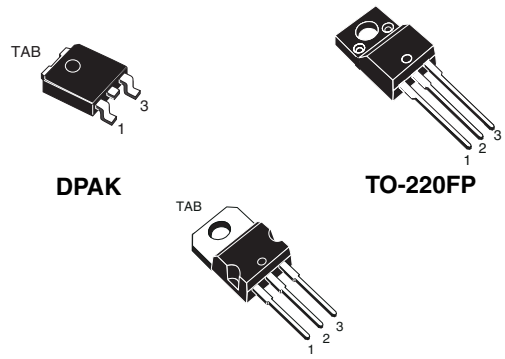
# STD10NM60ND, STF10NM60ND STP10NM60ND

## N-channel 600 V, 0.57 Ω, 8 A, DPAK, TO-220FP, TO-220 FDmesh™ II Power MOSFET (with fast diode)

## Features

| Order codes | $V_{DSS}$ @$T_J$max | $R_{DS(on)}$ max. | $I_D$ | $P_{TOT}$ |
|---|---|---|---|---|
| STD10NM60ND | 650 V | < 0.6 Ω | 8 A | 70 W |
| STF10NM60ND | | | | 25 W |
| STP10NM60ND | | | | 70 W |

- 100% avalanche tested
- Low input capacitance and gate charge
- Low gate input resistance
- Extremely high dv/dt avalanche capabilities




## Applications

- Switching applications

## Description

This FDmesh™ II Power MOSFET with intrinsic fast-recovery body diode is produced using the second generation of MDmesh™ technology. Utilizing a new strip-layout vertical structure, this revolutionary device features extremely low on-resistance and superior switching performance. It is ideal for bridge topologies and ZVS phase-shift converters.

**Figure 1. Internal schematic diagram**

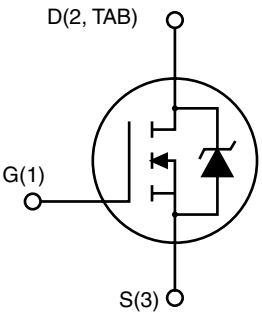



**Table 1. Device summary**

| Order codes | Marking | Package | Packaging |
|---|---|---|---|
| STD10NM60ND | 10NM60ND | DPAK | Tape and reel |
| STF10NM60ND | | TO-220FP | Tube |
| STP10NM60ND | | TO-220 | |

# Contents

# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol | Parameter | Value | | | Unit |
|---|---|---|---|---|---|
| | | DPAK | TO-220FP | TO-220 | |
| $V_{DS}$ | Drain-source voltage | 600 | | | V |
| $V_{GS}$ | Gate- source voltage | ± 25 | | | V |
| $I_D$ | Drain current (continuous) at $T_C$ = 25 °C | 8 | 8 (1) | 8 | A |
| $I_D$ | Drain current (continuous) at $T_C$ = 100 °C | 5 | 5 (1) | 5 | A |
| $I_{DM}$ (2) | Drain current (pulsed) | 32 | 32 (1) | 32 | A |
| $P_{TOT}$ | Total dissipation at $T_C$ = 25 °C | 70 | 25 | 70 | W |
| dv/dt(3) | Peak diode recovery voltage slope | 40 | | | 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. $I_{SD} \leq 8$ A, di/dt ≤400 A/µs, $V_{DS}$ peak $\leq V_{(BR)DSS}$, $V_{DD}$ = 80% $V_{(BR)DSS}$.

**Table 3. Thermal data**

| Symbol | Parameter | Value | | | Unit |
|---|---|---|---|---|---|
| | | DPAK | TO-220FP | TO-220 | |
| $R_{thj\text{-}case}$ | Thermal resistance junction-case max | 1.79 | 5 | 1.79 | °C/W |
| $R_{thj\text{-}amb}$ | Thermal resistance junction-ambient max | 62.50 | 62.50 | | °C/W |
| $R_{thj\text{-}pcb}$ | Thermal resistance junction-pcb max | 50 | | | °C/W |
| $T_J$ | Maximum lead temperature for soldering purpose | | 300 | | °C/W |

**Table 4. Avalanche characteristics**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $I_{AS}$ | Avalanche current, repetitive or not-repetitive (pulse width limited by Tj Max) | 2.5 | A |
| $E_{AS}$ | Single pulse avalanche energy (starting $T_J$=25 °C, $I_D$=$I_{AS}$, $V_{DD}$=50 V) | 130 | mJ |

# 2 Electrical characteristics

(Tcase =25 °C unless otherwise specified)

**Table 5. 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 | 600 | | | V |
| $I_{DSS}$ | Zero gate voltage drain current ($V_{GS}$ = 0) | $V_{DS}$ = 600 V<br>$V_{DS}$ = 600 V, $T_C$ =125 °C | | | 1<br>100 | µA<br>µA |
| $I_{GSS}$ | Gate-body leakage current ($V_{DS}$ = 0) | $V_{GS}$ = ± 25 V | | | ±100 | nA |
| $V_{GS(th)}$ | Gate threshold voltage | $V_{DS}$ = $V_{GS}$, $I_D$ = 250 µA | 3 | 4 | 5 | V |
| $R_{DS(on)}$ | Static drain-source on resistance | $V_{GS}$ = 10 V, $I_D$ = 4 A | | 0.57 | 0.6 | Ω |

**Table 6. Dynamic**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS}$ = 50 V, f = 1 MHz,<br>$V_{GS}$ = 0 | - | 577<br>32.4<br>1.76 | - | pF<br>pF<br>pF |
| $C_{oss\ eq}$ (1) | Equivalent capacitance time related | $V_{DS}$ = 0 to 480 V, $V_{GS}$ = 0 | - | 138 | - | pF |
| $R_g$ | Gate input resistance | f=1 MHz open drain | - | 6 | - | Ω |
| $Q_g$<br>$Q_{gs}$<br>$Q_{gd}$ | Total gate charge<br>Gate-source charge<br>Gate-drain charge | $V_{DD}$ = 480 V, $I_D$ = 8 A,<br>$V_{GS}$ = 10 V<br>*(see Figure 19)* | - | 20<br>4.3<br>11.6 | - | nC<br>nC<br>nC |

