



STB4NK60Z, STB4NK60Z-1, STD4NK60Z STD4NK60Z-1, STP4NK60Z, STP4NK60ZFP

N-channel 600 V, 1.76 Ω 4 A SuperMESH™ Power MOSFET
in DPAK, D²PAK, IPAK, I²PAK, TO-220, TO-220FP

Features

| Type | V _{DSS} | R _{DS(on)} max | P _W | I _D |
|-------------|------------------|----------------------------|----------------|----------------|
| STB4NK60Z | 600 V | < 2 Ω | 70 W | 4 A |
| STB4NK60Z-1 | 600 V | < 2 Ω | 70 W | 4 A |
| STD4NK60Z | 600 V | < 2 Ω | 70 W | 4 A |
| STD4NK60Z-1 | 600 V | < 2 Ω | 70 W | 4 A |
| STP4NK60Z | 600 V | < 2 Ω | 70 W | 4 A |
| STP4NK60ZFP | 600 V | < 2 Ω | 25 W | 4 A |

- 100% avalanche tested
- Very low intrinsic capacitances

Applications

- Switching applications

Description

These devices are N-channel Zener-protected Power MOSFETs developed using STMicroelectronics' SuperMESH™ technology, achieved through optimization of ST's well established strip-based PowerMESH™ layout. In addition to a significant reduction in on-resistance, this device is designed to ensure a high level of dv/dt capability for the most demanding applications.

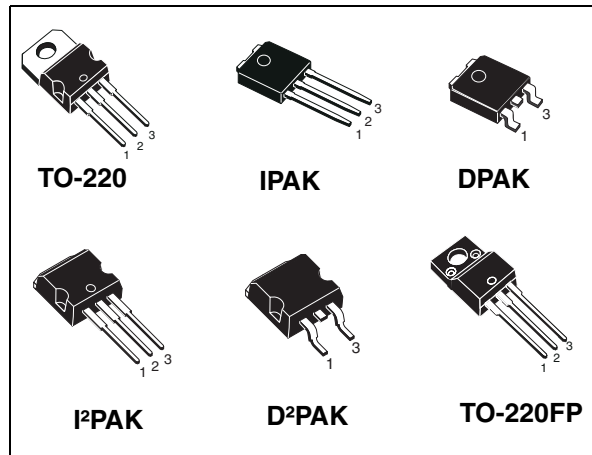


Figure 1. Internal schematic diagram

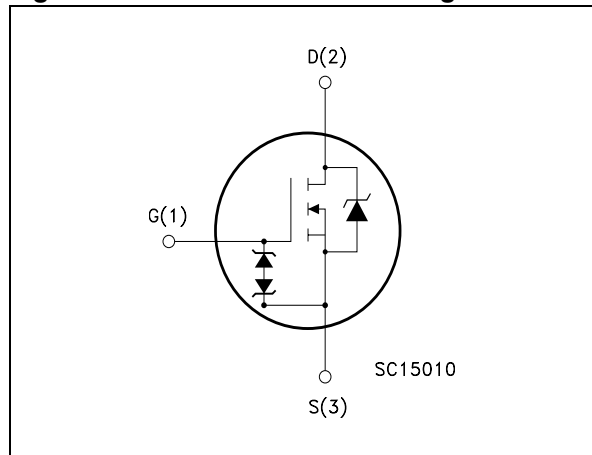


Table 1. Device summary

| Order codes | Marking | Package | Packaging |
|-------------|-----------|--------------------|---------------|
| STB4NK60Z | B4NK60Z | D ² PAK | Tape and reel |
| STB4NK60Z-1 | B4NK60Z | I ² PAK | Tube |
| STD4NK60Z | D4NK60Z | DPAK | Tape and reel |
| STD4NK60Z-1 | D4NK60Z | IPAK | Tube |
| STP4NK60Z | P4NK60Z | TO-220 | Tube |
| STP4NK60ZFP | P4NK60ZFP | TO-220FP | Tube |

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1 Electrical ratings

Table 2. Absolute maximum ratings

| Symbol | Parameter | Value | | Unit |
|--------------------------------|---|---|--------------------|------|
| | | TO-220 - D ² PAK DPAK-IPAK-I ² PAK | TO-220FP | |
| V _{DS} | Drain-source voltage (V _{GS} = 0) | 600 | | V |
| V _{GS} | Gate- source voltage | ± 30 | | V |
| I _D | Drain current (continuous) at T _C = 25 °C | 4 | 4 ⁽¹⁾ | A |
| I _D | Drain current (continuous) at T _C = 100 °C | 2.5 | 2.5 ⁽¹⁾ | A |
| I _{DM} ⁽²⁾ | Drain current (pulsed) | 16 | 16 ⁽¹⁾ | A |
| P _{TOT} | Total dissipation at T _C = 25 °C | 70 | 25 | W |
| | Derating factor | 0.56 | 0.2 | W/°C |
| V _{ESD(G-S)} | Gate source ESD(HBM-C=100 pF, R=1.5 kΩ) | 3000 | | V |
| dv/dt ⁽³⁾ | Peak diode recovery voltage slope | 4.5 | | 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 _{stg} | Storage temperature | -55 to 150 | | °C |
| T _j | Max operating junction temperature | 150 | | °C |

1. Limited only by maximum temperature allowed
2. Pulse width limited by safe operating area
3. I_{SD} ≤ 4 A, di/dt ≤ 200 A/μs, V_{DD} ≤ V_{(BR)DSS}, T_J ≤ T_{JMAX}.

Table 3. Thermal data

| Symbol | Parameter | Value | | | Unit |
|-----------------------|--|--|--------------|----------|------|
| | | TO-220 D ² PAK I ² PAK | DPAK IPAK | TO-220FP | |
| R _{thj-case} | Thermal resistance junction-case max | 1.78 | | 5 | °C/W |
| R _{thj-amb} | Thermal resistance junction-ambient max | 62.5 | 100 | 62.5 | °C/W |
| T _l | Maximum lead temperature for soldering purpose | 300 | | | °C |

Table 4. Avalanche characteristics

| Symbol | Parameter | Value | Unit |
|----------|---|-------|------|
| I_{AR} | Avalanche current, repetitive or not-repetitive (pulse width limited by T_J Max) | 4 | A |
| E_{AS} | Single pulse avalanche energy (starting $T_J = 25\text{ °C}$, $I_D = I_{AR}$, $V_{DD} = 50\text{ V}$) | 120 | mJ |

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 ($V_{GS} = 0$) | $V_{DS} = \text{Max rating}$ $V_{DS} = \text{Max rating}$, $T_C = 125\text{ °C}$ | | | 1 50 | μA μA |
| I_{GSS} | Gate-body leakage current ($V_{DS} = 0$) | $V_{GS} = \pm 20\text{ V}$ | | | ± 10 | μA |
| $V_{GS(th)}$ | Gate threshold voltage | $V_{DS} = V_{GS}$, $I_D = 50\text{ }\mu\text{A}$ | 3 | 3.75 | 4.5 | V |
| $R_{DS(on)}$ | Static drain-source on resistance | $V_{GS} = 10\text{ V}$, $I_D = 2\text{ A}$ | | 1.76 | 2 | Ω |

Table 6. Dynamic

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|----------------------------|-------------------------------|--|------|------|------|------|
| $g_{fs}^{(1)}$ | Forward transconductance | $V_{DS} = 15\text{ V}$, $I_D = 2\text{ A}$ | | 3 | | S |
| C_{iss} | Input capacitance | $V_{DS} = 25\text{ V}$, $f = 1\text{ MHz}$, $V_{GS} = 0$ | | 510 | | pF |
| C_{oss} | Output capacitance | | | 67 | | pF |
| C_{rss} | Reverse transfer capacitance | | | 13 | | pF |
| $C_{oss\text{ eq.}}^{(2)}$ | Equivalent output capacitance | $V_{DS} = 0$, $V_{DS} = 0$ to 480 V | | 38.5 | | pF |
| $t_{d(on)}$ | Turn-on delay time | $V_{DD} = 300\text{ V}$, $I_D = 2\text{ A}$, $R_G = 4.7\text{ }\Omega$, $V_{GS} = 10\text{ V}$ (see Figure 17) | | 12 | | ns |
| t_r | Rise time | | | 9.5 | | ns |
| $t_{d(off)}$ | Turn-off delay time | | | 29 | | ns |
| t_f | Fall time | | | 16.5 | | ns |
| $t_{r(Voff)}$ | Off-voltage rise time | $V_{DD} = 480\text{ V}$, $I_D = 4\text{ A}$, $R_G = 4.7\text{ }\Omega$, $V_{GS} = 10\text{ V}$ (see Figure 19) | | 12 | | ns |
| t_f | Fall time | | | 12 | | ns |
| t_c | Cross-over time | | | 19.5 | | ns |
| Q_g | Total gate charge | $V_{DD} = 480\text{ V}$, $I_D = 4\text{ A}$, $V_{GS} = 10\text{ V}$ (see Figure 18) | | 18.8 | 26 | nC |
| Q_{gs} | Gate-source charge | | | 3.8 | | nC |
| Q_{gd} | Gate-drain charge | | | 9.8 | | nC |

