

N-channel 950 V, 1 Ω typ., 9 A Zener-protected SuperMESH™ 5 Power MOSFETs in DPAK, TO-220, TO-247 and IPAK packages

Datasheet - production data

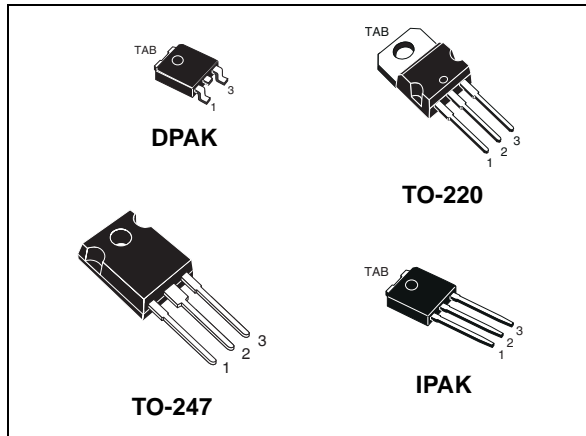
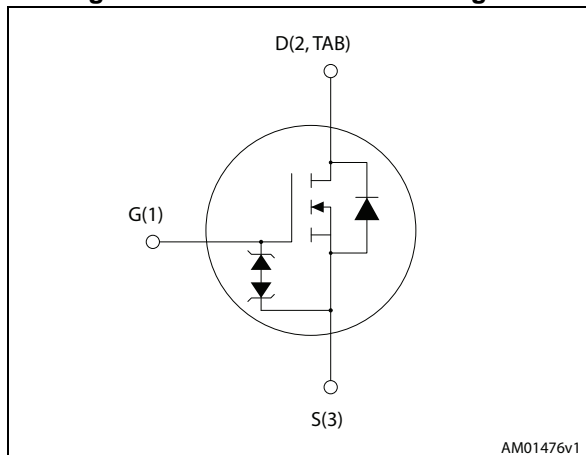


Figure 1. Internal schematic diagram



Features

| Order codes | V_{DS} | $R_{DS(on)}$ max. | I_D | P_{TOT} |
|-------------|----------|-------------------|-------|-----------|
| STD6N95K5 | 950 V | 1.25 Ω | 9 A | 90 W |
| STP6N95K5 | | | | |
| STW6N95K5 | | | | |
| STU6N95K5 | | | | |

- DPAK 950 V 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 MOSFETs 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 | Packages | Packaging |
|-------------|---------|----------|---------------|
| STD6N95K5 | 6N95K5 | DPAK | Tape and reel |
| STP6N95K5 | | TO-220 | Tube |
| STW6N95K5 | | TO-247 | |
| STU6N95K5 | | IPAK | |

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1 Electrical ratings

Table 2. Absolute maximum ratings

| Symbol | Parameter | Value | Unit |
|--------------------|---|-------------|------------------|
| V_{GS} | Gate- source voltage | ± 30 | V |
| I_D | Drain current (continuous) at $T_C = 25\text{ }^\circ\text{C}$ | 9 | A |
| I_D | Drain current (continuous) at $T_C = 100\text{ }^\circ\text{C}$ | 6 | A |
| $I_{DM}^{(1)}$ | Drain current (pulsed) | 36 | A |
| P_{TOT} | Total dissipation at $T_C = 25\text{ }^\circ\text{C}$ | 90 | W |
| $I_{AR}^{(2)}$ | Max current during repetitive or single pulse avalanche | 3 | A |
| E_{AS} | Single pulse avalanche energy (starting $T_J = 25\text{ }^\circ\text{C}$, $I_D=I_{AS}$, $V_{DD}= 50\text{ V}$) | 90 | 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 T_{stg} | Operating junction temperature Storage temperature | - 55 to 150 | $^\circ\text{C}$ |

1. Pulse width limited by safe operating area.
2. Pulse width limited by T_{Jmax} .
3. $I_{SD} \leq 9\text{ A}$, $di/dt \leq 100\text{ A}/\mu\text{s}$, $V_{DS(peak)} \leq V_{(BR)DSS}$
4. $V_{DS} \leq 760\text{ V}$

Table 3. Thermal data

| Symbol | Parameter | Value | | | Unit |
|---------------------|--------------------------------------|--------------|------|--------|---------------------------|
| | | TO-220, IPAK | DPAK | TO-247 | |
| $R_{thj-case}$ | Thermal resistance junction-case max | 1.39 | | | $^\circ\text{C}/\text{W}$ |
| $R_{thj-amb}$ | Thermal resistance junction-amb max | 62.5 | | 50 | $^\circ\text{C}/\text{W}$ |
| $R_{thj-pcb}^{(1)}$ | Thermal resistance junction-pcb max | | 50 | | $^\circ\text{C}/\text{W}$ |

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

2 Electrical characteristics

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

Table 4. On/off states

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---------------|-----------------------------------|--|------|------|----------|---------------|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage | $V_{GS} = 0, I_D = 1\text{ mA}$ | 950 | | | V |
| I_{DSS} | Zero gate voltage drain current | $V_{GS} = 0, V_{DS} = 950\text{ V}$ | | | 1 | μA |
| | | $V_{GS} = 0, V_{DS} = 950\text{ V}, T_C = 125\text{ °C}$ | | | 50 | μA |
| I_{GSS} | Gate body leakage current | $V_{DS} = 0, V_{GS} = \pm 20\text{ V}$ | | | ± 10 | μA |
| $V_{GS(th)}$ | Gate threshold voltage | $V_{DS} = V_{GS}, I_D = 100\text{ }\mu\text{A}$ | 3 | 4 | 5 | V |
| $R_{DS(on)}$ | Static drain-source on-resistance | $V_{GS} = 10\text{ V}, I_D = 3\text{ A}$ | | 1 | 1.25 | Ω |