1. $C_{oss\ eq}$ 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% $V_{DSS}$

**Table 7. Switching times**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max | Unit |
|---|---|---|---|---|---|---|
| $t_{d(on)}$<br>$t_r$<br>$t_{d(off)}$<br>$t_f$ | Turn-on delay time<br>Rise time<br>Turn-off-delay time<br>Fall time | $V_{DD}$ = 300 V, $I_D$ = 4 A,<br>$R_G$ = 4.7 Ω, $V_{GS}$ = 10 V<br>*(see Figure 18)* | - | 9.2<br>10<br>32<br>9.8 | - | ns<br>ns<br>ns<br>ns |

**Table 8. Source drain diode**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max | Unit |
|---|---|---|---|---|---|---|
| $I_{SD}$<br>$I_{SDM}$ (1) | Source-drain current<br>Source-drain current (pulsed) | | - | | 8<br>32 | A<br>A |
| $V_{SD}$ (2) | Forward on voltage | $I_{SD}$ = 8 A, $V_{GS}$ = 0 | - | | 1.5 | V |
| $t_{rr}$<br>$Q_{rr}$<br>$I_{RRM}$ | Reverse recovery time<br>Reverse recovery charge<br>Reverse recovery current | $I_{SD}$ = 8 A, di/dt = 100 A/µs<br>$V_{DD}$= 60 V<br>*(see Figure 20)* | - | 118<br>680<br>11 | | ns<br>nC<br>A |
| $t_{rr}$<br>$Q_{rr}$<br>$I_{RRM}$ | Reverse recovery time<br>Reverse recovery charge<br>Reverse recovery current | $I_{SD}$ = 8 A, di/dt = 100 A/µs<br>$V_{DD}$= 60 V $T_J$ = 150 °C<br>*(see Figure 20)* | - | 150<br>918<br>12 | | ns<br>nC<br>A |

