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# STD3N80K5, STF3N80K5, STP3N80K5, STU3N80K5

## N-channel 800 V, 2.8 Ω typ., 2.5 A Zener-protected SuperMESH™ 5 Power MOSFET in DPAK, TO-220FP, TO-220 and IPAK packages

**Datasheet – production data**

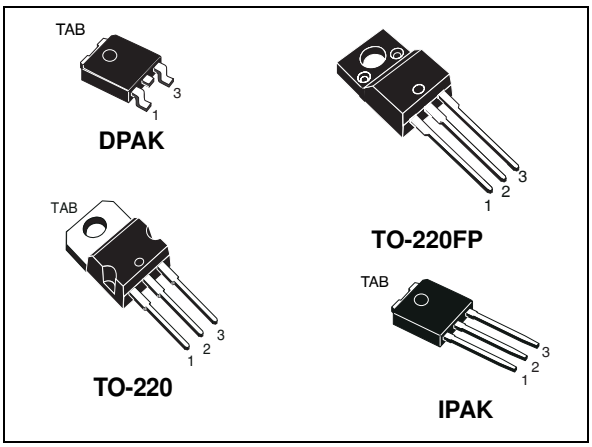
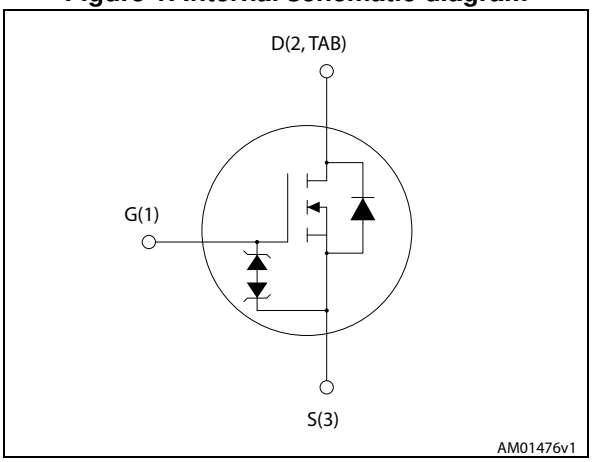



**Figure 1. Internal schematic diagram**




## Features

| Order codes | $V_{DS}$ | $R_{DS(on)}$max | $I_D$ | $P_{TOT}$ |
|---|---|---|---|---|
| STD3N80K5 | 800 V | 3.5 Ω | 2.5 A | 60 W |
| STF3N80K5 | | | | 20 W |
| STP3N80K5 | | | | 60 W |
| STU3N80K5 | | | | |

- TO-220 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 devices are N-channel Power MOSFETs developed using SuperMESH™ 5 technology. This revolutionary, avalanche-rugged, high voltage Power MOSFET technology is based on an innovative proprietary vertical structure. The result is a drastic reduction in on-resistance and ultra low gate charge for applications which require superior power density and high efficiency.

**Table 1. Device summary**

| Order code | Marking | Package | Packaging |
|---|---|---|---|
| STD3N80K5 | 3N80K5 | DPAK | Tape and reel |
| STF3N80K5 | | TO-220FP | Tube |
| STP3N80K5 | | TO-220 | |
| STU3N80K5 | | 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 | 2.5(1) | | | | A |
| $I_D$ | Drain current (continuous) at $T_C$ = 100 °C | 1.6 | | | | A |
| $I_{DM}$ (2) | Drain current (pulsed) | 10 | | | | A |
| $P_{TOT}$ | Total dissipation at $T_C$ = 25 °C | 60 | 20 | 60 | 60 | W |
| $I_{AR}$ | Max current during repetitive or single pulse avalanche (pulse width limited by $T_{jmax}$) | 1 | | | | A |
| $E_{AS}$ | Single pulse avalanche energy (starting $T_J$ = 25 °C, $I_D$=$I_{AS}$, $V_{DD}$= 50 V) | 65 | | | | mJ |
| dv/dt (3) | Peak diode recovery voltage slope | 4.5 | | | | V/ns |
| dv/dt (4) | MOSFET dv/dt ruggedness | 50 | | | | V/ns |
| $T_j$<br>$T_{stg}$ | Operating junction temperature<br>Storage temperature | -55 to 150 | | | | °C |

1. For TO-220FP limited by maximum junction temperature.
2. Pulse width limited by safe operating area.
3. $I_{SD} \leq$ 2.5 A, di/dt $\leq$ 100 A/$\mu$s, peak $V_{DS} \leq V_{(BR)DSS}$
4. $V_{DS} \leq$ 640 V

**Table 3. Thermal data**

| Symbol | Parameter | Value | | | | Unit |
|---|---|---|---|---|---|---|
| | | DPAK | TO-220FP | TO-220 | IPAK | |
| $R_{thj\text{-}case}$ | Thermal resistance junction-case | 2.08 | 6.25 | 2.08 | | °C/W |
| $R_{thj\text{-}pcb}$ | Thermal resistance junction-pcb | 50(1) | | | | |
| $R_{thj\text{-}amb}$ | Thermal resistance junction-amb | | 62.5 | 62.5 | 100 | |

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

# 2 Electrical characteristics

($T_{CASE}$ = 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 ($V_{GS}$= 0) | $I_D$ = 1 mA | 800 | | | V |
| $I_{DSS}$ | Zero gate voltage drain current ($V_{GS}$ = 0) | $V_{DS}$ = 800 V | | | 1 | µA |
| | | $V_{DS}$ = 800 V $T_j$=125 °C | | | 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, $I_D$= 1 A | | 2.8 | 3.5 | Ω |

**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 | - | 130 | - | pF |
| $C_{oss}$ | Output capacitance | | - | 14 | - | pF |
| $C_{rss}$ | Reverse transfer capacitance | | - | 0.6 | - | pF |
| $C_{o(tr)}$(1) | Equivalent capacitance time related | $V_{GS}$ = 0, $V_{DS}$ = 0 | - | 20 | - | pF |
| $C_{o(er)}$(2) | Equivalent capacitance energy related | | - | 9 | - | pF |
| $R_G$ | Intrinsic gate resistance | f = 1 MHz, $I_D$=0 | - | 15.5 | - | Ω |
| $Q_g$ | Total gate charge | $V_{DD}$ = 640 V, $I_D$ = 2.5 A $V_{GS}$ =10 V | - | 9.5 | - | nC |
| $Q_{gs}$ | Gate-source charge | | - | 1.5 | - | nC |
| $Q_{gd}$ | Gate-drain charge | | - | 7.5 | - | 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 | $V_{DD}$ = 400 V, $I_D$ = 1.25 A, $R_G$=4.7 Ω, $V_{GS}$=10 V | - | 8.5 | - | ns |
| $t_r$ | Rise time | | - | 7.5 | - | ns |
| $t_{d(off)}$ | Turn-off delay time | | - | 20.5 | - | ns |
| $t_f$ | Fall time | | - | 25 | - | ns |

