



# STD2HNK60Z, STD2HNK60Z-1 STF2HNK60Z, STD2HNK60Z-AP

N-channel 600 V, 4.4  $\Omega$  2 A Zener-protected SuperMESH™  
Power MOSFET in TO-92-TO-220FP-DPAK-IPAK packages

Datasheet — production data

## Features

| Order codes    | V <sub>DSS</sub> | R <sub>DS(on)</sub><br>max. | I <sub>D</sub> | P <sub>TOT</sub> |
|----------------|------------------|-----------------------------|----------------|------------------|
| STD2HNK60Z     | 600 V            | < 4.8 $\Omega$              | 2 A            | 45 W             |
| STD2HNK60Z-1   | 600 V            | < 4.8 $\Omega$              | 2 A            | 45 W             |
| STF2HNK60Z     | 600 V            | < 4.8 $\Omega$              | 2 A            | 20 W             |
| STQ2HNK60ZR-AP | 600 V            | < 4.8 $\Omega$              | 0.5 A          | 3 W              |

- Gate charge minimized
- 100% avalanche tested
- Extremely high dv/dt capability
- ESD improved capability
- New high voltage benchmark

## 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.

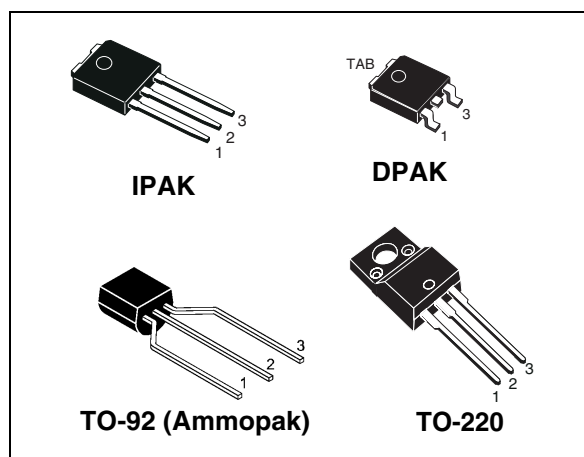


Figure 1. Internal schematic diagram

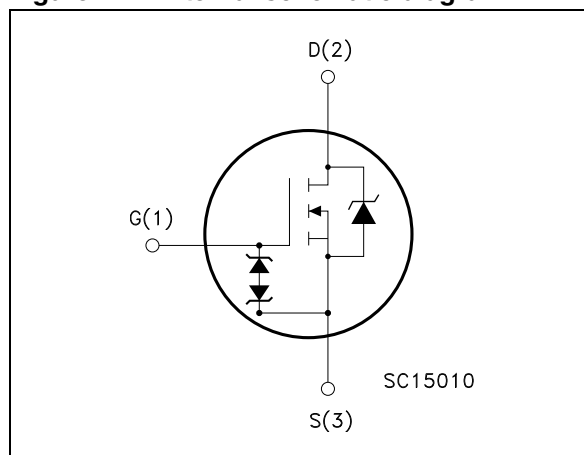


Table 1. Device summary

| Order codes    | Marking   | Package  | Packaging     |
|----------------|-----------|----------|---------------|
| STD2HNK60Z     | D2HNK60Z  | DPAK     | Tape and reel |
| STD2HNK60Z-1   | D2HNK60Z  | IPAK     | Tube          |
| STF2HNK60Z     | F2HNK60Z  | TO-220FP | Tube          |
| STQ2HNK60ZR-AP | Q2HNK60ZR | TO-92    | Ammopak       |

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol                             | Parameter                                             | Value                  |          |       | Unit |
|------------------------------------|-------------------------------------------------------|------------------------|----------|-------|------|
|                                    |                                                       | I <sub>PAK</sub> ,DPAK | TO-220FP | TO-92 |      |
| V <sub>DS</sub>                    | Drain-source voltage                                  | 600                    |          |       | V    |
| V <sub>GS</sub>                    | Gate-source voltage                                   | ±30                    |          |       | V    |
| I <sub>D</sub>                     | Drain current (continuous) at T <sub>C</sub> = 25 °C  | 2.0                    | 2.0      | 0.5   | A    |
| I <sub>D</sub>                     | Drain current (continuous) at T <sub>C</sub> = 100 °C | 1.26                   | 1.26     | 0.32  | A    |
| I <sub>DM</sub> <sup>(1)</sup>     | Drain current (pulsed)                                | 8                      | 8        | 2     | A    |
| P <sub>TOT</sub>                   | Total dissipation at T <sub>C</sub> = 25 °C           | 45                     | 20       | 3     | W    |
|                                    | Derating factor                                       | 0.36                   | 0.16     | 0.025 | W/°C |
| V <sub>ESD(G-S)</sub>              | Gate source ESD (HBM-C=100 pF, R=1.5 kΩ)              | 2000                   |          |       | V    |
| V <sub>ISO</sub>                   | Insulation withstand voltage (DC)                     |                        | 2500     |       | V    |
| dv/dt <sup>(2)</sup>               | Peak diode recovery voltage slope                     | 4.5                    |          |       | V/ns |
| T <sub>J</sub><br>T <sub>stg</sub> | Operating junction temperature<br>Storage temperature | - 55 to 150            |          |       | °C   |
| T <sub>I</sub>                     | Maximum lead temperature for soldering purpose        | 300                    |          | 260   | °C   |