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

## 2.1 Electrical characteristics (curves)

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

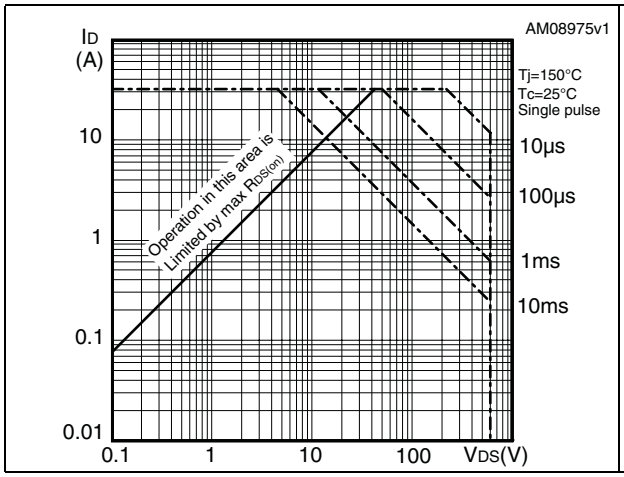



**Figure 3. Thermal impedance for DPAK**

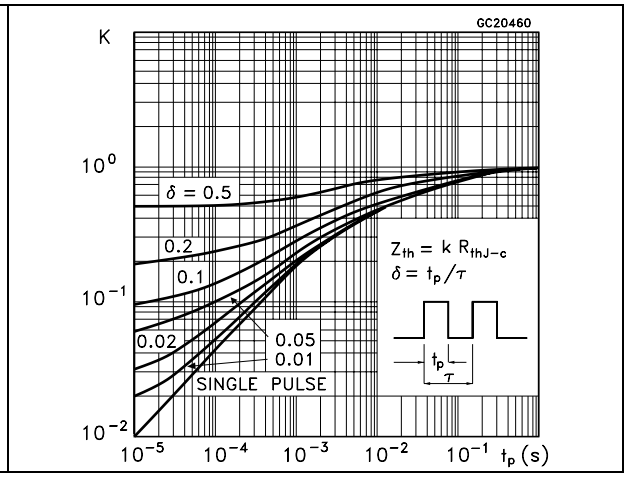



**Figure 4. Safe operating area for TO-220FP**

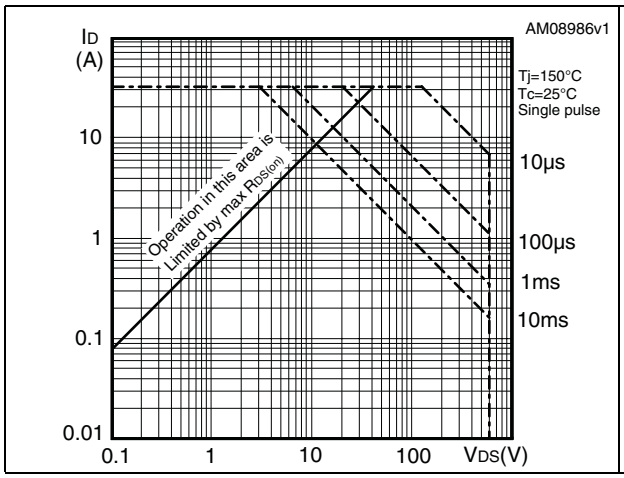



**Figure 5. Thermal impedance for TO-220FP**

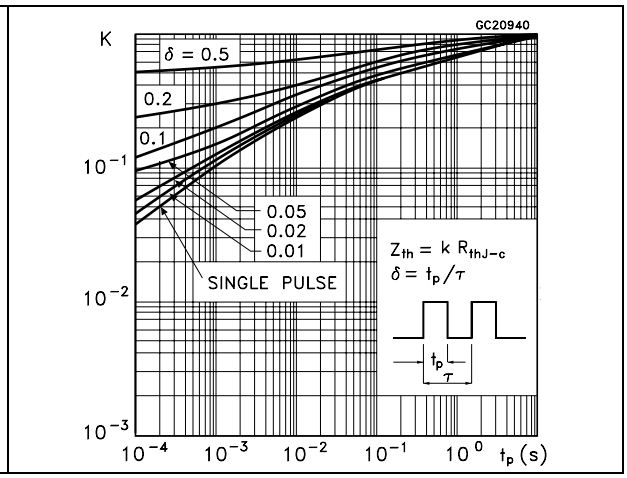



