# STB25N80K5, STF25N80K5, STP25N80K5, STW25N80K5

## N-channel 800 V, 0.19 Ω typ., 19.5 A SuperMESH™5 Power MOSFET in $D^2PAK$, TO-220FP, TO-220 and TO-247 packages

**Datasheet — production data**

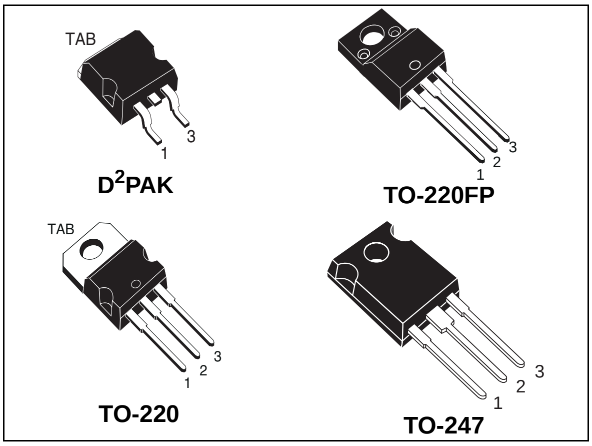
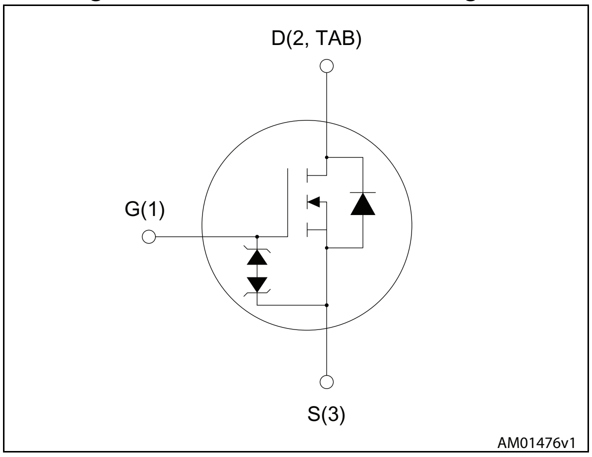



**Figure 1. Internal schematic diagram**




## Features

| Order codes | $V_{DS}$ @ $T_{Jmax}$ | $R_{DS(on)}$ max | $I_D$ | $P_{TOT}$ |
|---|---|---|---|---|
| STB25N80K5 | 800 V | < 0.260 Ω | 19.5 A | 250 W |
| STF25N80K5 | | | | 40 W |
| STP25N80K5 | | | | 250 W |
| STW25N80K5 | | | | |

- 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 N-channel Zener-protected Power MOSFET are designed using ST's revolutionary avalanche-rugged very high voltage SuperMESH™ 5 technology, based on an innovative proprietary vertical structure. The result is a dramatic reduction in on-resistance, and ultra-low gate charge for applications which require superior power density and high efficiency.

**Table 1. Device summary**

| Order codes | Marking | Package | Packaging |
|---|---|---|---|
| STB25N80K5 | 25N80K5 | $D^2PAK$ | Tape and reel |
| STF25N80K5 | | TO-220FP | Tube |
| STP25N80K5 | | TO-220 | |
| STW25N80K5 | | TO-247 | |

# Contents

# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol | Parameter | Value | | Unit |
|---|---|---|---|---|
| | | $D^2PAK$, TO-220, TO-247 | TO-220FP | |
| $V_{GS}$ | Gate- source voltage | ± 30 | | V |
| $I_D$ | Drain current (continuous) at $T_C$ = 25 °C | 19.5 | 19.5(1) | A |
| $I_D$ | Drain current (continuous) at $T_C$ = 100 °C | 12.3 | 12.3 (1) | A |
| $I_{DM}$ (2) | Drain current (pulsed) | 78 | 78 (1) | A |
| $P_{TOT}$ | Total dissipation at $T_C$ = 25 °C | 250 | 40 | W |
| $I_{AR}$ | Max current during repetitive or single pulse avalanche (pulse width limited by $T_{jmax}$ ) | 6.5 | | A |
| $E_{AS}$ | Single pulse avalanche energy (starting $T_J$ = 25 °C, $I_D$=$I_{AS}$, $V_{DD}$= 50 V) | 200 | | mJ |
| $V_{iso}$ | 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 | 6 | | V/ns |
| $T_j$<br>$T_{stg}$ | Operating junction temperature<br>Storage temperature | -55 to 150 | | °C |

1. Limited by package.
2. Pulse width limited by safe operating area.
3. $I_{SD} \leq$ 19.5 A, di/dt $\leq$ 100 A/µs, $V_{Peak} \leq V_{(BR)DSS}$

**Table 3. Thermal data**

| Symbol | Parameter | Value | | | | Unit |
|---|---|---|---|---|---|---|
| | | TO-220 | TO-247 | $D^2PAK$ | TO-220FP | |
| $R_{thj-case}$ | Thermal resistance junction-case max | 0.5 | | | 3.1 | °C/W |
| $R_{thj-amb}$ | Thermal resistance junction-amb max | 62.5 | 50 | | 62.5 | |
| $R_{thj-pcb}$(1) | Thermal resistance junction-pcb max | | | 30 | | |

1. When mounted on 1inch² FR-4 board, 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<br>$V_{DS}$ = 800 V, Tc=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, $I_D$= 10 A | | 0.19 | 0.260 | 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 | - | 1600 | - | pF |
| $C_{oss}$ | Output capacitance | | - | 130 | - | pF |
| $C_{rss}$ | Reverse transfer capacitance | | - | 2 | - | pF |
| $C_{o(tr)}$(1) | Equivalent capacitance time related | $V_{GS}$ = 0, $V_{DS}$ = 0 to 640 V | - | 185 | - | pF |
| $C_{o(er)}$(2) | Equivalent capacitance energy related | | - | 300 | - | pF |
| $R_G$ | Intrinsic gate resistance | f = 1 MHz open drain | - | 4 | - | Ω |
| $Q_g$ | Total gate charge | $V_{DD}$ = 640 V, $I_D$ = 19.5 A<br>$V_{GS}$ =10 V<br>*(see Figure 19)* | - | 40 | - | nC |
| $Q_{gs}$ | Gate-source charge | | - | 10 | | nC |
| $Q_{gd}$ | Gate-drain charge | | - | 25 | | 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, $I_D$ = 10 A, $R_G$=4.7 Ω, $V_{GS}$=10 V (see *Figure 21*) | - | 25 | - | ns |
| $t_r$ | Rise time | | - | 13 | - | ns |
| $t_{d(off)}$ | Turn-off delay time | | - | 60 | - | ns |
| $t_f$ | Fall time | | - | 15 | - | ns |