**Table 7. Source drain diode**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $I_{SD}$ | Source-drain current | | - | | 2.5 | A |
| $I_{SDM}$(1) | Source-drain current (pulsed) | | - | | 10 | A |
| $V_{SD}$(2) | Forward on voltage | $I_{SD}$= 2.5 A, $V_{GS}$=0 | - | | 1.5 | V |
| $t_{rr}$ | Reverse recovery time | $I_{SD}$= 2.5 A, $V_{DD}$= 60 V di/dt = 100 A/µs, | - | 265 | | ns |
| $Q_{rr}$ | Reverse recovery charge | | - | 1.2 | | µC |
| $I_{RRM}$ | Reverse recovery current | | - | 9.2 | | A |
| $t_{rr}$ | Reverse recovery time | $I_{SD}$= 2.5 A,$V_{DD}$= 60 V di/dt=100 A/µs, Tj=150 °C | - | 430 | | ns |
| $Q_{rr}$ | Reverse recovery charge | | - | 1.9 | | µC |
| $I_{RRM}$ | Reverse recovery current | | - | 8.8 | | 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 | $I_{GS}$= ± 1mA, $I_D$= 0 | 30 | - | - | V |

The built-in back-to-back Zener diodes have been specifically designed to enhance not only the device's ESD capability, but also to make them capable of safely absorbing any voltage transients that may occasionally be applied from gate to source. In this respect, the Zener voltage is appropriate to achieve efficient and cost-effective protection of device integrity. The integrated Zener diodes thus eliminate the need for external components.

