# STD5N95K3, STF5N95K3, STP5N95K3, STU5N95K3

## N-channel 950 V, 3 Ω typ., 4 A Zener-protected SuperMESH3™ Power MOSFET in DPAK, TO-220FP, TO-220 and IPAK packages

**Datasheet – production data**

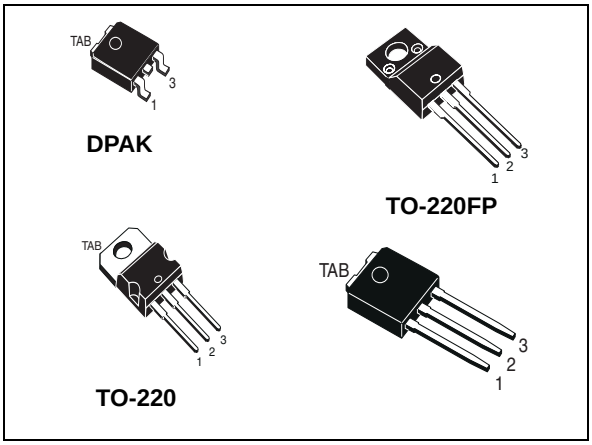
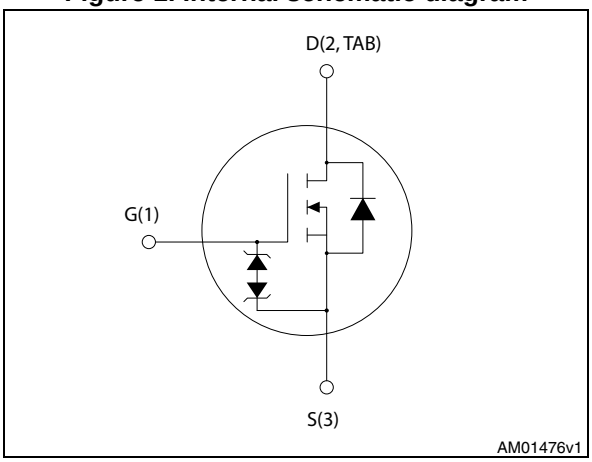



**Figure 1. Internal schematic diagram**




## Features

| Order codes | $V_{DS}$ | $R_{DS(on)}$ max | $I_D$ | $P_{TOT}$ |
|---|---|---|---|---|
| STD5N95K3 | 950 V | 3.5 Ω | 4 A | 90 W |
| STF5N95K3 | | | | 25 W |
| STP5N95K3 | | | | 90 W |
| STU5N95K3 | | | | 90 W |

- 100% avalanche tested
- Extremely large avalanche performance
- Gate charge minimized
- Very low intrinsic capacitances
- Zener-protected

## Applications

- Switching applications

## Description

These SuperMESH3™ Power MOSFETs are the result of improvements applied to STMicroelectronics' SuperMESH™ technology, combined with a new optimized vertical structure. These devices boast an extremely low on-resistance, superior dynamic performance and high avalanche capability, rendering them suitable for the most demanding applications.

**Table 1. Device summary**

| Order codes | Marking | Package | Packaging |
|---|---|---|---|
| STD5N95K3 | 5N95K3 | DPAK | Tape and reel |
| STF5N95K3 | | TO-220FP | Tube |
| STP5N95K3 | | TO-220 | |
| STU5N95K3 | | IPAK | |

# Contents

# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol | Parameter | Value | | | | Unit |
|---|---|---|---|---|---|---|
| | | DPAK | TO-220FP | TO-220 | IPAK | |
| $V_{GS}$ | Gate- source voltage | ±30 | | | | V |
| $I_D$ | Drain current (continuous) at $T_C$ = 25 °C | 4 | 4(1) | 4 | | A |
| $I_D$ | Drain current (continuous) at $T_C$ = 100 °C | 3 | 3(1) | 3 | | A |
| $I_{DM}$ (2) | Drain current (pulsed) | 16 | 16(1) | 16 | | A |
| $P_{TOT}$ | Total dissipation at $T_C$ = 25 °C | 90 | 25 | 90 | | W |
| $I_{AR}$ | Avalanche current, repetitive or not-repetitive (pulse width limited by $T_J$ max) | 4 | | | | A |
| $E_{AS}$ | Single pulse avalanche energy (starting $T_J$ = 25 °C, $I_D$ = $I_{AR}$, $V_{DD}$ = 50 V) | 100 | | | | mJ |
| dv/dt(3) | Peak diode recovery voltage slope | 5 | | | | V/ns |
| $V_{ISO}$ | Insulation withstand voltage (RMS) from all three leads to external heat sink (t = 1 s,$T_C$ = 25 °C) | | 2500 | | | V |
| $T_J$<br>$T_{stg}$ | Operating junction temperature<br>Storage temperature | -55 to 150 | | | | °C |

1. Limited by maximum junction temperature
2. Pulse width limited by safe operating area
3. $I_{SD}$ ≤ 4 A, di/dt ≤ 100 A/µs, peak $V_{DS} \leq V_{(BR)DSS}$

**Table 3. Thermal data**

| Symbol | Parameter | Value | | | | Unit |
|---|---|---|---|---|---|---|
| | | DPAK | TO-220FP | TO-220 | IPAK | |
| $R_{thj\text{-}case}$ | Thermal resistance junction-case max | 1.39 | 5 | 1.39 | | °C/W |
| $R_{thj\text{-}amb}$ | Thermal resistance junction-ambient max | | 62.5 | | 100 | °C/W |
| $R_{thj\text{-}pcb}$(1) | Thermal resistance junction-pcb max | 50 | | | | °C/W |

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

# 2 Electrical characteristics

(Tcase =25 °C unless otherwise specified)

**Table 4. On /off states**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage | $I_D$ = 1 mA, $V_{GS}$ = 0 | 950 | | | V |
| $I_{DSS}$ | Zero gate voltage drain current ($V_{GS}$ = 0) | $V_{DS}$ = 950 V<br>$V_{DS}$ = 950 V, $T_C$=125 °C | | | 1<br>50 | µA<br>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, $I_D$ = 2 A | | 3 | 3.5 | Ω |

**Table 5. Dynamic**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $C_{iss}$ | Input capacitance | $V_{DS}$ = 25 V, f = 1 MHz, $V_{GS}$ = 0 | - | 460 | - | pF |
| $C_{oss}$ | Output capacitance | | - | 38 | - | pF |
| $C_{rss}$ | Reverse transfer capacitance | | - | 1 | - | pF |
| $C_{o(tr)}$(1) | Equivalent capacitance time related | $V_{DS}$ = 0 to 760 V, $V_{GS}$ = 0 | - | 970 | - | pF |
| $C_{o(er)}$(2) | Equivalent capacitance energy related | $V_{DS}$ = 0 to 760 V, $V_{GS}$ = 0 | - | 15 | - | pF |
| $R_g$ | Gate input resistance | f=1 MHz , $I_D$ = 0 | - | 5.5 | - | Ω |
| $Q_g$ | Total gate charge | $V_{DD}$ = 760 V, $I_D$ = 4 A, $V_{GS}$ = 10 V *(see Figure 20)* | - | 19 | - | nC |
| $Q_{gs}$ | Gate-source charge | | - | 4.7 | - | nC |
| $Q_{gd}$ | Gate-drain charge | | - | 12 | - | nC |