Table 5. Dynamic

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|-------------------|---------------------------------------|--|------|------|------|----------|
| C_{iss} | Input capacitance | $V_{GS} = 0, V_{DS} = 100\text{ V}, f = 1\text{ MHz}$ | - | 450 | - | pF |
| C_{oss} | Output capacitance | | - | 30 | - | pF |
| C_{rss} | Reverse transfer capacitance | | - | 1.6 | - | pF |
| $C_{o(tr)}^{(1)}$ | Equivalent capacitance time related | $V_{GS} = 0, V_{DS} = 0\text{ to }760\text{ V}$ | - | 45 | - | pF |
| $C_{o(er)}^{(2)}$ | Equivalent capacitance energy related | | - | 19 | - | pF |
| R_G | Intrinsic gate resistance | $f = 1\text{ MHz}, I_D = 0$ | - | 7 | - | Ω |
| Q_g | Total gate charge | $V_{DD} = 760\text{ V}, I_D = 6\text{ A}, V_{GS} = 10\text{ V},$ (see Figure 18) | - | 13 | - | nC |
| Q_{gs} | Gate-source charge | | - | 3 | - | nC |
| Q_{gd} | Gate-drain charge | | - | 7 | - | 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 | $V_{DD} = 475\text{ V}$, $I_D = 3\text{ A}$, $R_G = 4.7\ \Omega$, $V_{GS} = 10\text{ V}$ (see Figure 20) | - | 12 | - | ns |
| t_r | Rise time | | - | 12 | - | ns |
| $t_{d(off)}$ | Turn-off delay time | | - | 33 | - | ns |
| t_f | Fall time | | - | 21 | - | ns |

Table 7. Source drain diode

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|----------------|-------------------------------|---|------|------|------|---------------|
| I_{SD} | Source-drain current | | - | | 9 | A |
| I_{SDM} | Source-drain current (pulsed) | | - | | 36 | A |
| $V_{SD}^{(1)}$ | Forward on voltage | $I_{SD} = 6\text{ A}$, $V_{GS} = 0$ | - | | 1.6 | V |
| t_{rr} | Reverse recovery time | $I_{SD} = 6\text{ A}$, $V_{DD} = 60\text{ V}$ $di/dt = 100\text{ A}/\mu\text{s}$, (see Figure 19) | - | 372 | | ns |
| Q_{rr} | Reverse recovery charge | | - | 4 | | μC |
| I_{RRM} | Reverse recovery current | | - | 22 | | A |
| t_{rr} | Reverse recovery time | $I_{SD} = 6\text{ A}$, $V_{DD} = 60\text{ V}$ $di/dt = 100\text{ A}/\mu\text{s}$, $T_j = 150\text{ }^\circ\text{C}$ (see Figure 19) | - | 522 | | ns |
| Q_{rr} | Reverse recovery charge | | - | 5 | | μC |
| I_{RRM} | Reverse recovery current | | - | 20 | | A |

1. 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 | $I_{GS} = \pm 1\text{ mA}$, $I_D = 0$ | 30 | - | - | V |

The built-in back-to-back Zener diodes have specifically been designed to enhance the device's ESD capability. 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 DPAK and IPAK