**Figure 6. Safe operating area for TO-220**

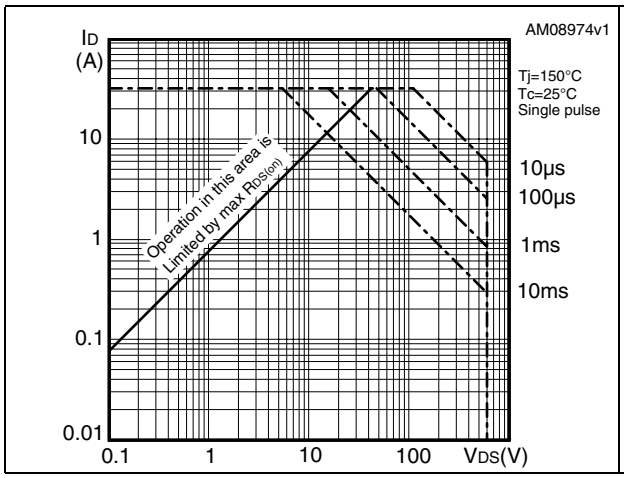



**Figure 7. Thermal impedance for TO-220**

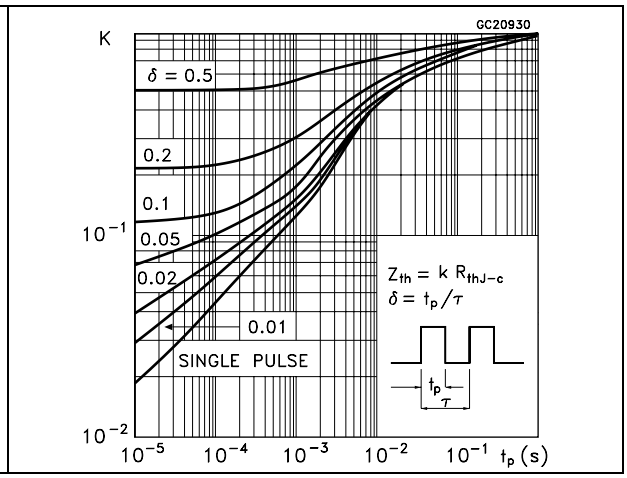


**Figure 8. Output characteristics**

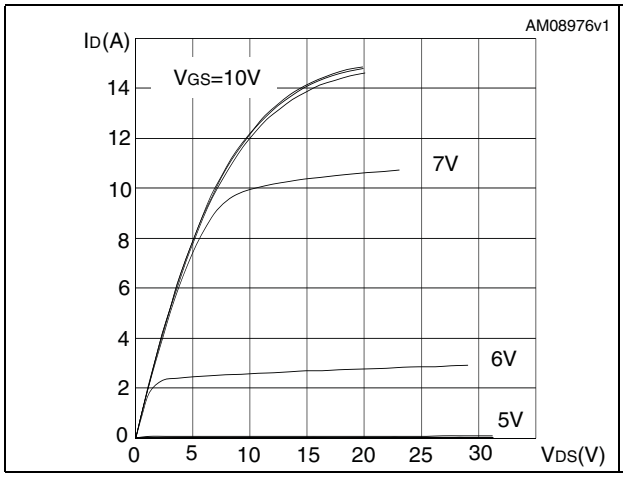



**Figure 9. Transfer characteristics**

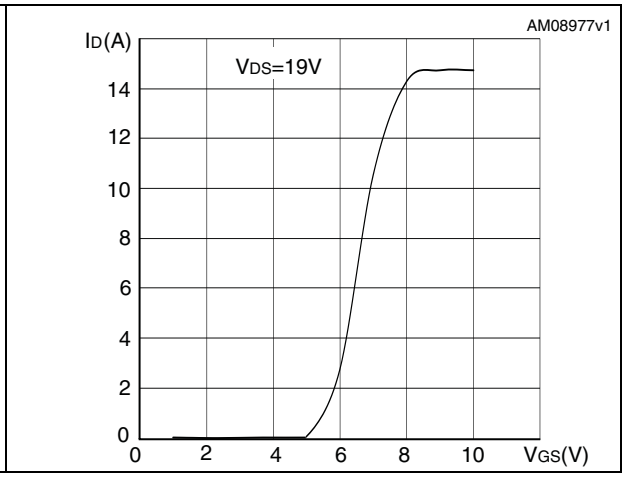



**Figure 10. Gate charge vs gate-source voltage**

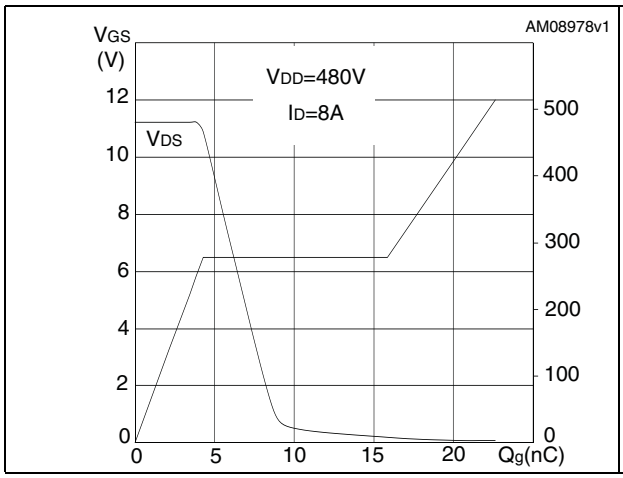



**Figure 11. Static drain-source on resistance**

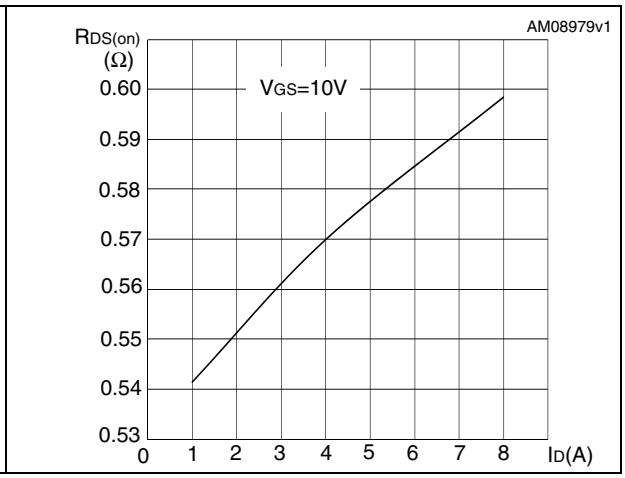