1. Time related 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. Energy related 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 |
|---|---|---|---|---|---|---|
| $t_{d(on)}$ | Turn-on delay time | $V_{DD}$ = 475 V, $I_D$ = 2 A, $R_G$ = 4.7 Ω, $V_{GS}$ = 10 V *(see Figure 19)* | - | 17 | - | ns |
| $t_r$ | Rise time | | - | 7 | - | ns |
| $t_{d(off)}$ | Turn-off-delay time | | - | 32 | - | ns |
| $t_f$ | Fall time | | - | 18 | - | ns |

**Table 7. Source drain diode**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $I_{SD}$ | Source-drain current | | - | | 4 | A |
| $I_{SDM}$ (1) | Source-drain current (pulsed) | | - | | 16 | A |
| $V_{SD}$ (2) | Forward on voltage | $I_{SD}$ = 4 A, $V_{GS}$ = 0 | - | | 1.6 | V |
| $t_{rr}$ | Reverse recovery time | $I_{SD}$ = 4 A, di/dt = 100 A/µs $V_{DD}$= 60 V *(see Figure 21)* | - | 410 | | ns |
| $Q_{rr}$ | Reverse recovery charge | | - | 3.5 | | µC |
| $I_{RRM}$ | Reverse recovery current | | - | 17 | | A |
| $t_{rr}$ | Reverse recovery time | $I_{SD}$ = 4 A, di/dt = 100 A/µs $V_{DD}$= 60 V $T_J$ = 150 °C *(see Figure 21)* | - | 516 | | ns |
| $Q_{rr}$ | Reverse recovery charge | | - | 4.1 | | µC |
| $I_{RRM}$ | Reverse recovery current | | - | 16 | | 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 | 30 | - | - | V |

The built-in back-to-back Zener diodes have specifically been designed to enhance not only the device's ESD capability, but also to make them safely absorb possible voltage transients that may occasionally be applied from gate to source. In this respect the Zener voltage is appropriate to achieve an efficient and cost-effective intervention to protect the device's integrity. These integrated Zener diodes thus avoid the usage of external components.