1. Pulsed: pulse duration=300 μs , duty cycle 1.5%

2. $C_{oss\text{ eq.}}$ 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. Source drain diode

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|-----------------|-------------------------------|---|------|------|------|------|
| I_{SD} | Source-drain current | | | | 4 | A |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) | | | | 16 | A |
| $V_{SD}^{(2)}$ | Forward on voltage | $I_{SD} = 4 \text{ A}, V_{GS} = 0$ | | | 1.6 | V |
| t_{rr} | Reverse recovery time | $I_{SD} = 4 \text{ A}, di/dt = 100 \text{ A}/\mu\text{s}$ | | 400 | | ns |
| Q_{rr} | Reverse recovery charge | $V_{DD} = 24 \text{ V}, T_j = 150 \text{ }^\circ\text{C}$ | | 1700 | | nC |
| I_{RRM} | Reverse recovery current | (see Figure 19) | | 8.5 | | A |

1. Pulsed: pulse duration = 300 μs , duty cycle 1.5%

2. Pulse width limited by safe operating area

Table 8. Gate-source Zener diode

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|------------|-------------------------------|--|------|------|------|------|
| BV_{GSO} | Gate-source breakdown voltage | $I_{gs} = \pm 1 \text{ mA}$ (open drain) | 30 | | | V |

The built-in back-to-back Zener diodes have specifically been designed to enhance not only the device's ESD capability, but also to make them safely absorb possible voltage transients that may occasionally be applied from gate to source. 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 TO-220 / DPAK / IPAK / D²PAK / I²PAK

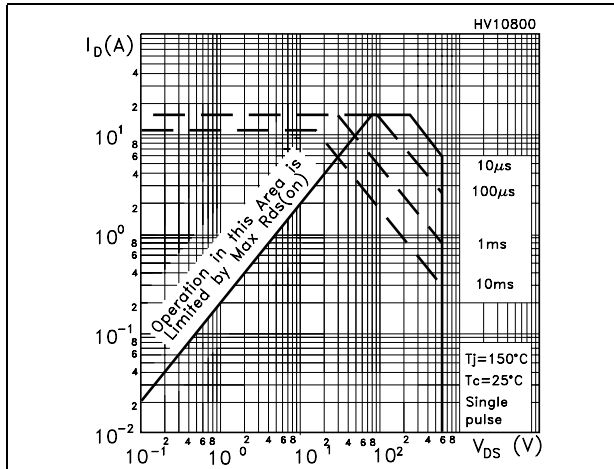


Figure 3. Thermal impedance for TO-220 / DPAK / IPAK / D²PAK / I²PAK

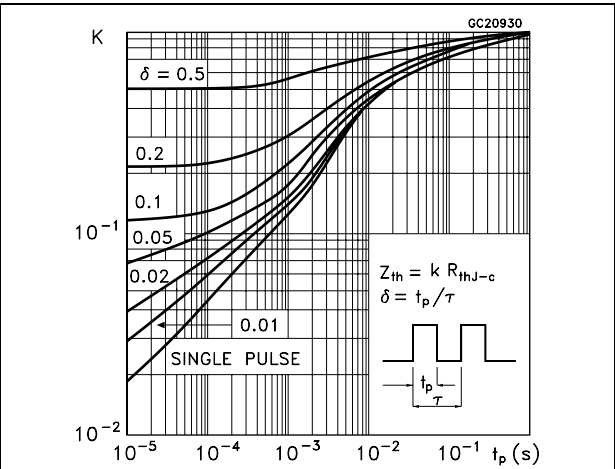


Figure 4. Safe operating area for TO-220FP

Figure 5. Thermal impedance for TO-220FP

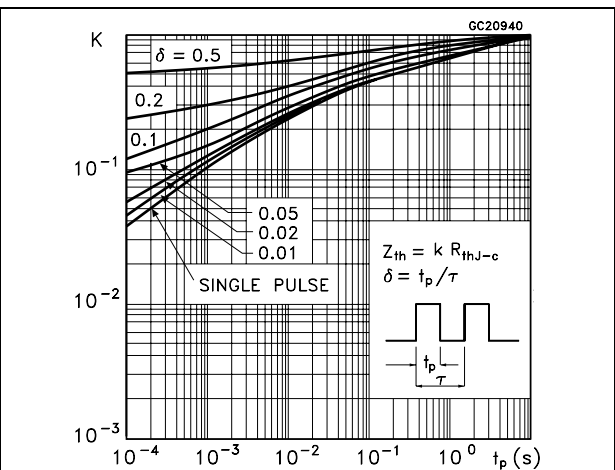
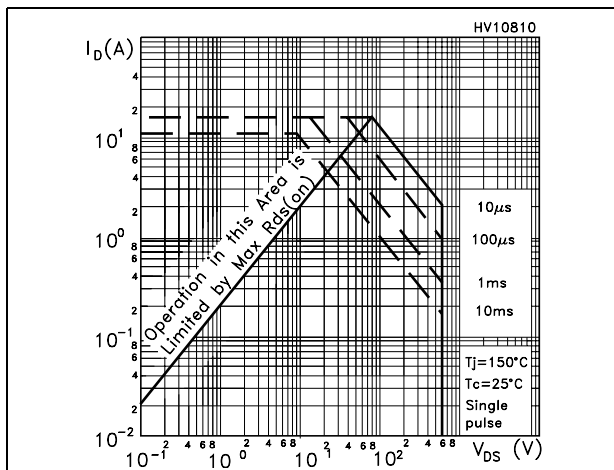


Figure 6. Output characteristics

Figure 7. Transfer characteristics

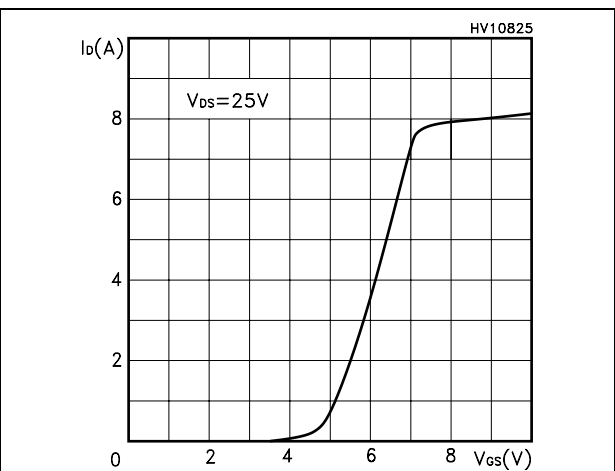
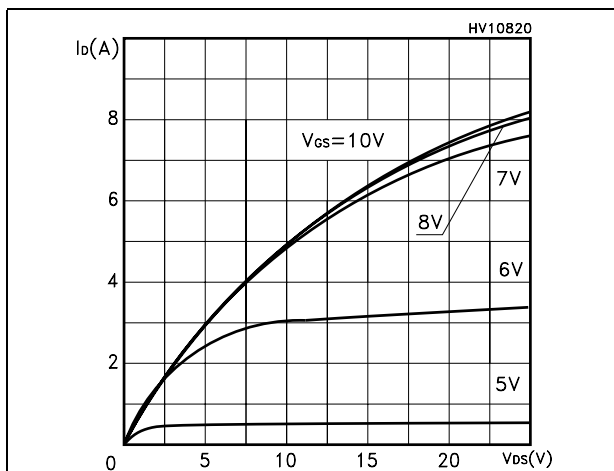


