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° |

## 4.2 DPAK (TO-252) type C2 package information

Figure 23. **DPAK (TO-252) type C2 package outline**

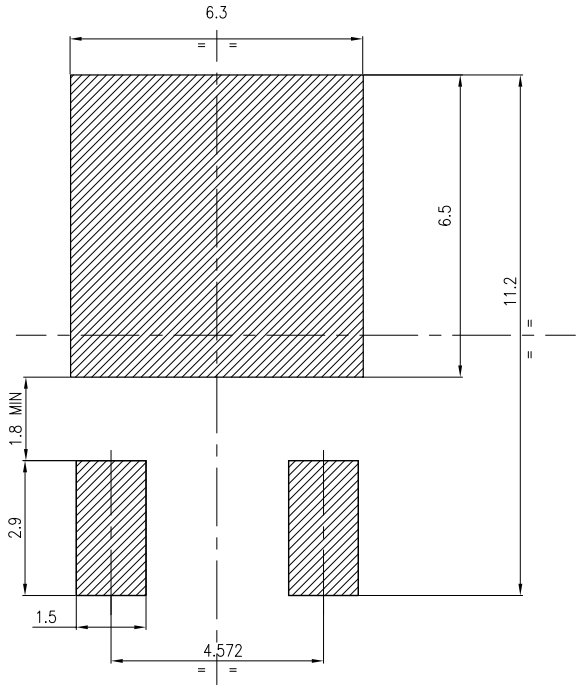



0068772_C2_24

Table 9. **DPAK (TO-252) type C2 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 | 5.10 | | 5.60 |
| E | 6.50 | 6.60 | 6.70 |
| E1 | 5.20 | | 5.50 |
| 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° |