## 2.1 Electrical characteristics (curves)

**Figure 2. Safe operating area for IPAK, DPAK**

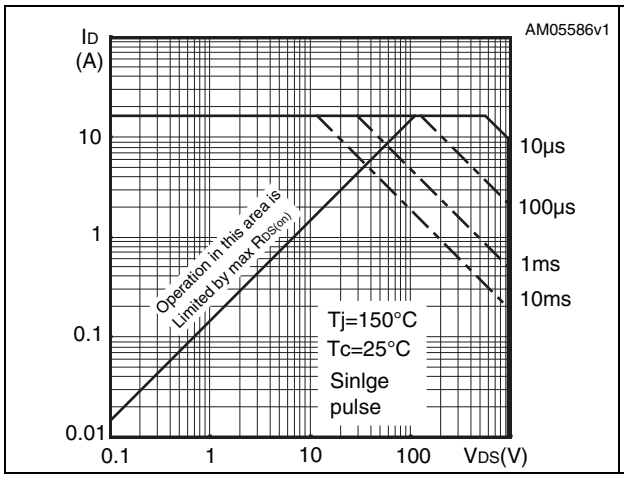



**Figure 3. Thermal impedance for IPAK, DPAK**

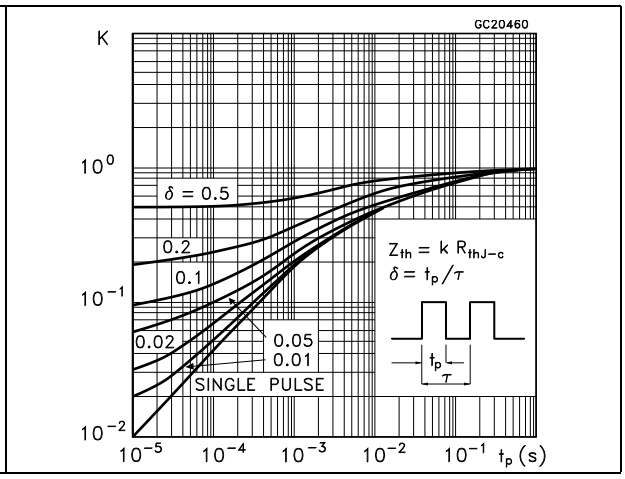



**Figure 4. Safe operating area for TO-220FP**

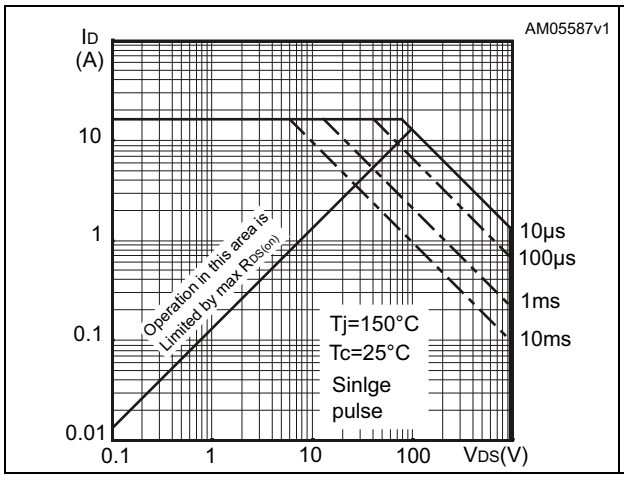



**Figure 5. Thermal impedance for TO-220FP**

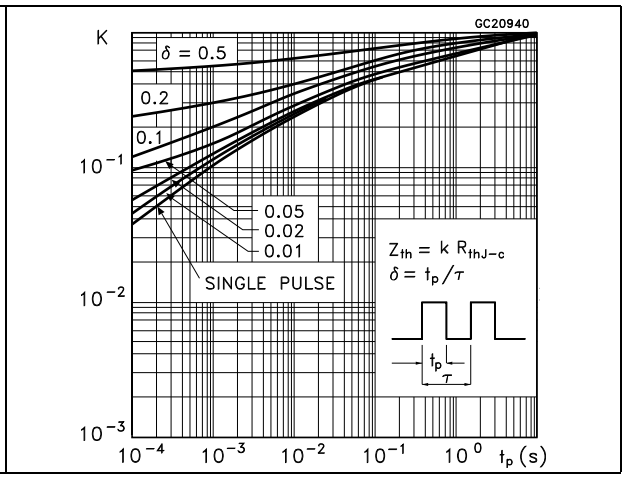



**Figure 6. Safe operating area for TO-220**

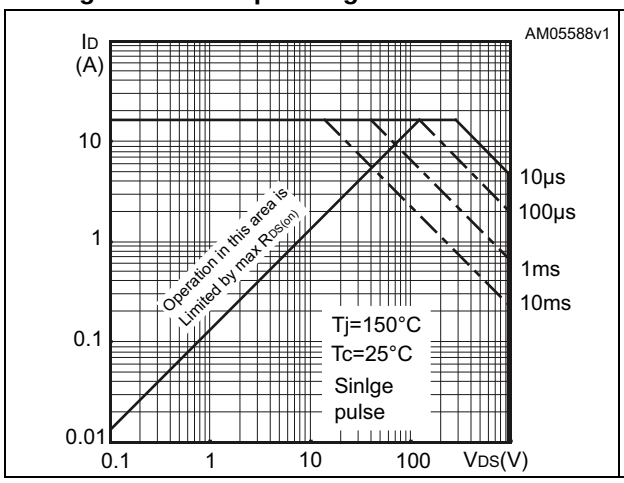



**Figure 7. Thermal impedance for TO-220**

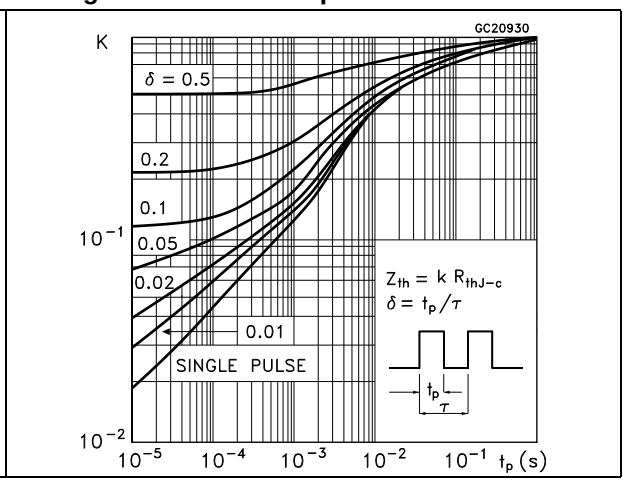


**Figure 8. Output characteristics**

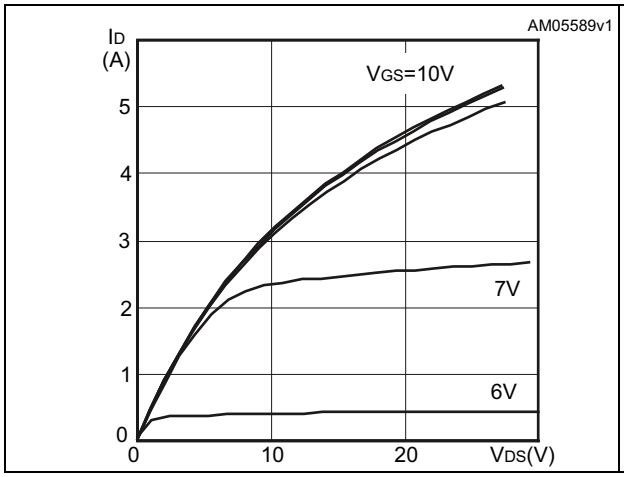



**Figure 9. Transfer characteristics**

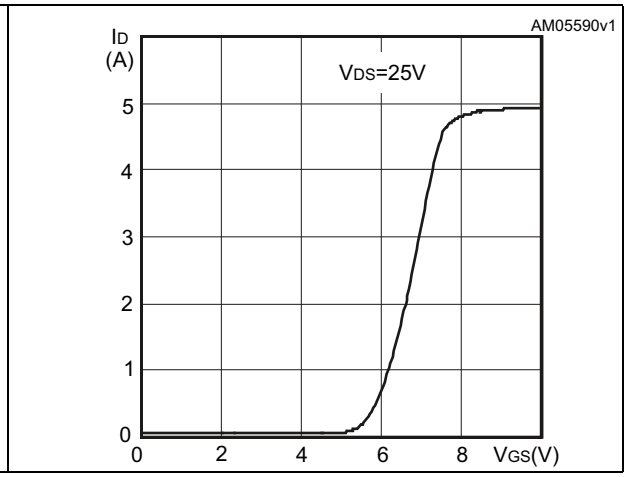