Figure 8. Transconductance

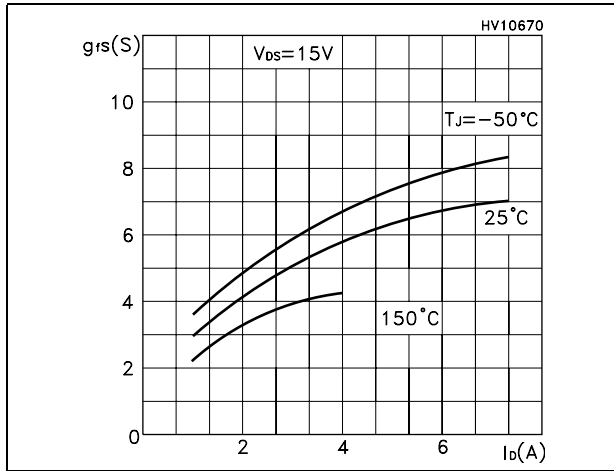


Figure 9. Static drain-source on resistance

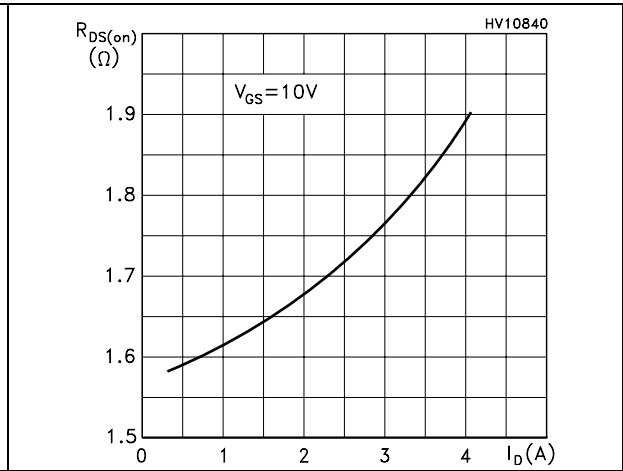


Figure 10. Gate charge vs gate-source voltage

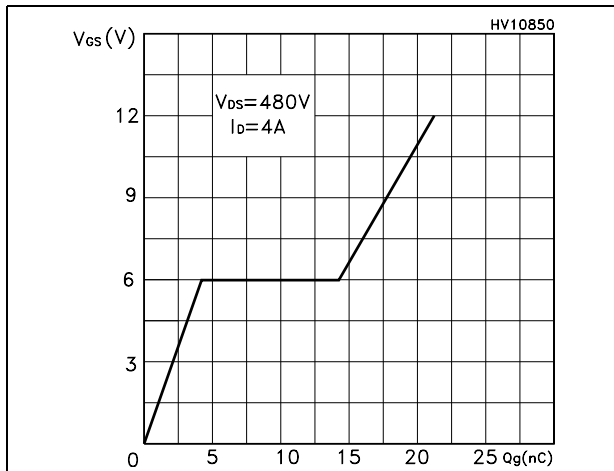


Figure 11. Capacitance variations

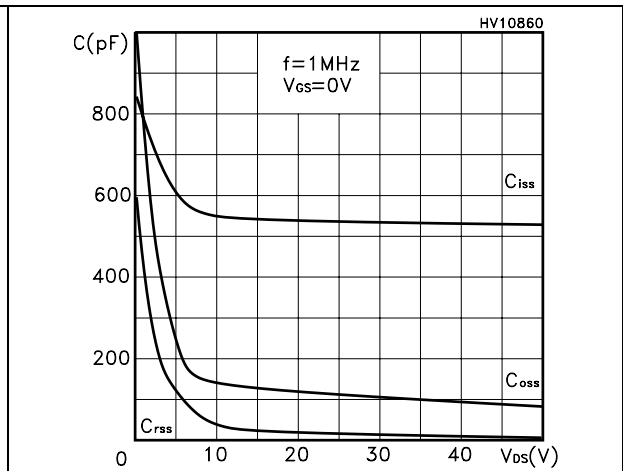


Figure 12. Normalized gate threshold voltage vs temperature

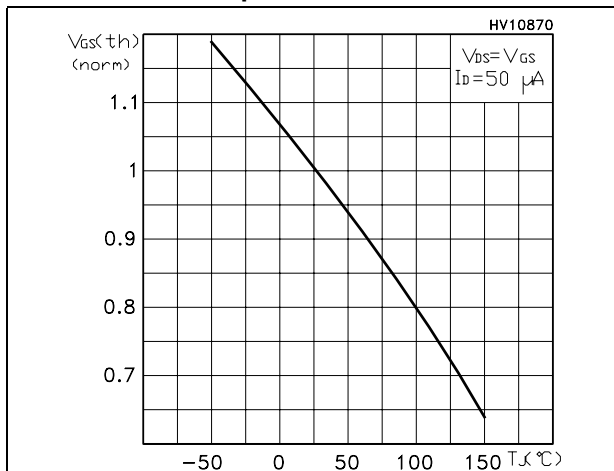


Figure 13. Normalized B_{VDS} vs temperature

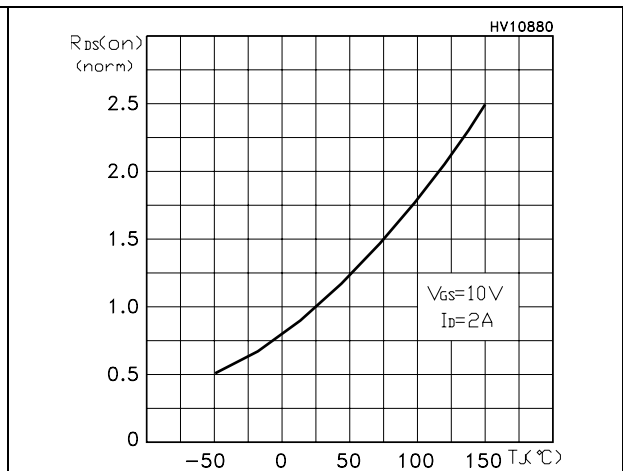


Figure 14. Normalized on resistance vs temperature

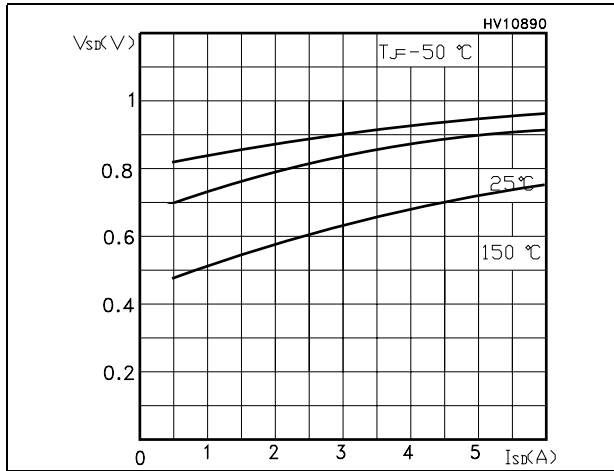


Figure 15. Source-drain diode forward characteristic

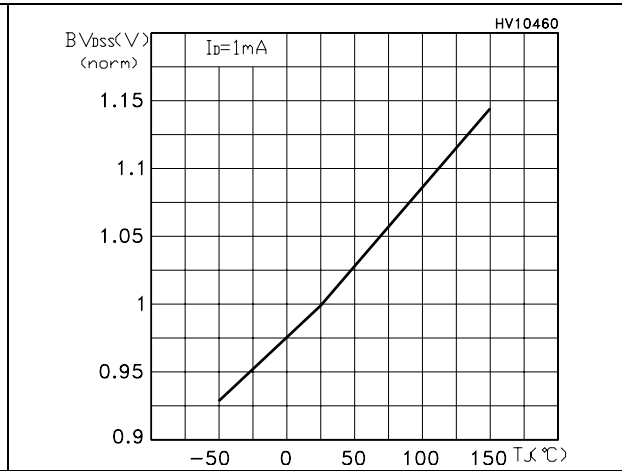
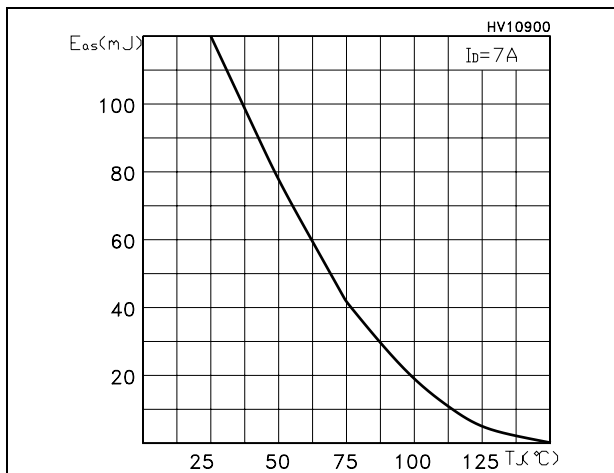