Figure 24. **DPAK (TO-252) recommended footprint (dimensions are in mm)**



## 4.3 DPAK (TO-252) packing information

Figure 25. **DPAK (TO-252) tape outline**

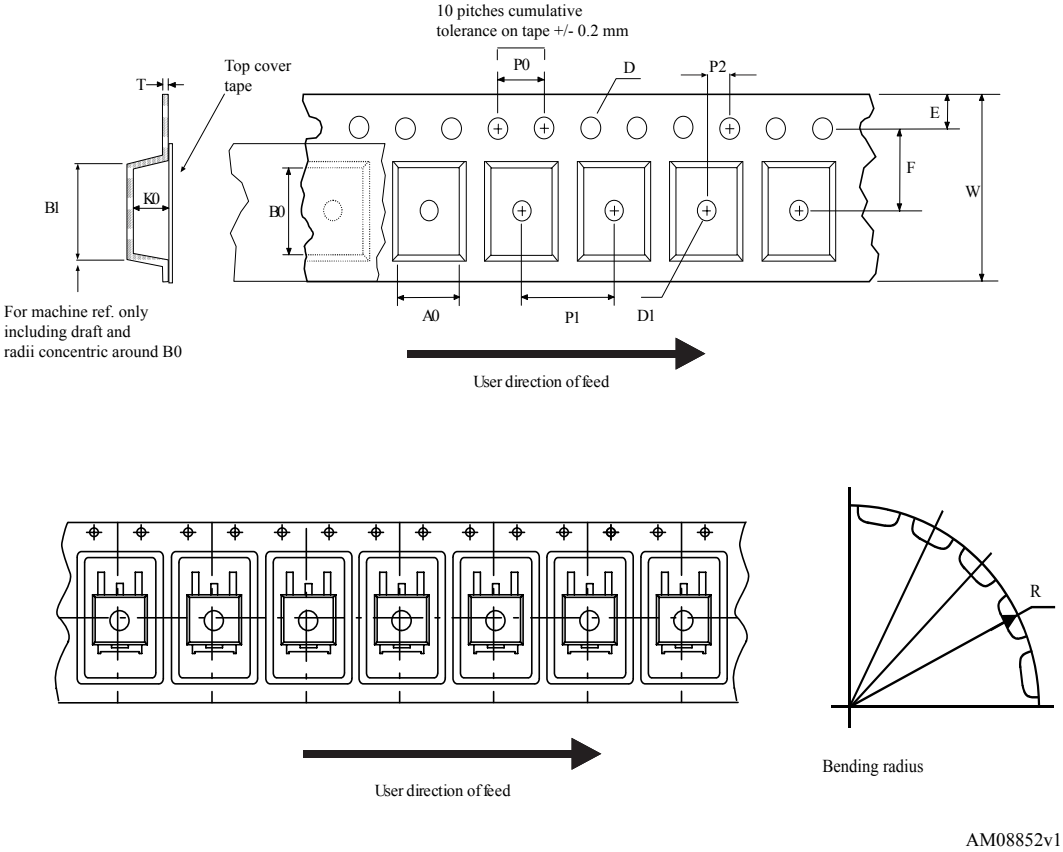
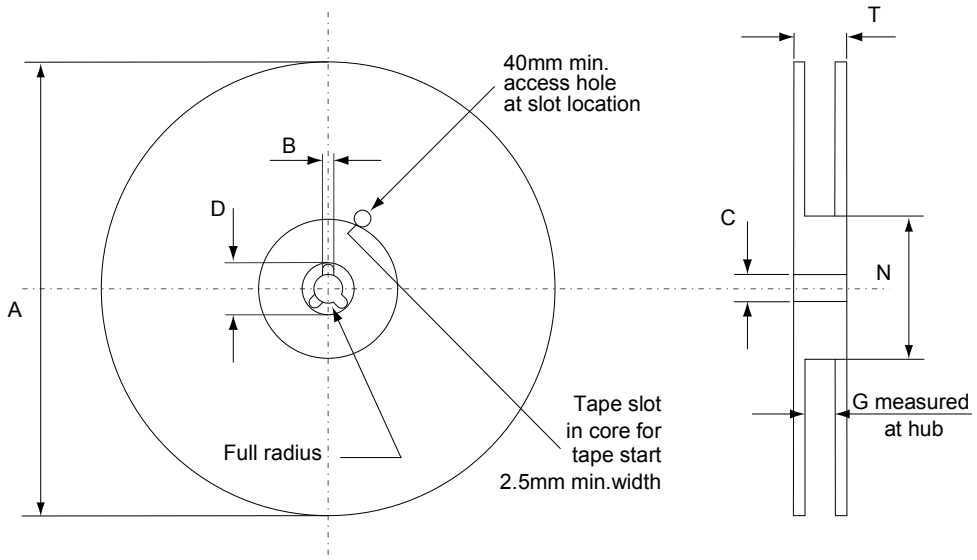