**Figure 10. Gate charge vs gate-source voltage**

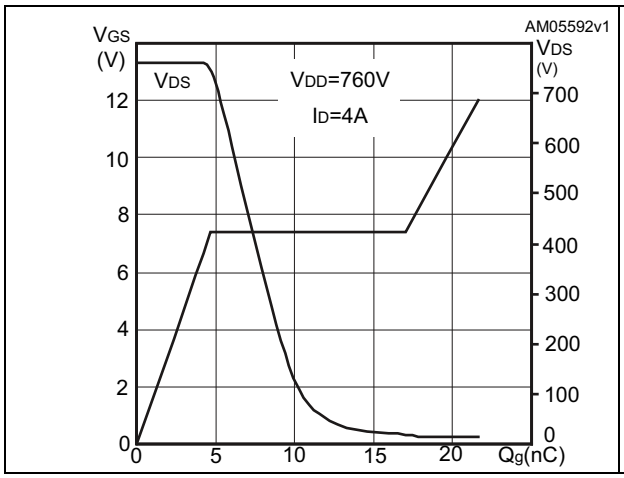



**Figure 11. Static drain-source on-resistance**

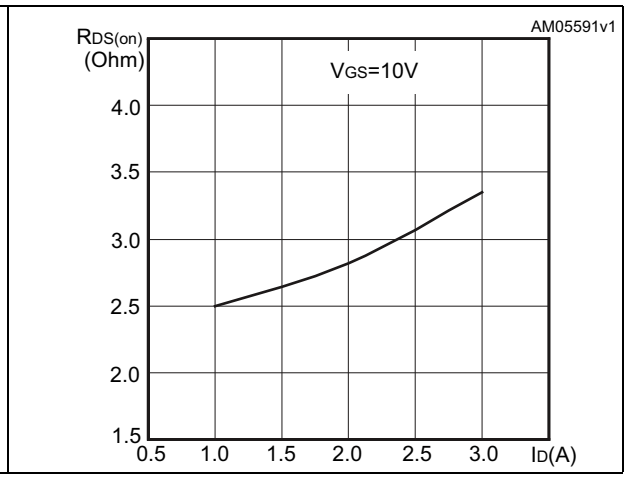



**Figure 12. Capacitance variations**

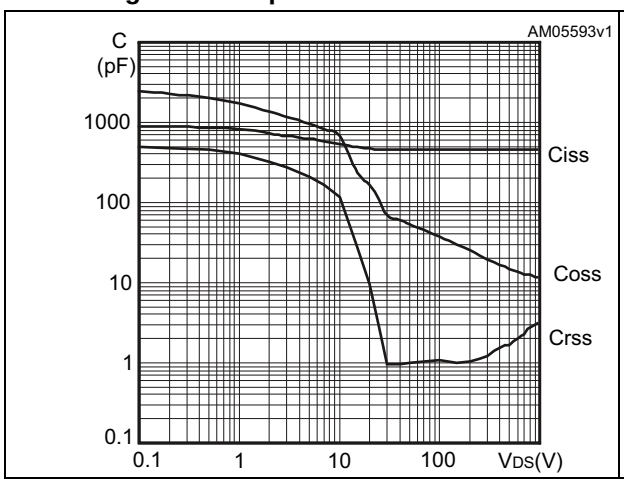



**Figure 13. Output capacitance stored energy**

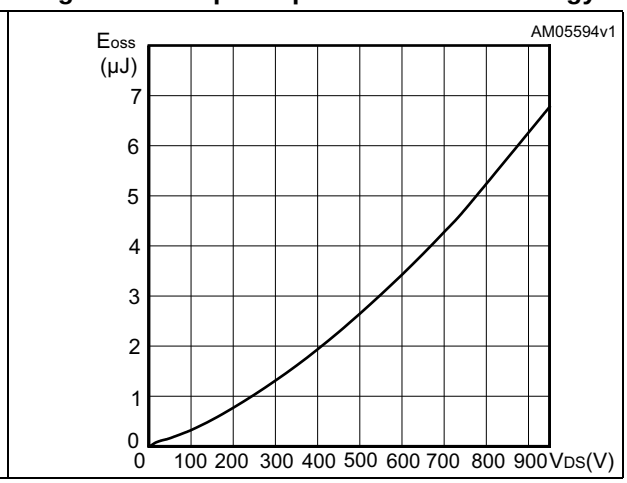


**Figure 14. Normalized gate threshold voltage vs temperature**

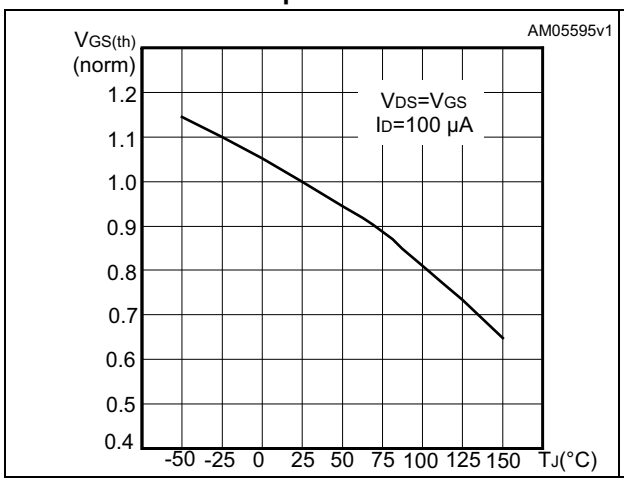



**Figure 15. Normalized on-resistance vs temperature**

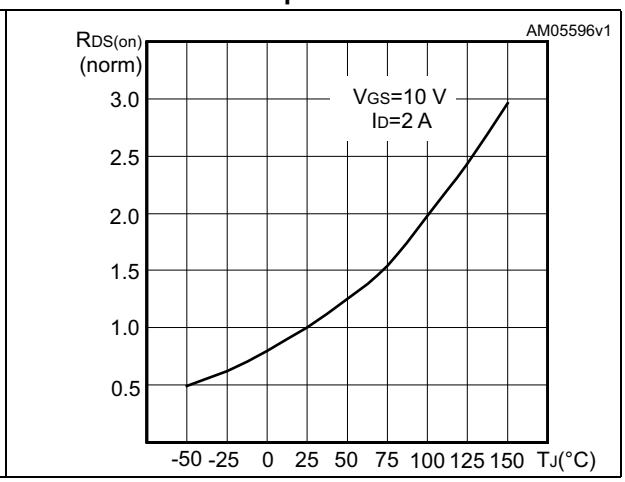



**Figure 16. Source-drain diode forward characteristics**

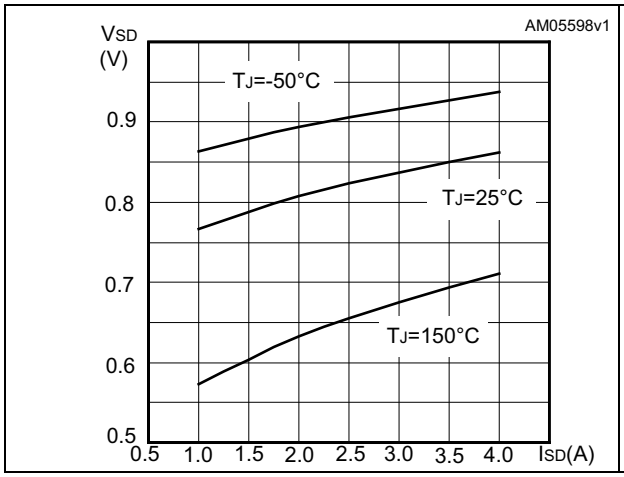



**Figure 17. Normalized $B_{VDSS}$ vs temperature**

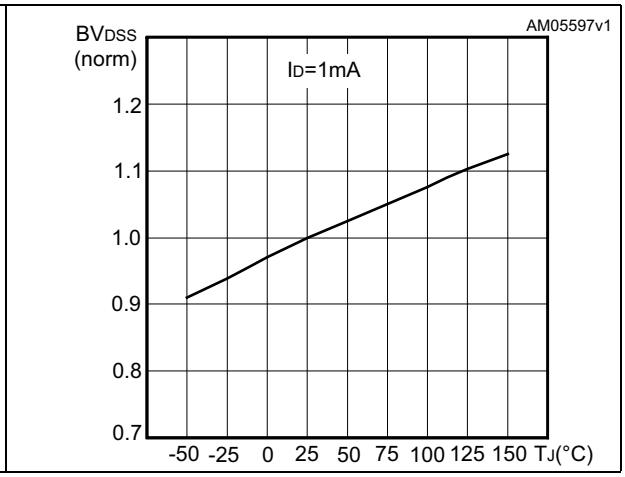
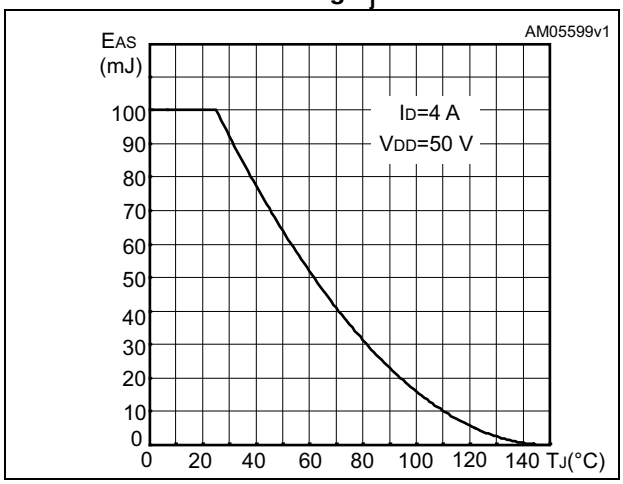