**Figure 12. Capacitance variations**

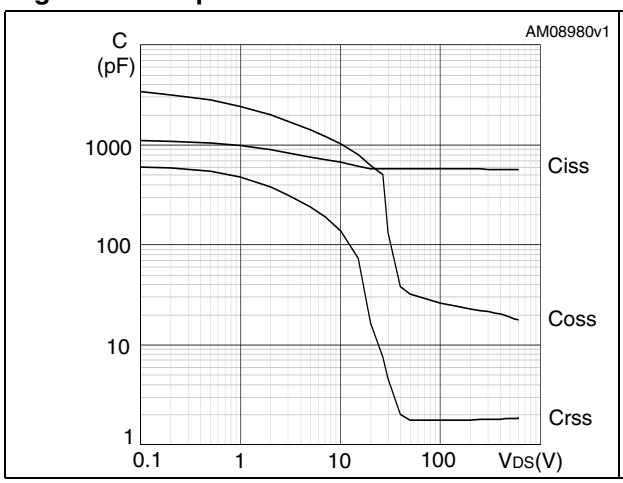



**Figure 13. Output capacitance stored energy**

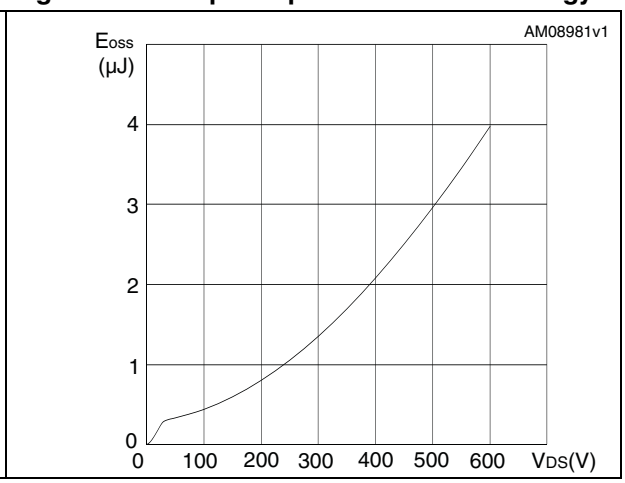


**Figure 14. Normalized gate threshold voltage vs temperature**

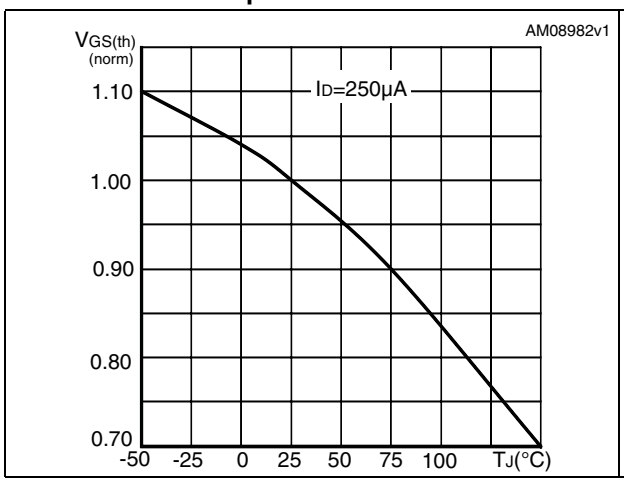



**Figure 15. Normalized on resistance vs temperature**

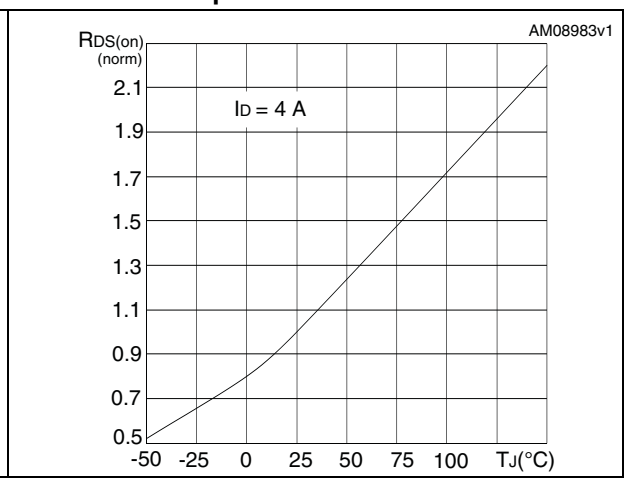



**Figure 16. Source-drain diode forward characteristics**

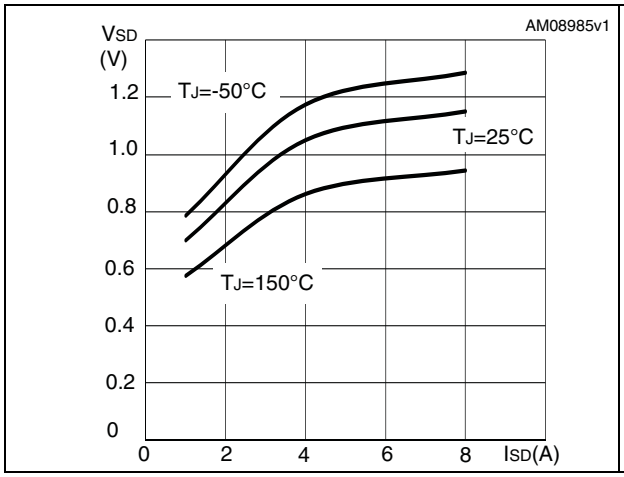
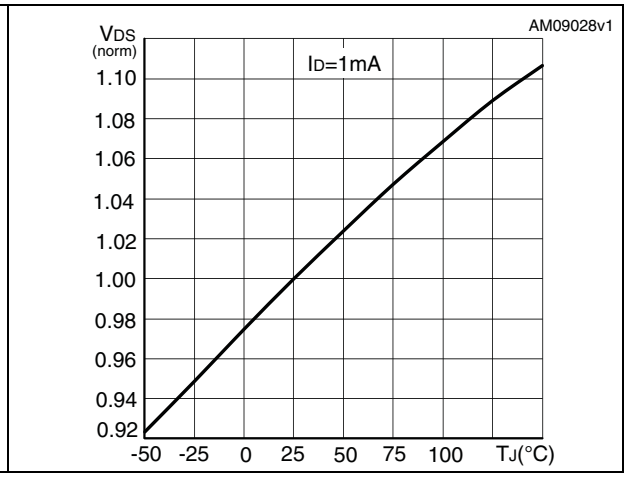