Figure 26. **DPAK (TO-252) reel outline**



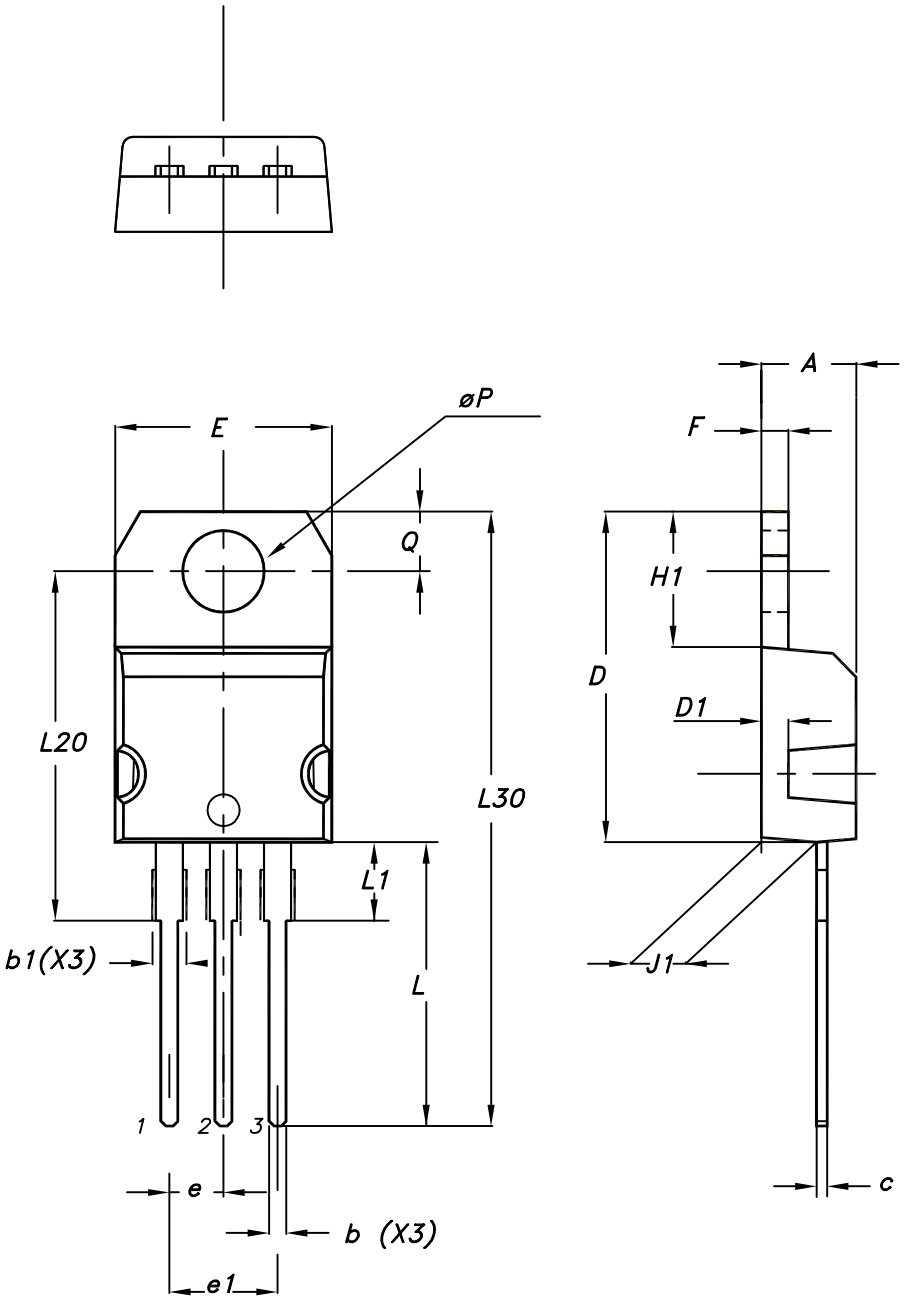

AM06038v1

Table 10. **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 | | | |

## 4.4 TO-220 type A package information

Figure 27. **TO-220 type A package outline**