## 2.1 Electrical characteristics (curves)

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

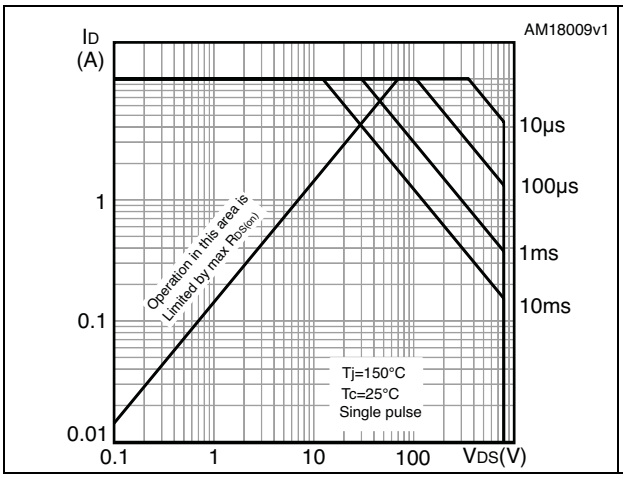



**Figure 3. Thermal impedance for DPAK and IPAK**

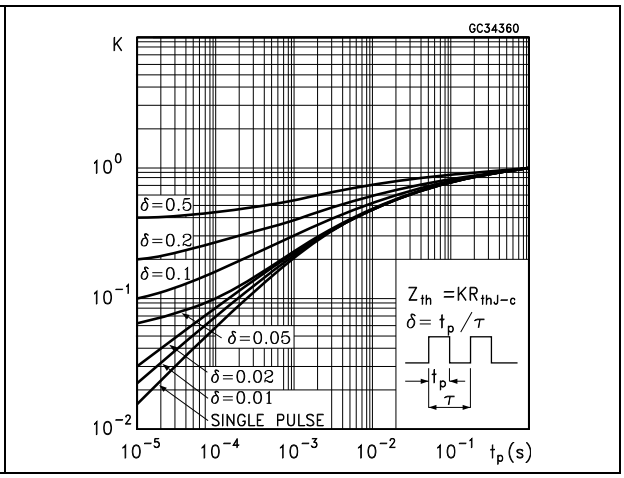



**Figure 4. Safe operating area for TO-220FP**

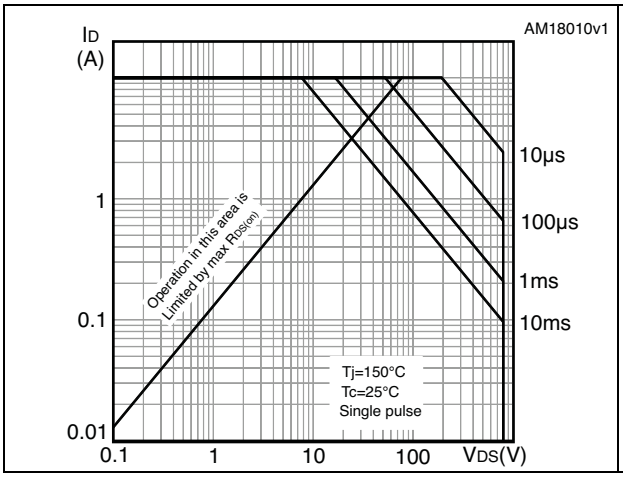



**Figure 5. Thermal impedance for TO-220FP**

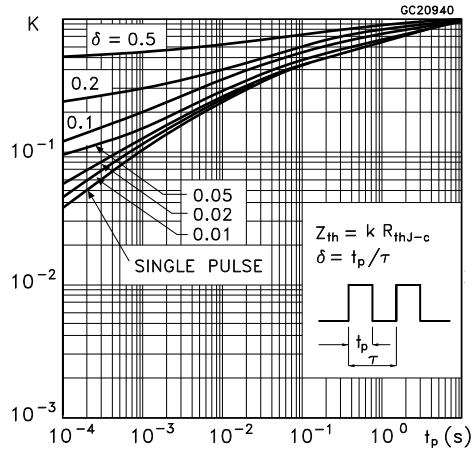



**Figure 6. Safe operating area for TO-220**

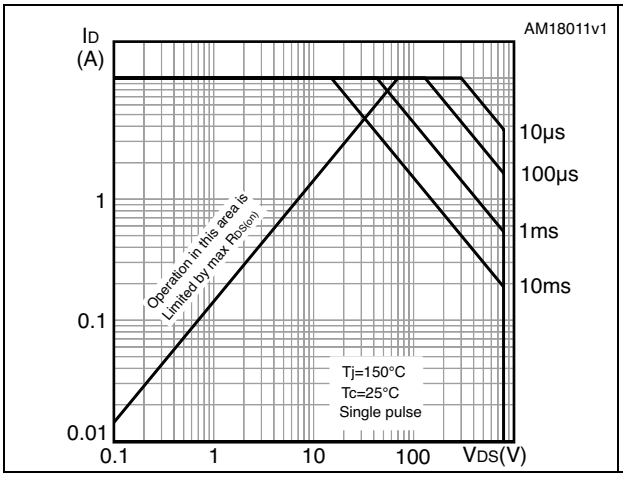



**Figure 7. Thermal impedance for TO-220**

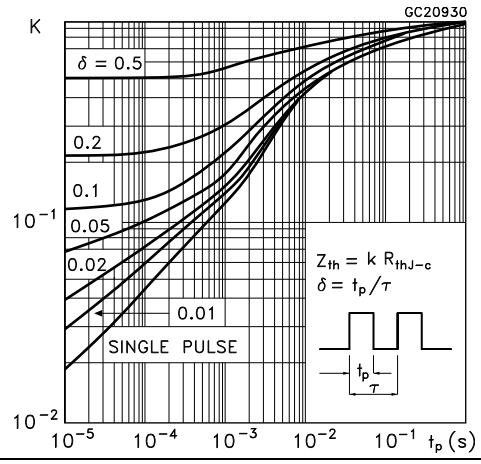


**Figure 8. Output characteristics**

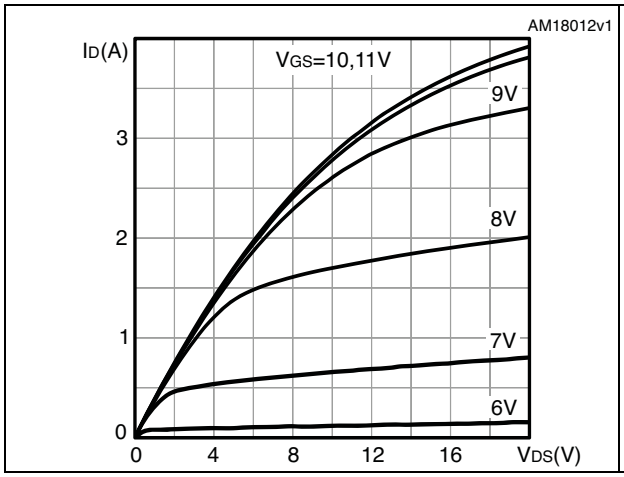



**Figure 9. Transfer characteristics**

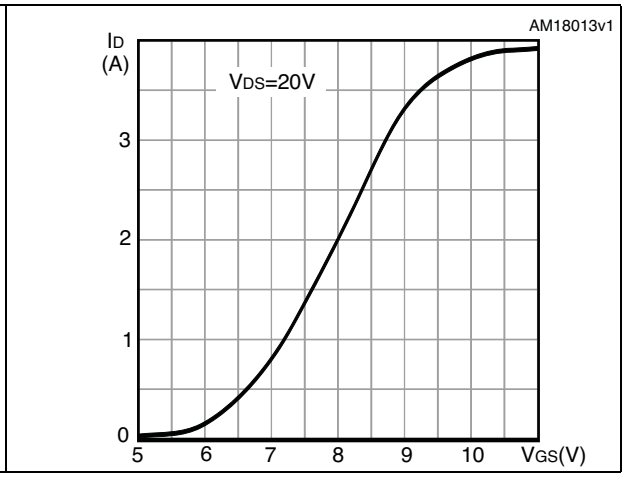