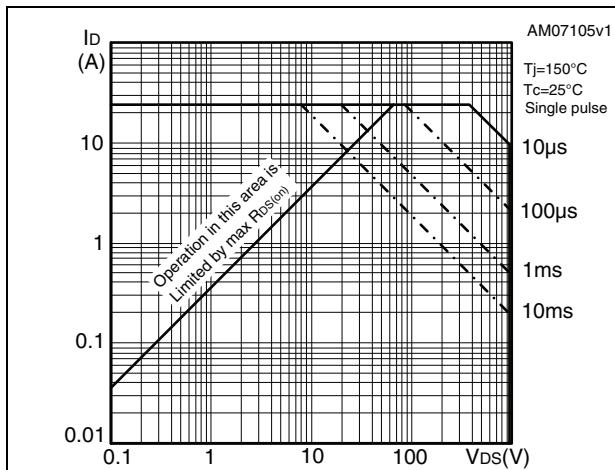


Figure 3. Thermal impedance for DPAK and IPAK

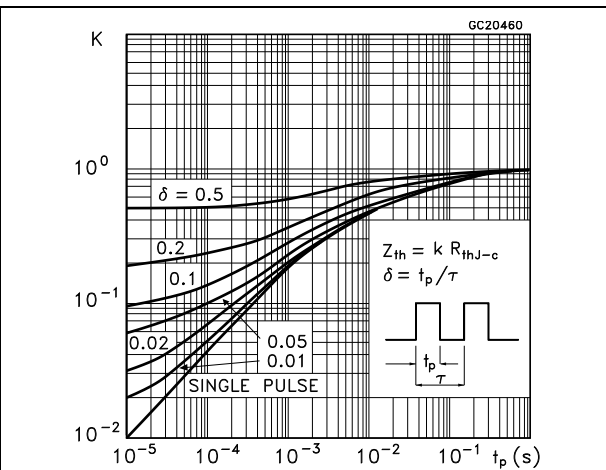


Figure 4. Safe operating area for TO-220 and TO-247

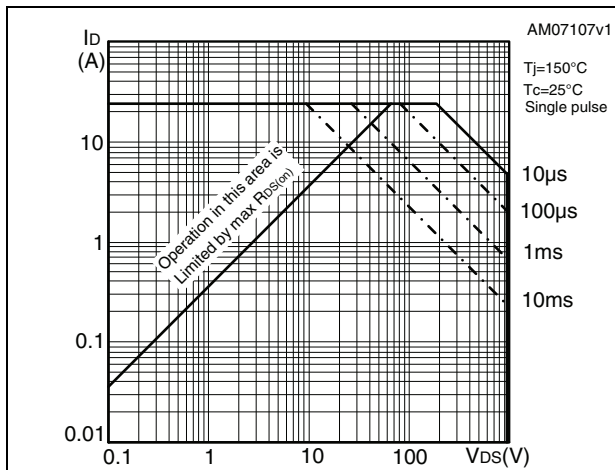


Figure 5. Thermal impedance for TO-220 and TO-247

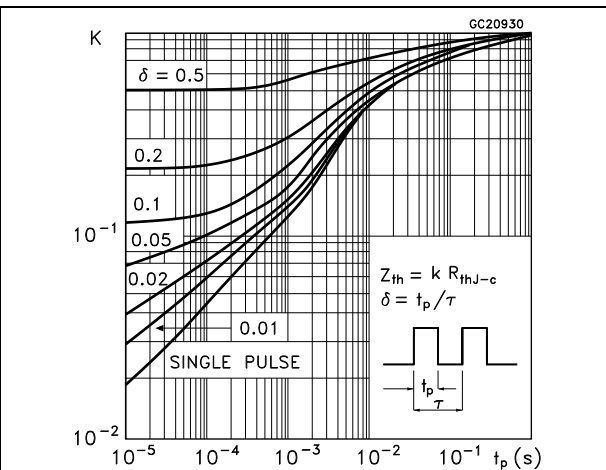


Figure 6. Output characteristics

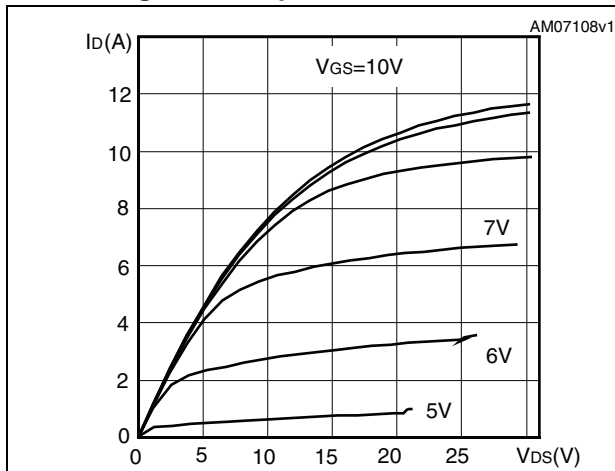


Figure 7. Transfer characteristics

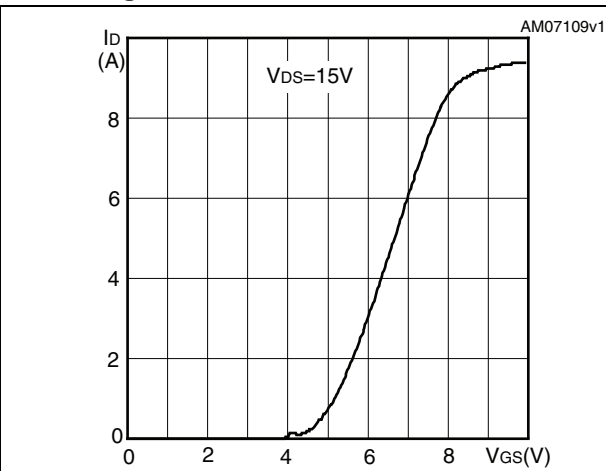


Figure 8. Gate charge vs gate-source voltage

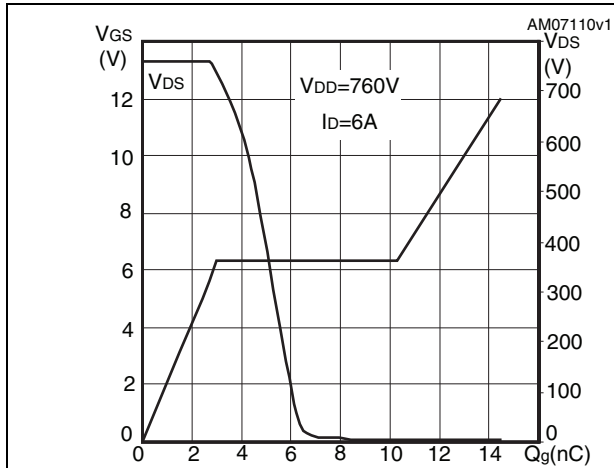


Figure 9. Static drain-source on-resistance

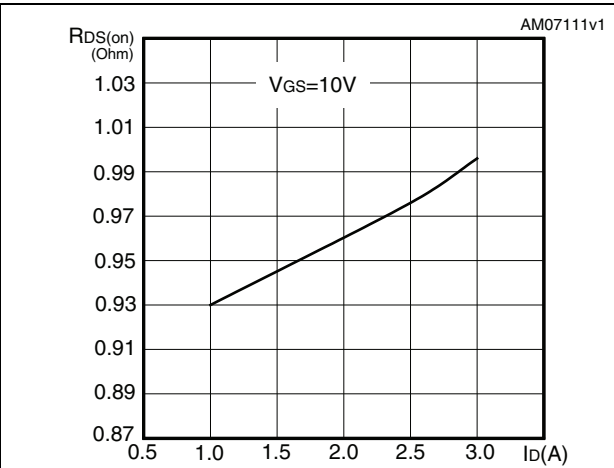


Figure 10. Capacitance variations

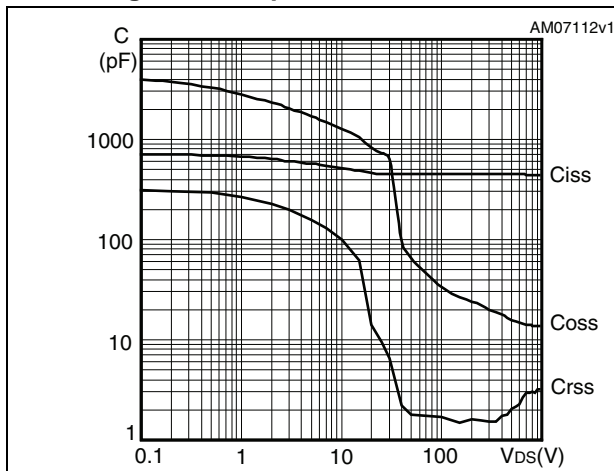


Figure 11. Output capacitance stored energy

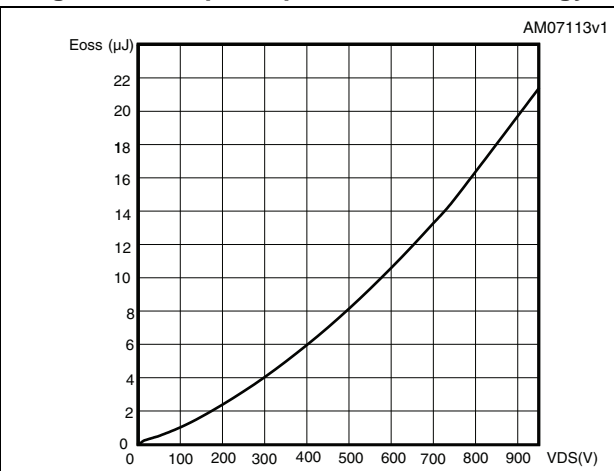


Figure 12. Normalized gate threshold voltage vs temperature