**Figure 18. Maximum avalanche energy vs starting $T_j$**



# 3 Test circuits

**Figure 19. Switching times test circuit for resistive load**

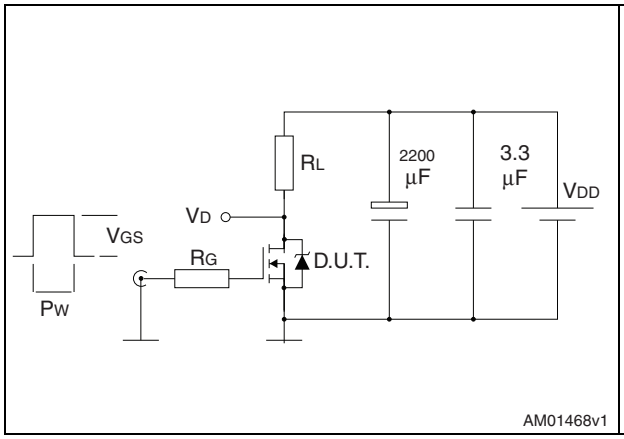



**Figure 20. Gate charge test circuit**

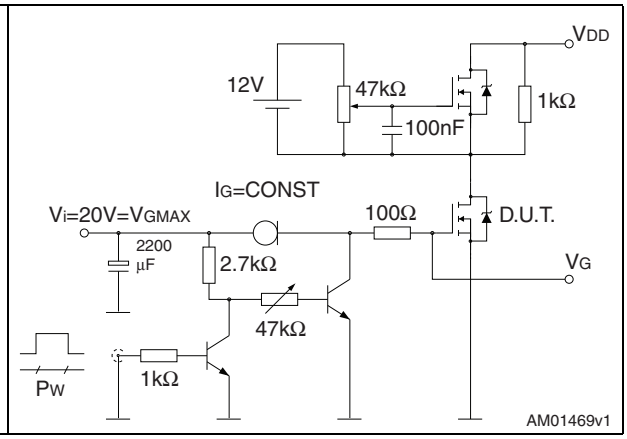



**Figure 21. Test circuit for inductive load switching and diode recovery times**

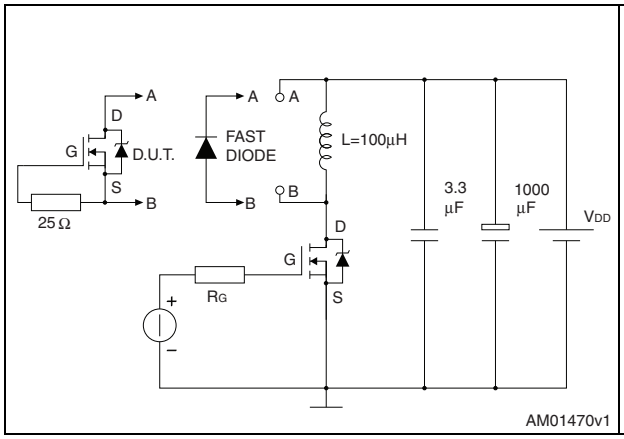



**Figure 22. Unclamped inductive load test circuit**

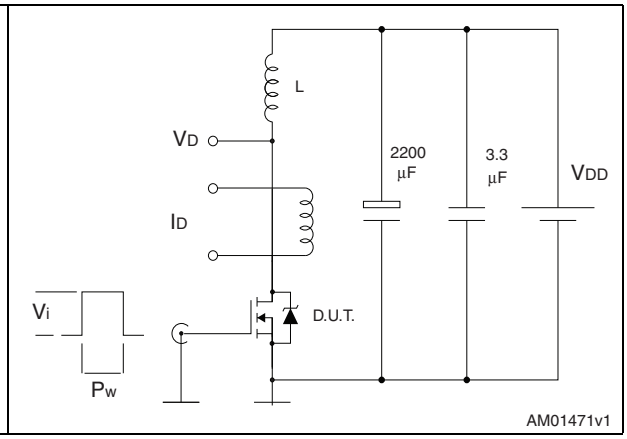



**Figure 23. Unclamped inductive waveform**

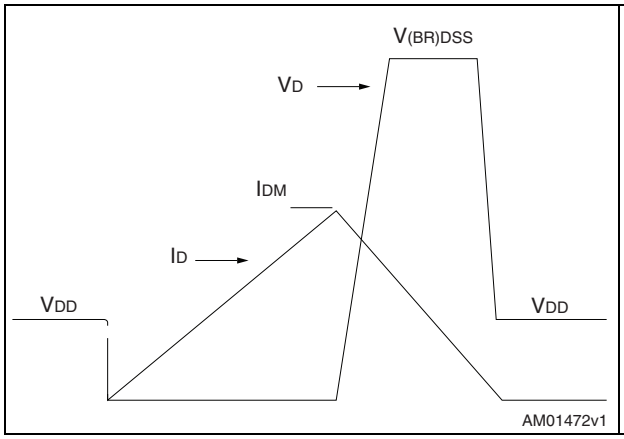
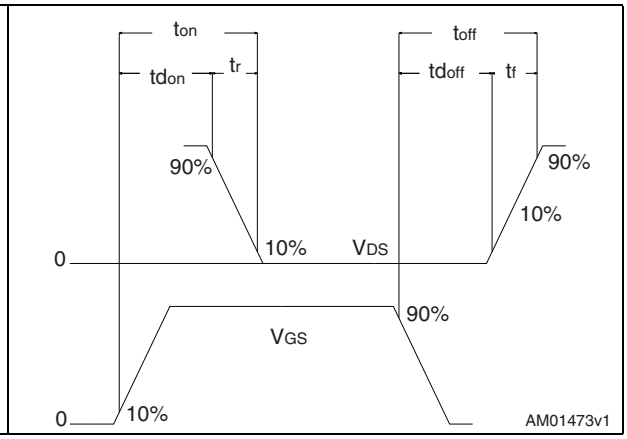



**Figure 24. Switching time waveform**



# 4 Package mechanical data

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.

**Table 9. DPAK (TO-252) 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 | | 5.10 | |
| E | 6.40 | | 6.60 |
| E1 | | 4.70 | |
| e | | 2.28 | |
| e1 | 4.40 | | 4.60 |
| H | 9.35 | | 10.10 |
| L | 1.00 | | 1.50 |
| (L1) | | 2.80 | |
| L2 | | 0.80 | |
| L4 | 0.60 | | 1.00 |
| R | | 0.20 | |
| V2 | 0° | | 8° |