**Figure 10. Gate charge vs gate-source voltage**

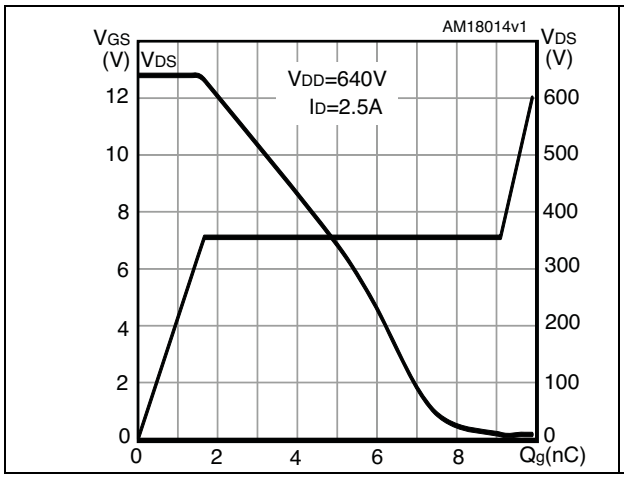



**Figure 11. Static drain-source on-resistance**

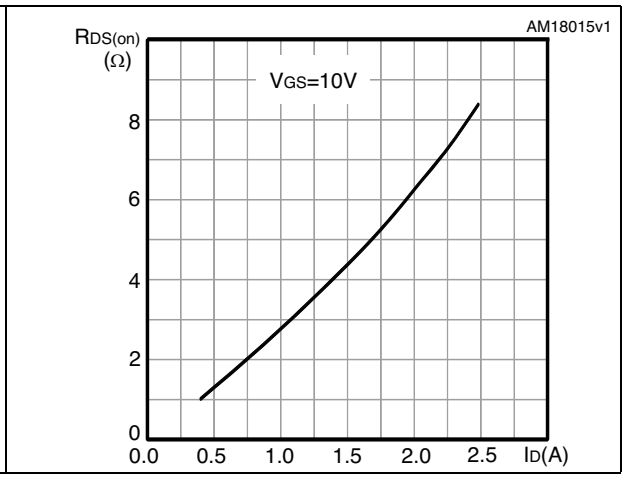



**Figure 12. Capacitance variations**

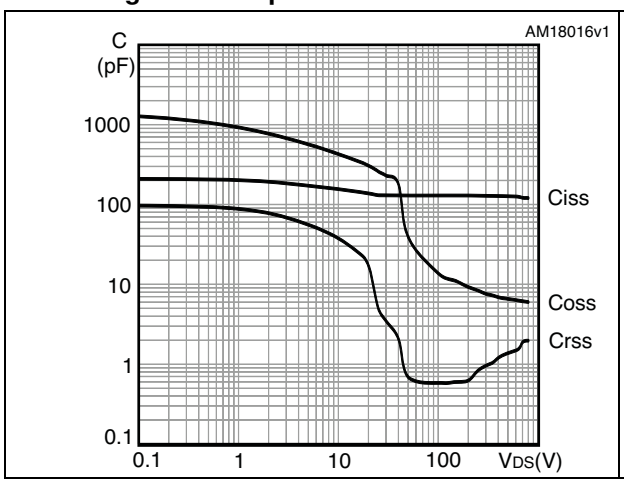



**Figure 13. Output capacitance stored energy**

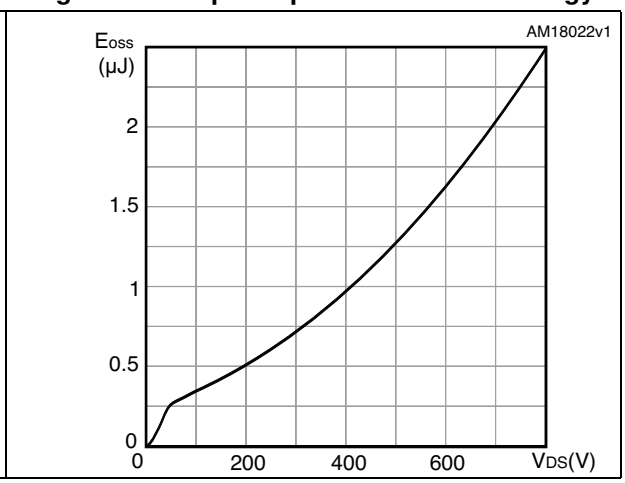


**Figure 14. Normalized gate threshold voltage vs temperature**

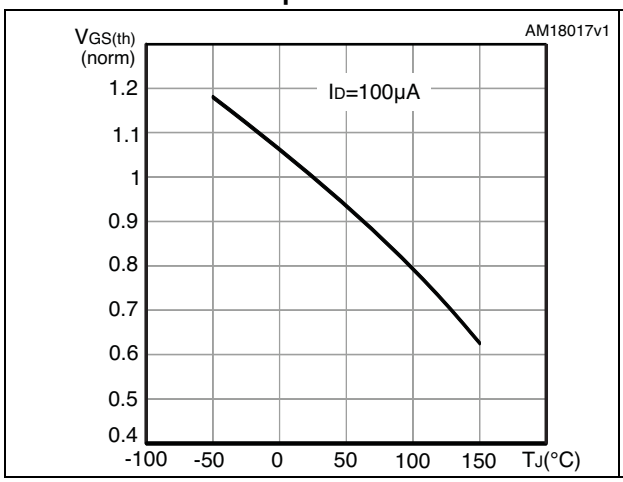



**Figure 15. Normalized on-resistance vs temperature**

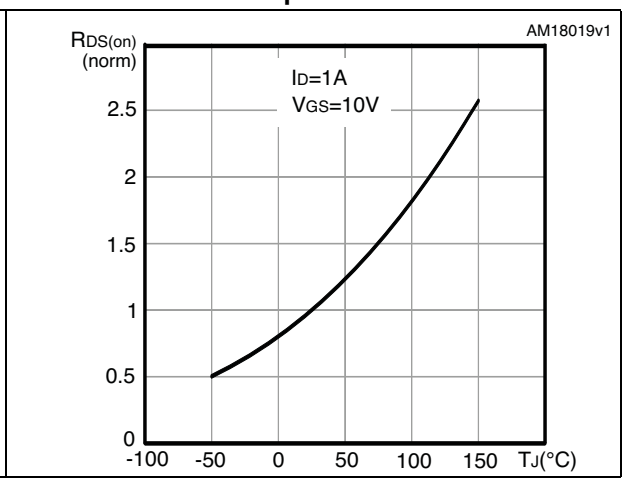



**Figure 16. Normalized $V_{DS}$ vs temperature**

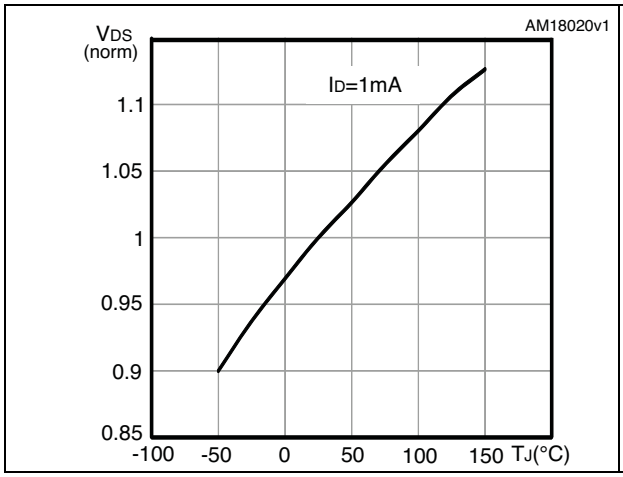
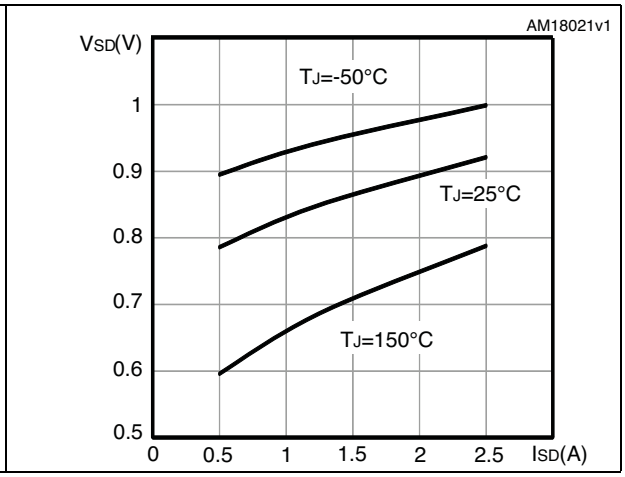