**Table 7. Source drain diode**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $I_{SD}$ | Source-drain current | | - | | 19.5 | A |
| $I_{SDM}$ | Source-drain current (pulsed) | | - | | 78 | A |
| $V_{SD}$ (1) | Forward on voltage | $I_{SD}$= 19.5 A, $V_{GS}$=0 | - | | 1.5 | V |
| $t_{rr}$ | Reverse recovery time | $I_{SD}$= 19.5 A, $V_{DD}$= 60 V di/dt = 100 A/µs, (see *Figure 20*) | - | 515 | | ns |
| $Q_{rr}$ | Reverse recovery charge | | - | 11 | | µC |
| $I_{RRM}$ | Reverse recovery current | | - | 43.2 | | A |
| $t_{rr}$ | Reverse recovery time | $I_{SD}$= 19.5 A,$V_{DD}$= 60 V di/dt=100 A/µs, Tj=150 °C (see *Figure 20*) | - | 615 | | ns |
| $Q_{rr}$ | Reverse recovery charge | | - | 13 | | µC |
| $I_{RRM}$ | Reverse recovery current | | - | 43 | | A |

1. Pulsed: pulse duration = 300µs, 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 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 D²PAK**

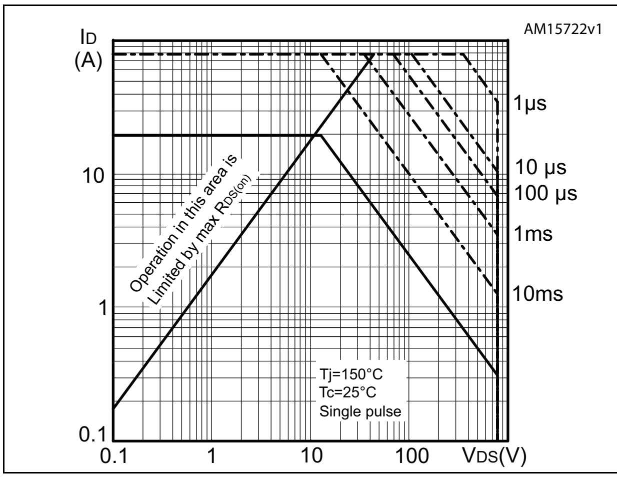



**Figure 3. Thermal impedance for D²PAK and TO-220**

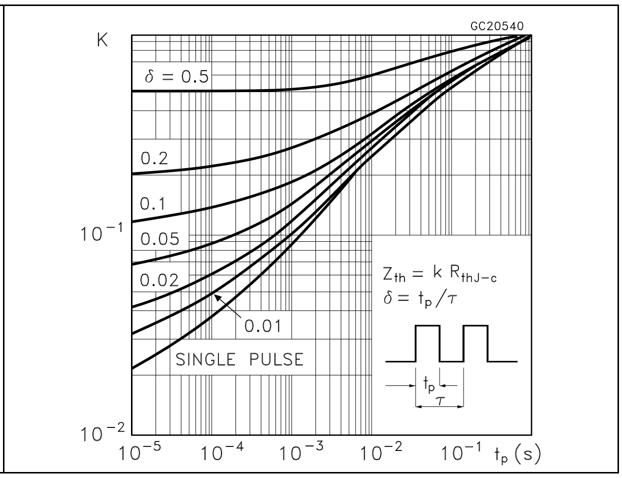



**Figure 4. Safe operating area for TO-220FP**

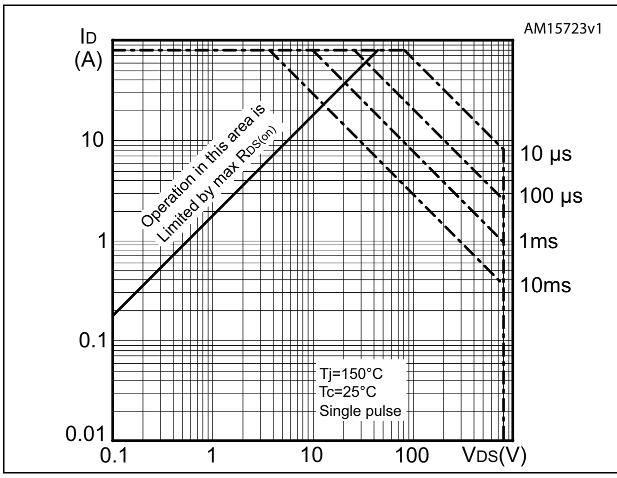