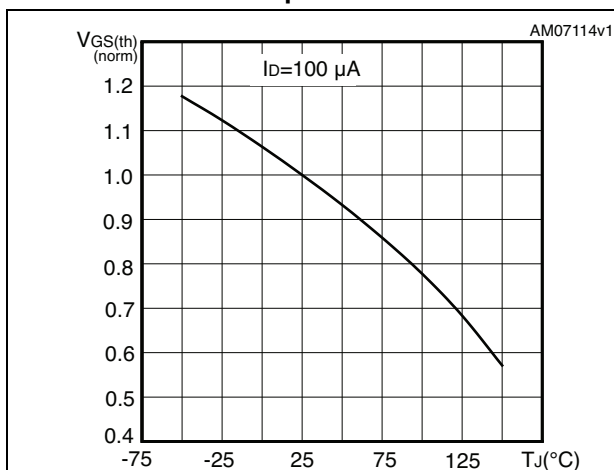


Figure 13. Normalized on-resistance vs temperature

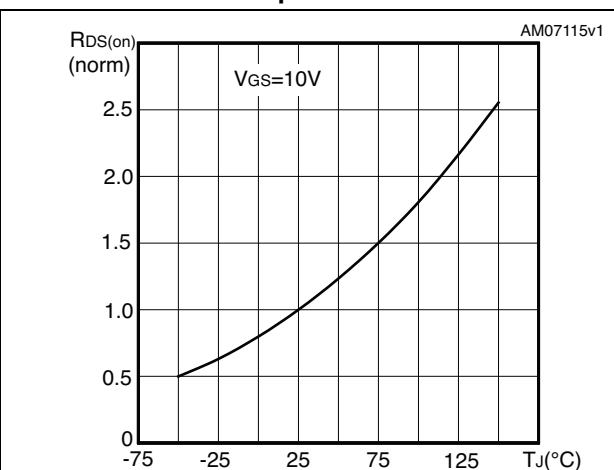


Figure 14. Source-drain diode forward characteristics

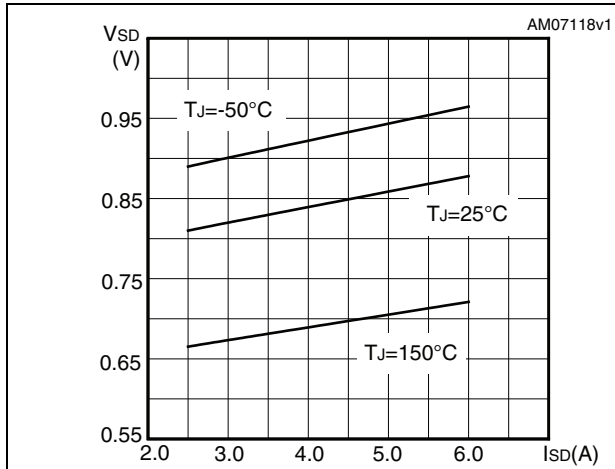


Figure 15. Normalized $V_{(BR)DSS}$ vs temperature

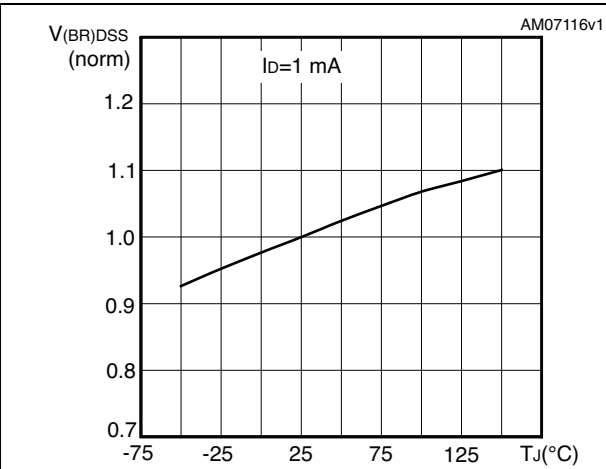
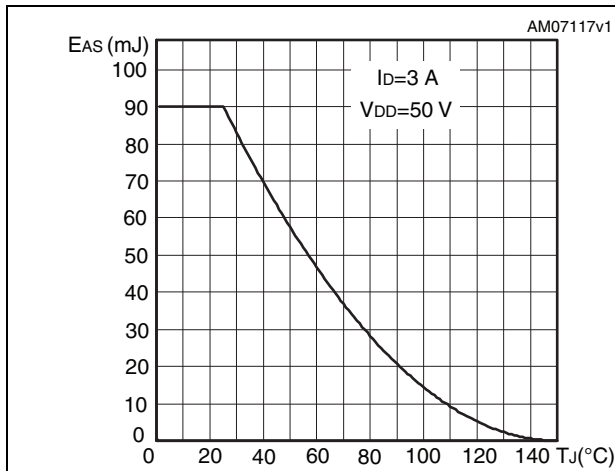


Figure 16. Maximum avalanche energy vs starting T_j



3 Test circuits

Figure 17. Switching times test circuit for resistive load

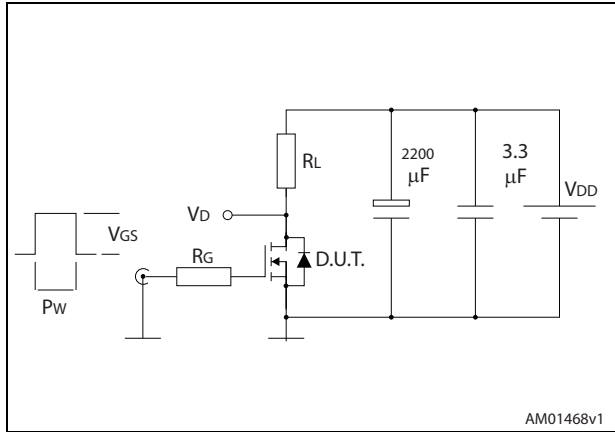


Figure 18. Gate charge test circuit



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

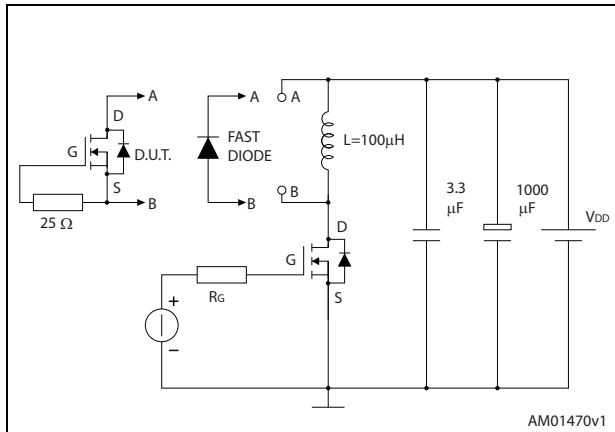


Figure 20. Unclamped inductive load test circuit



Figure 21. Unclamped inductive waveform

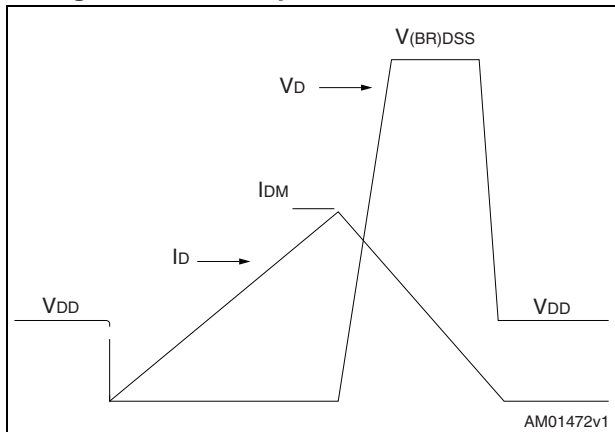


Figure 22. Switching time waveform



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.