Figure 16. Avalanche energy vs temperature



3 Test circuits

Figure 17. Switching times test circuit for resistive load

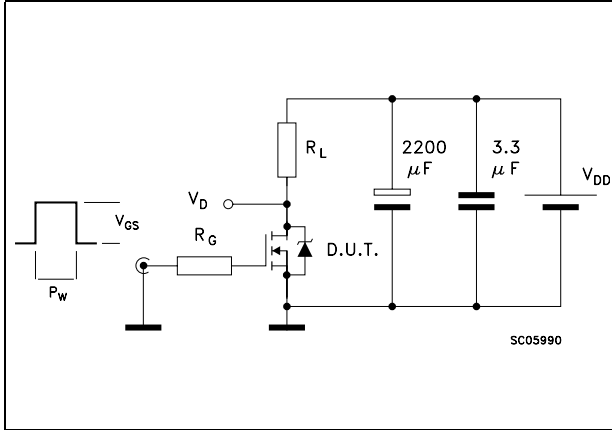


Figure 18. Gate charge test circuit

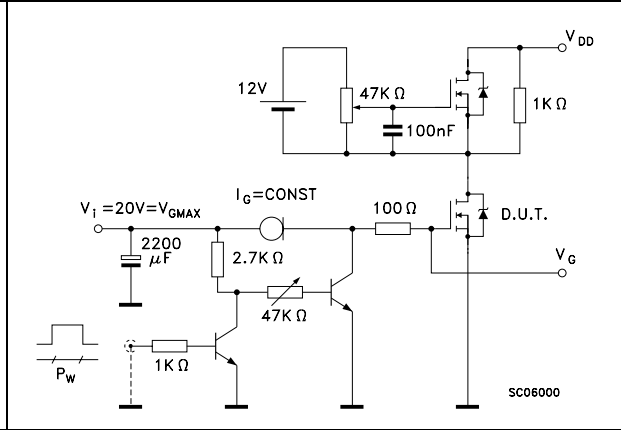


Figure 19. Test circuit for inductive load switching and diode recovery times

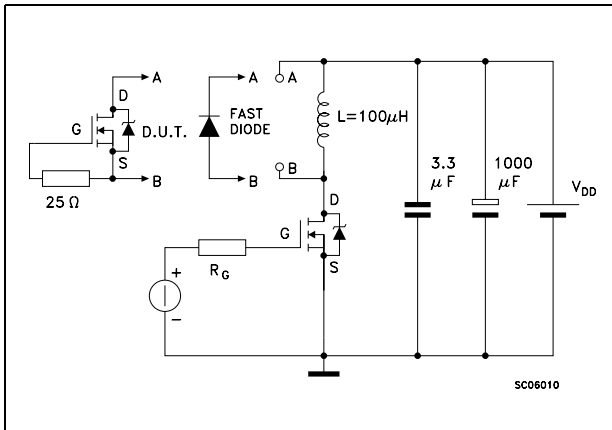


Figure 20. Unclamped inductive load test circuit

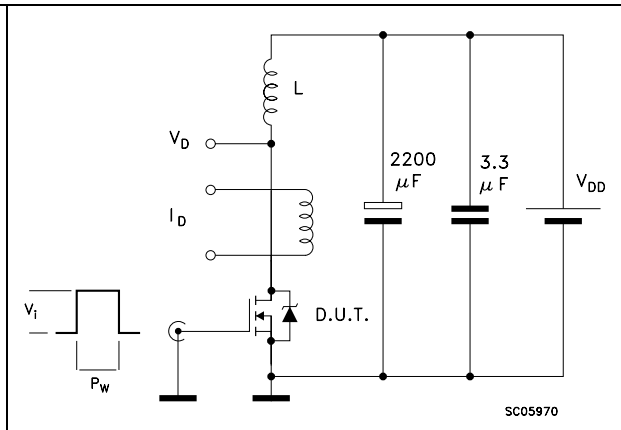


Figure 21. Unclamped inductive waveform

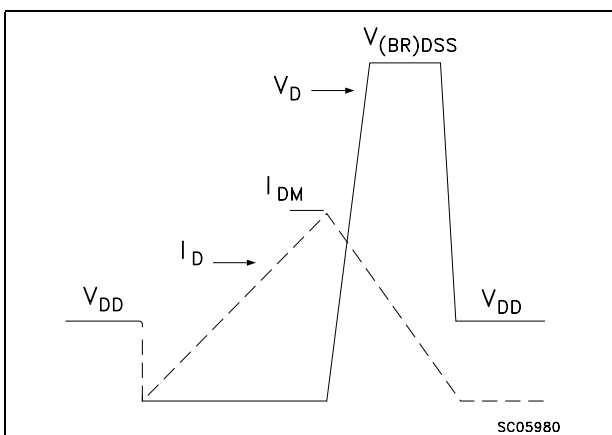
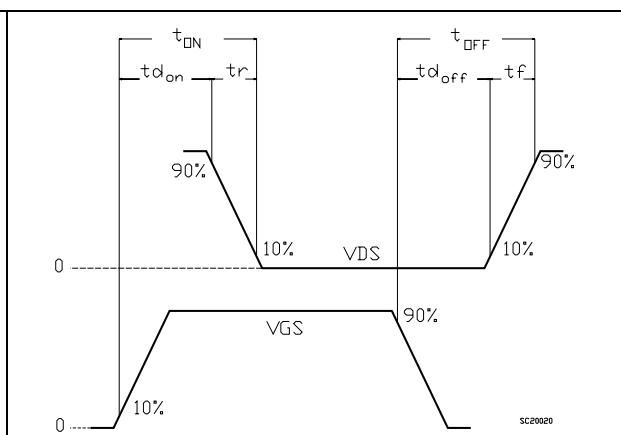


Figure 22. Switching time waveform



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. 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 23. TO-220 type A drawing