**Figure 5. Thermal impedance for TO-220FP**

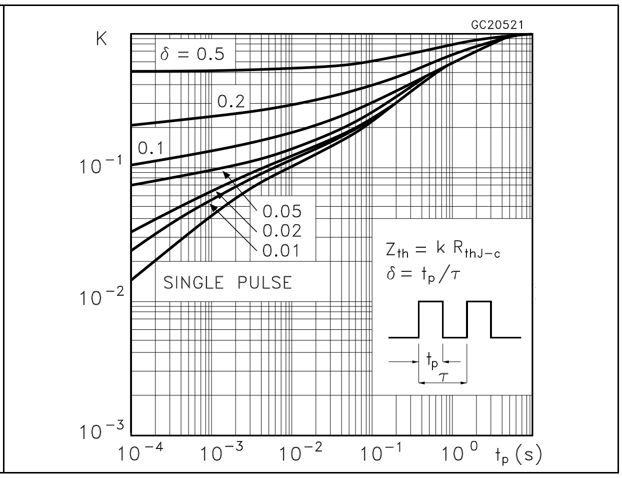



**Figure 6. Safe operating area for TO-220**

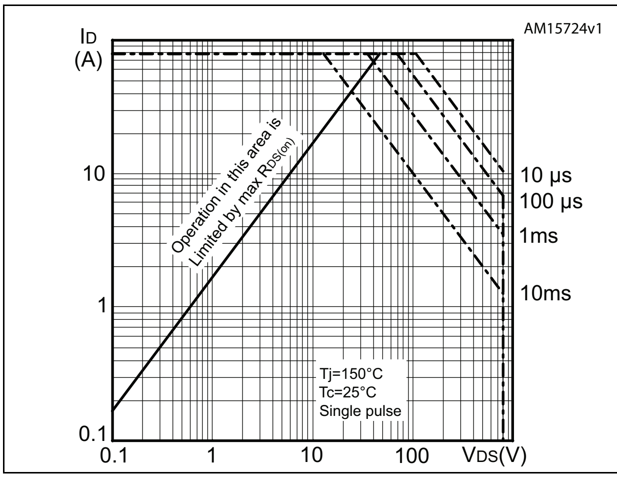



**Figure 7. Normalized $B_{VDSS}$ vs temperature**

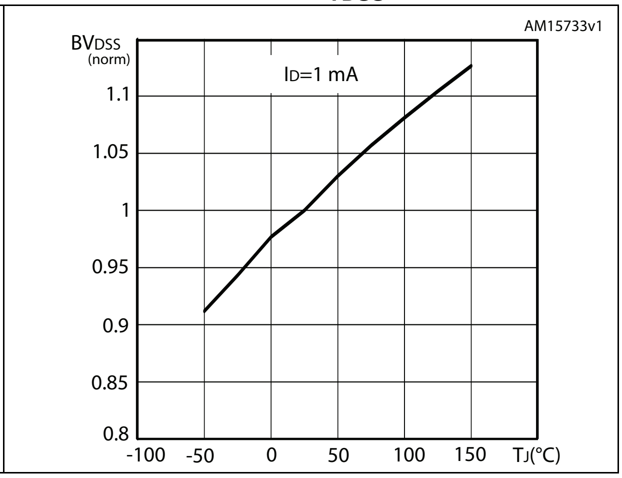


**Figure 8. Safe operating area for TO-247**

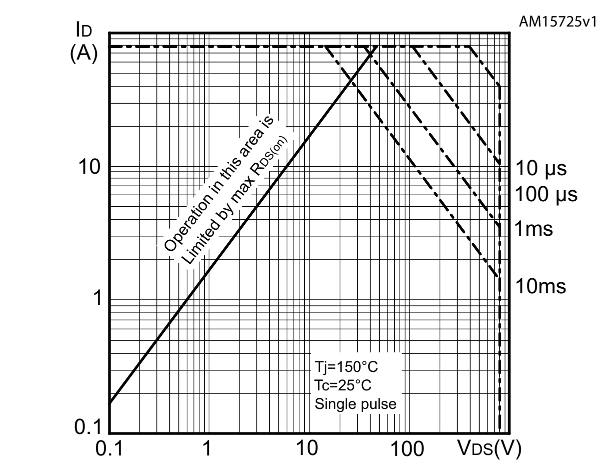



**Figure 9. Thermal impedance for TO-247**

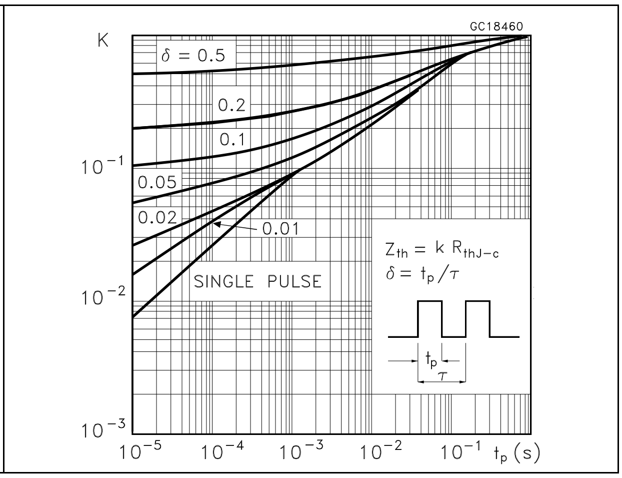



**Figure 10. Output characteristics**

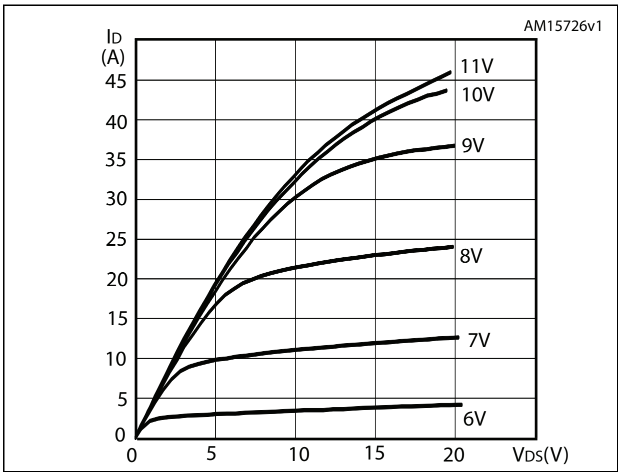



**Figure 11. Transfer characteristics**

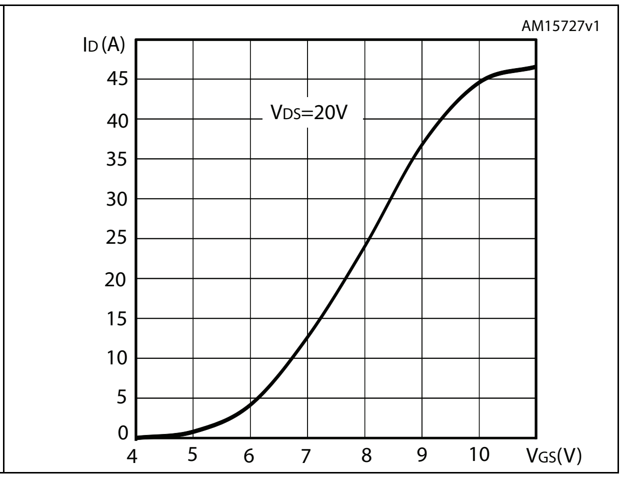



**Figure 12. Static drain-source on-resistance**

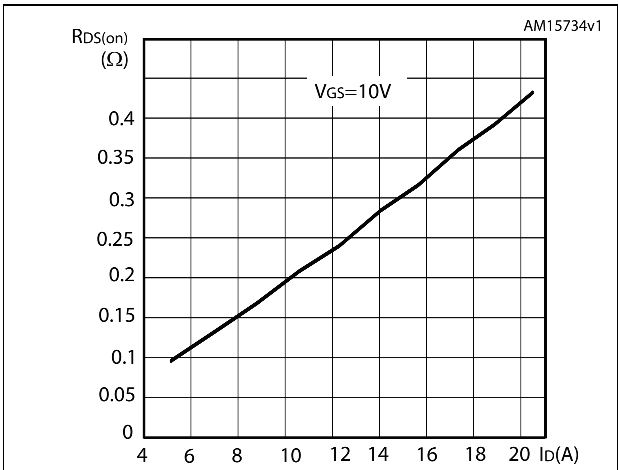



**Figure 13. Gate charge vs gate-source voltage**

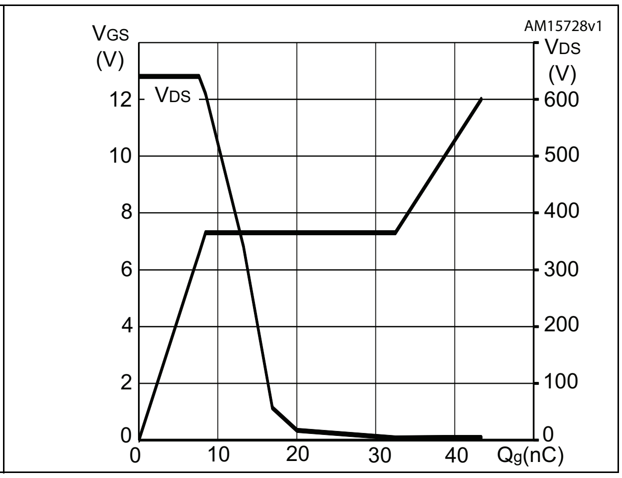


**Figure 14. Capacitance variations**

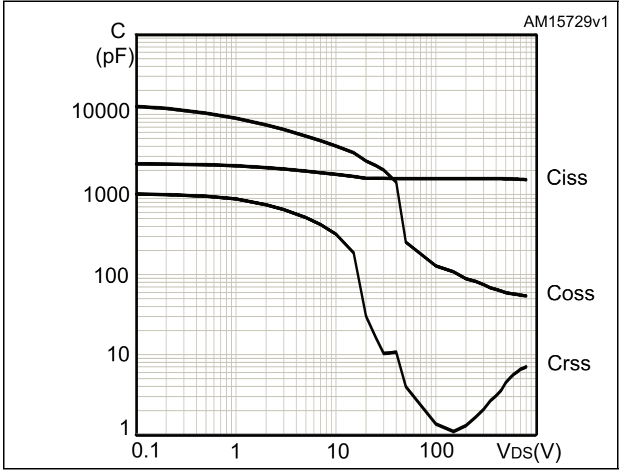



**Figure 15. Output capacitance stored energy**

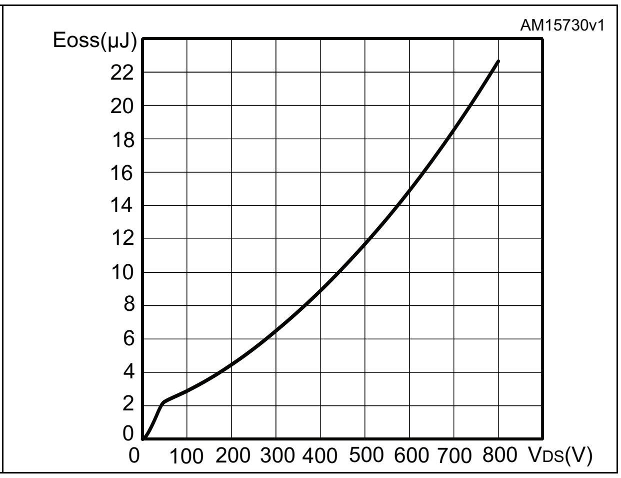



**Figure 16. Normalized on-resistance vs temperature**

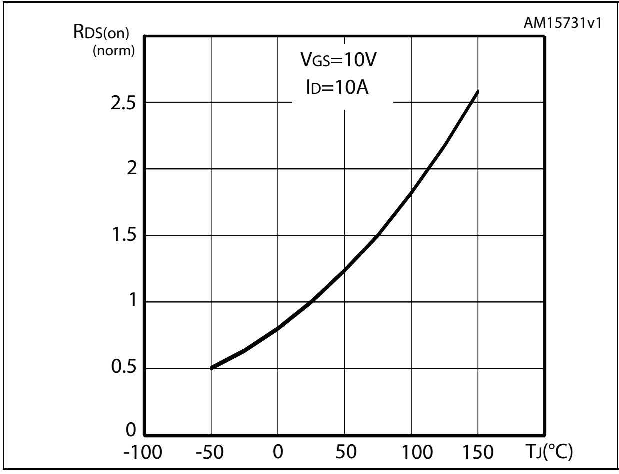
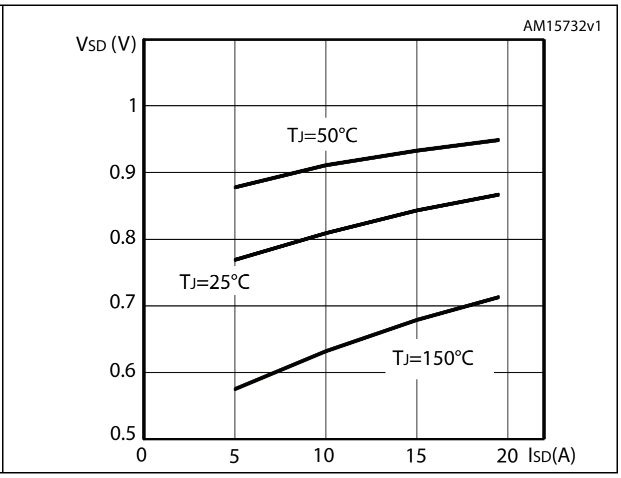