4.1 DPAK, STD6N95K5

Figure 23. DPAK (TO-252) type A drawing

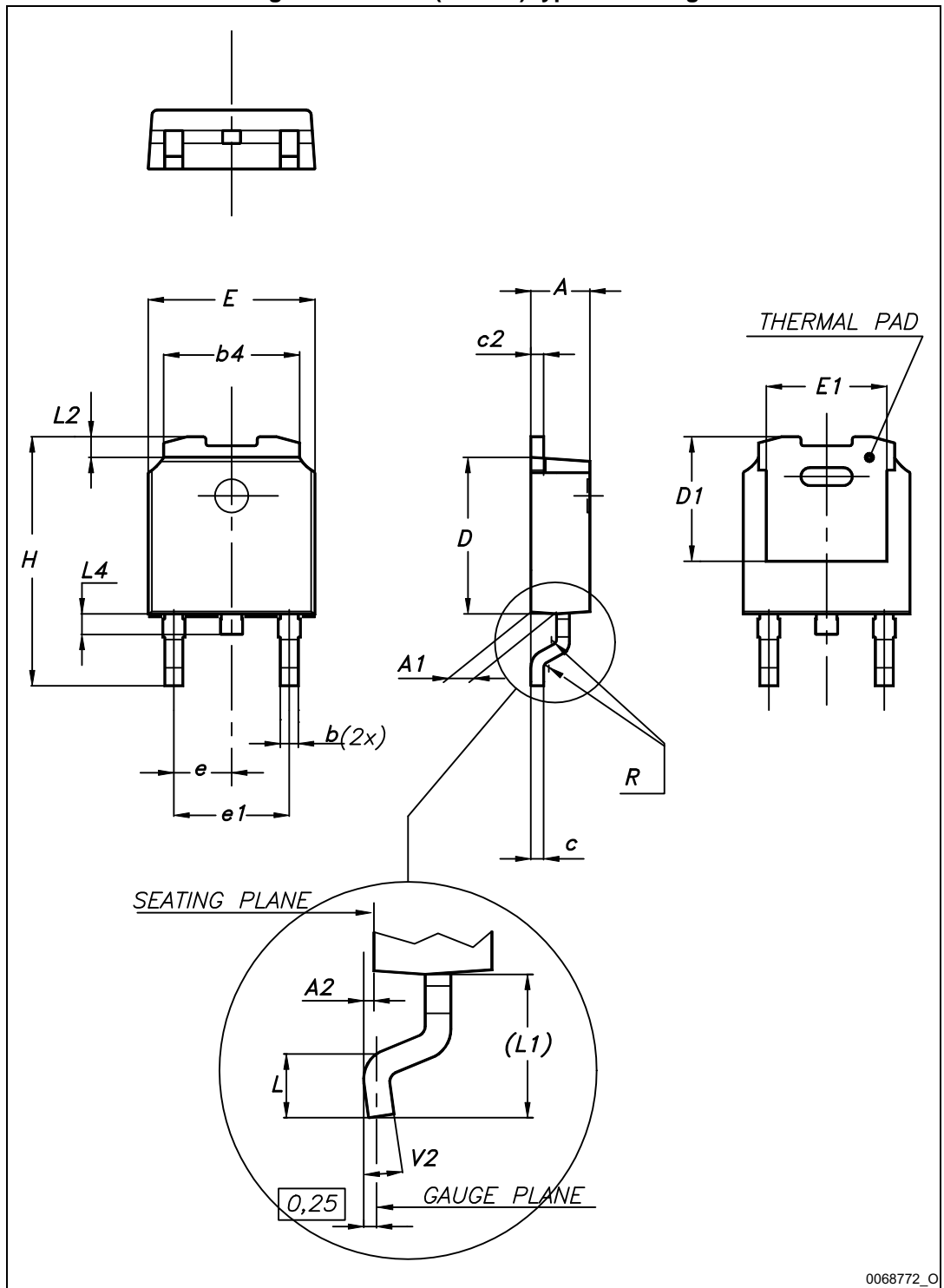
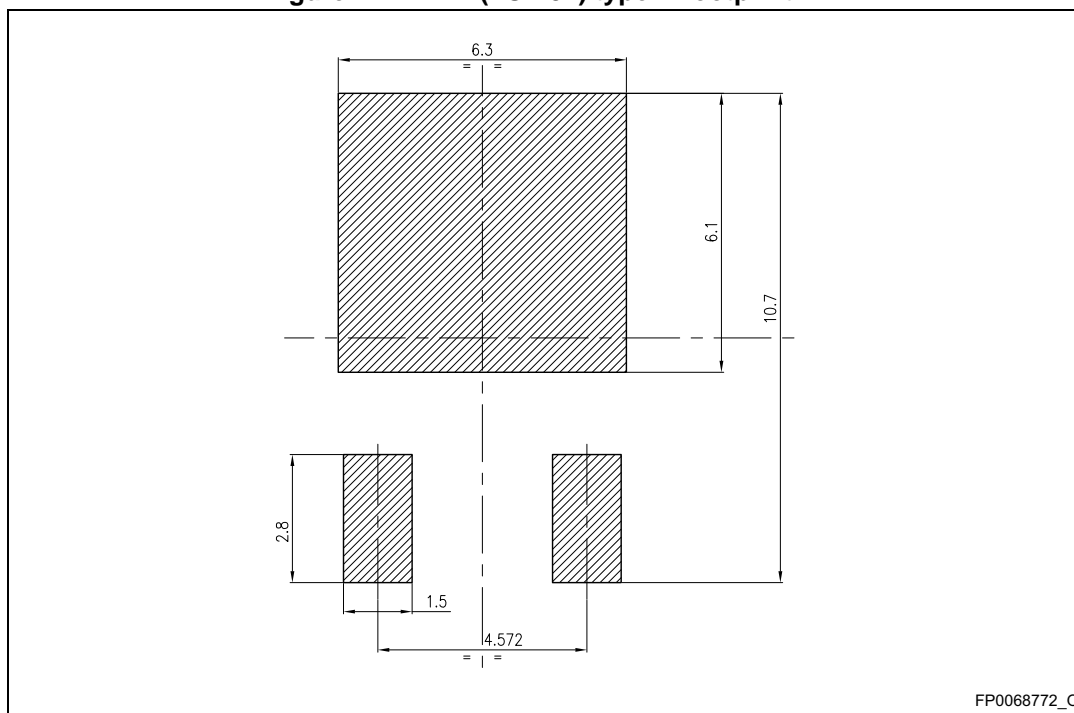