**Figure 17. Source-drain diode forward characteristics**



# 3 Test circuits

**Figure 18. Switching times test circuit for resistive load**

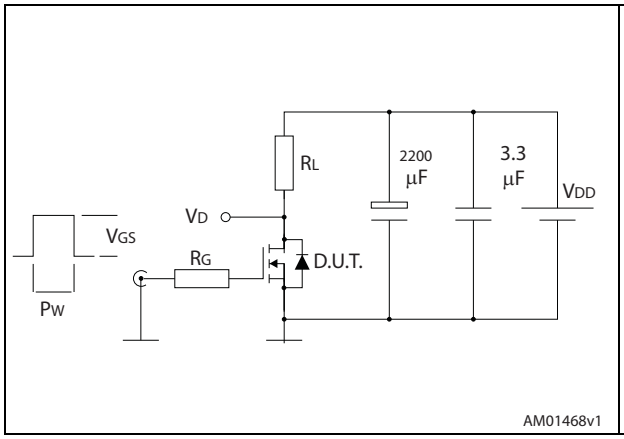



**Figure 19. Gate charge test circuit**

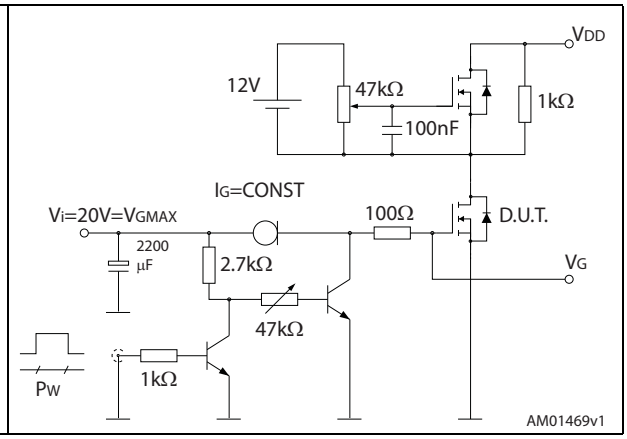



**Figure 20. Test circuit for inductive load switching and diode recovery times**

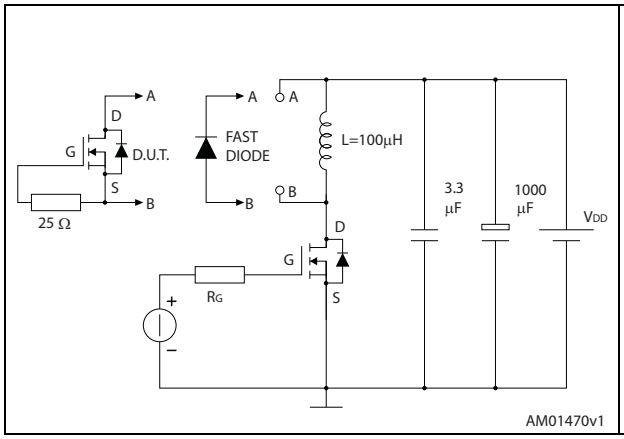