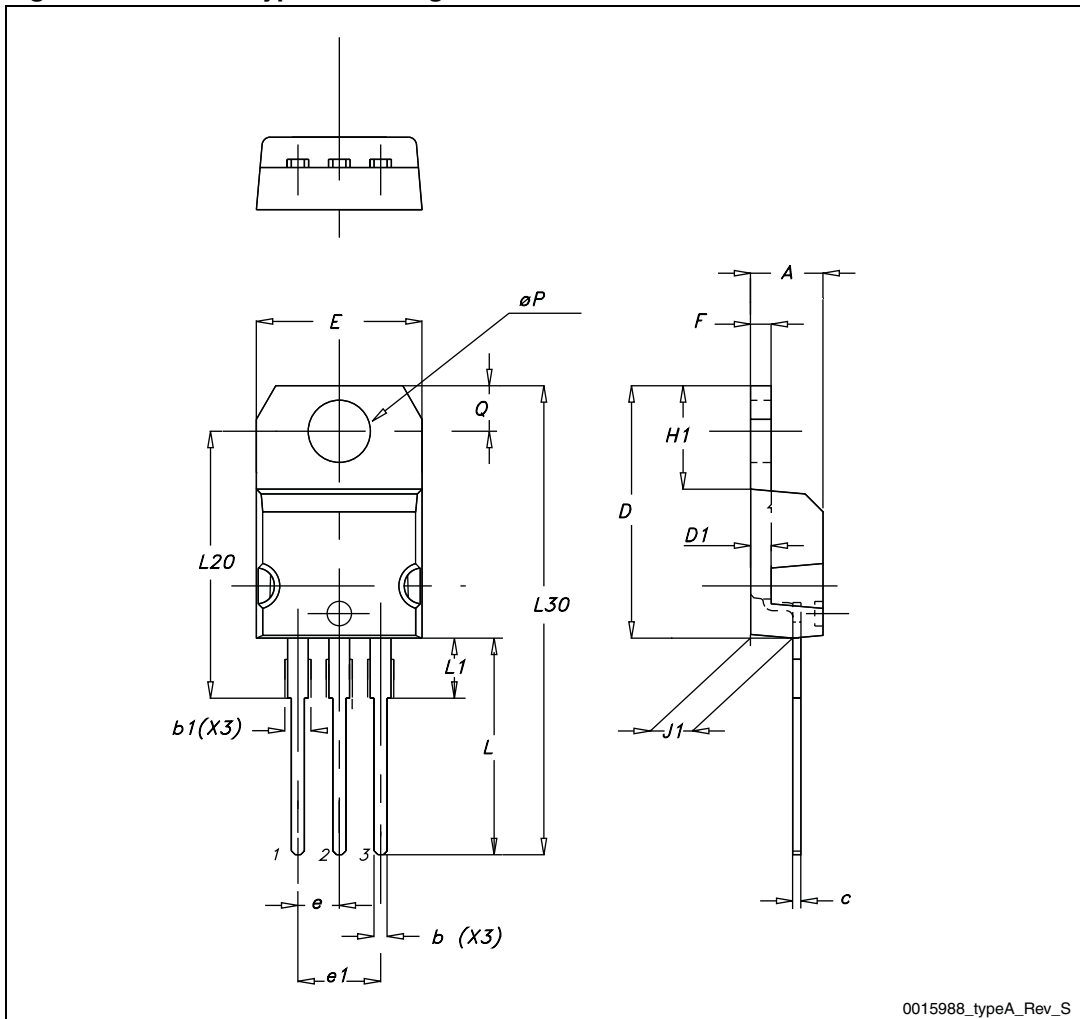


Table 10. TO-220FP mechanical data

| 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 |
| Dia | 3 | | 3.2 |

Figure 24. TO-220FP drawing

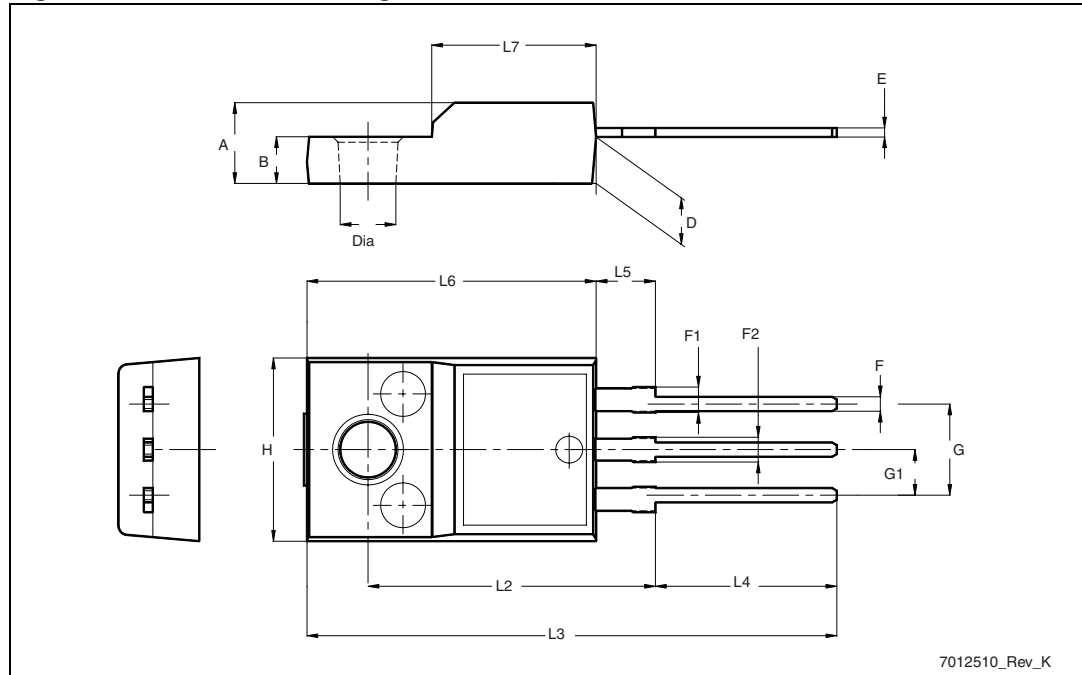


Table 11. I²PAK (TO-262) mechanical data

| DIM. | mm. | | |
|------|------|-----|-------|
| | min. | typ | max. |
| A | 4.40 | | 4.60 |
| A1 | 2.40 | | 2.72 |
| b | 0.61 | | 0.88 |
| b1 | 1.14 | | 1.70 |
| c | 0.49 | | 0.70 |
| c2 | 1.23 | | 1.32 |
| D | 8.95 | | 9.35 |
| e | 2.40 | | 2.70 |
| e1 | 4.95 | | 5.15 |
| E | 10 | | 10.40 |
| L | 13 | | 14 |
| L1 | 3.50 | | 3.93 |
| L2 | 1.27 | | 1.40 |

Figure 25. I²PAK (TO-262) drawing

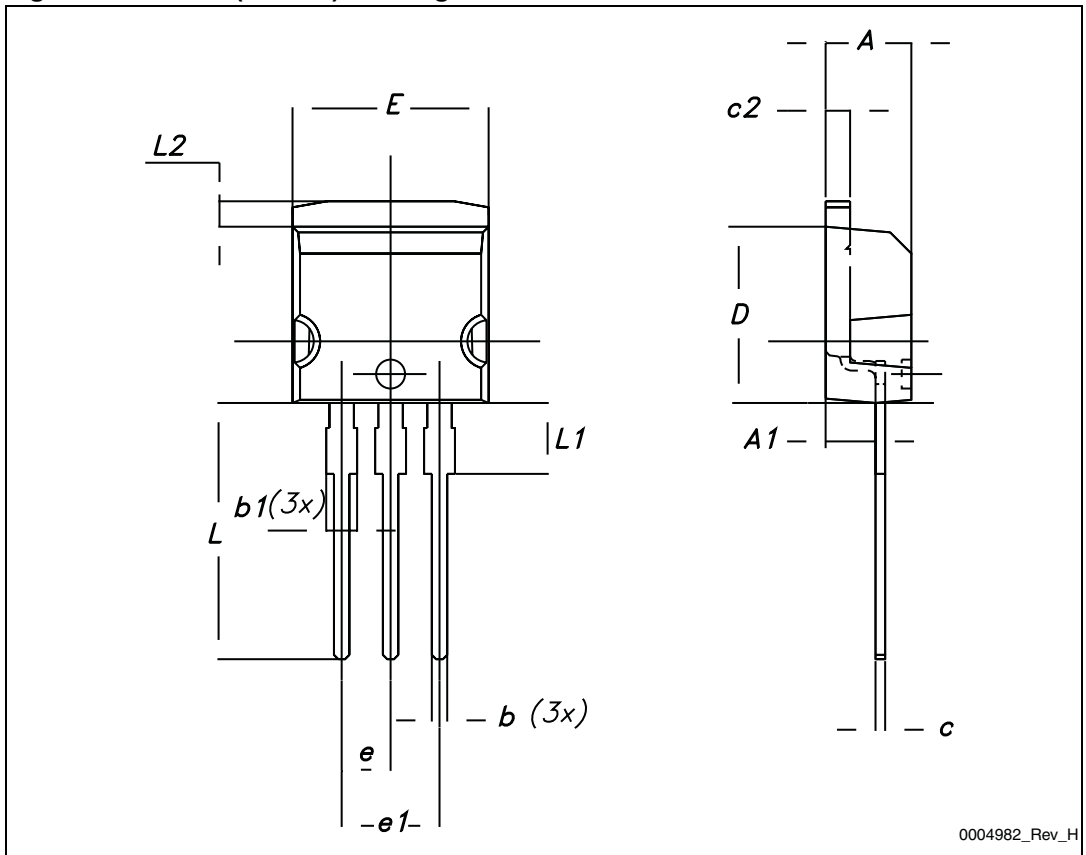
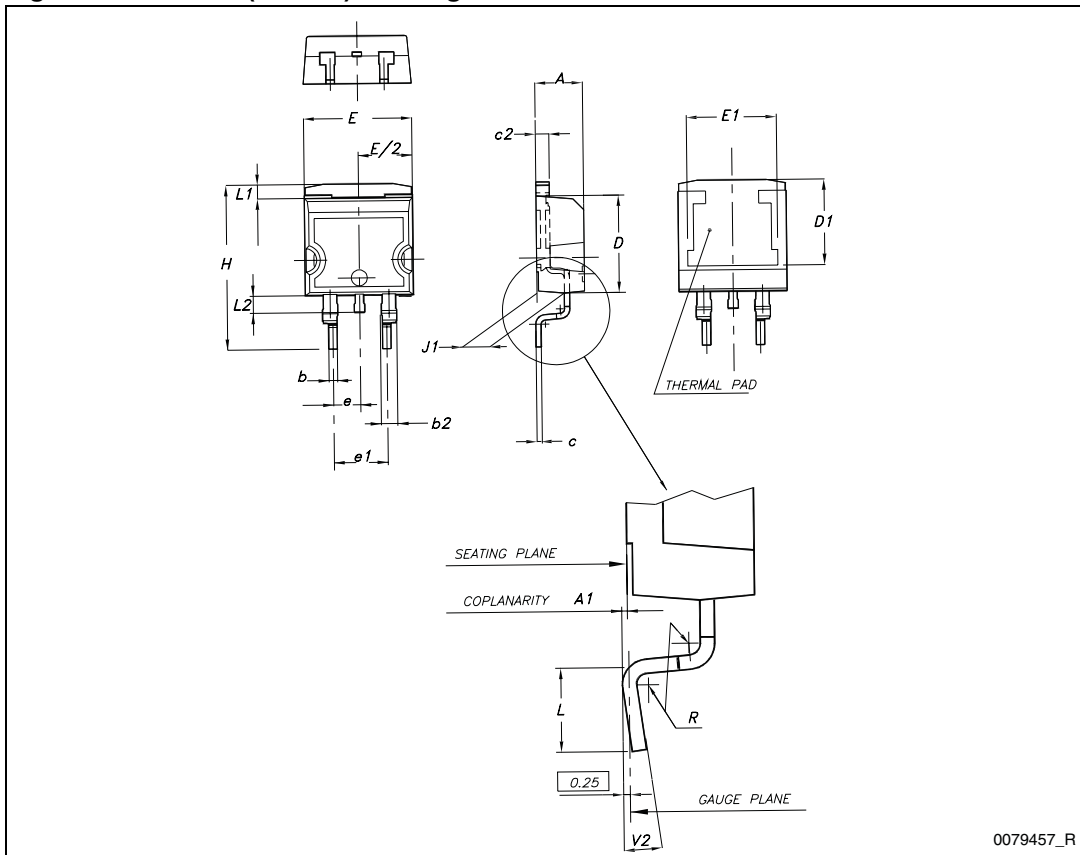