Table 9. DPAK (TO-252) type A mechanical data

| 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 24. DPAK (TO-252) type A footprint (a)



a. All dimensions are in millimeters

4.2 TO-220, STP6N95K5

Figure 25. TO-220 type A drawing

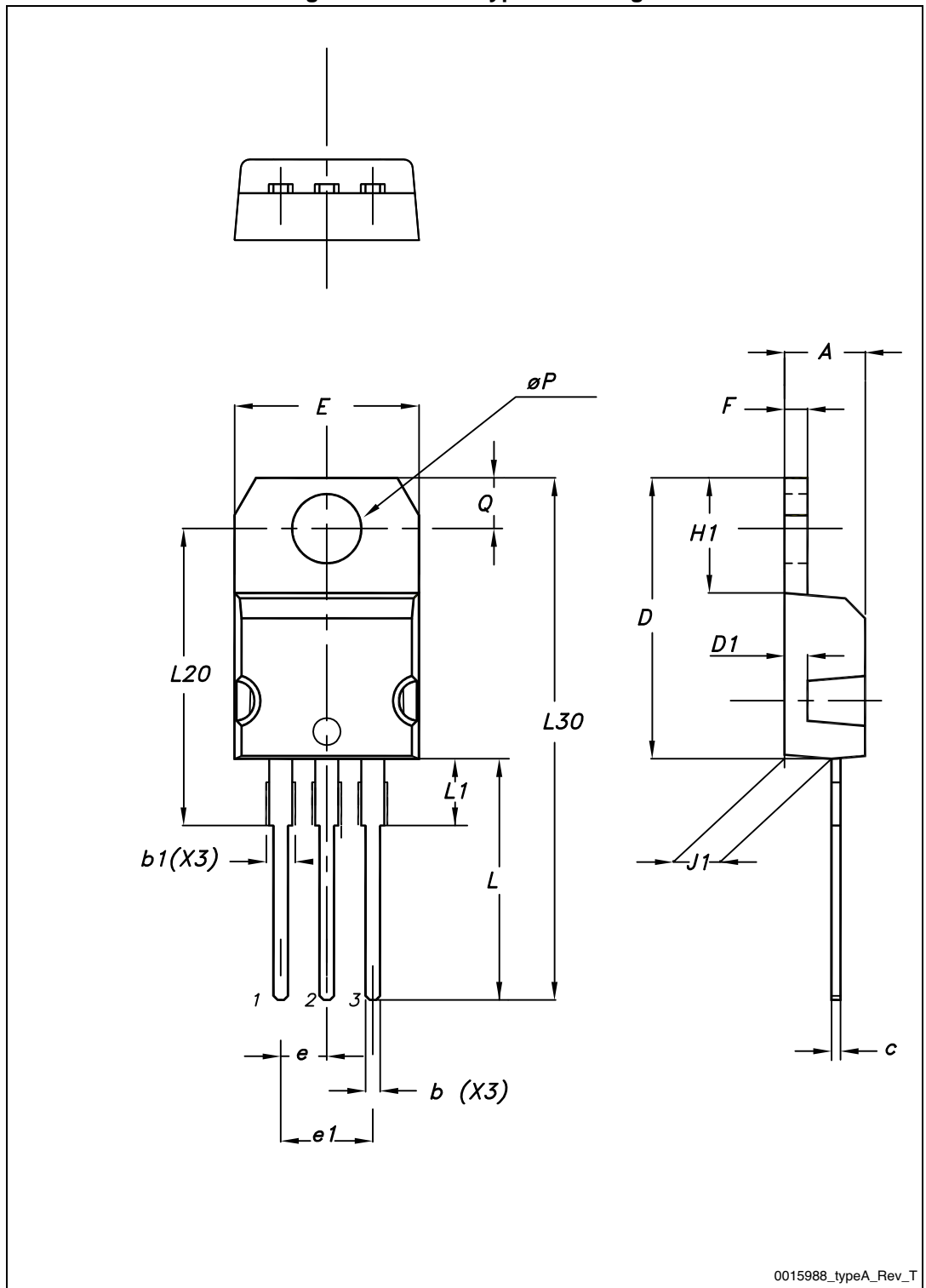


Table 10. TO-220 type A mechanical data

| 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 |

4.3 TO-247, STW6N95K5

Figure 26. TO-247 drawing