**Figure 17. Normalized $V_{DS}$ vs temperature**



# 3 Test circuits

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

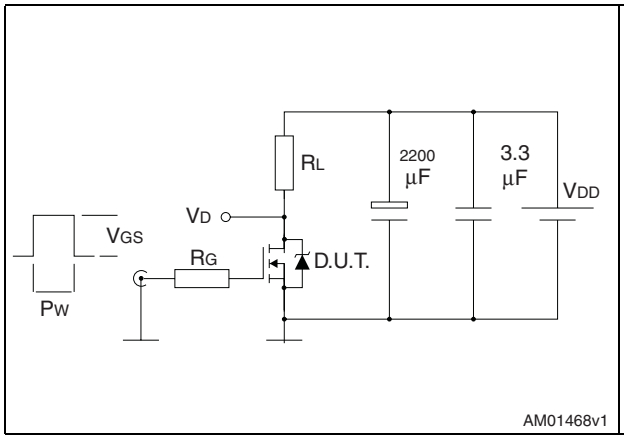



**Figure 19. Gate charge test circuit**

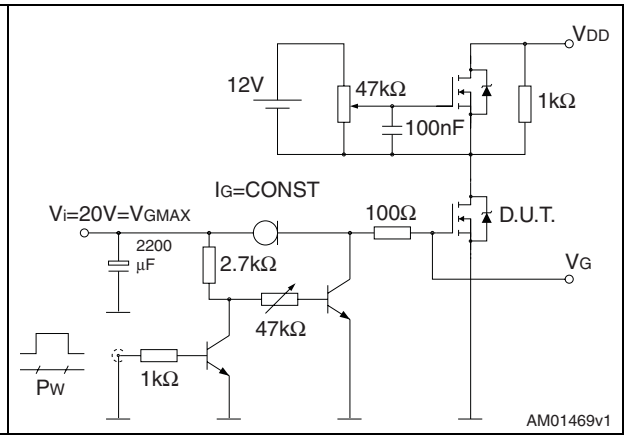



**Figure 20. Test circuit for inductive load switching and diode recovery times**

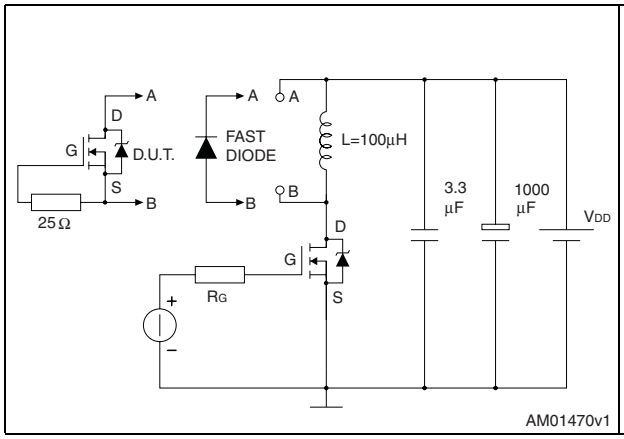



**Figure 21. Unclamped inductive load test circuit**

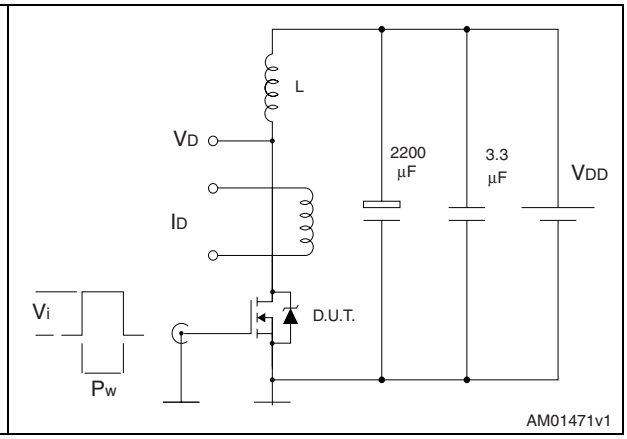



**Figure 22. Unclamped inductive waveform**

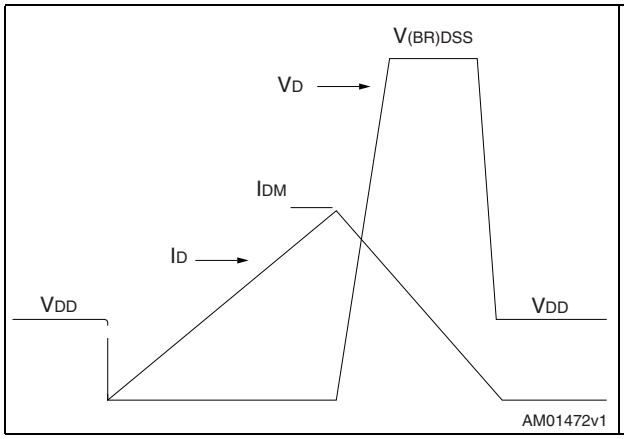
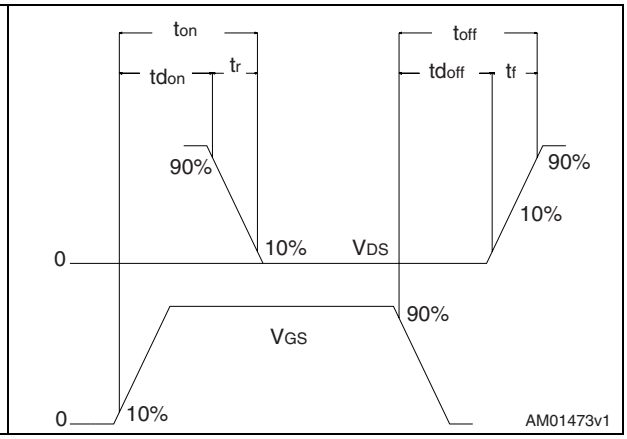



**Figure 23. Switching time waveform**



# 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. 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 | | |
| L1 | | 2.80 | |
| L2 | | 0.80 | |
| L4 | 0.60 | | 1 |
| R | | 0.20 | |
| V2 | 0° | | 8° |

**Figure 24. DPAK (TO-252) drawing**

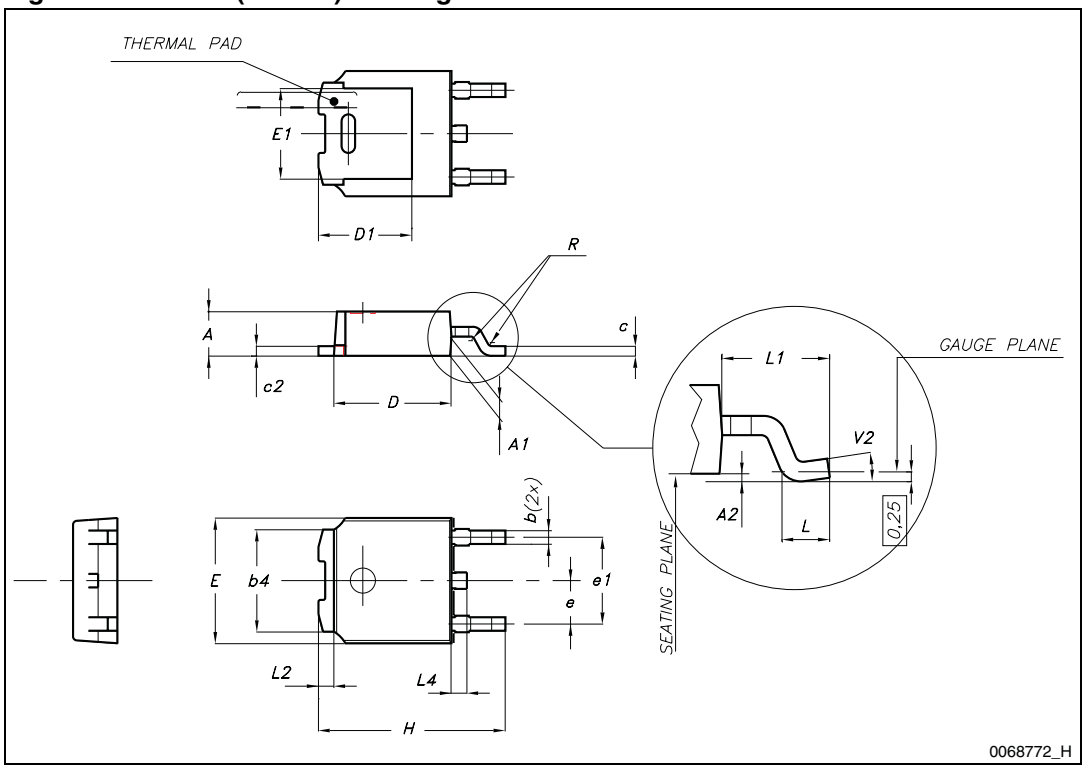
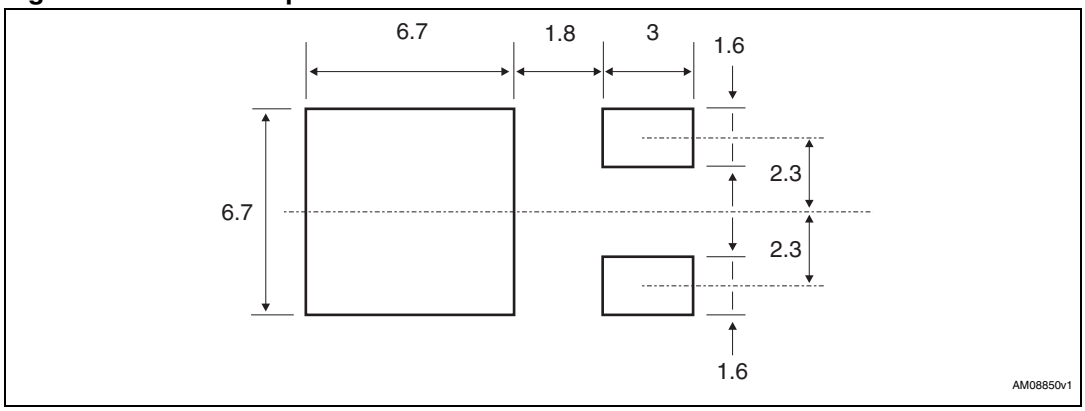