Table 12. D²PAK (TO-263) mechanical data

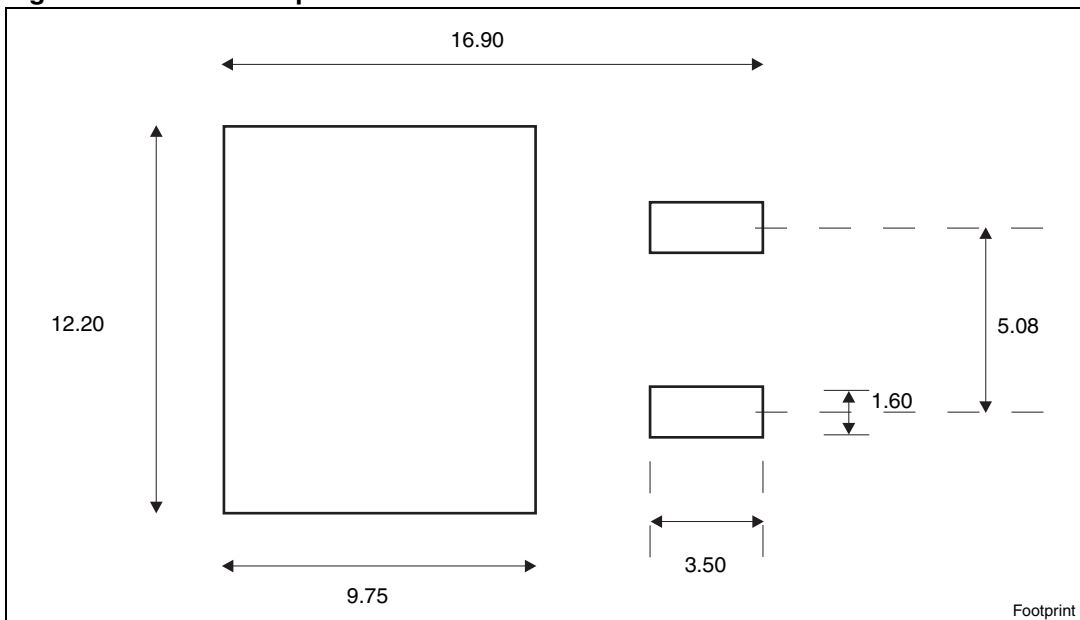
| Dim. | mm | | |
|------|------|------|-------|
| | Min. | Typ. | Max. |
| A | 4.40 | | 4.60 |
| A1 | 0.03 | | 0.23 |
| b | 0.70 | | 0.93 |
| b2 | 1.14 | | 1.70 |
| c | 0.45 | | 0.60 |
| c2 | 1.23 | | 1.36 |
| D | 8.95 | | 9.35 |
| D1 | 7.50 | | |
| E | 10 | | 10.40 |
| E1 | 8.50 | | |
| e | | 2.54 | |
| 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 26. D²PAK (TO-263) drawing



0079457_R

Figure 27. D²PAK footprint^(a)



a. All dimension are in millimeters

Table 13. 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 | | 0.3 | |
| 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° | |

Figure 28. IPAK (TO-251) drawing

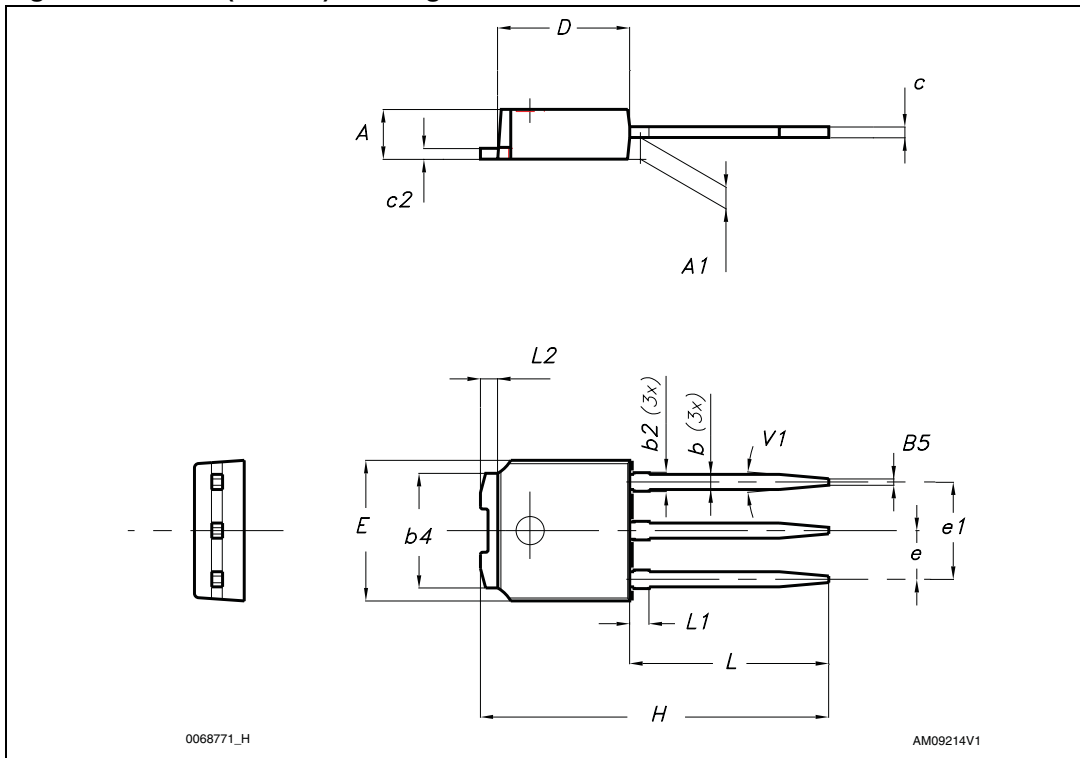


Table 14. DPAK (TO-252) mechanical data

| 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 | | 1.50 |
| L1 | | 2.80 | |
| L2 | | 0.80 | |
| L4 | 0.60 | | 1 |
| R | | 0.20 | |
| V2 | 0° | | 8° |