**Figure 17. Source-drain diode forward characteristics**



# 3 Test circuits

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

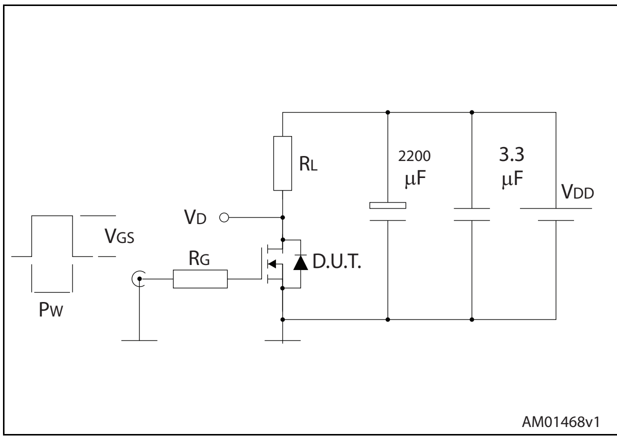



**Figure 19. Gate charge test circuit**

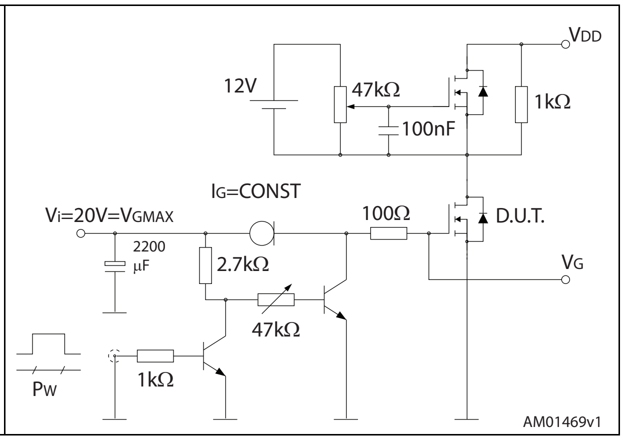



**Figure 20. Test circuit for inductive load switching and diode recovery times**

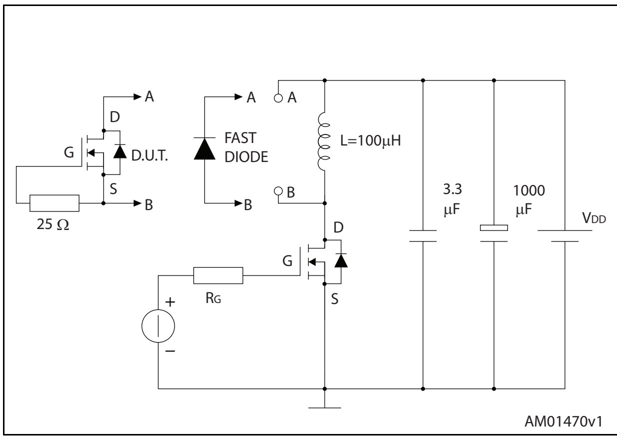



**Figure 21. Unclamped inductive load test circuit**

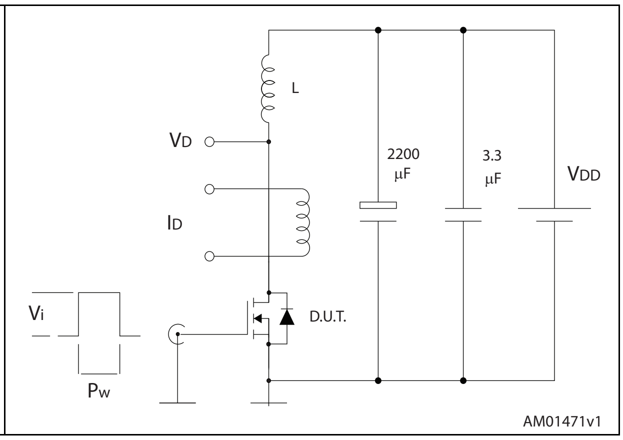



**Figure 22. Unclamped inductive waveform**

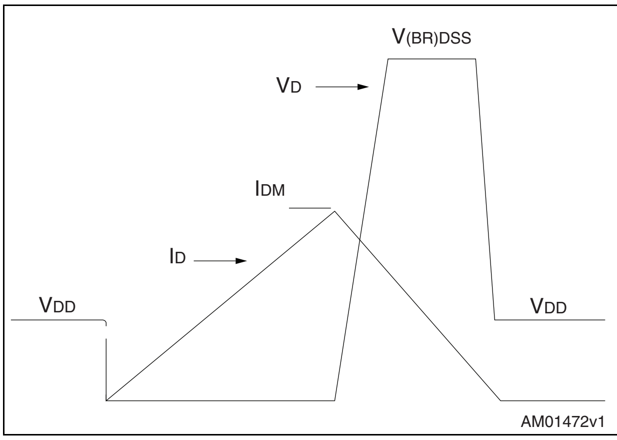
