

N-channel 600 V, 0.32 Ω typ., 11 A, FDmesh™ II Power MOSFET
(with fast diode) in DPAK, TO-220FP and TO-220 packages

Datasheet – production data

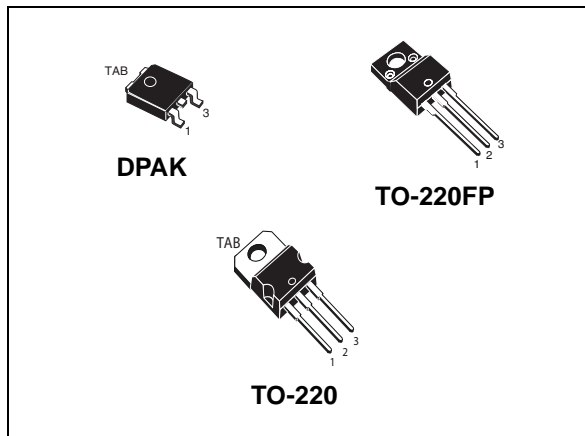
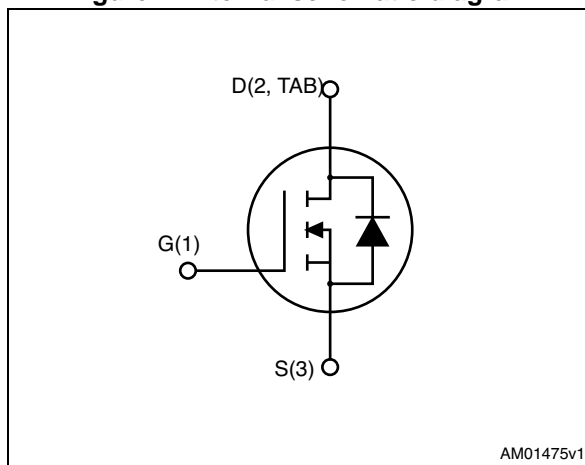


Figure 1. Internal schematic diagram



Features

| Order codes | $V_{DS} @ T_{Jmax}$ | $R_{DS(on) max}$ | I_D |
|-------------|---------------------|------------------|-------|
| STD13NM60ND | 650 V | 0.38 Ω | 11 A |
| STF13NM60ND | | | |
| STP13NM60ND | | | |

- The worldwide best $R_{DS(on)}$ * area among fast recovery diode devices
- 100% avalanche tested
- Low input capacitance and gate charge
- Low gate input resistance
- Extremely high dv/dt and avalanche capabilities

Applications

- Switching applications

Description

These FDmesh™ II Power MOSFETs with intrinsic fast-recovery body diode are produced using the second generation of MDmesh™ technology. Utilizing a new strip-layout vertical structure, these revolutionary devices feature extremely low on-resistance and superior switching performance. They are ideal for bridge topologies and ZVS phase-shift converters.

Table 1. Device summary

| Order codes | Marking | Package | Packaging |
|-------------|----------|----------|---------------|
| STD13NM60ND | 13NM60ND | DPAK | Tape and reel |
| STF13NM60ND | | TO-220FP | Tube |
| STP13NM60ND | | TO-220 | |

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1 Electrical ratings

Table 2. Absolute maximum ratings

| Symbol | Parameter | Value | | Unit |
|----------------|---|--------------|---------------------|------------------|
| | | DPAK, TO-220 | TO-220FP | |
| V_{DS} | Drain-source voltage | 600 | | V |
| V_{GS} | Gate-source voltage | ± 25 | | V |
| I_D | Drain current (continuous) at $T_C = 25^\circ\text{C}$ | 11 | 11 ⁽¹⁾ | A |
| I_D | Drain current (continuous) at $T_C = 100^\circ\text{C}$ | 6.93 | 6.93 ⁽¹⁾ | A |
| $I_{DM}^{(2)}$ | Drain current (pulsed) | 44 | 44 ⁽¹⁾ | A |
| P_{TOT} | Total dissipation at $T_C = 25^\circ\text{C}$ | 109 | 25 | W |
| $dv/dt^{(3)}$ | Peak diode recovery voltage slope | 40 | | V/ns |
| $dv/dt^{(4)}$ | MOSFET dv/dt ruggedness | 40 | | V/ns |
| V_{ISO} | Insulation withstand voltage (RMS) from all three leads to external heat sink ($t=1\text{s}; T_C=25^\circ\text{C}$) | | 2500 | V |
| T_{stg} | Storage temperature | -55 to 150 | | $^\circ\text{C}$ |
| T_j | Max. operating junction temperature | 150 | | $^\circ\text{C}$ |

- Limited by maximum junction temperature
- Pulse width limited by safe operating area
- $I_{SD} \leq 11\text{ A}$, $di/dt \leq 400\text{ A}/\mu\text{s}$, $V_{DD} = 80\% V_{(BR)DSS}$, $V_{DS(\text{peak})} \leq V_{(BR)DSS}$
- $V_{DS} \leq 480\text{ V}$

Table 3. Thermal data

| Symbol | Parameter | Value | | | Unit |
|---------------------|--------------------------------------|-------|----------|--------|---------------------------|
| | | DPAK | TO-220FP | TO-220 | |
| $R_{thj-case}$ | Thermal resistance junction-case max | 1.15 | 5 | 1.15 | $^\circ\text{C}/\text{W}$ |
| $R_{thj-amb}$ | Thermal resistance junction-amb max | | 62.5 | | $^\circ\text{C}/\text{W}$ |
| $R_{thj-pcb}^{(1)}$ | Thermal resistance junction-pcb max | 50 | | | $^\circ\text{C}/\text{W}$ |

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

Table 4. Avalanche characteristics

| Symbol | Parameter | Max value | Unit |
|----------|--|-----------|------|
| I_{AS} | Avalanche current, repetitive or not-repetitive ⁽¹⁾ | 3 | A |
| E_{AS} | Single pulse avalanche energy ⁽²⁾ | 162 | mJ |

- Pulse width limited by T_j max
- starting $T_j = 25^\circ\text{C}$, $I_D = I_{AS}$, $V_{DD} = 50\text{ V}$