0015988_typeA_Rev_21

Table 11. **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 |

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

Figure 28. **IPAK (TO-251) type A package outline**

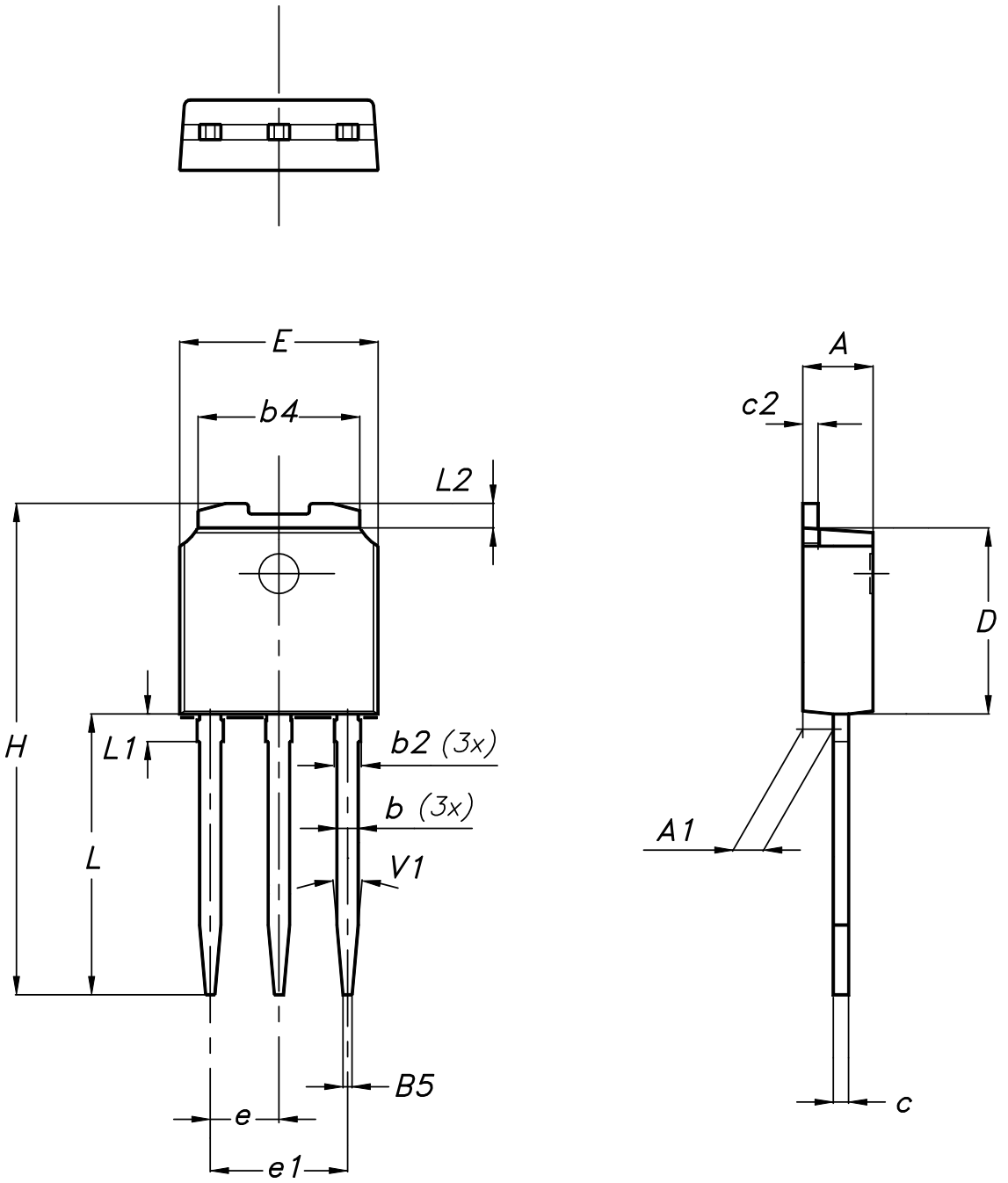
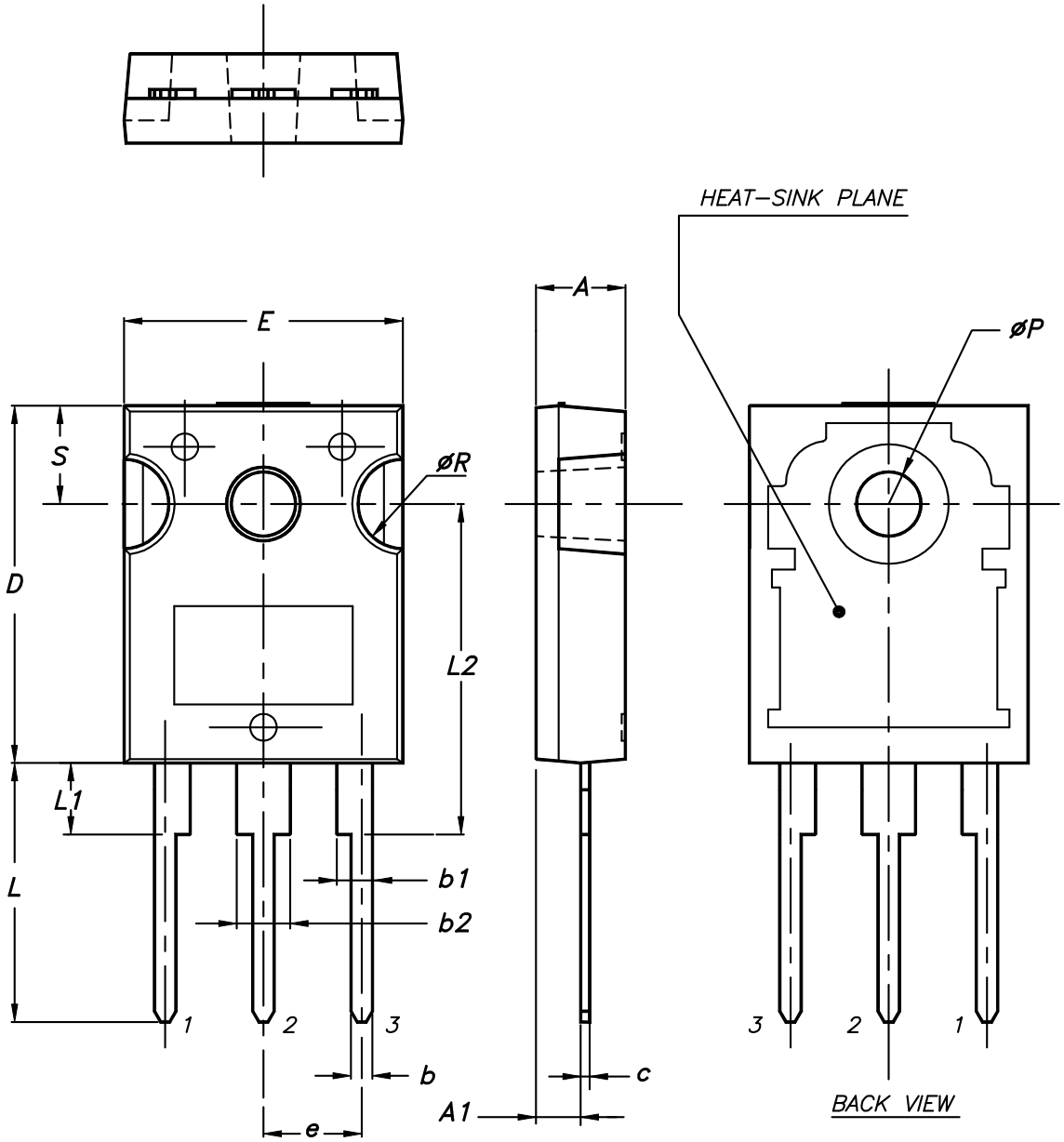