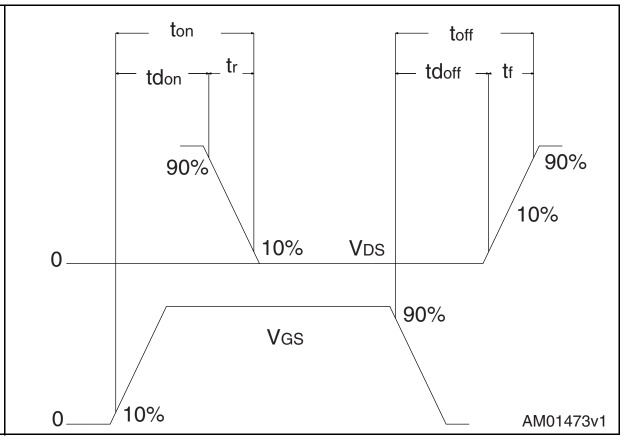



**Figure 23. Switching time waveform**



# 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.

Table 9. D²PAK (TO-263) 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 | | |
| E | 10 | | 10.40 |
| E1 | 8.50 | | |
| e | | 2.54 | |
| e1 | 4.88 | | 5.28 |
| H | 15 | | 15.85 |
| J1 | 2.49 | | 2.69 |
| L | 2.29 | | 2.79 |
| L1 | 1.27 | | 1.40 |
| L2 | 1.30 | | 1.75 |
| R | | 0.4 | |
| V2 | 0° | | 8° |

**Figure 24. D²PAK (TO-263) drawing**

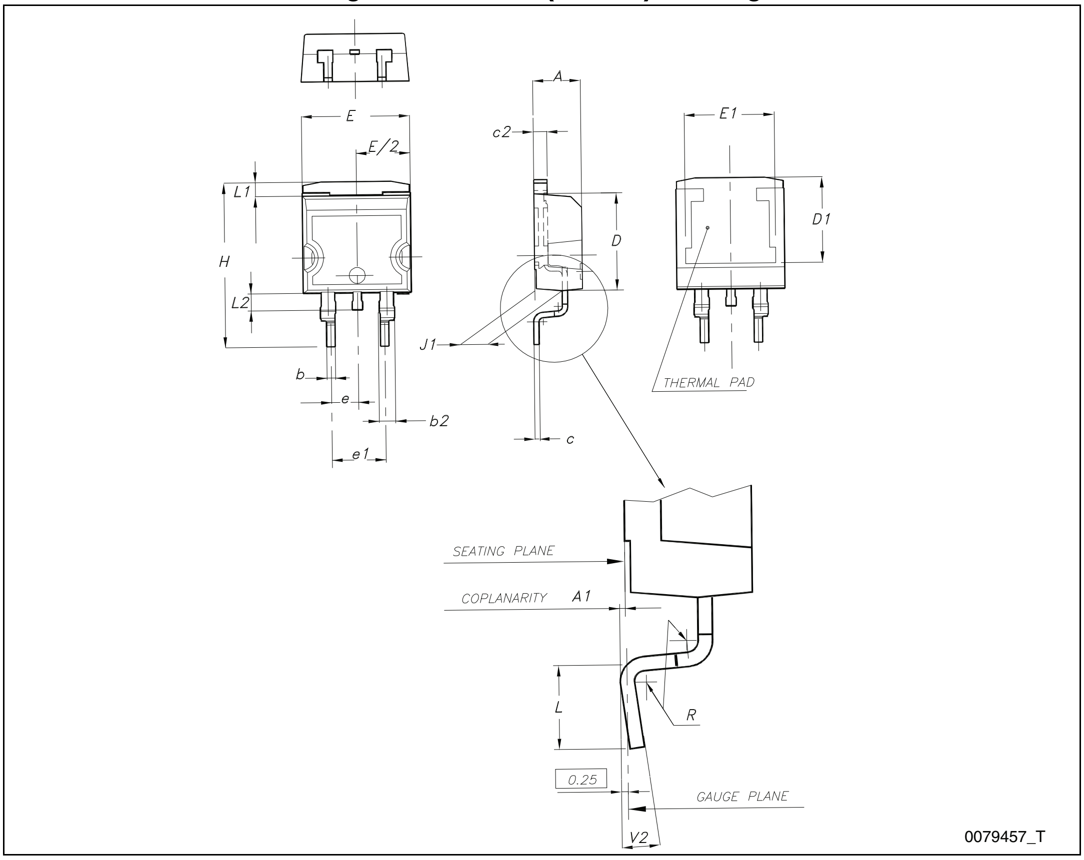
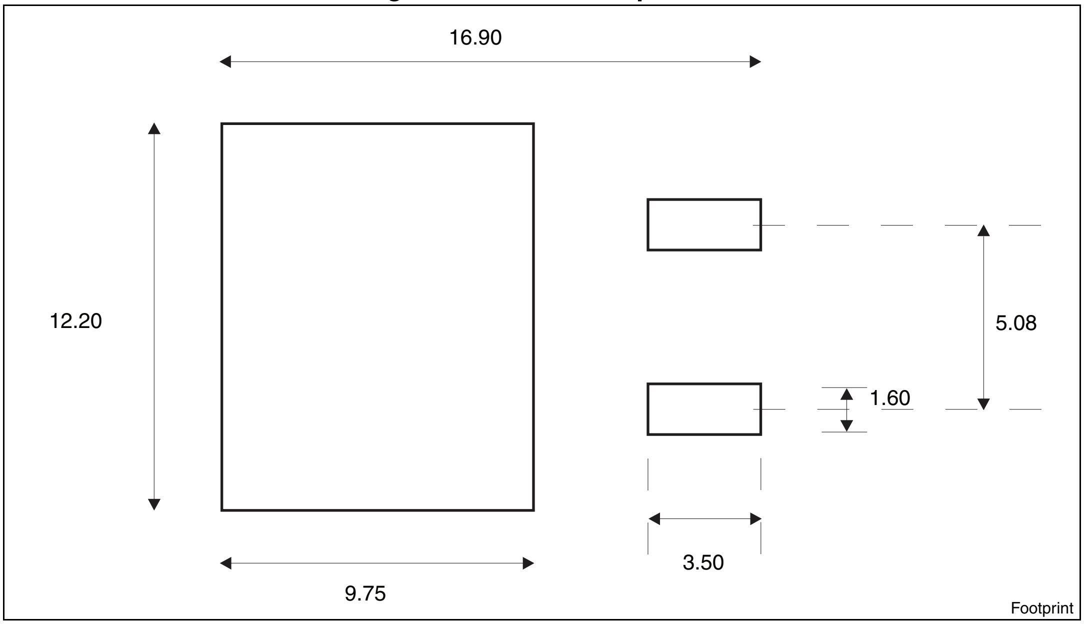