**Figure 25. DPAK footprint[a]**




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**

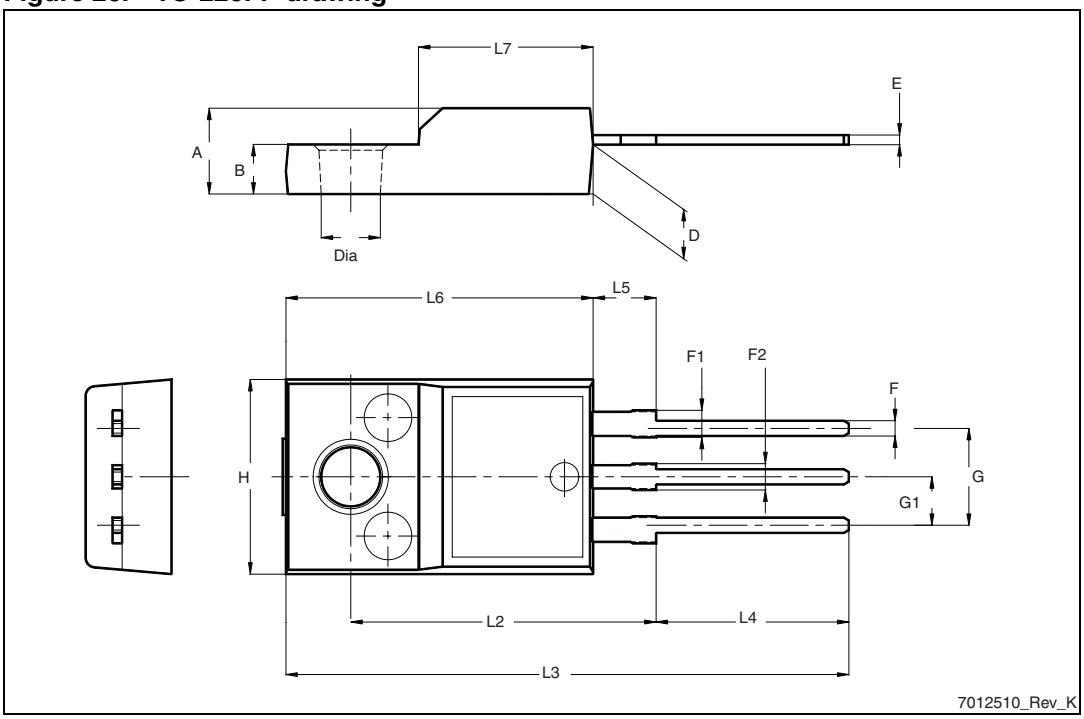
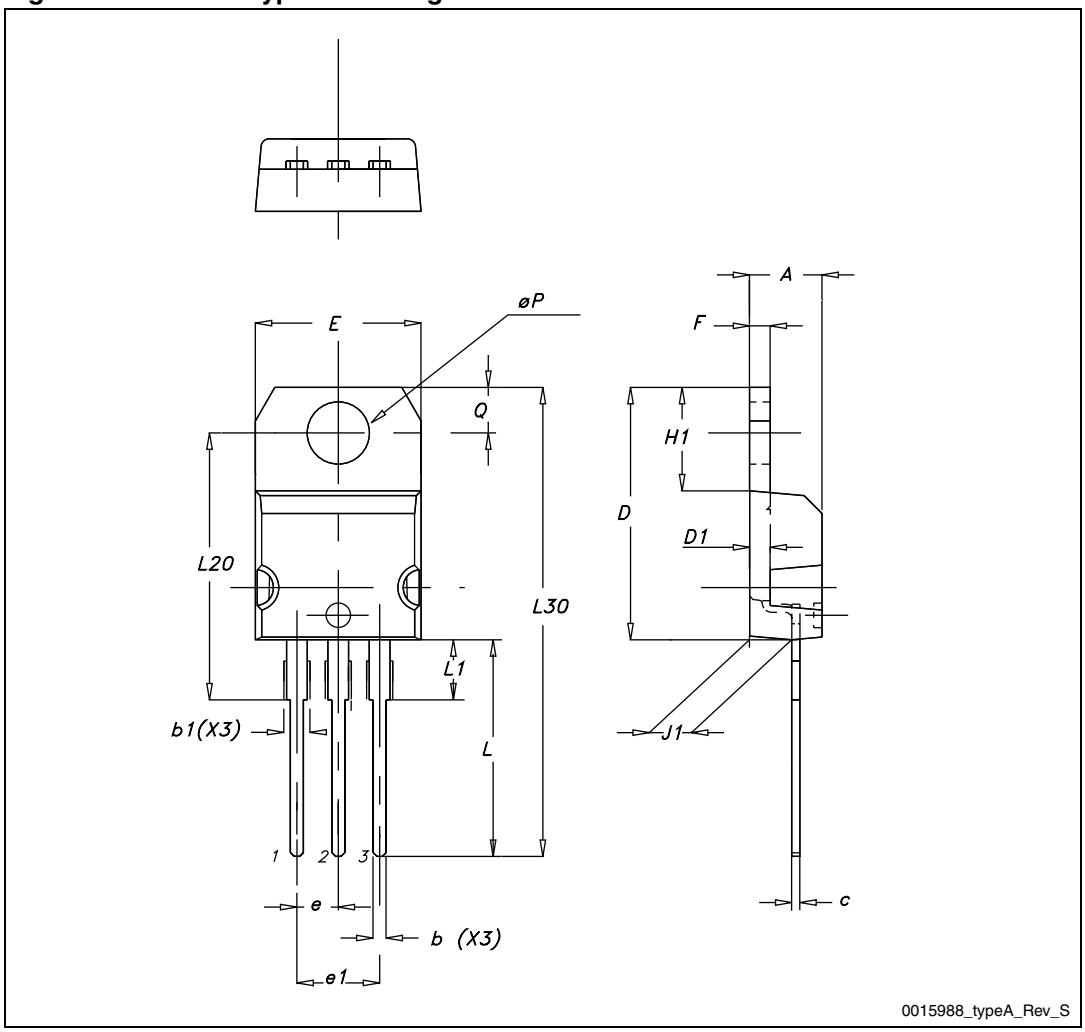


Table 11. TO-220 type A mechanical data

| 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**



# 5 Packaging mechanical data

Table 12. 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 28. Tape for DPAK (TO-252)**