2 Electrical characteristics

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

Table 5. On/off states

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---------------|--|--|------|------|-----------|--------------------------------|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage | $I_D = 1\text{ mA}$, $V_{GS} = 0$ | 600 | | | V |
| I_{DSS} | Zero gate voltage drain current ($V_{GS} = 0$) | $V_{DS} = 600\text{ V}$ $V_{DS} = 600\text{ V}$, $T_C = 125\text{ °C}$ | | | 1 100 | μA μA |
| I_{GSS} | Gate body leakage current ($V_{DS} = 0$) | $V_{GS} = \pm 20\text{ V}$ | | | ± 100 | nA |
| $V_{GS(th)}$ | Gate threshold voltage | $V_{DS} = V_{GS}$, $I_D = 250\text{ }\mu\text{A}$ | 3 | 4 | 5 | V |
| $R_{DS(on)}$ | Static drain-source on resistance | $V_{GS} = 10\text{ V}$, $I_D = 5.5\text{ A}$ | | 0.32 | 0.38 | Ω |

Table 6. Dynamic

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|----------------------------|-------------------------------|---|------|------|------|----------|
| C_{iss} | Input capacitance | $V_{DS} = 50\text{ V}$, $f = 1\text{ MHz}$, $V_{GS} = 0$ | - | 845 | - | pF |
| C_{oss} | Output capacitance | | - | 47 | - | pF |
| C_{rss} | Reverse transfer capacitance | | - | 2.5 | - | pF |
| $C_{oss\text{ eq.}}^{(1)}$ | Equivalent output capacitance | $V_{GS} = 0$, $V_{DS} = 0\text{ V to } 480\text{ V}$ | - | 121 | - | pF |
| R_g | Gate input resistance | $f = 1\text{ MHz}$ Gate DC Bias = 0 Test signal level = 20 mV open drain | - | 4.3 | - | Ω |
| Q_g | Total gate charge | $V_{DD} = 480\text{ V}$, $I_D = 11\text{ A}$ $V_{GS} = 10\text{ V}$ (see Figure 18) | - | 24.5 | - | nC |
| Q_{gs} | Gate-source charge | | - | 4.8 | - | nC |
| Q_{gd} | Gate-drain charge | | - | 17 | - | nC |

1. $C_{oss\text{ eq.}}$ 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 |
|--------------|---------------------|--|-----|------|-----|------|
| $t_{d(on)}$ | Turn-on delay time | $V_{DD} = 300\text{ V}$, $I_D = 5.5\text{ A}$, $R_G = 4.7\ \Omega$, $V_{GS} = 10\text{ V}$ (see Figure 17) | - | 46.5 | - | ns |
| t_r | Rise time | | - | 10 | - | ns |
| $t_{d(off)}$ | Turn-off delay time | | - | 9.6 | - | ns |
| t_f | Fall time | | - | 15.4 | - | ns |

Table 8. Source drain diode

| Symbol | Parameter | Test conditions | Min | Typ | Max | Unit |
|-----------------|-------------------------------|--|-----|------|-----|------|
| I_{SD} | Source-drain current | | - | | 11 | A |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) | | - | | 44 | A |
| $V_{SD}^{(2)}$ | Forward on voltage | $I_{SD} = 11\text{ A}$, $V_{GS} = 0$ | - | | 1.6 | V |
| t_{rr} | Reverse recovery time | $I_{SD} = 11\text{ A}$, $di/dt = 100\text{ A}/\mu\text{s}$, $V_{DD} = 100\text{ V}$ (see Figure 19) | - | 150 | | ns |
| Q_{rr} | Reverse recovery charge | | - | 755 | | nC |
| I_{RRM} | Reverse recovery current | | - | 12 | | A |
| t_{rr} | Reverse recovery time | $V_{DD} = 100\text{ V}$ $di/dt = 100\text{ A}/\mu\text{s}$, $I_{SD} = 11\text{ A}$ $T_j = 150\text{ }^\circ\text{C}$ (see Figure 19) | - | 187 | | ns |
| Q_{rr} | Reverse recovery charge | | - | 1271 | | nC |
| I_{RRM} | Reverse recovery current | | - | 13.6 | | 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