**Figure 25. D²PAK footprint**[a]




a. All dimension 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 26. TO-220FP drawing**

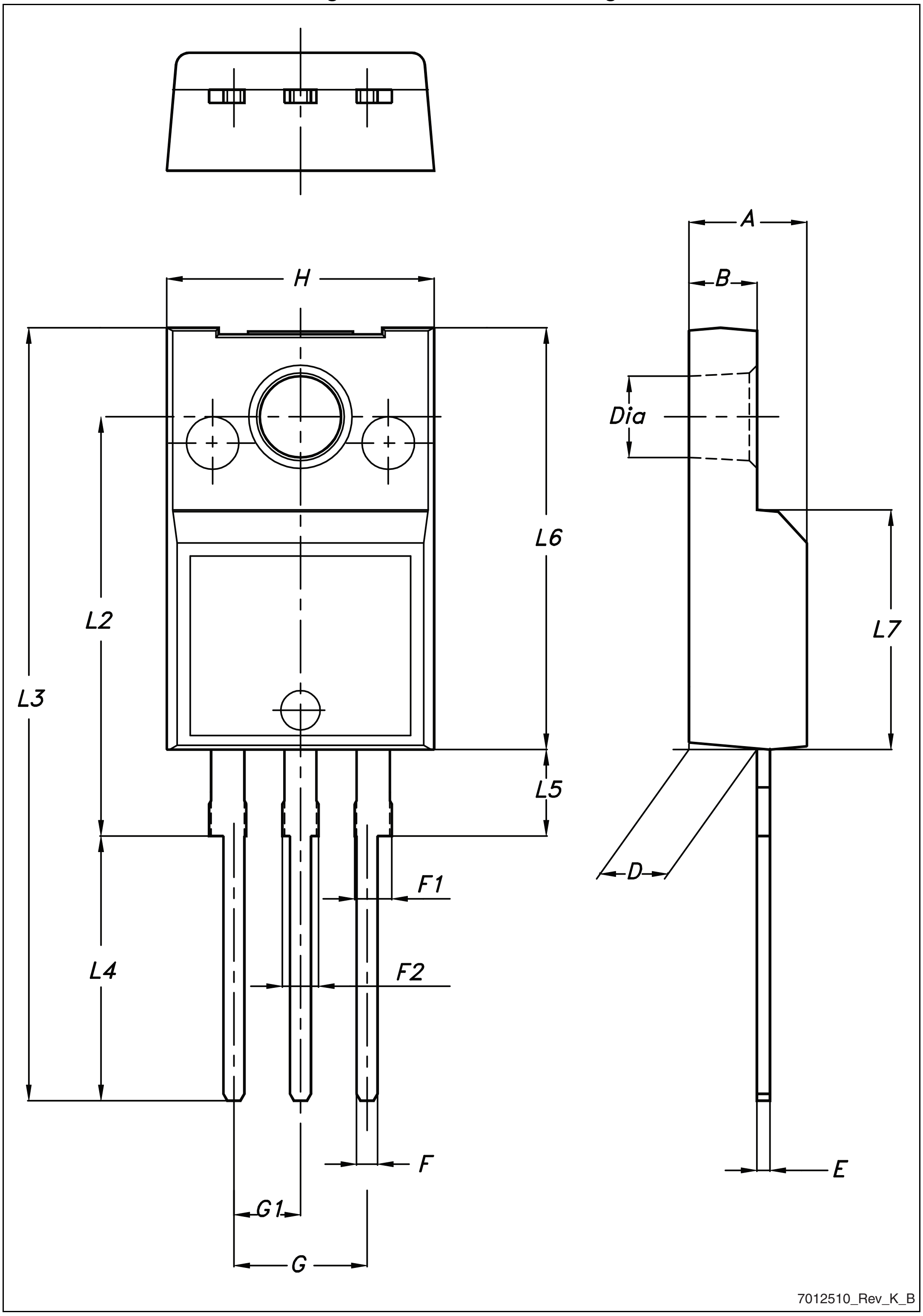


**Table 11. TO-220 type A mechanical data**

| 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 27. TO-220 type A drawing