**Figure 25. DPAK (TO-252) drawing**

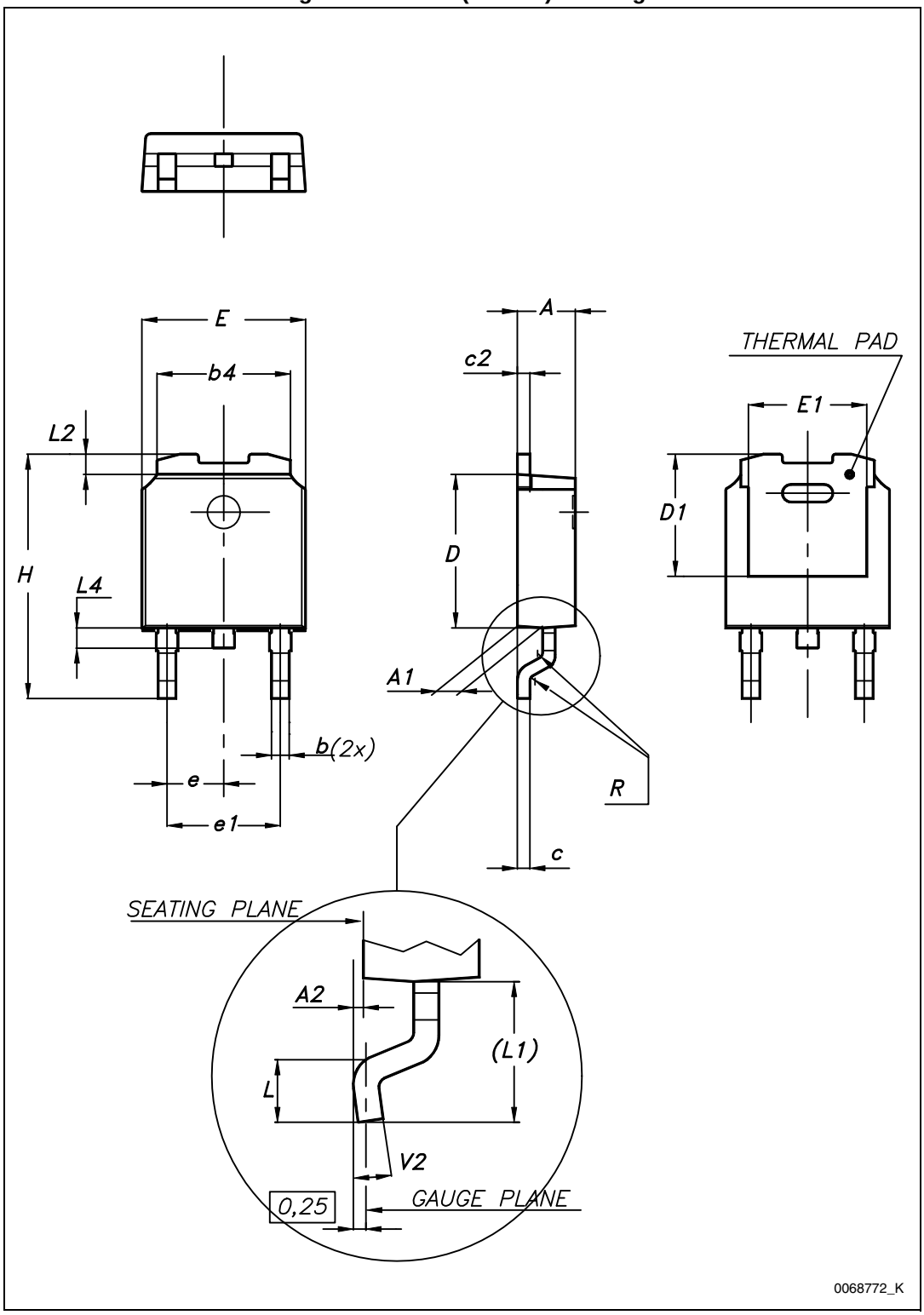
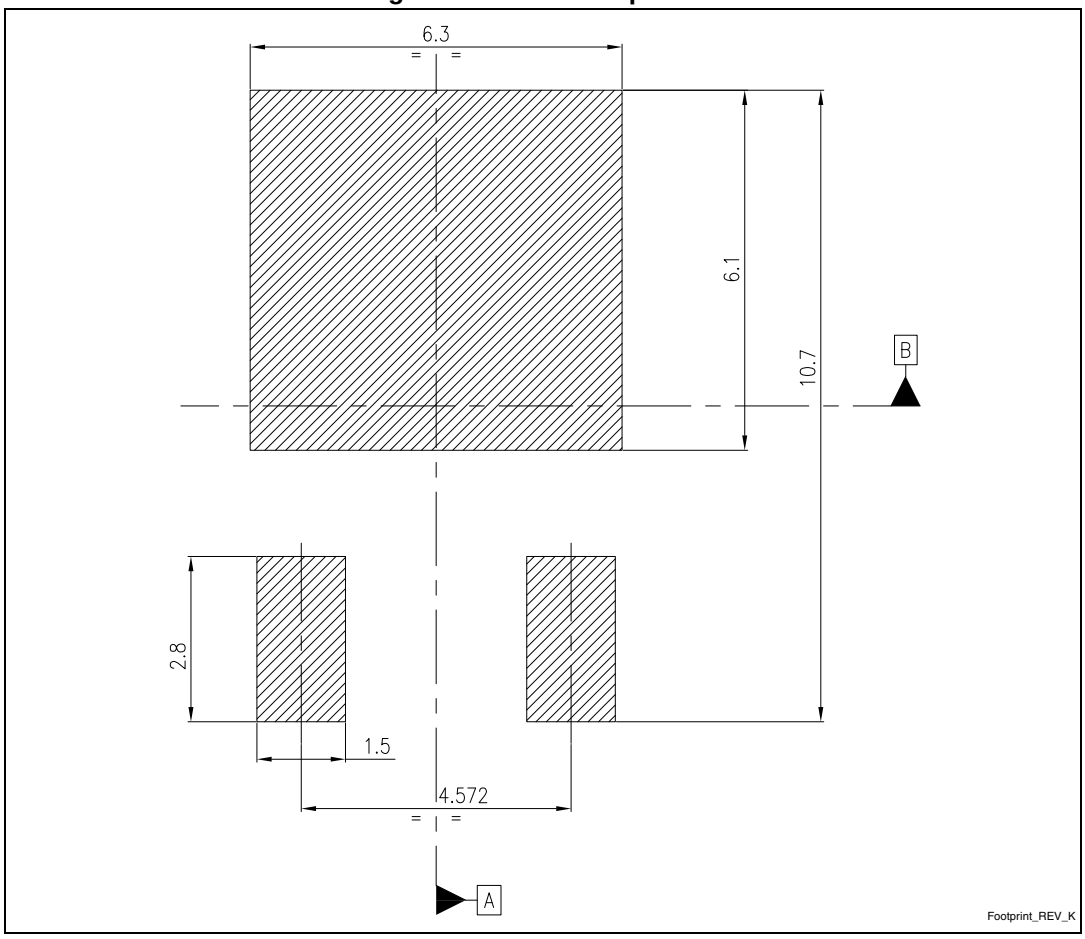


**Figure 26. DPAK footprint [(a)]**




a. All dimensions are in millimeters

**Table 10. TO-220FP 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 |

Figure 27. TO-220FP drawing

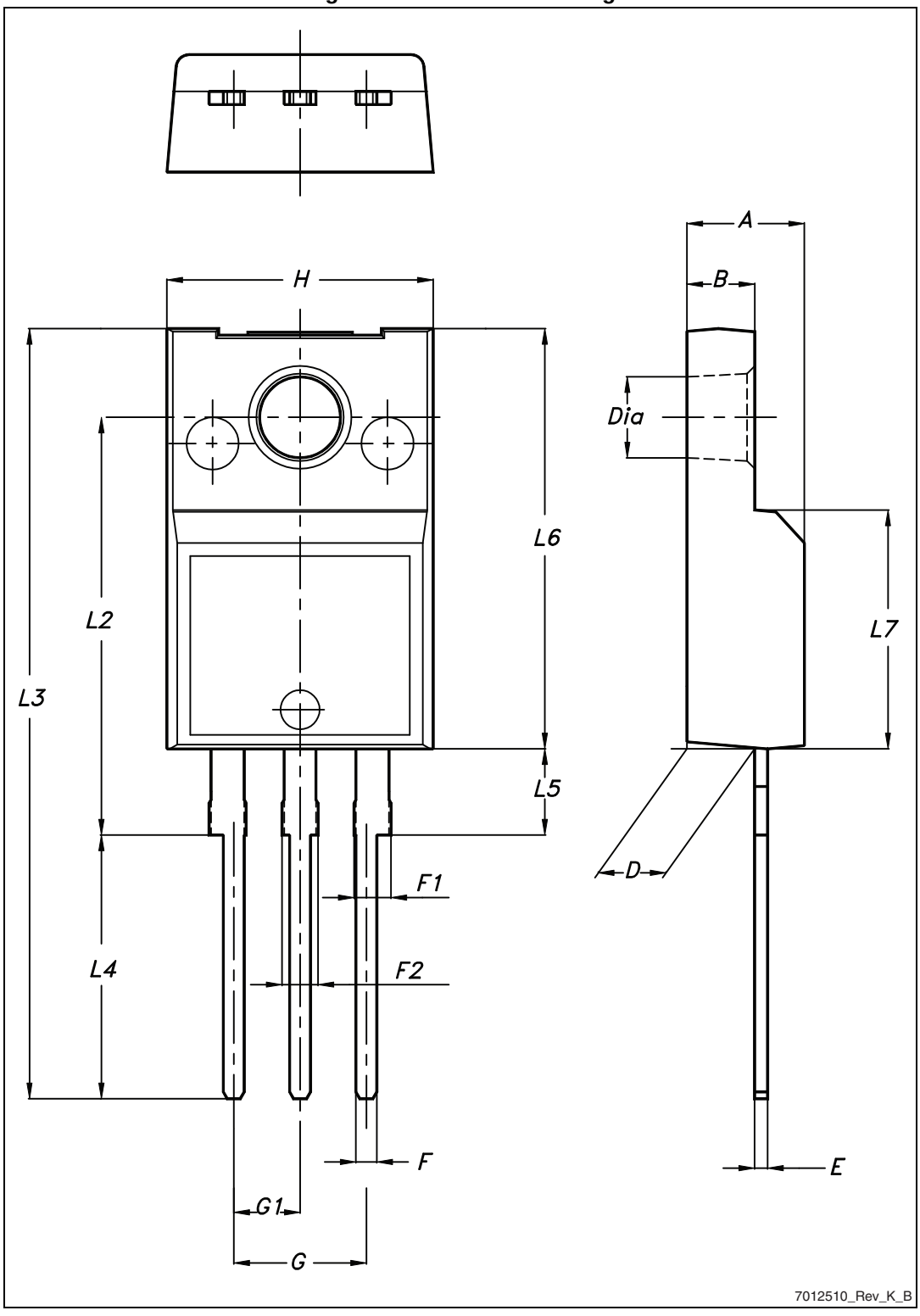


**Table 11. TO-220 type A mechanical data**

| 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 | |
| ∅P | 3.75 | | 3.85 |
| Q | 2.65 | | 2.95 |