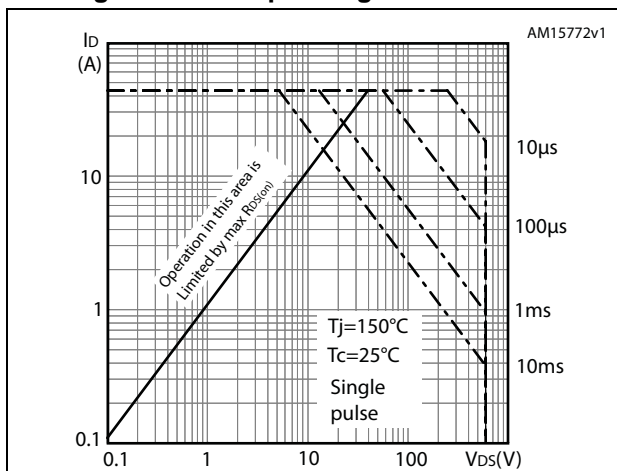


Figure 3. Thermal impedance for DPAK

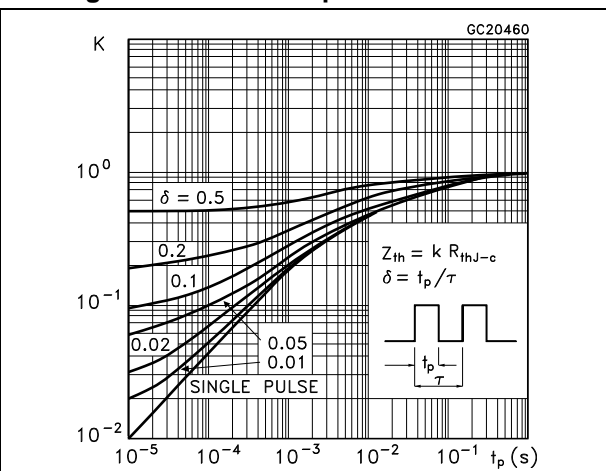


Figure 4. Safe operating area for TO-220FP

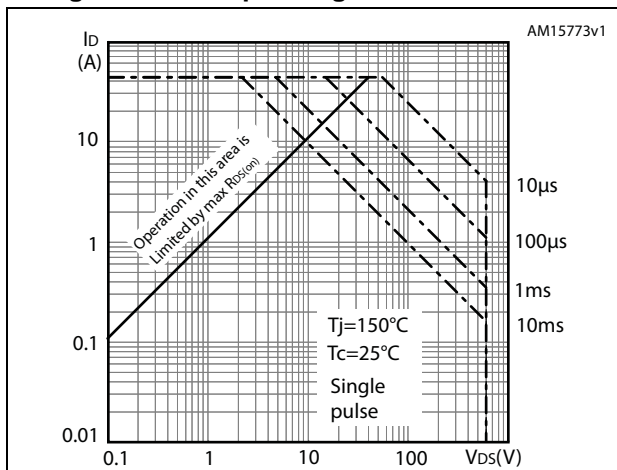


Figure 5. Thermal impedance for TO-220FP

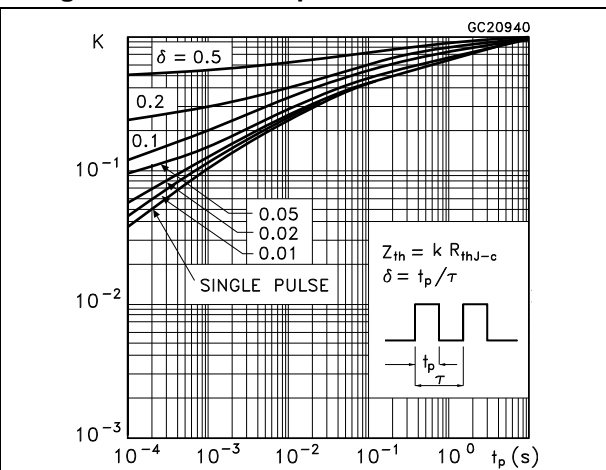


Figure 6. Safe operating area for TO-220

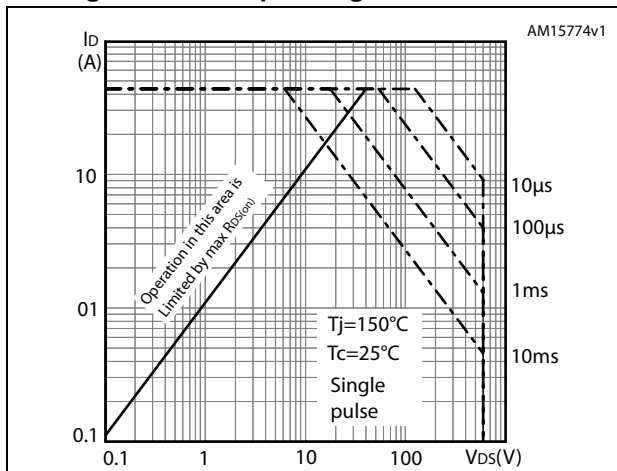


Figure 7. Thermal impedance for TO-220

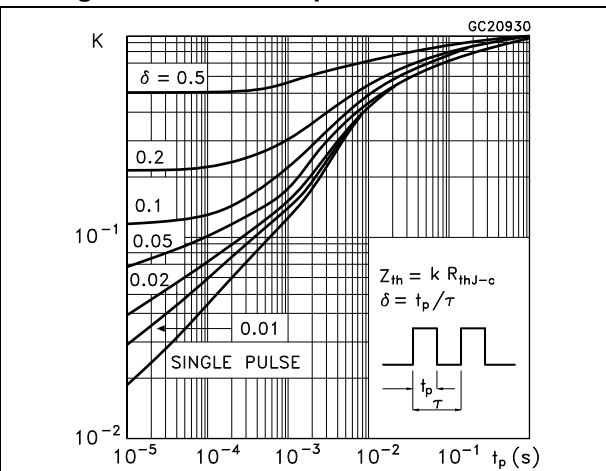


Figure 8. Output characteristics

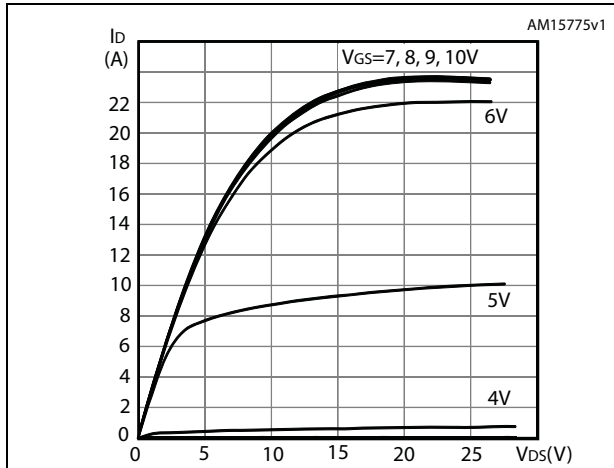


Figure 9. Transfer characteristics

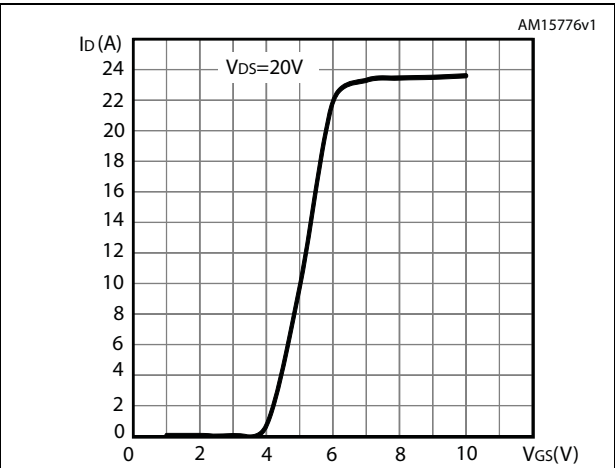