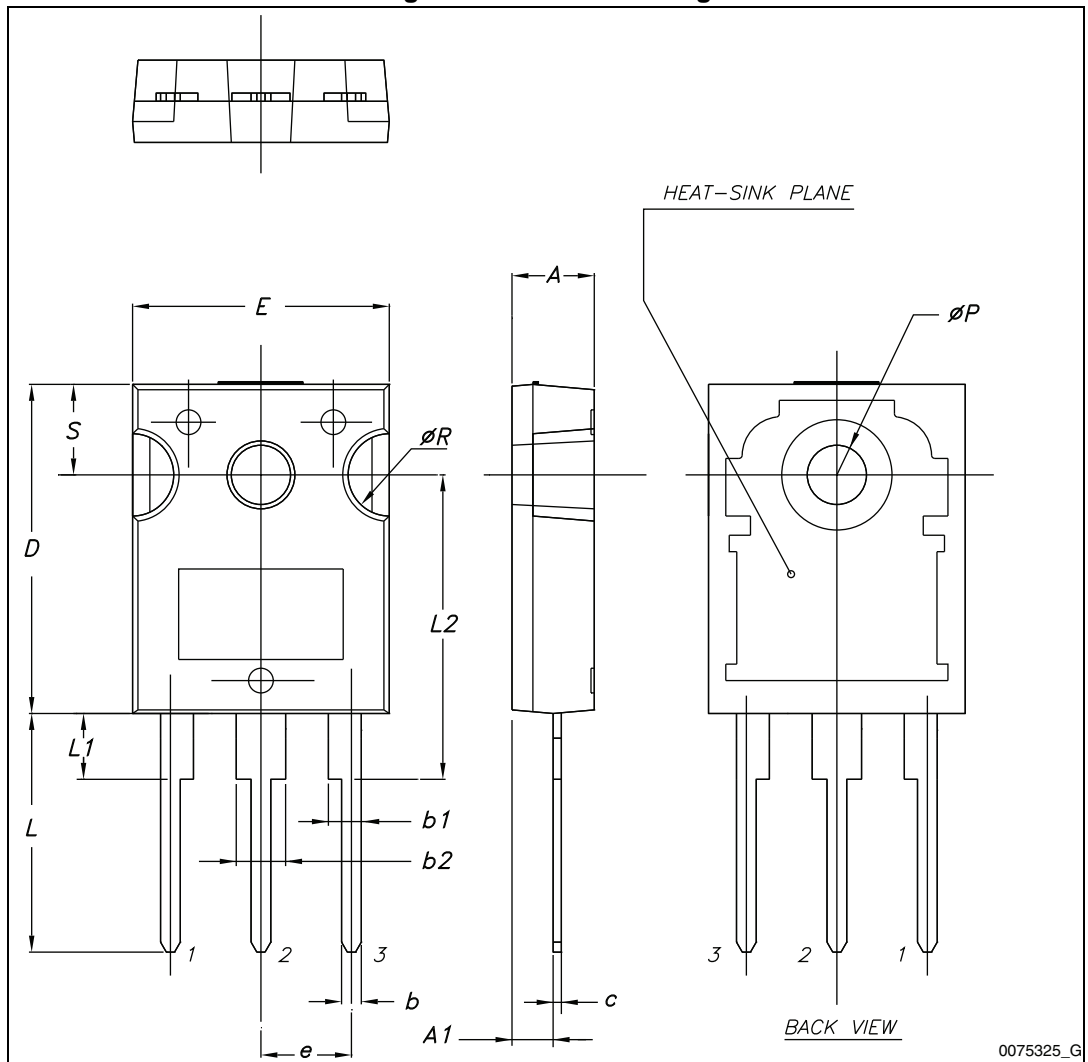


Table 11. TO-247 mechanical data

| 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 | |
| ØP | 3.55 | | 3.65 |
| ØR | 4.50 | | 5.50 |
| S | 5.30 | 5.50 | 5.70 |

4.4 IPAK, STU6N95K5

Figure 27. IPAK (TO-251) drawing

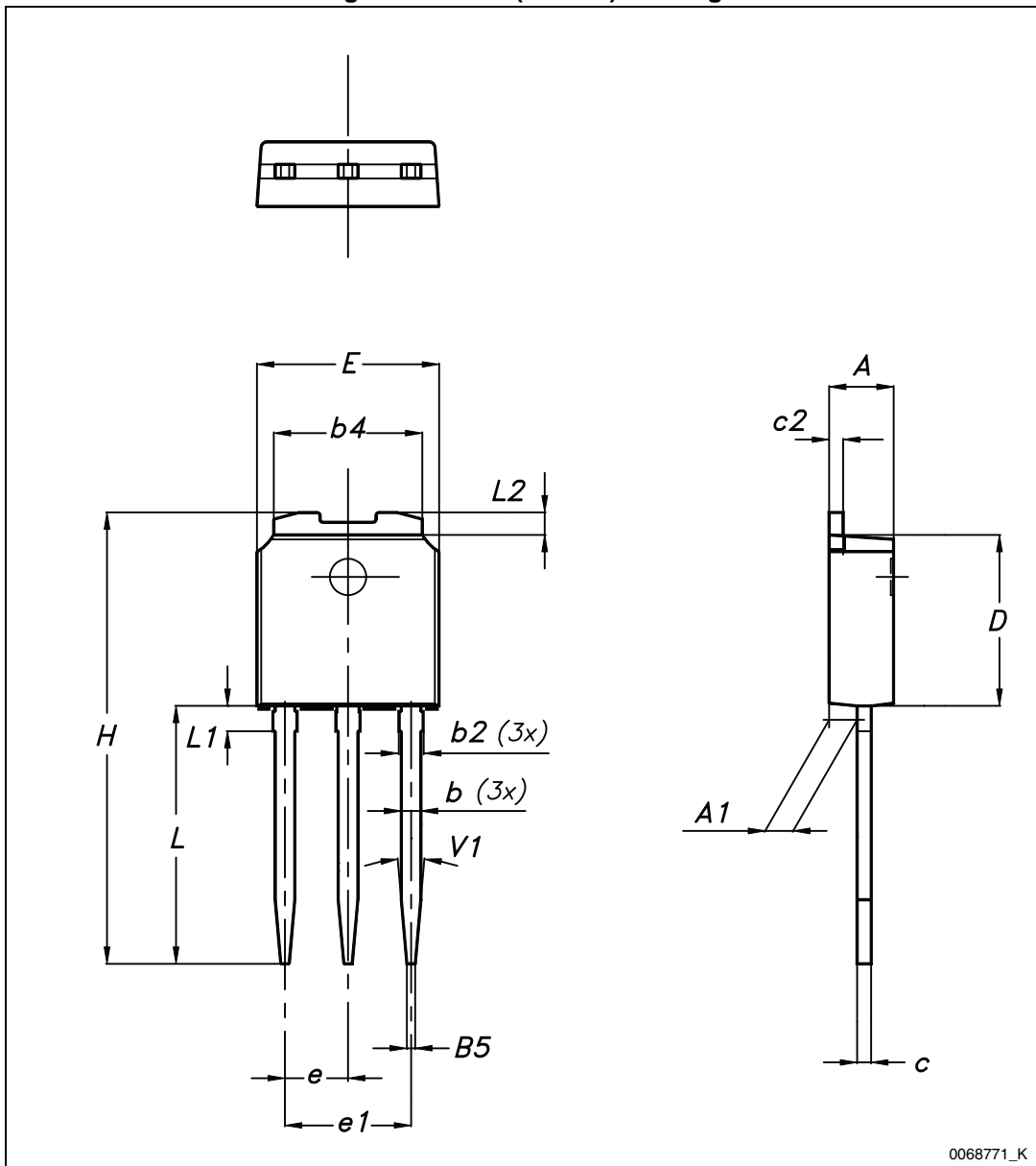


Table 12. IPAK (TO-251) mechanical data

| 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 mechanical data

Figure 28. Tape for DPAK (TO-252)