1. Pulse width limited by safe operating area.

2. I<sub>SD</sub> ≤ 2 A, di/dt ≤ 200 A/μs, V<sub>DD</sub> = 80%V<sub>(BR)DSS</sub>.

**Table 3. Thermal data**

| Symbol                | Parameter                               | I <sub>PAK</sub> /DPAK | TO-220FP | TO-92 | Unit |
|-----------------------|-----------------------------------------|------------------------|----------|-------|------|
| R <sub>thj-case</sub> | Thermal resistance junction-case max    | 2.77                   | 6.25     |       | °C/W |
| R <sub>thj-amb</sub>  | Thermal resistance junction-ambient max | 100                    | 62.5     | 120   | °C/W |
| R <sub>thj-lead</sub> | Thermal resistance junction-lead max    |                        |          | 40    | °C/W |

**Table 4. Avalanche data**

| Symbol          | Parameter                                                                                                                  | Value | Unit |
|-----------------|----------------------------------------------------------------------------------------------------------------------------|-------|------|
| I <sub>AR</sub> | Avalanche current, repetitive or not repetitive (pulse width limited by T <sub>jmax</sub> )                                | 2     | A    |
| E <sub>AS</sub> | Single pulse avalanche energy (starting T <sub>j</sub> = 25 °C, I <sub>D</sub> =I <sub>AR</sub> , V <sub>DD</sub> = 50 mV) | 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 ( $V_{GS} = 0$ ) | $V_{DS} = 600\text{ V}$ ,<br>$V_{DS} = 600\text{ V}$ , $T_c = 125\text{ °C}$ |      |      | 1<br>50  | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$     | Gate body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20\text{ V}$                                                   |      |      | $\pm 10$ | $\mu\text{A}$                  |
| $V_{GS(th)}$  | 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                | $V_{GS} = 10\text{ V}$ , $I_D = 1\text{ A}$                                  |      | 4.4  | 4.8      | $\Omega$                       |

**Table 6. Dynamic**

| Symbol                              | Parameter                                                               | Test conditions                                                                           | Min. | Typ.            | Max. | Unit           |
|-------------------------------------|-------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|------|-----------------|------|----------------|
| $g_{fs}^{(1)}$                      | Forward transconductance                                                | $V_{DS} = 15\text{ V}$ , $I_D = 1\text{ A}$                                               | -    | 1.5             |      | S              |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GS} = 0$                                | -    | 280<br>38<br>7  |      | pF<br>pF<br>pF |
| $C_{oss\text{ eq}}^{(2)}$           | Equivalent output capacitance                                           | $V_{GS} = 0$ , $V_{DS} = 0\text{ to }480\text{ V}$                                        | -    | 30              |      | pF             |
| $Q_g$<br>$Q_{gs}$<br>$Q_{gd}$       | Total gate charge<br>Gate-source charge<br>Gate-drain charge            | $V_{DD} = 480\text{ V}$ , $I_D = 2\text{ A}$<br>$V_{GS} = 10\text{ V}$<br>(see Figure 19) | -    | 11<br>2.25<br>6 | 15   | nC<br>nC<br>nC |

1. Pulsed: pulse duration=300 $\mu\text{s}$ , 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. Switching times**

| Symbol       | Parameter           | Test conditions                                                                                           | Min. | Typ. | Max. | Unit |
|--------------|---------------------|-----------------------------------------------------------------------------------------------------------|------|------|------|------|
| $t_{d(on)}$  | Turn-on delay time  | $V_{DD}=300\text{ V}$ , $I_D=1\text{ A}$ ,<br>$R_G=4.7\ \Omega$ , $V_{GS}=10\text{ V}$<br>(see Figure 18) | -    | 10   | -    | ns   |
| $t_r$        | Rise time           |                                                                                                           |      | 30   |      | ns   |
| $t_{d(off)}$ | Turn-off delay time |                                                                                                           | -    | 23   | -    | ns   |
| $t_f$        | Fall time           |                                                                                                           |      | 50   |      | ns   |