Figure 10. Gate charge vs gate-source voltage

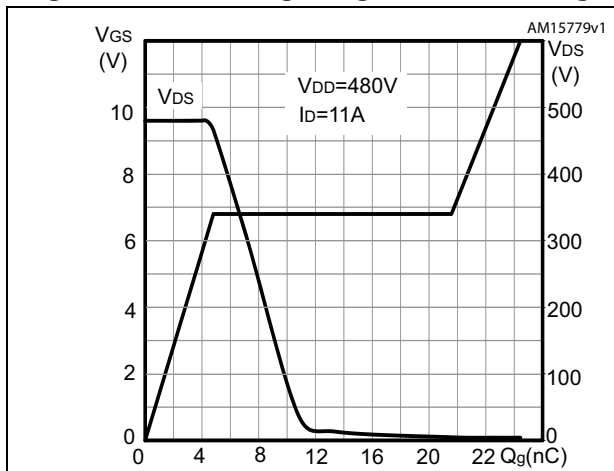


Figure 11. Static drain-source on-resistance

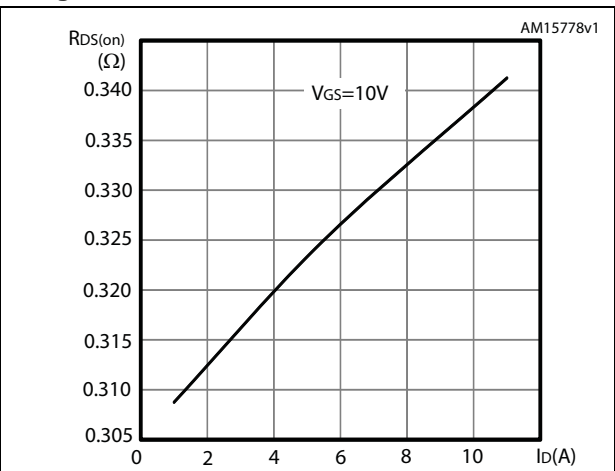


Figure 12. Capacitance variations

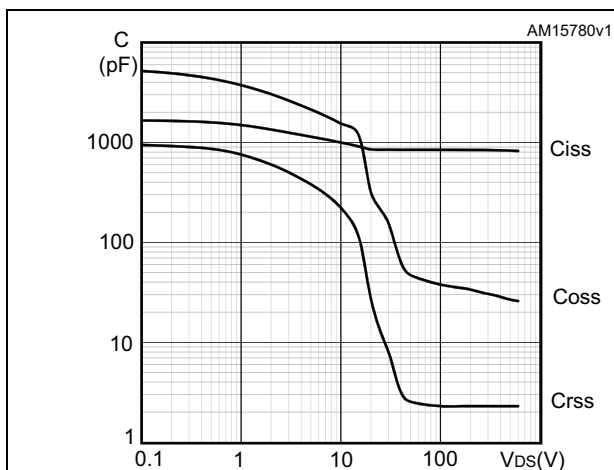


Figure 13. Normalized gate threshold voltage vs. temperature

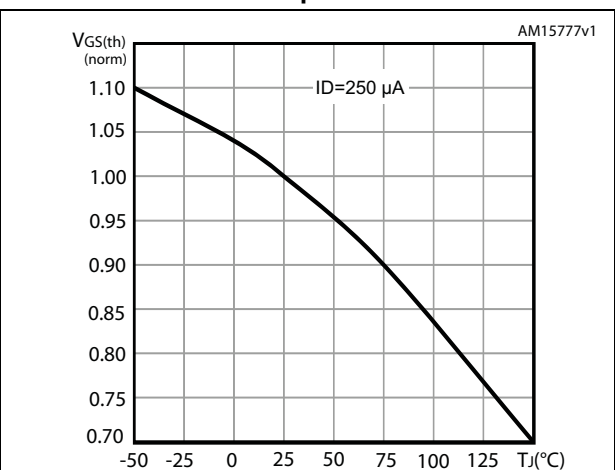


Figure 14. Normalized on-resistance vs temperature

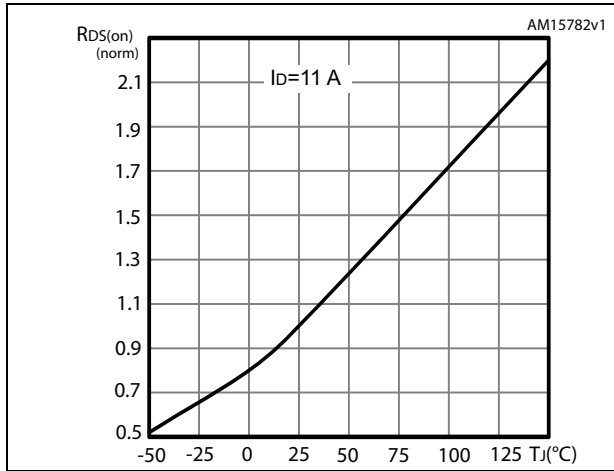


Figure 15. Source-drain diode forward characteristics

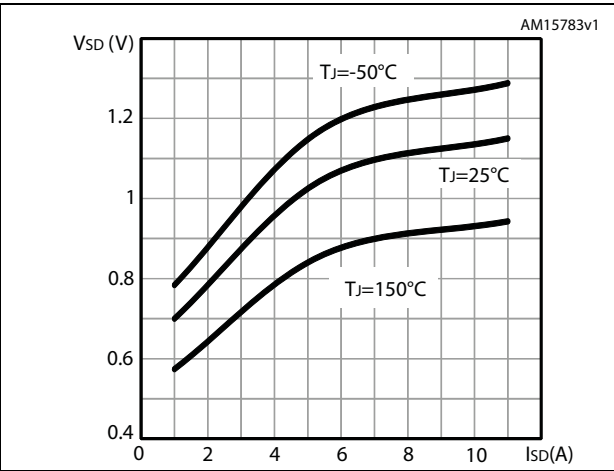
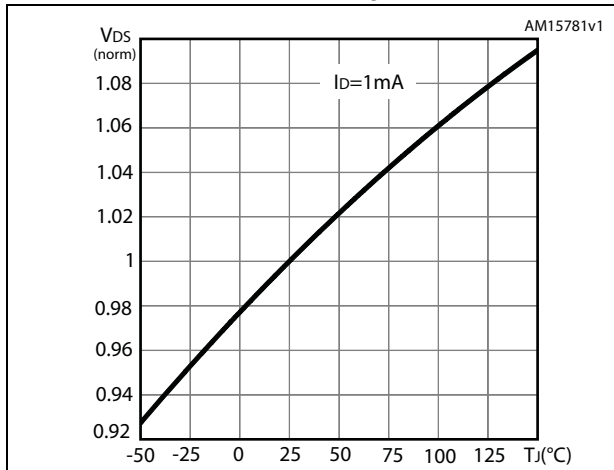