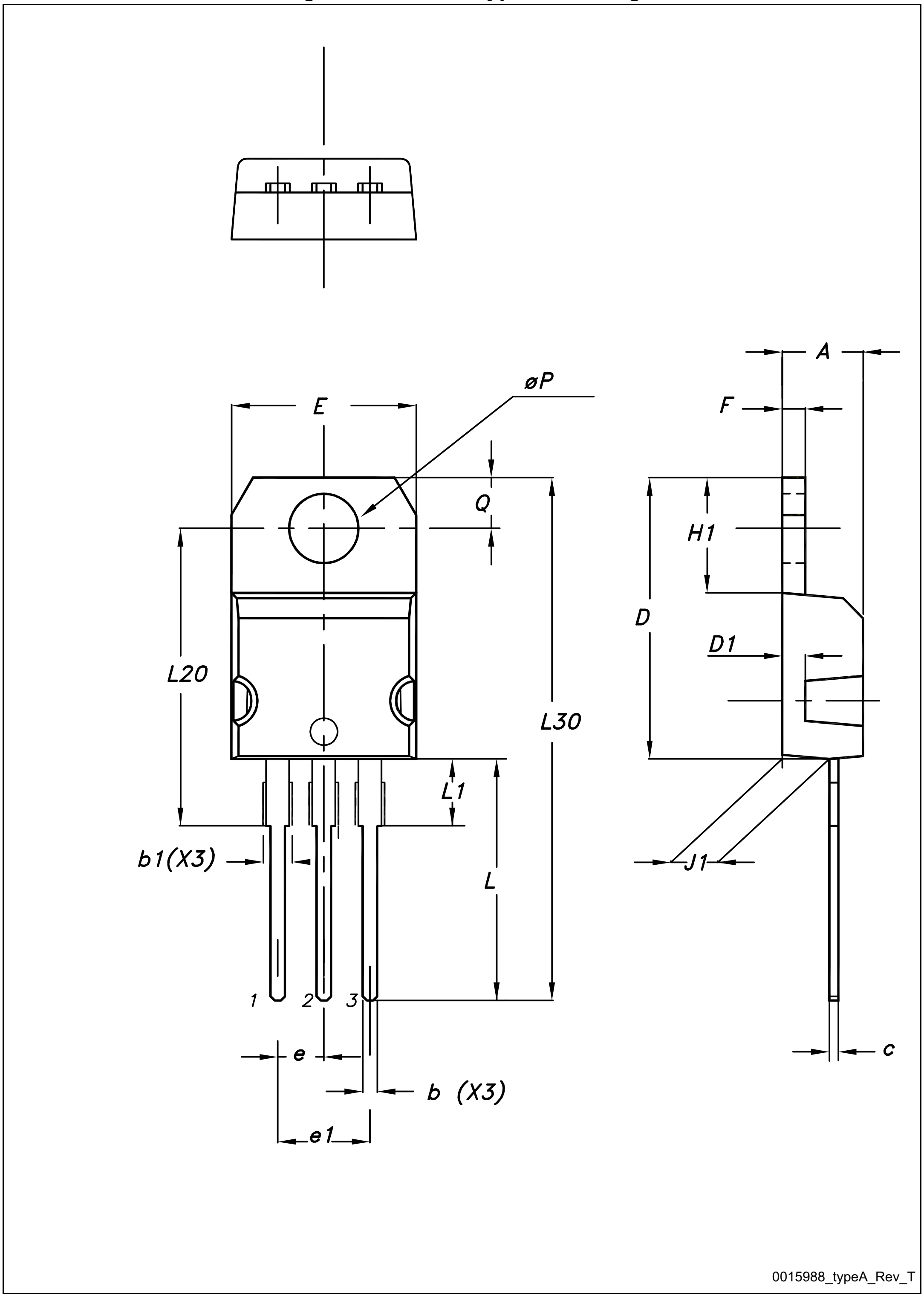
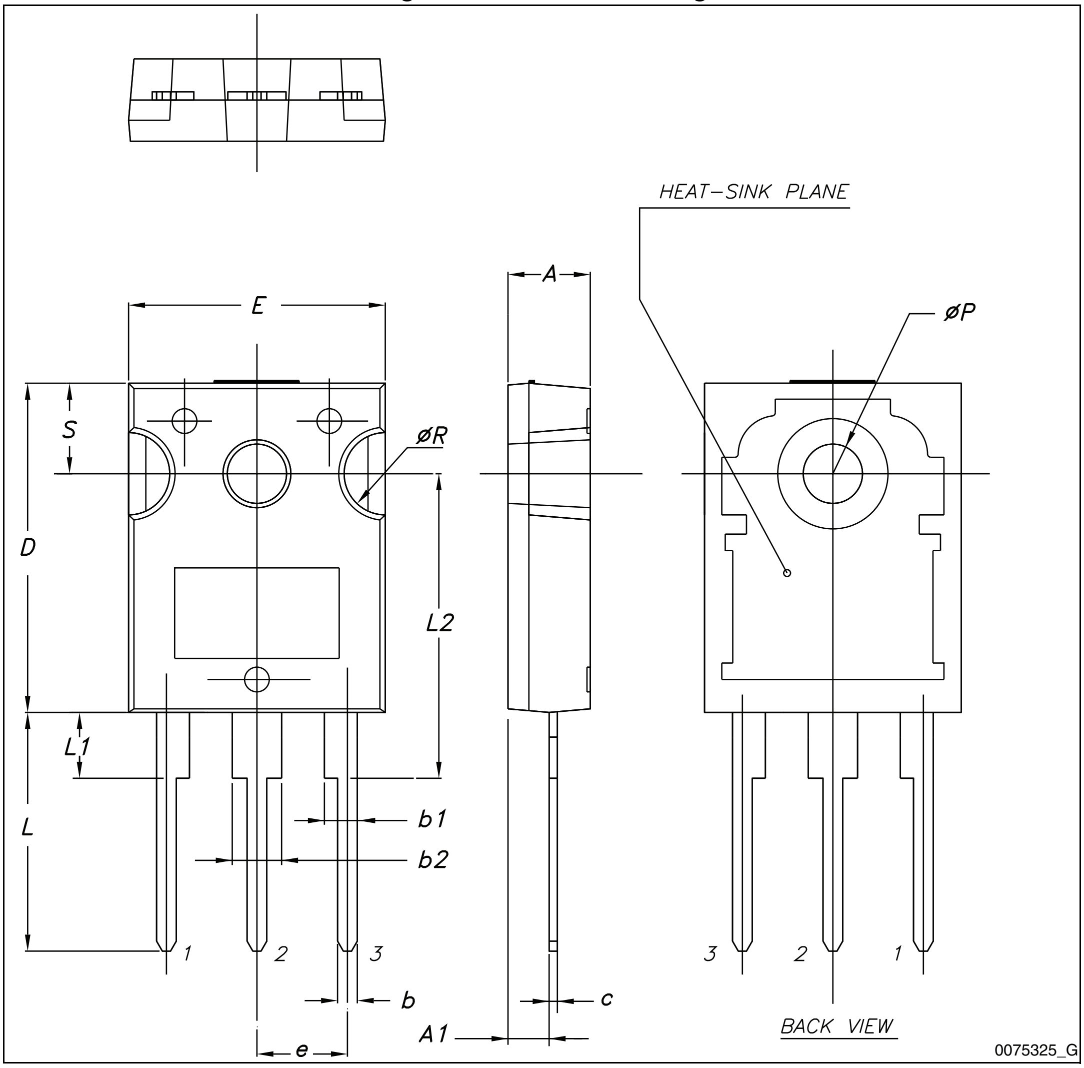