**Figure 28. TO-220 type A drawing**

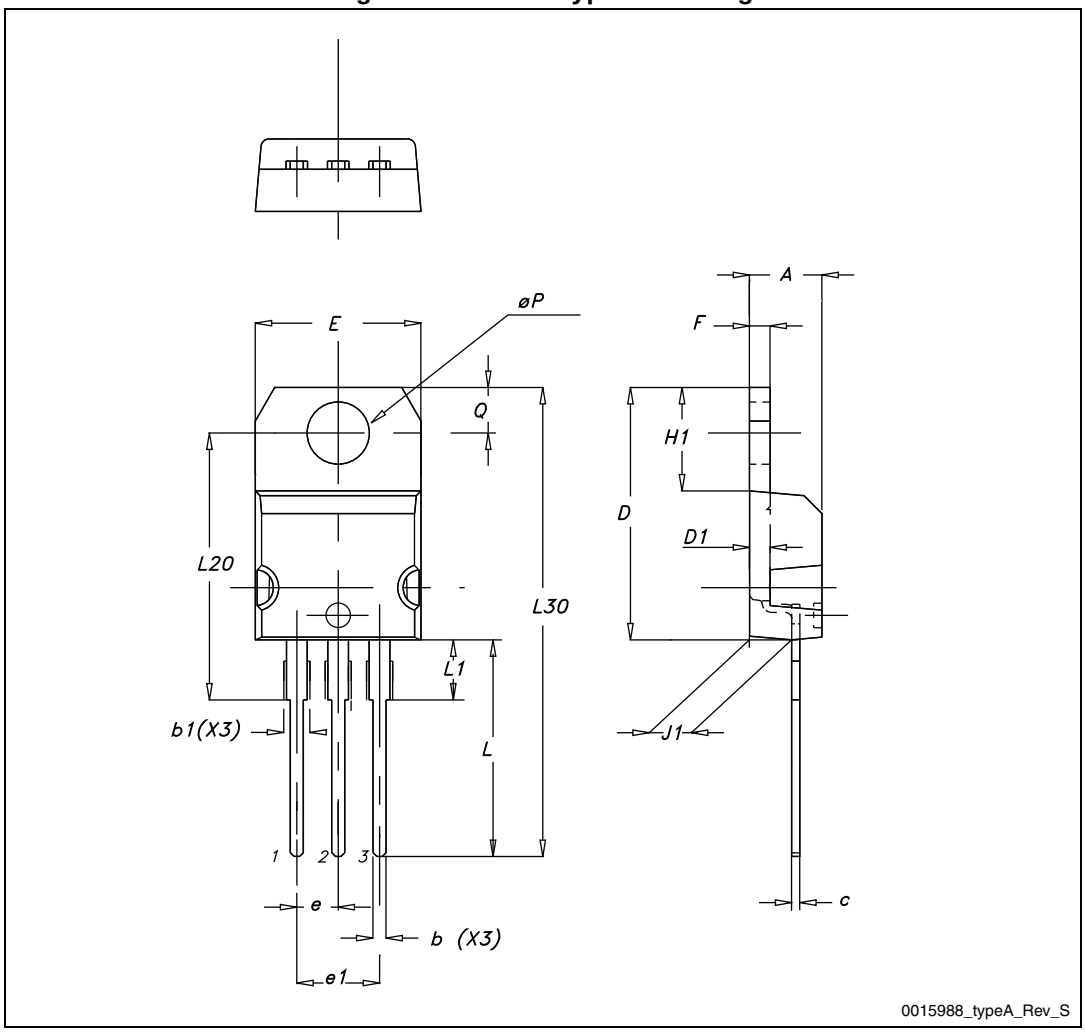
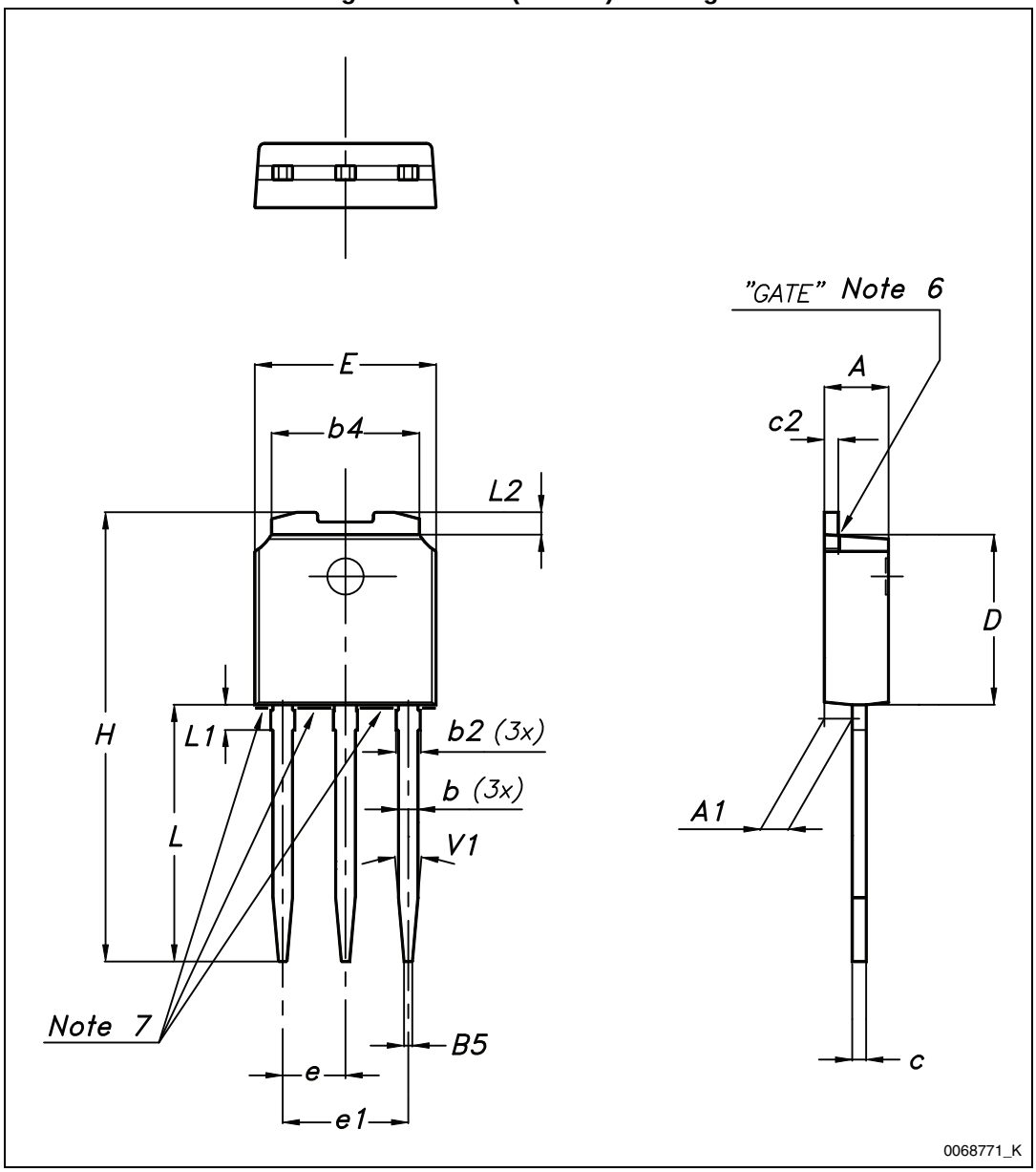