Figure 16. Normalized V_{DS} vs temperature



3 Test circuits

Figure 17. Switching times test circuit for resistive load

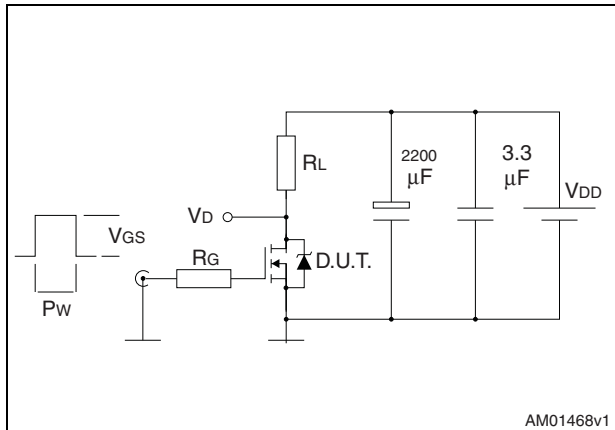


Figure 18. Gate charge test circuit

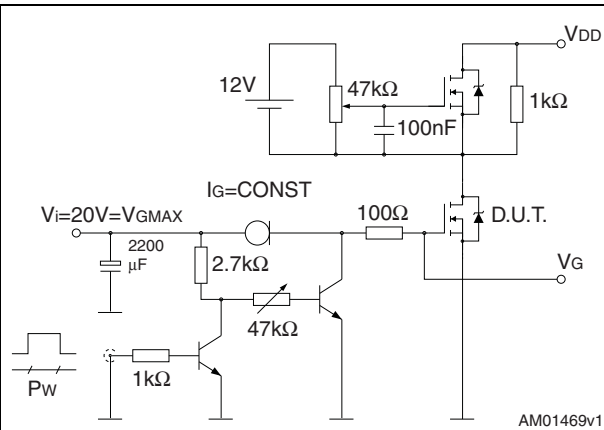


Figure 19. Test circuit for inductive load switching and diode recovery times

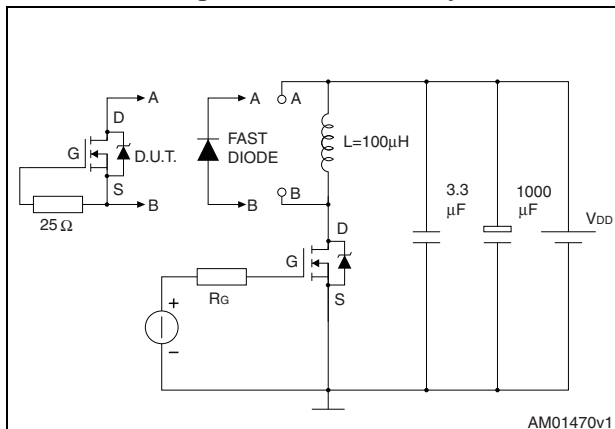


Figure 20. Unclamped inductive load test circuit

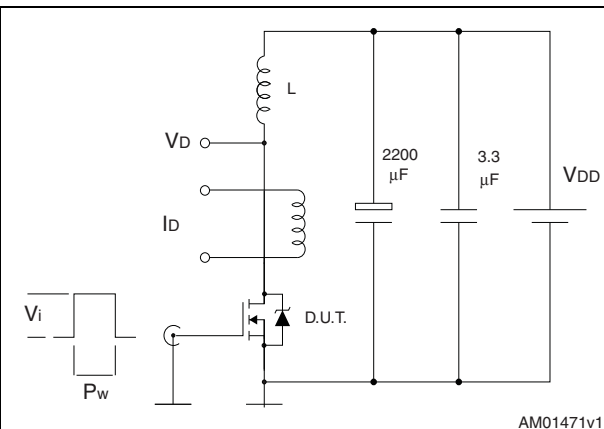


Figure 21. Unclamped inductive waveform

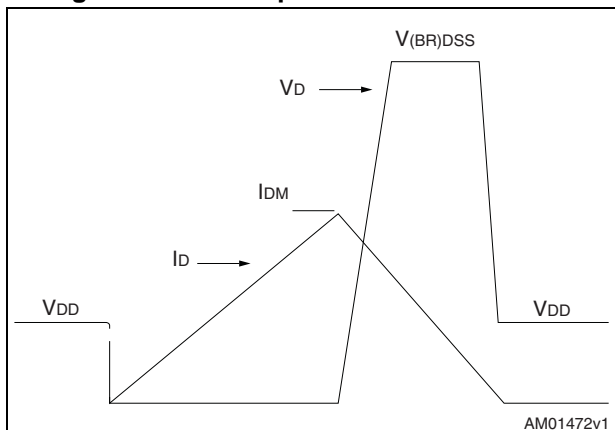
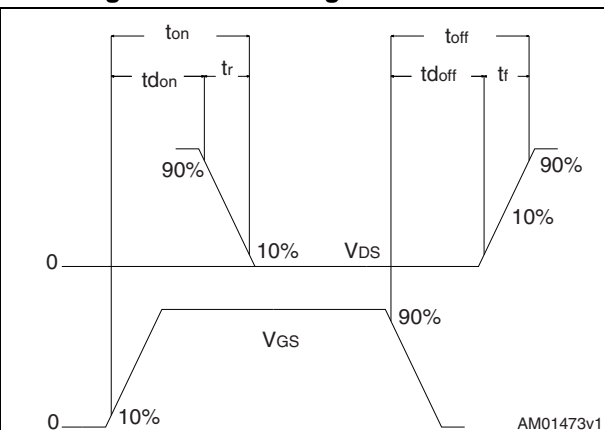