Table 12. **IPAK (TO-251) type A package mechanical data**

| 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° | |

## 4.6 TO-247 package information

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




0075325_9

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 Ordering information

Table 14. **Ordering information**

| Order code | Marking | Package | Packing |
|---|---|---|---|
| STD6N95K5 | 6N95K5 | DPAK | Tape and reel |
| STP6N95K5 | 6N95K5 | TO-220 | Tube |
| STU6N95K5 | 6N95K5 | IPAK | Tube |
| STW6N95K5 | 6N95K5 | TO-247 | Tube |

## Revision history

Table 15. **Document revision history**

| Date | Revision | Changes |
|---|---|---|
| 12-Jan-2010 | 1 | First release. |
| 01-Jul-2010 | 2 | Document status promoted from preliminary data to datasheet. |
| 31-Aug-2012 | 3 | Inserted new device in IPAK.<br>Updated *Table 1: Device summary*, *Table 2: Absolute maximum ratings*, and *Table 3: Thermal data.*<br>Updated *Section 4: Package mechanical data* and *Section 5: Packaging mechanical data*.<br>Minor text changes in the cover page. |
| 16-May-2014 | 4 | The part number STF6N95K5 has been moved to a separate datasheet.<br>Added: MOSFET dv/dt ruggedness parameter in *Table 2*<br>Updated: *Section 4: Package mechanical data*<br>Minor text changes |
| 22-Mar-2018 | 5 | Removed maturity status indication and updated title and description from cover page.<br>The document status is production data.<br>Updated Section 1 Electrical ratings, Section 2 Electrical characteristics.<br>Updated Figure 9. Capacitance variations and Figure 12. Normalized on-resistance vs temperature.<br>Updated Section 4 Package information.<br>Minor text changes. |

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