**Figure 21. Unclamped inductive load test circuit**

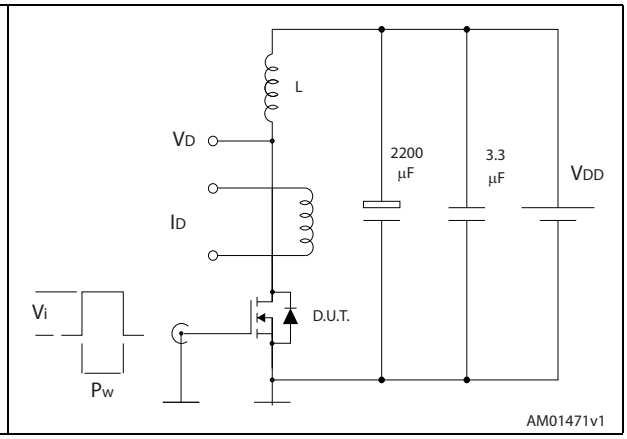



**Figure 22. Unclamped inductive waveform**

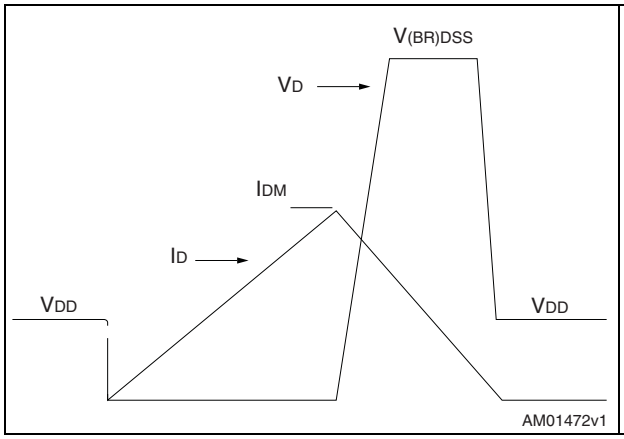
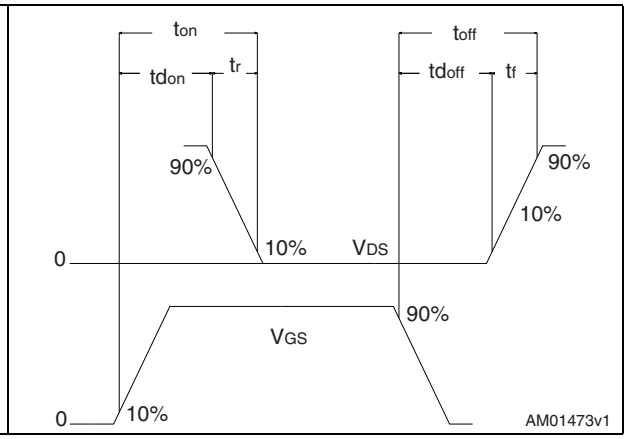



**Figure 23. Switching time waveform**



# 4 Package 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.

Figure 24. DPAK (TO-252) type A drawing

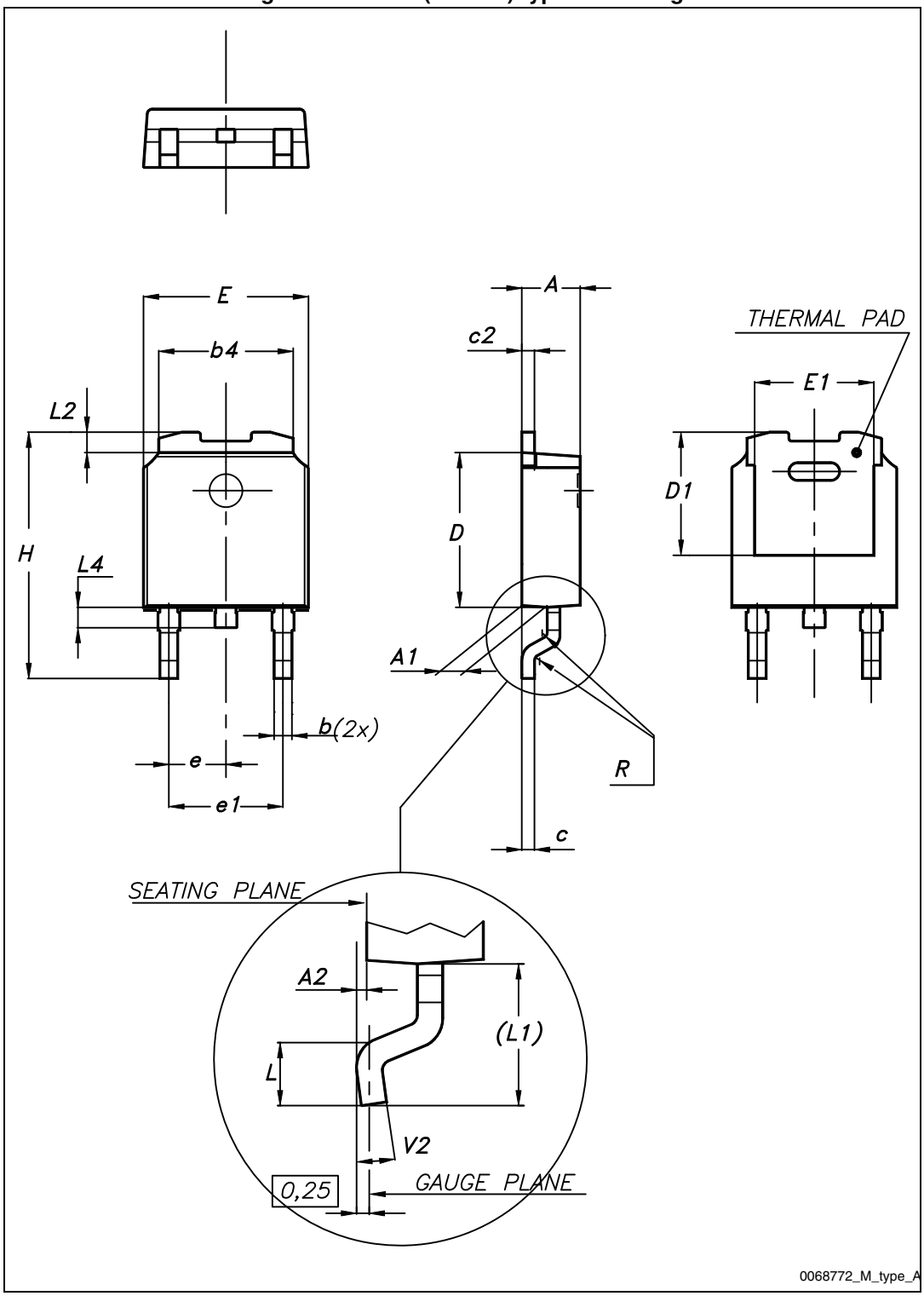
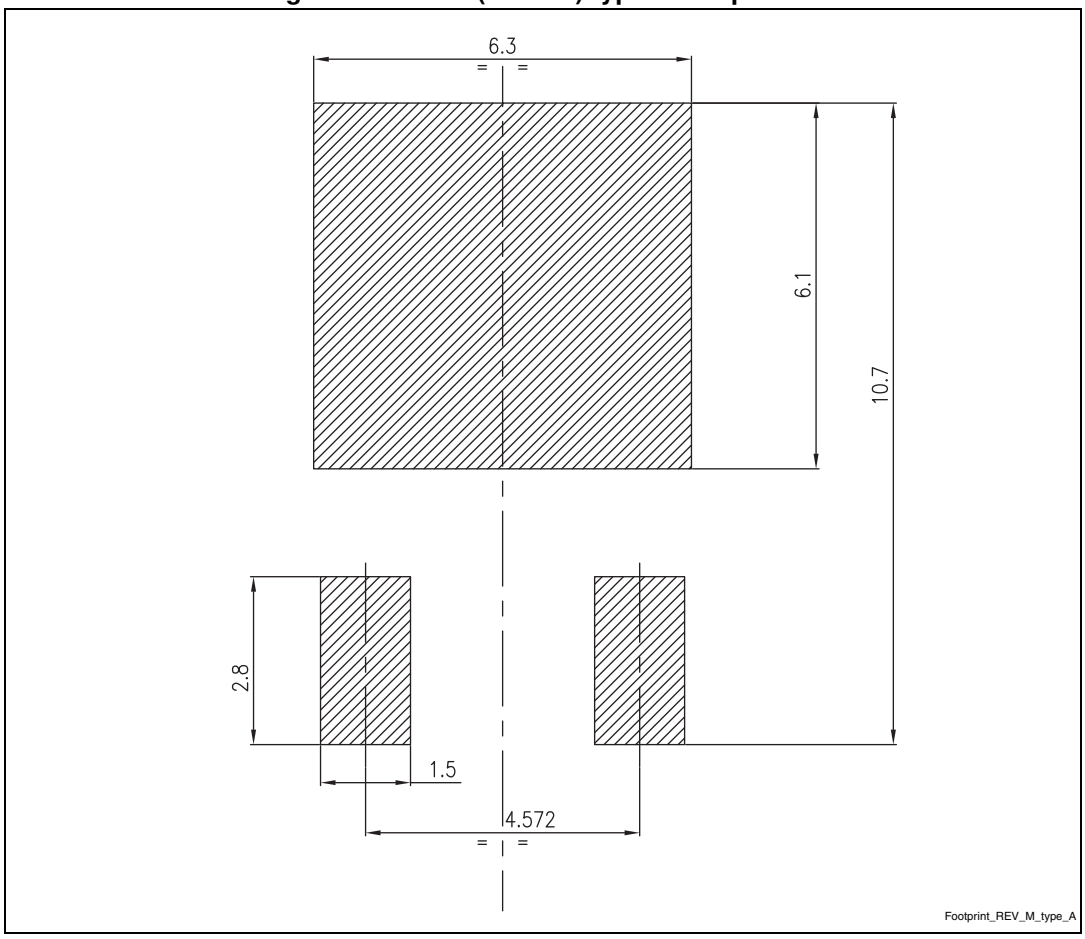