Figure 29. DPAK (TO-252) drawing

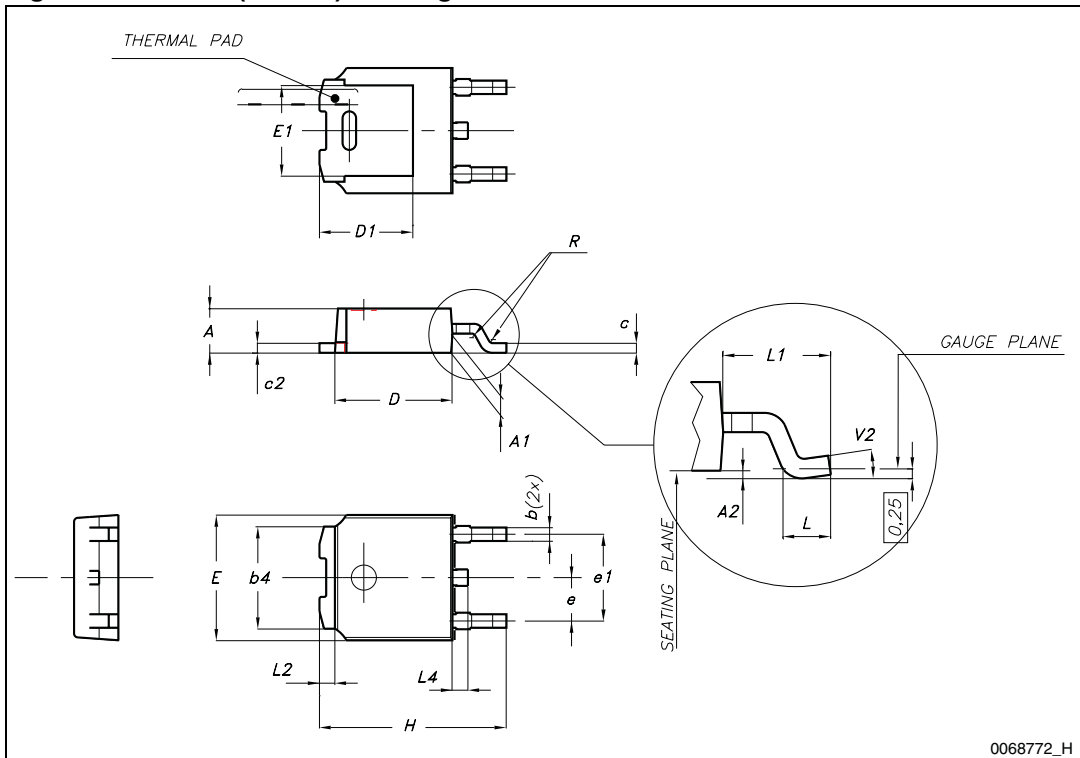
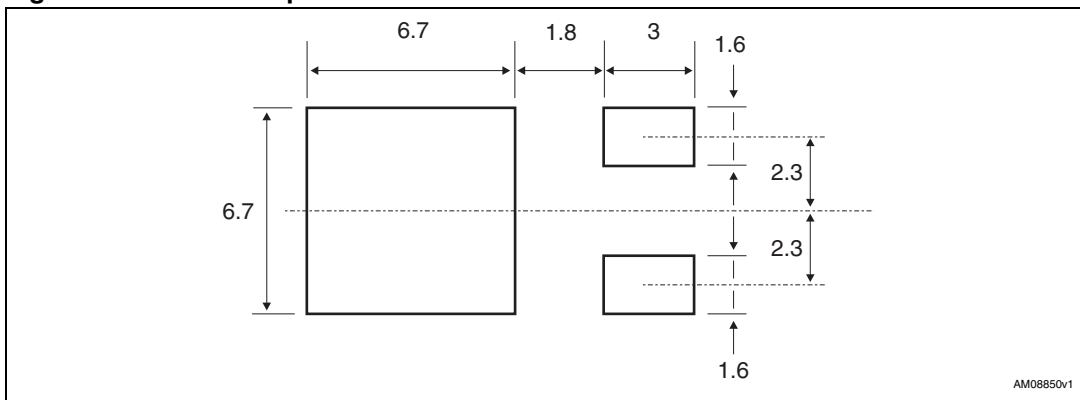


Figure 30. DPAK footprint^(b)



b. All dimension are in millimeters

5 Packaging mechanical data

Table 15. 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 31. Tape for DPAK (TO-252)

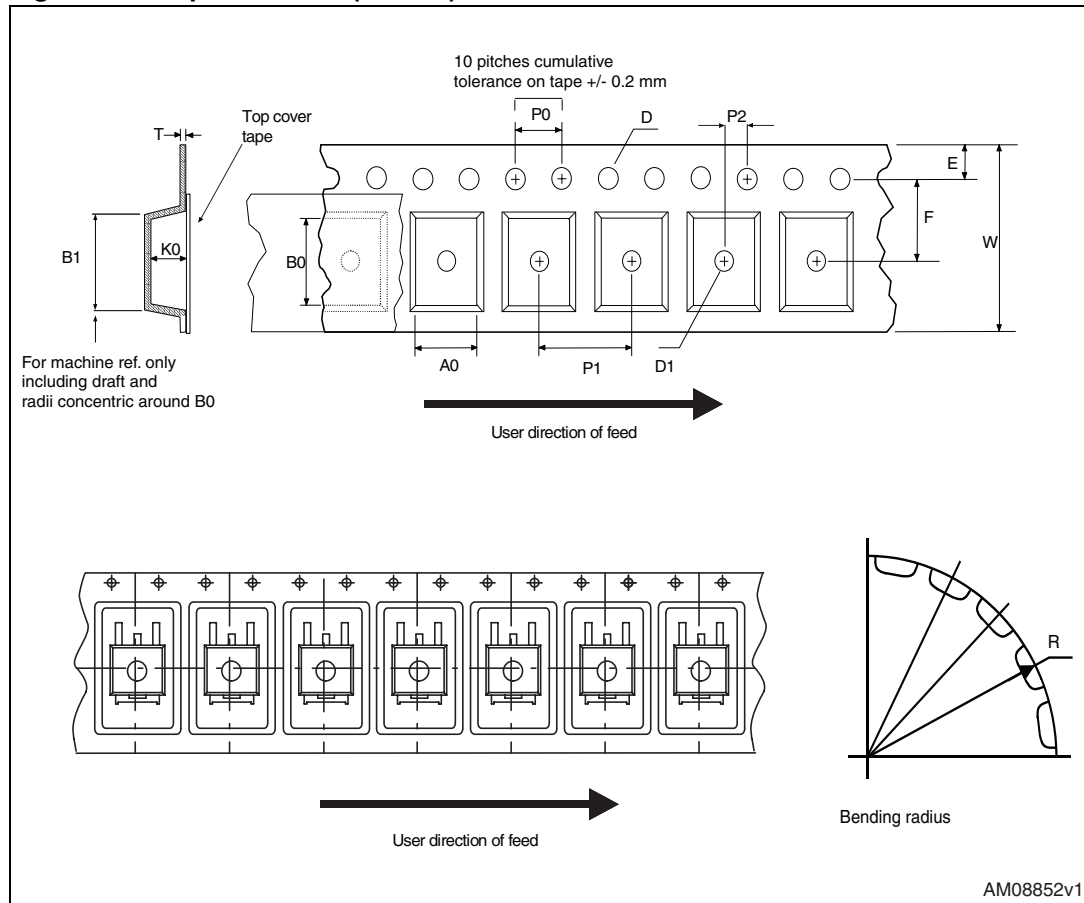


Figure 32. Reel for DPAK (TO-252)