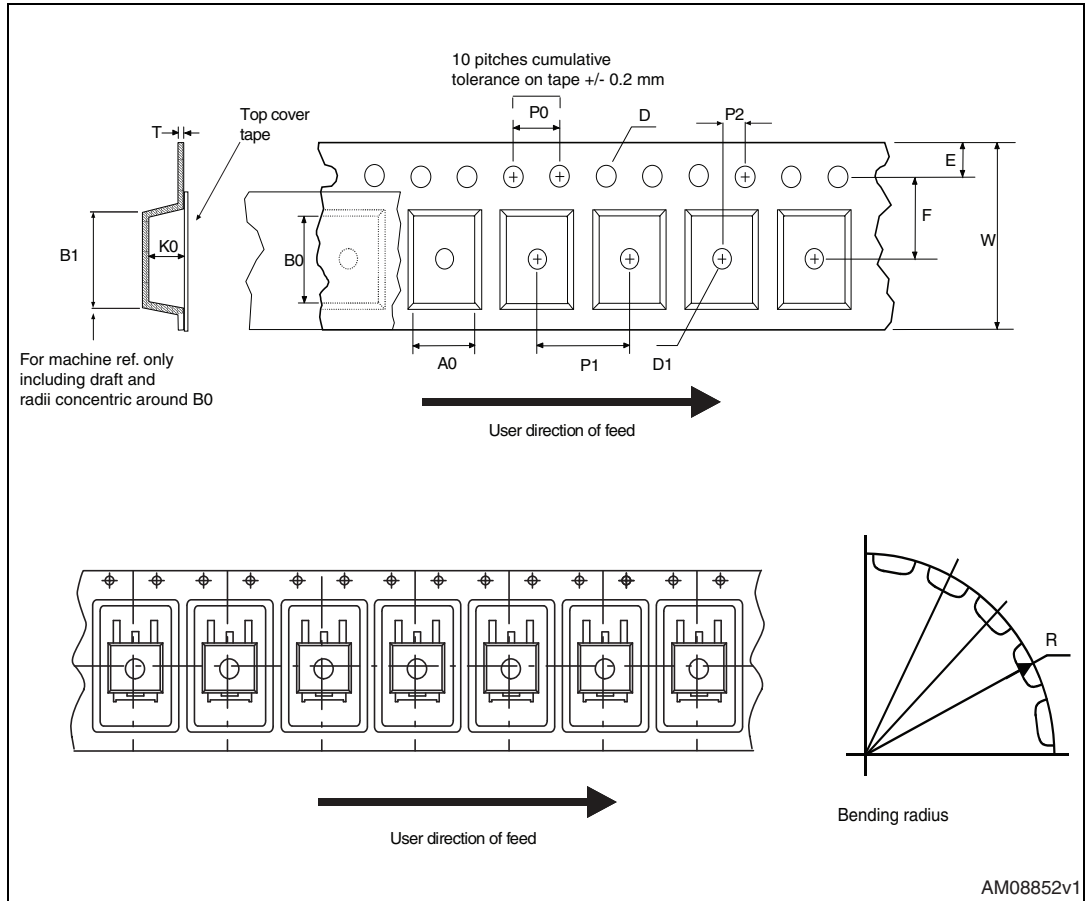


Figure 29. Reel for DPAK (TO-252)

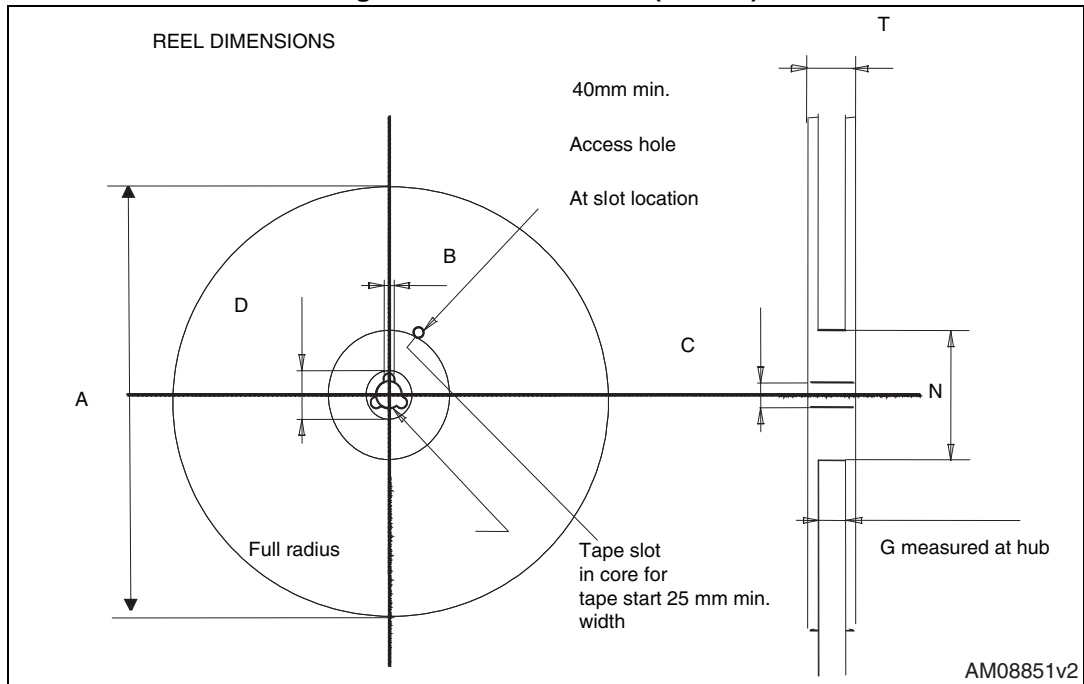


Table 13. DPAK (TO-252) tape and reel mechanical data

| 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 | | | |

6 Revision history

Table 14. Document revision history

| Date | Revision | Changes |
|-------------|----------|---|
| 12-Jan-2010 | 1 | First release. |
| 01-Jul-2010 | 2 | Document status promoted from preliminary data to datasheet. |
| 31-Aug-2012 | 3 | Inserted new device in IPAK. Updated Table 1: Device summary , Table 2: Absolute maximum ratings , and Table 3: Thermal data . Updated Section 4: Package mechanical data and Section 5: Packaging mechanical data . Minor text changes in the cover page. |
| 16-May-2014 | 4 | <ul style="list-style-type: none">– The part number STF6N95K5 has been moved to a separate datasheet– Added: MOSFET dv/dt ruggedness parameter in Table 2– Updated: Section 4: Package mechanical data– Minor text changes |

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