Figure 22. Switching time waveform



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 23. DPAK (TO-252) drawing

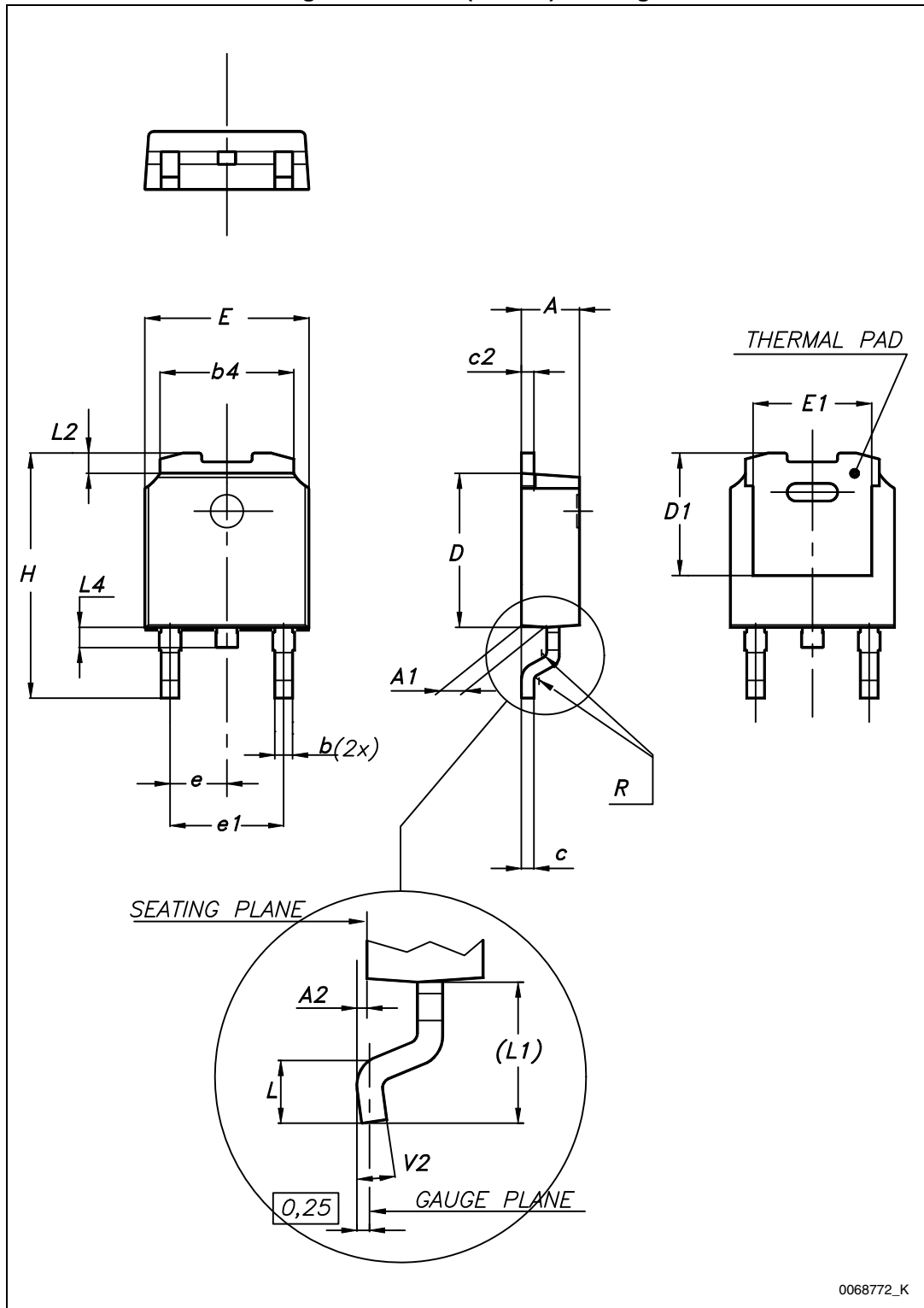
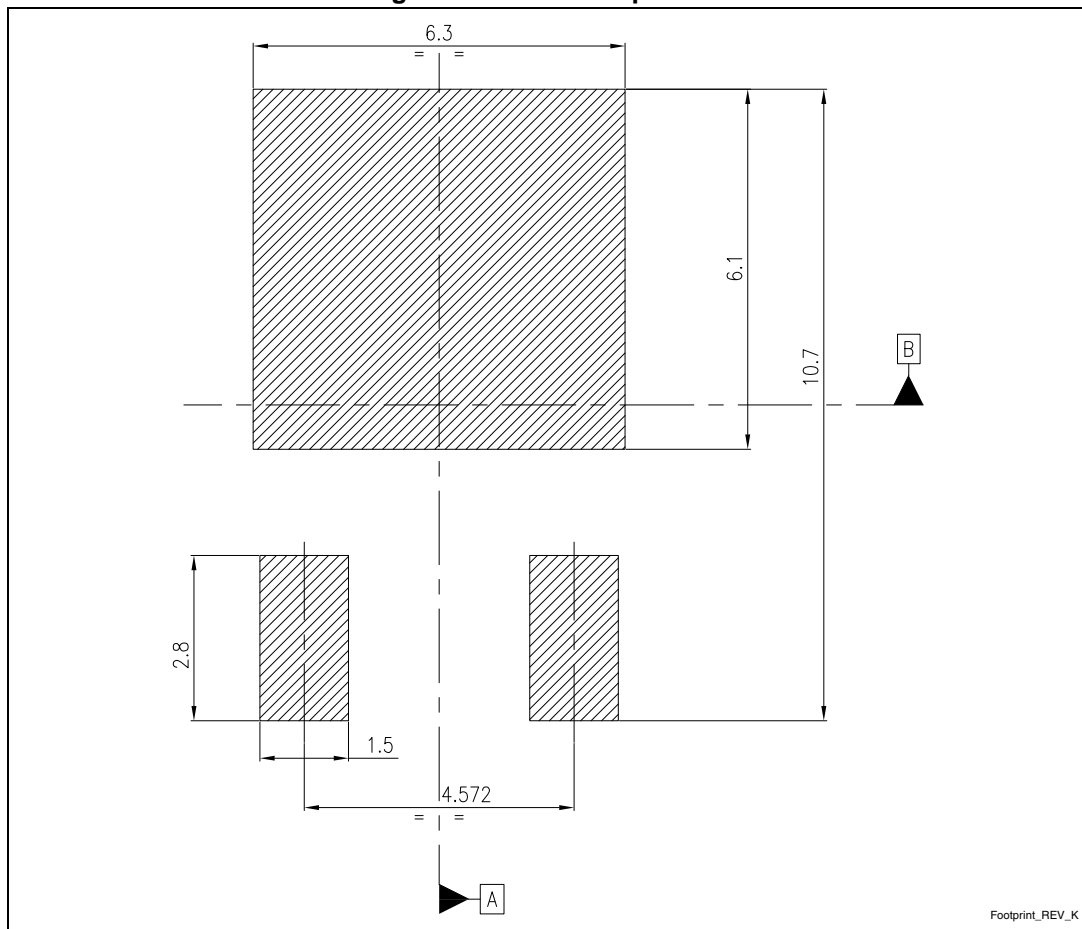


Figure 24. DPAK footprint (a)