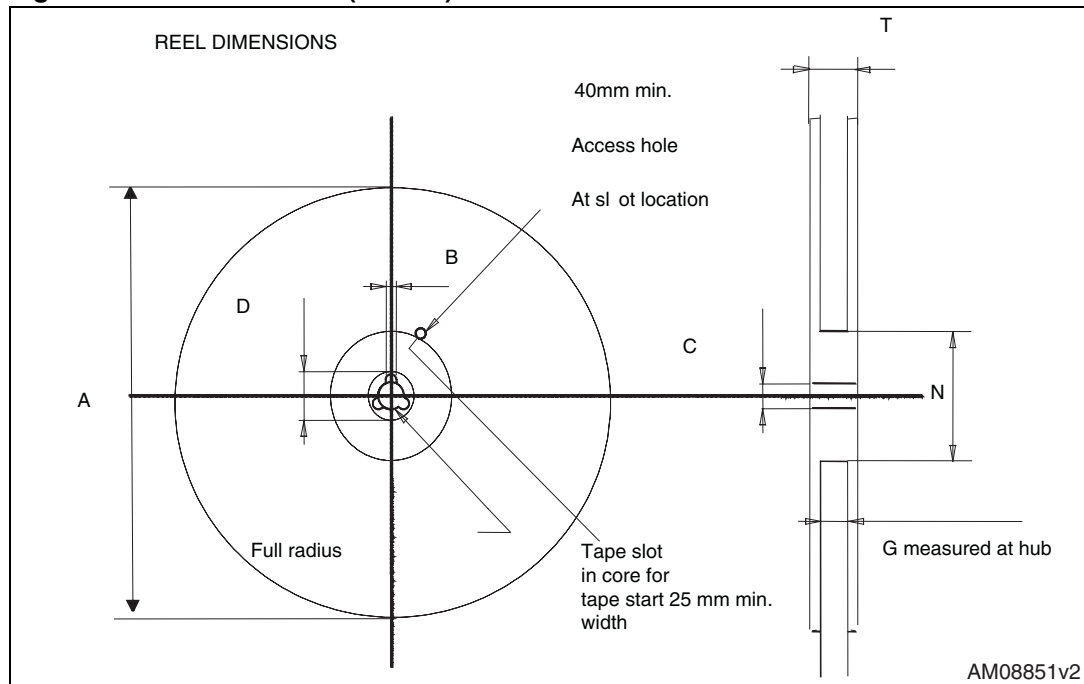
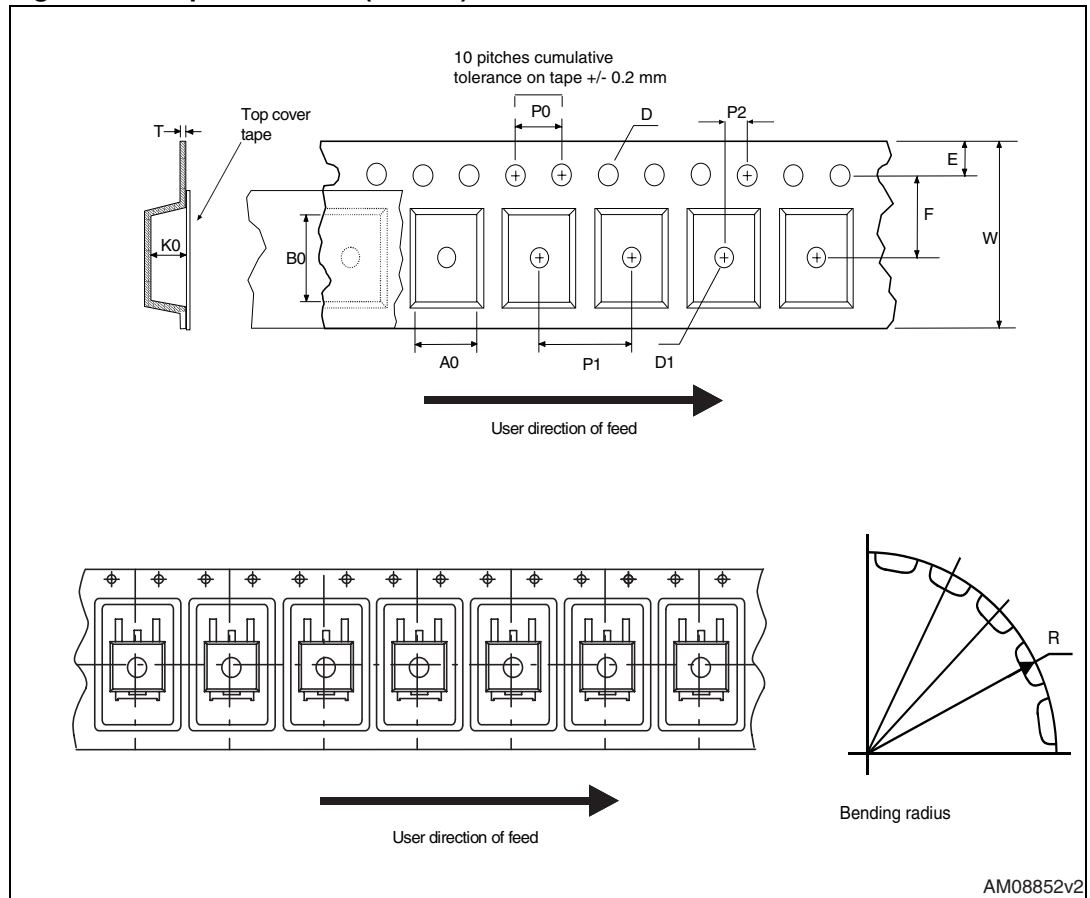


Table 16. D²PAK (TO-263) tape and reel mechanical data

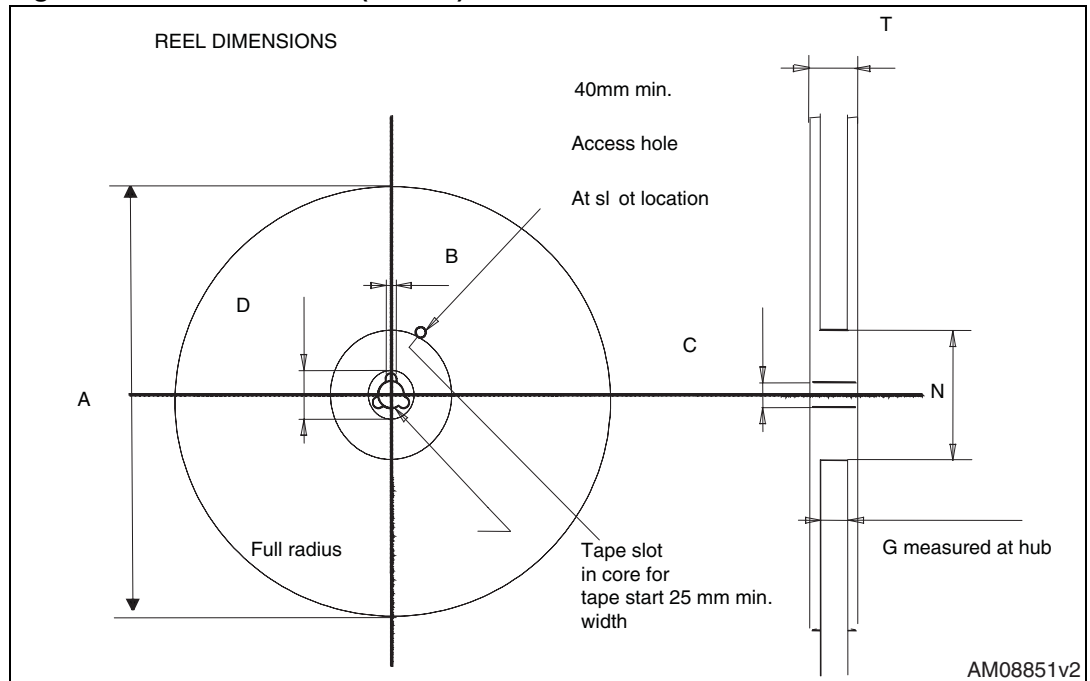
| Tape | | | Reel | | |
|------|------|------|------|----------|------|
| Dim. | mm | | Dim. | mm | |
| | Min. | Max. | | Min. | Max. |
| A0 | 10.5 | 10.7 | A | | 330 |
| B0 | 15.7 | 15.9 | B | 1.5 | |
| D | 1.5 | 1.6 | C | 12.8 | 13.2 |
| D1 | 1.59 | 1.61 | D | 20.2 | |
| E | 1.65 | 1.85 | G | 24.4 | 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 33. Tape for D²PAK (TO-263)



AM08852v2

Figure 34. Reel for D²PAK (TO-263)



AM08851v2

6 Revision history

Table 17. Document revision history

| Date | Revision | Changes |
|-------------|----------|---|
| 25-Oct-2006 | 4 | Document reformatted no content change. |
| 04-Mar-2008 | 5 | Modified TO-220 and TO-220FP mechanical data. |
| 16-Apr-2008 | 6 | Minor text changes to improve readability. |
| 11-Jul-2011 | 7 | Updated package mechanical data Section 4 and packaging mechanical data Section 5 . |

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