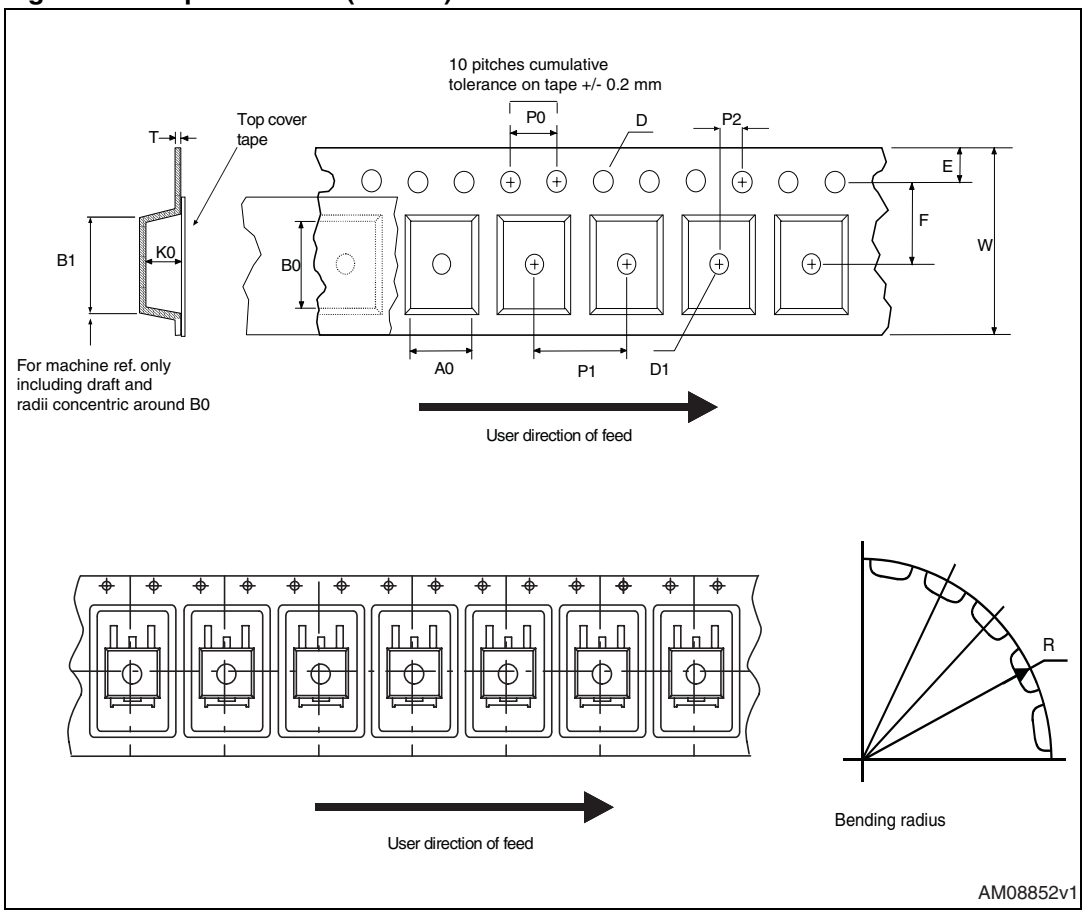
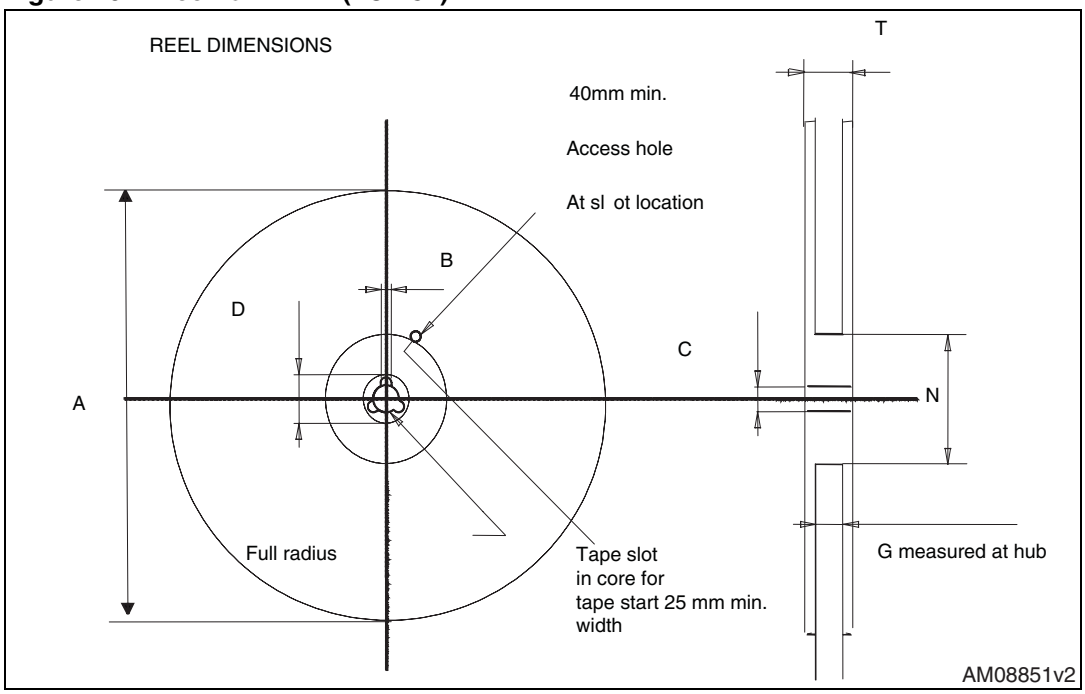



**Figure 29. Reel for DPAK (TO-252)**



# 6 Revision history

Table 13. Document revision history

| Date | Revision | Changes |
|---|---|---|
| 10-Feb-2011 | 1 | First release. |
| 17-Nov-2011 | 2 | Updated features in table and description in cover page.<br>Updated *Table 2: Absolute maximum ratings*, *Table 5: On /off states*, *Table 15: Normalized on resistance vs temperature*, *Figure 17: Normalized $V_{DS}$ vs temperature* and *Section 4: Package mechanical data*. |