Table 9. DPAK (TO-252) type A mechanical data

| 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) type A footprint [(a)]**




a. All dimensions are in millimeters

Figure 26. TO-220FP drawing

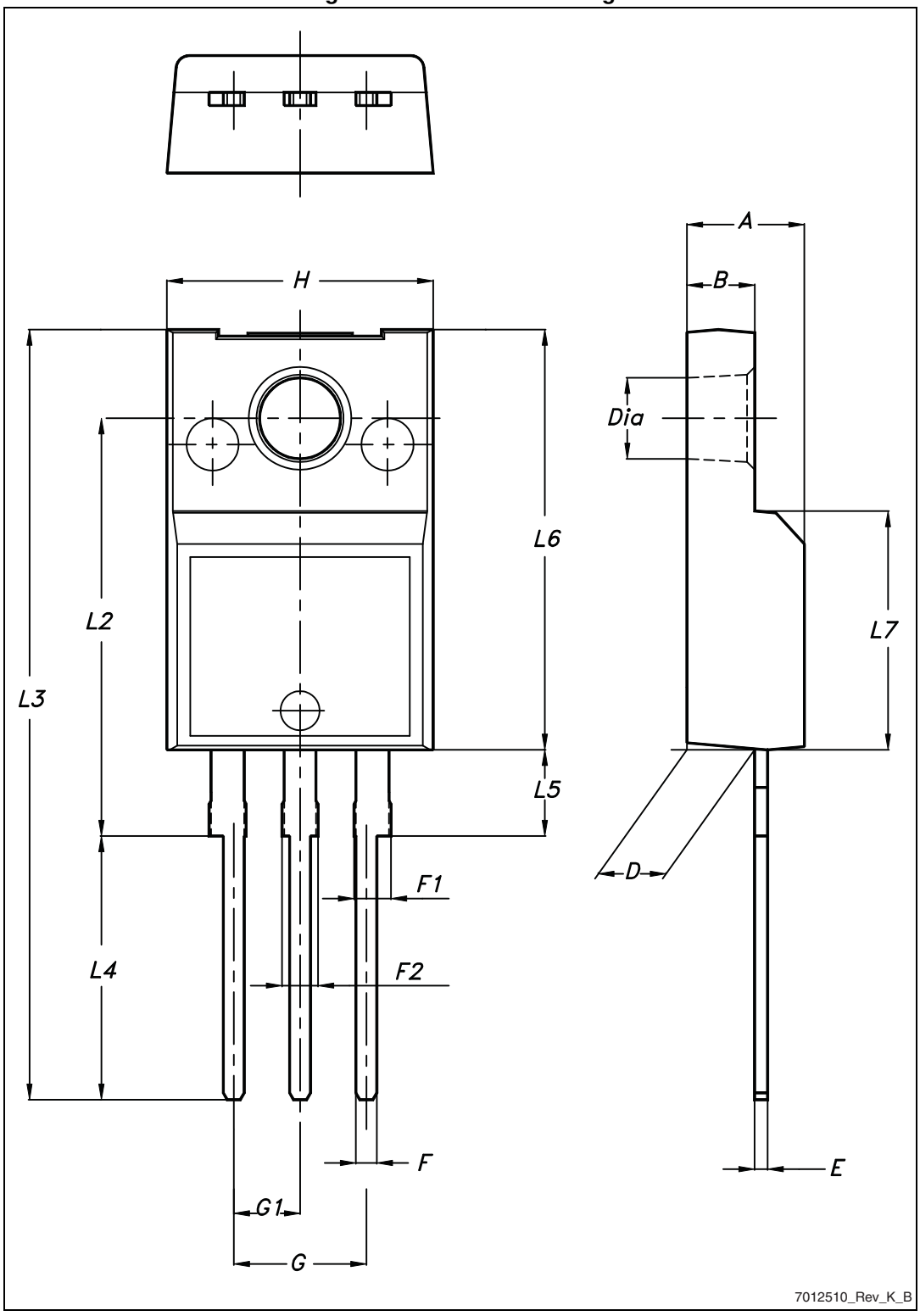


Table 10. TO-220FP mechanical data

| 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 |
| ∅ | 3 | | 3.2 |

Figure 27. TO-220 drawing

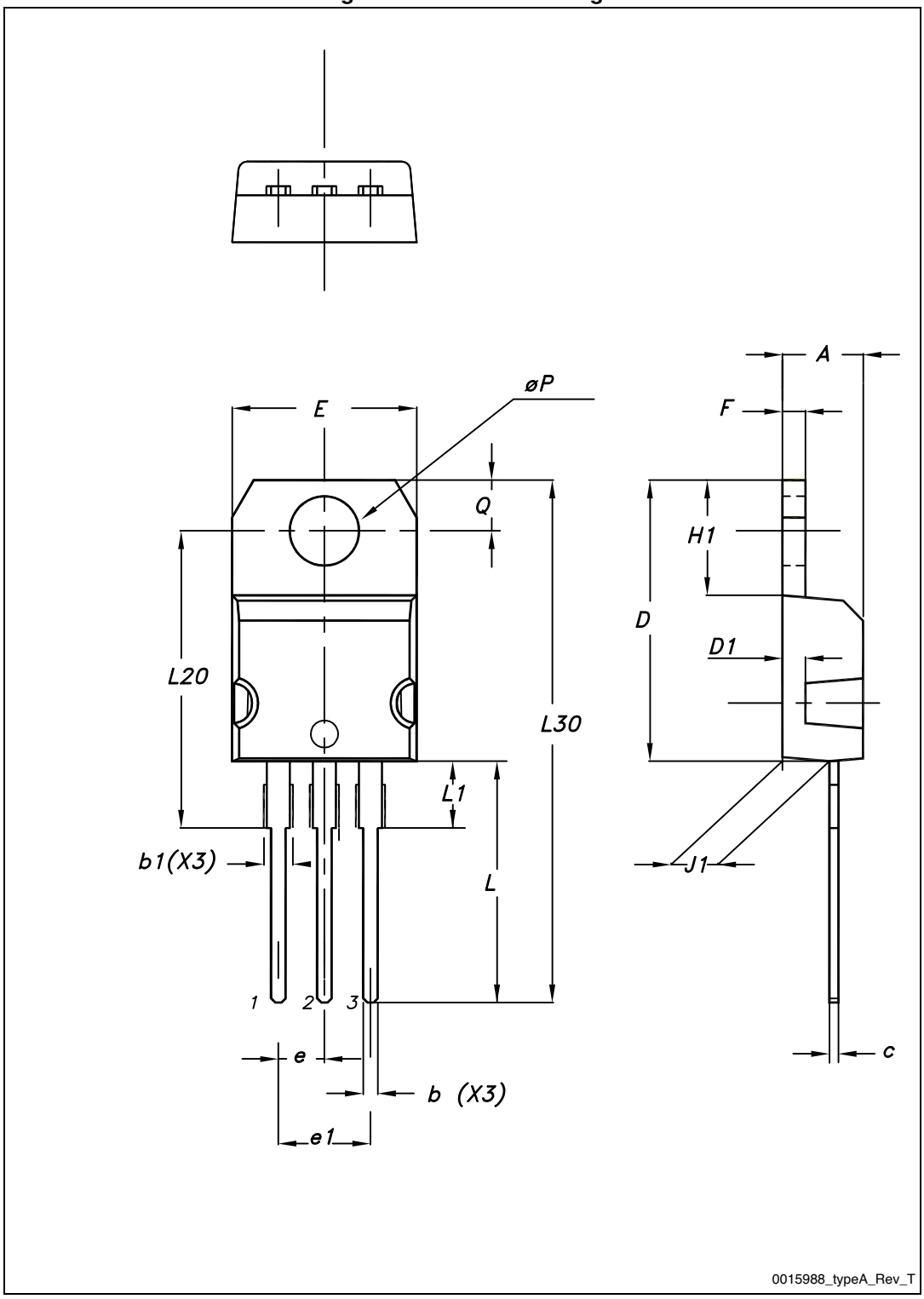


**Table 11. TO-220 mechanical data**

| 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. IPAK drawing**

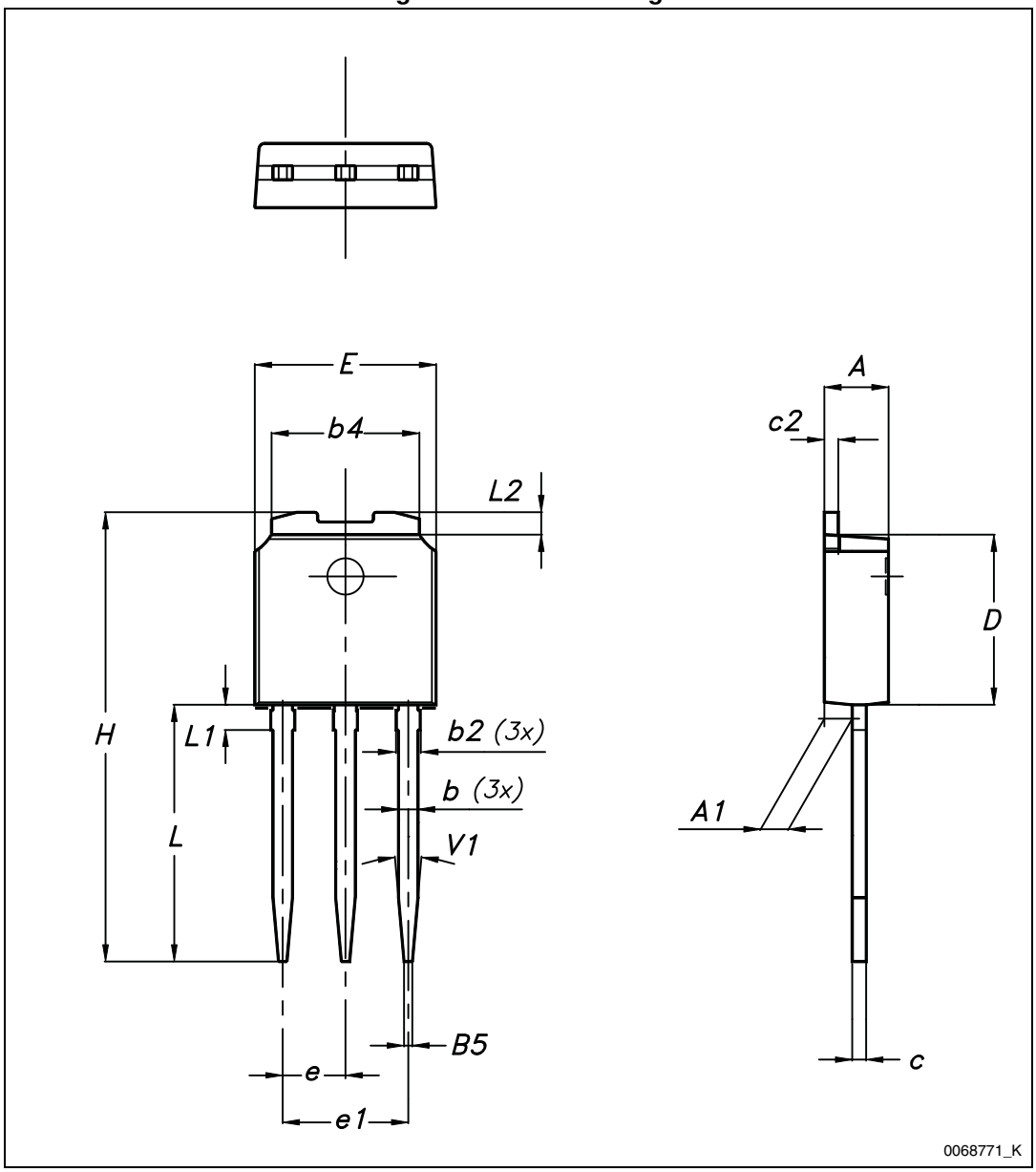


Table 12. IPAK mechanical data

| 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° | |

# 5 Packaging information

**Figure 29. Tape for DPAK**

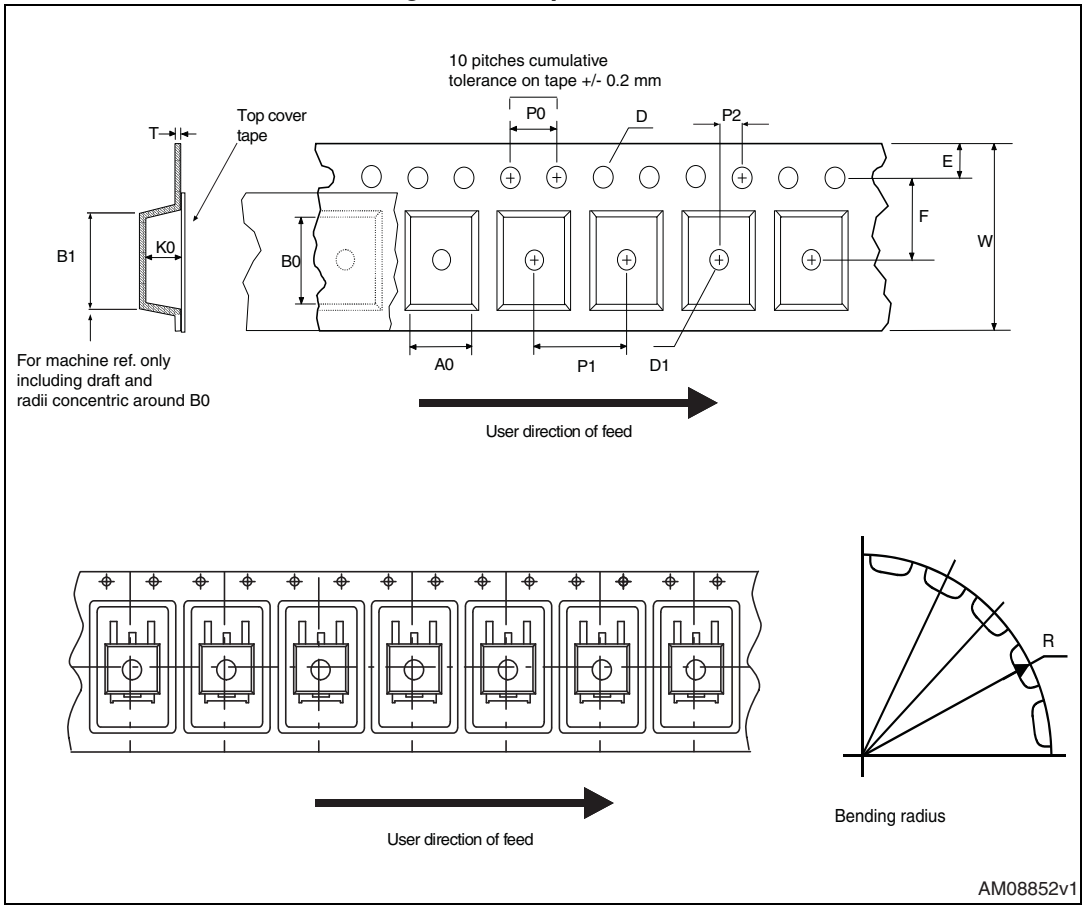