**Table 12. TO-247 mechanical data**

| 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 | |
| ∅P | 3.55 | | 3.65 |
| ∅R | 4.50 | | 5.50 |
| S | 5.30 | 5.50 | 5.70 |

**Figure 28. TO-247 drawing**



# 5 Packaging information

**Table 13. D²PAK (TO-263) 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 qty | | 1000 |
| P2 | 1.9 | 2.1 | Bulk qty | | 1000 |
| R | 50 | | | | |
| T | 0.25 | 0.35 | | | |
| W | 23.7 | 24.3 | | | |

Figure 29. Tape

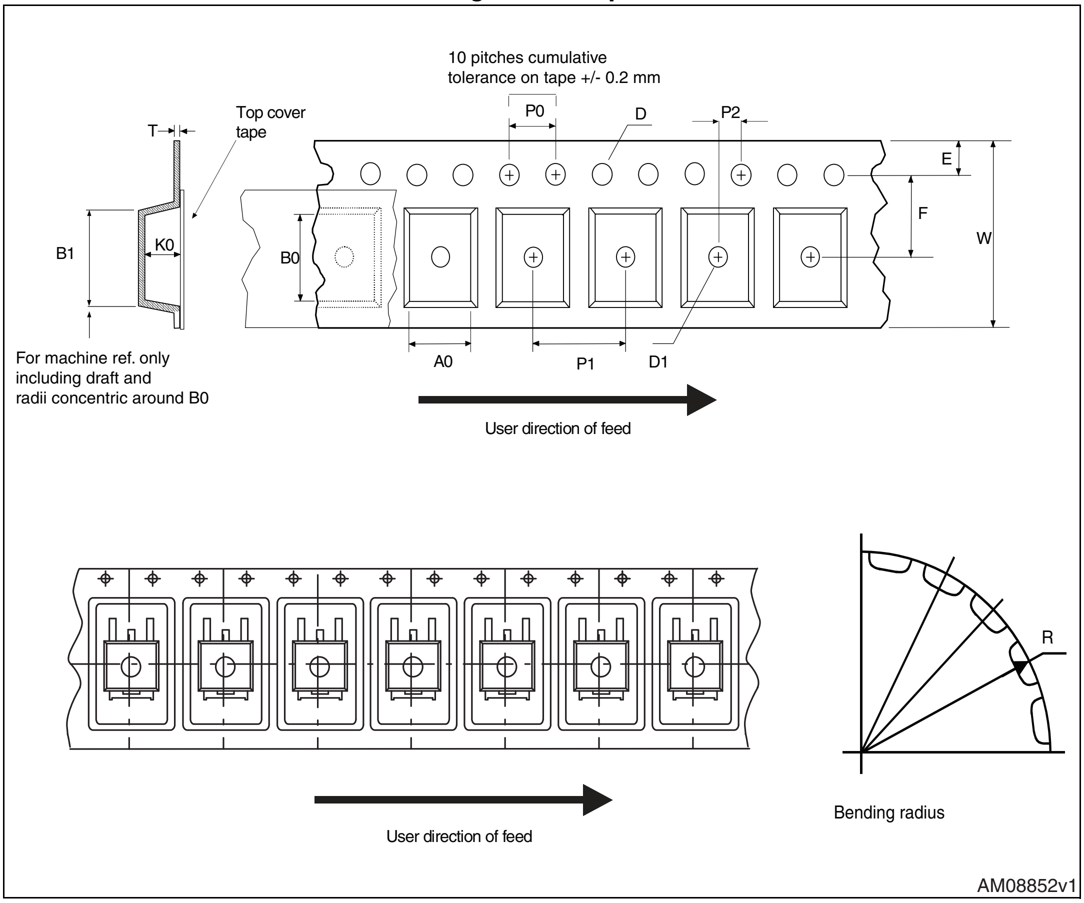
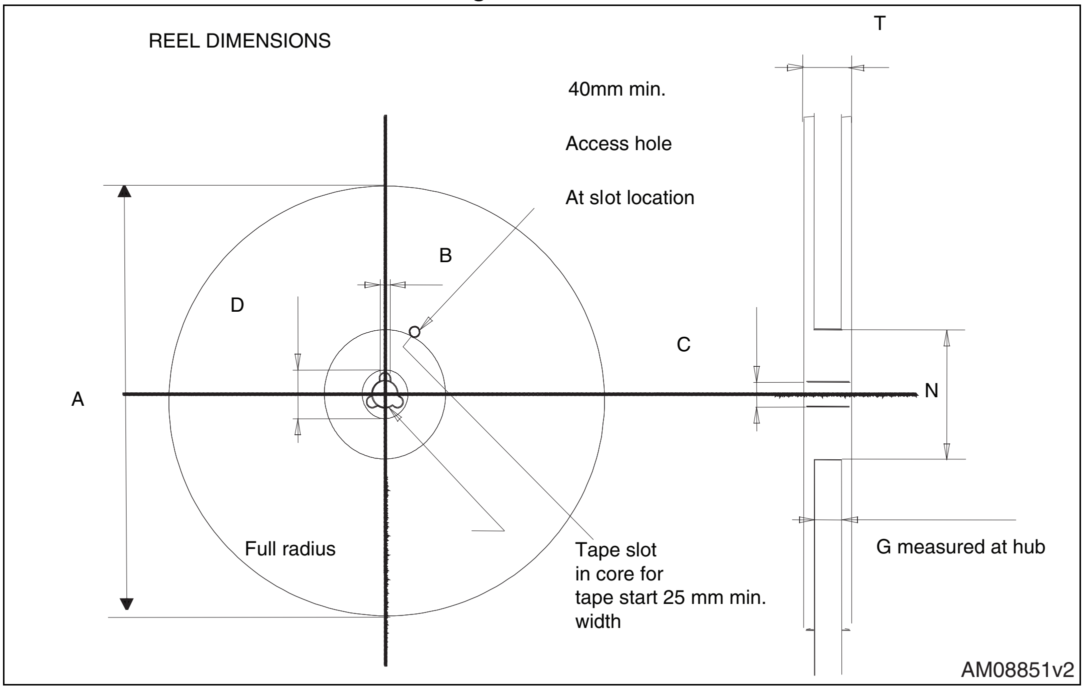



Figure 30. Reel



# 6 Revision history

**Table 14. Document revision history**

| Date | Revision | Changes |
|---|---|---|
| 17-Jul-2012 | 1 | First release. |
| 04-Jun-2013 | 2 | – Modified: $I_{AR}$, $E_{AS}$, dv/dt on *Table 2*, $R_{DS(on)}$ value on *Table 4*, entire values on *Table 5*, *6* and *7*<br>– Updated: *Section 4: Package mechanical data*<br>– Minor text changes<br>– Updated: *Table 11* and *Figure 27*<br>– Document status promoted from preliminary data to production data |