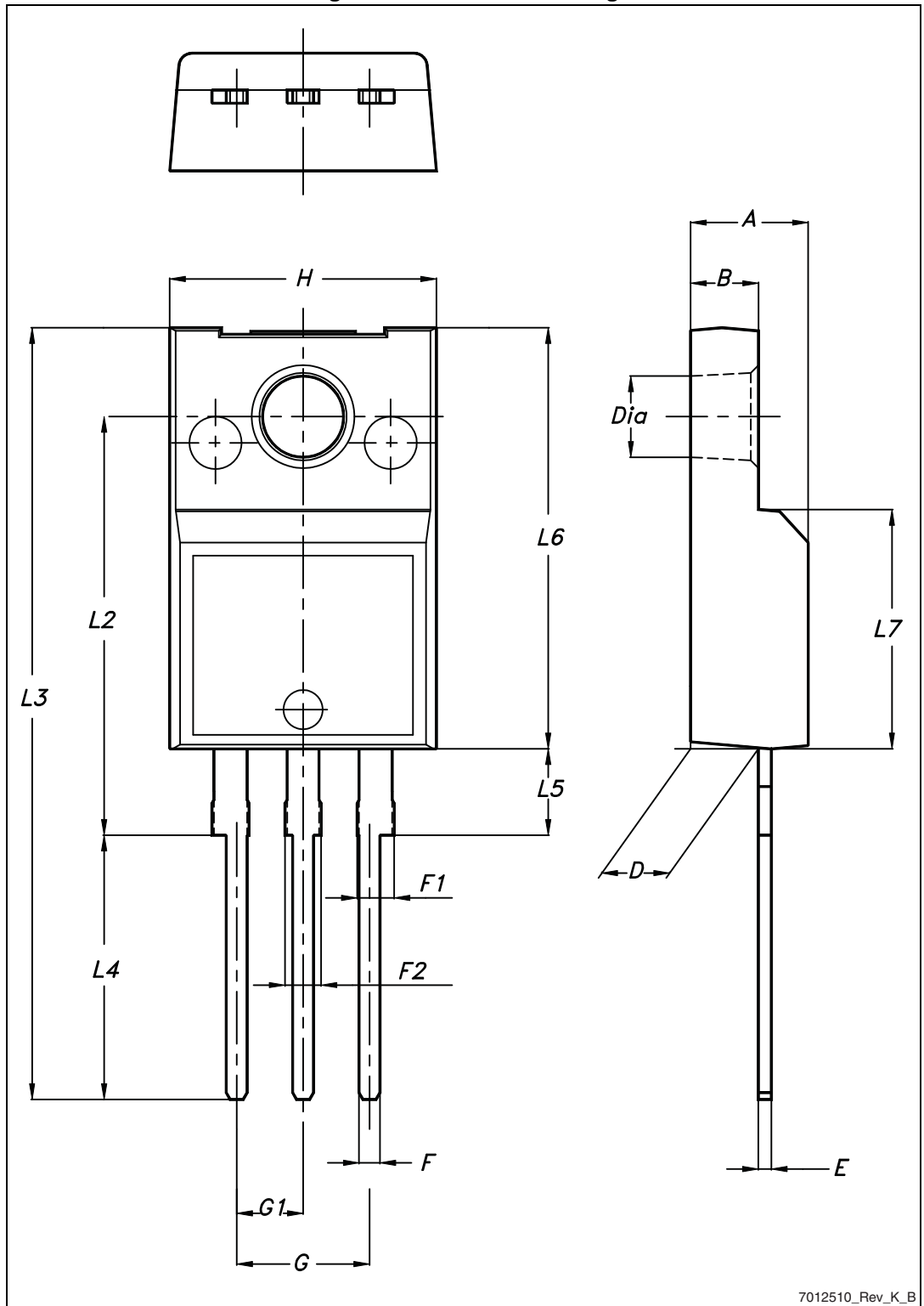


a. All dimensions are in millimeters

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 25. TO-220FP drawing

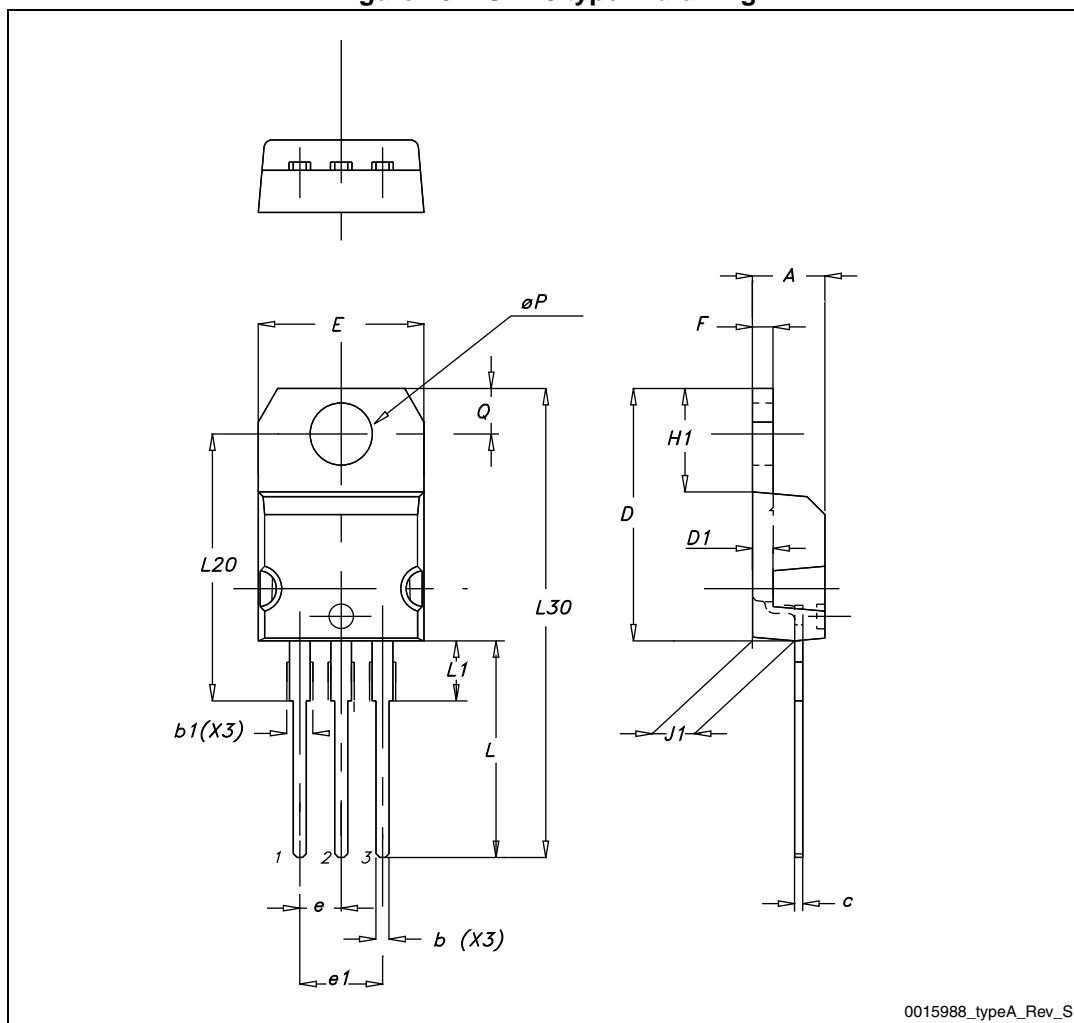


7012510_Rev_K_B

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 | |
| ØP | 3.75 | | 3.85 |
| Q | 2.65 | | 2.95 |