**Figure 30. Reel for DPAK**

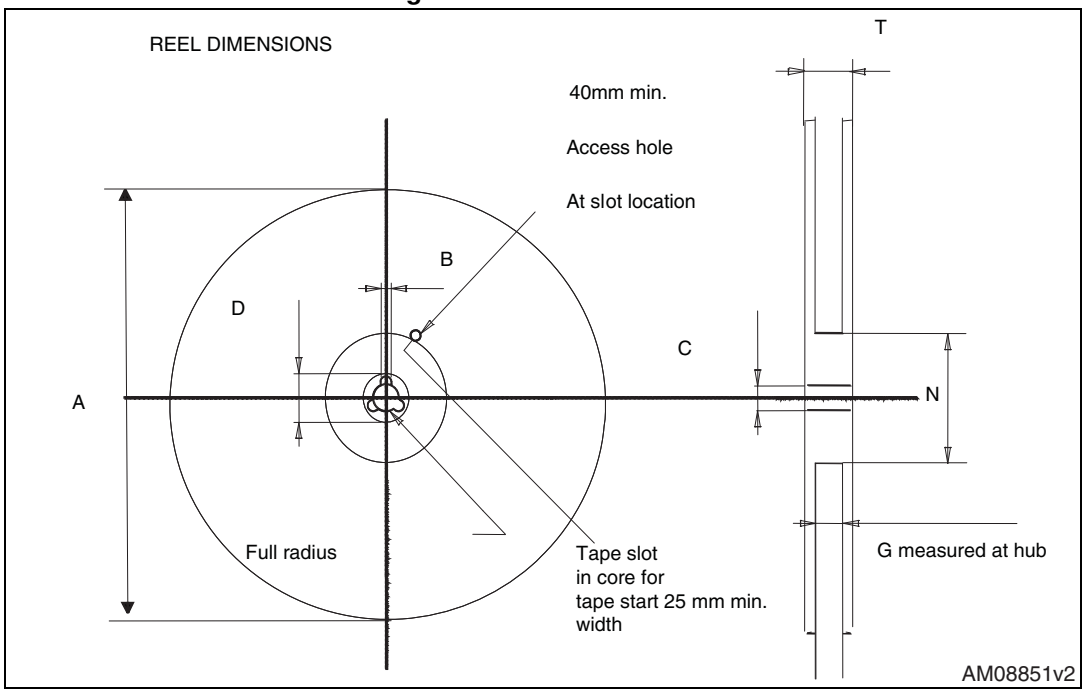



**Table 13. DPAK tape and reel mechanical data**

| 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 | | | |

# 6 Revision history

Table 14. Document revision history

| Date | Revision | Changes |
|---|---|---|
| 12-Jul-2013 | 1 | First release. |
| 15-Jan-2014 | 2 | – Modified: $P_{TOT}$ and $E_{AS}$ values in *Table 2*<br>– Modified: $R_{thj\text{-}case}$ values in *Table 3*<br>– Modified: the entire typical values in *Table 5* and *6*<br>– Modified: $I_{SD}$ and $I_{SDM}$ max values and typical values in *Table 7*<br>– Updated: *Table 24* and *Table 9*<br>– Added: *Section 2.1: Electrical characteristics (curves)*<br>– Minor text changes |
| 17-Jan-2014 | 3 | – Modified: *Figure 8* and *9*<br>– Minor text changes |