Table 12. IPAK (TO-251) mechanical data

| DIM | mm. | | |
|---|---|---|---|
| | min. | typ. | max. |
| A | 2.20 | | 2.35 |
| 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 | | 6.15 |
| E | 6.40 | | 6.55 |
| 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° | |

**Figure 29. IPAK (TO-251) drawing**



# 5 Packaging mechanical data

**Table 13. 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 | | | |

**Figure 30. Tape for DPAK (TO-252)**

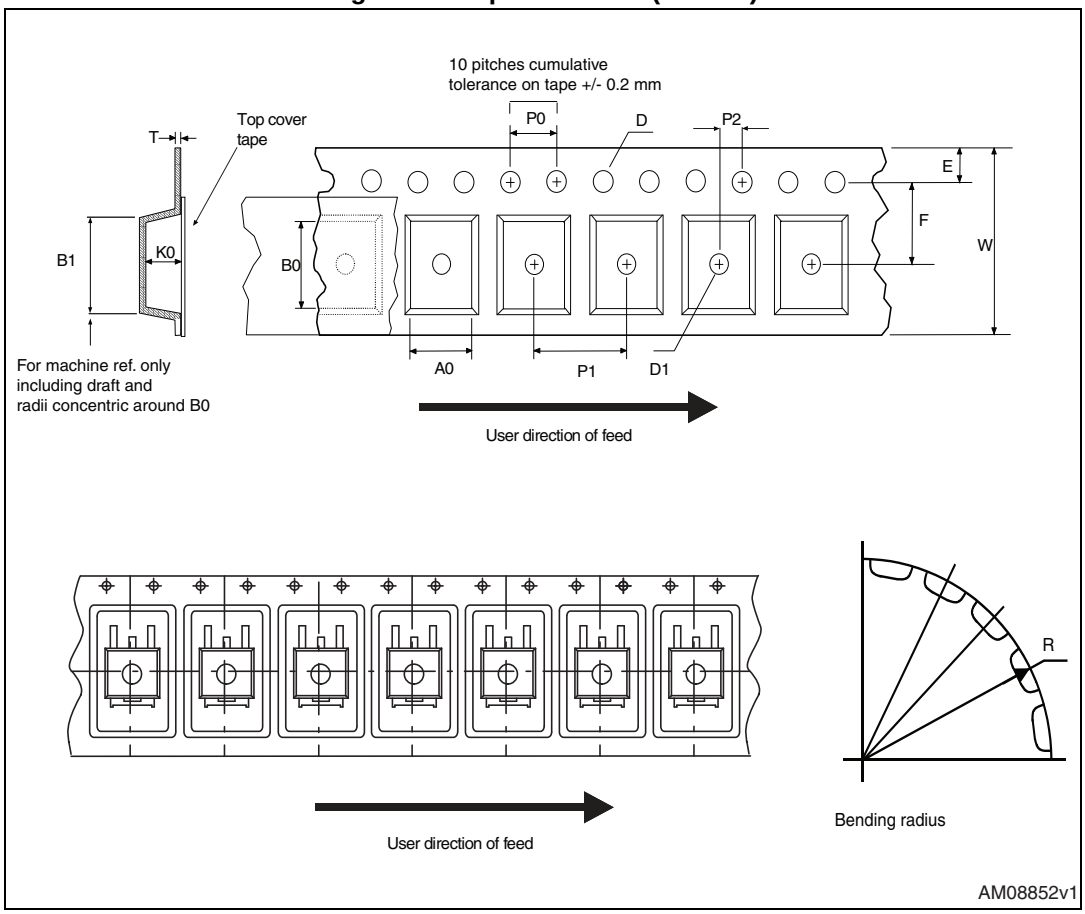
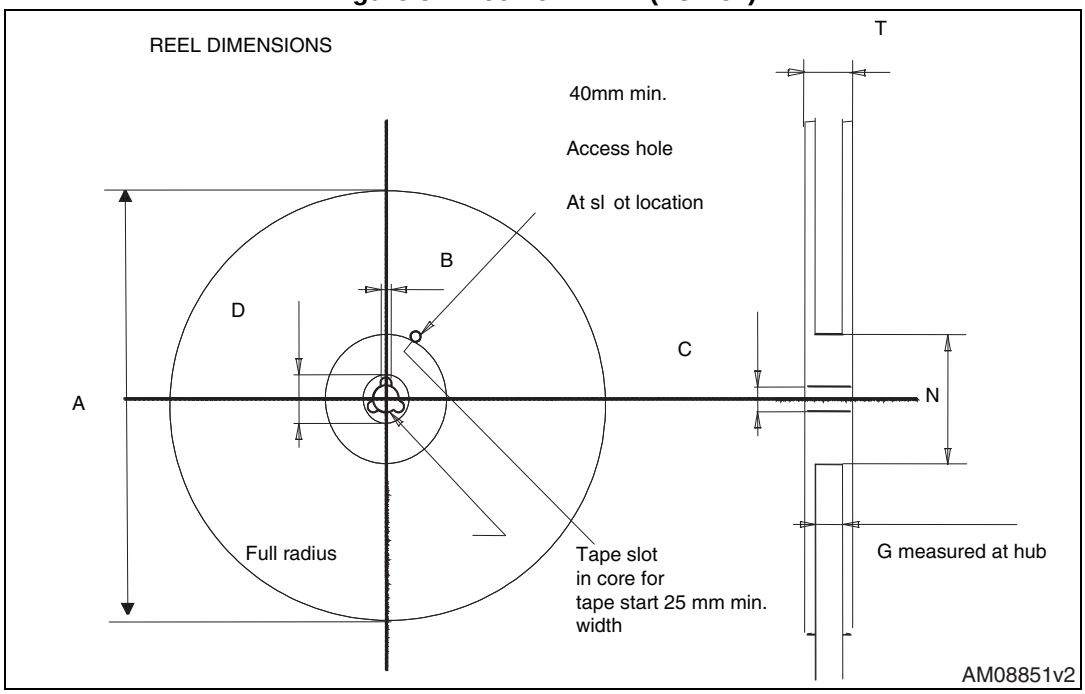



**Figure 31. Reel for DPAK (TO-252)**



# 6 Revision history

Table 14. Document revision history

| Date | Revision | Changes |
|---|---|---|
| 12-May-2009 | 1 | First release |
| 11-Dec-2009 | 2 | Document status promoted from preliminary data to datasheet |
| 15-May-2013 | 3 | – Updated: *Section 4: Package mechanical data*<br>– Minor text change on the cover page. |

Общество с ограниченной ответственностью «МосЧип» ИНН 7719860671 / КПП 771901001
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