Figure 26. 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 27. Tape for DPAK (TO-252)

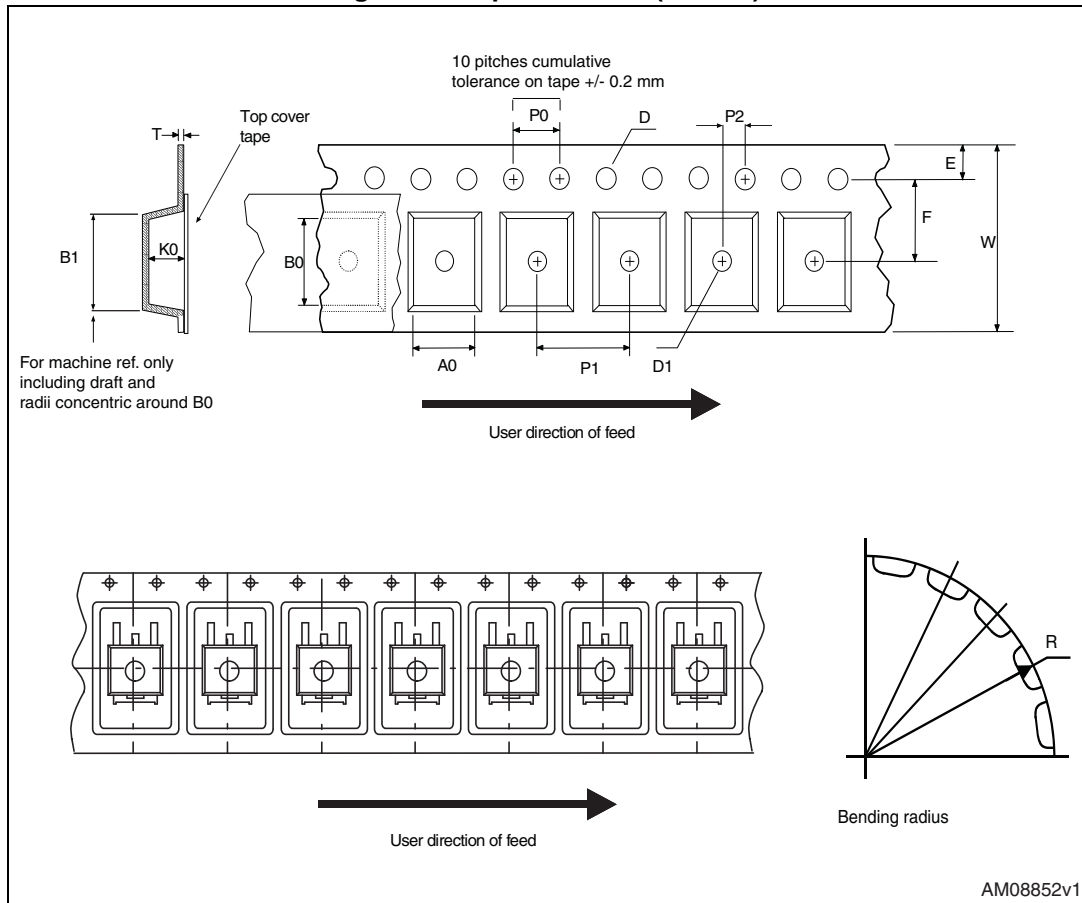
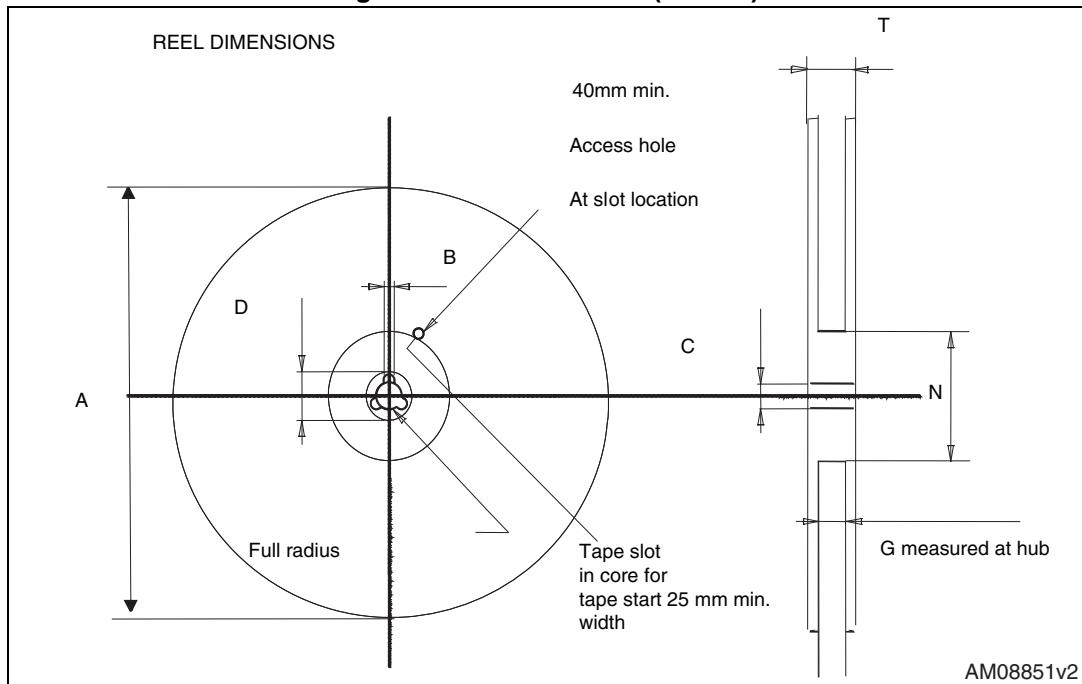


Figure 28. Reel for DPAK (TO-252)



6 Revision history

Table 13. Document revision history

| Date | Revision | Changes |
|-------------|----------|----------------|
| 15-May-2013 | 1 | First release. |

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