**Table 8. Source drain diode**

| Symbol          | Parameter                     | Test conditions                                                                                                      | Min. | Typ. | Max. | Unit |
|-----------------|-------------------------------|----------------------------------------------------------------------------------------------------------------------|------|------|------|------|
| $I_{SD}$        | Source-drain current          |                                                                                                                      | -    |      | 2    | A    |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |                                                                                                                      |      |      | 8    | A    |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD} = 2\text{ A}$ , $V_{GS} = 0$                                                                                 | -    |      | 1.3  | V    |
| $t_{rr}$        | Reverse recovery time         | $I_{SD}=2\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ ,<br>$V_{DD}=20\text{ V}$                                   | -    | 178  |      | ns   |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                      |      | 445  |      | nC   |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                      |      | 5    |      | A    |
| $t_{rr}$        | Reverse recovery time         | $I_{SD}=2\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ ,<br>$V_{DD}=20\text{ V}$ , $T_j=150\text{ }^\circ\text{C}$ | -    | 200  |      | ns   |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                      |      | 500  |      | nC   |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                      |      | 5    |      | A    |

1. Pulse width limited by safe operating area

2. Pulsed: pulse duration=300 $\mu\text{s}$ , duty cycle 1.5%

## 2.1 Electrical characteristics (curves)

Figure 2. Safe operating area for TO-92

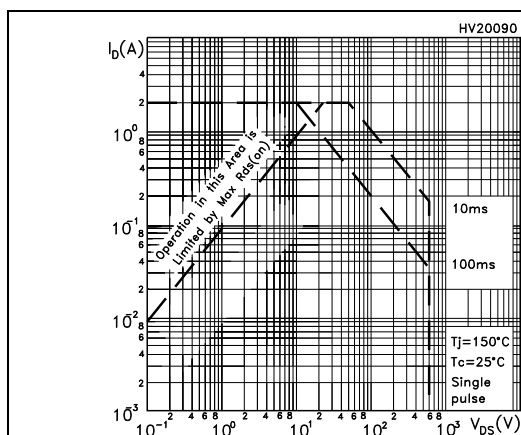


Figure 3. Thermal impedance for TO-92

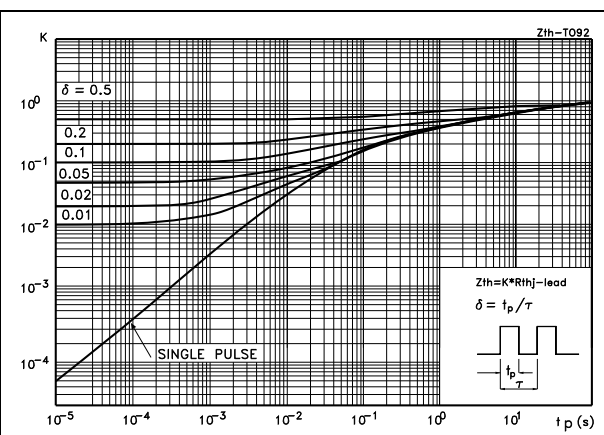


Figure 4. Safe operating area for TO-220FP

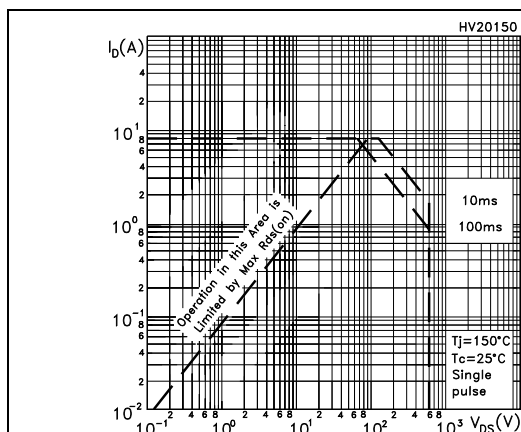


Figure 5. Thermal impedance for TO-220FP

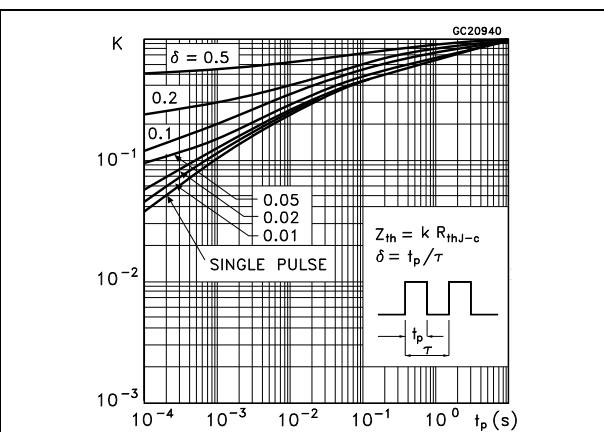


Figure 6. Safe operating area for IPAK/DPAK

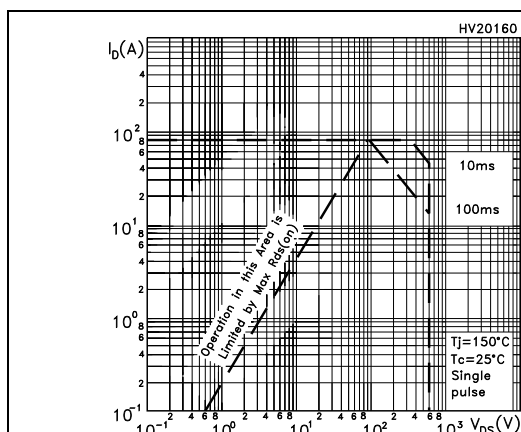


Figure 7. Thermal impedance for IPAK/DPAK

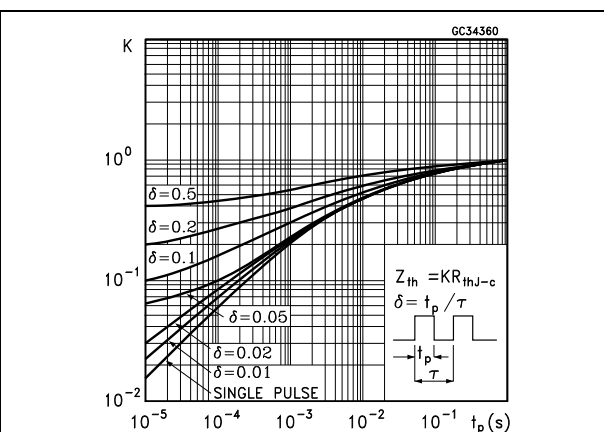


Figure 8. Output characteristics

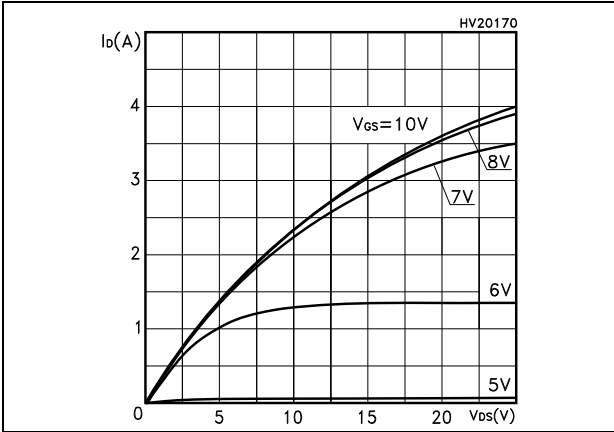


Figure 9. Transfer characteristics

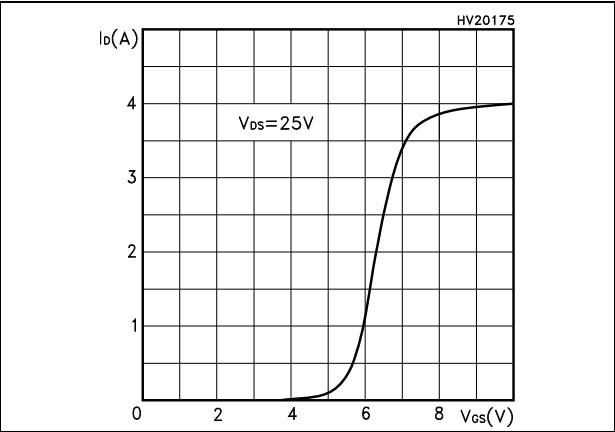


Figure 10. Normalized  $B_{V_{DS}}$  vs temperature

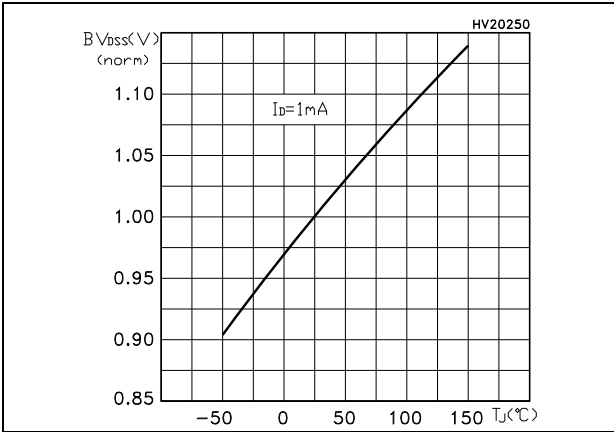


Figure 11. Static drain-source on-resistance

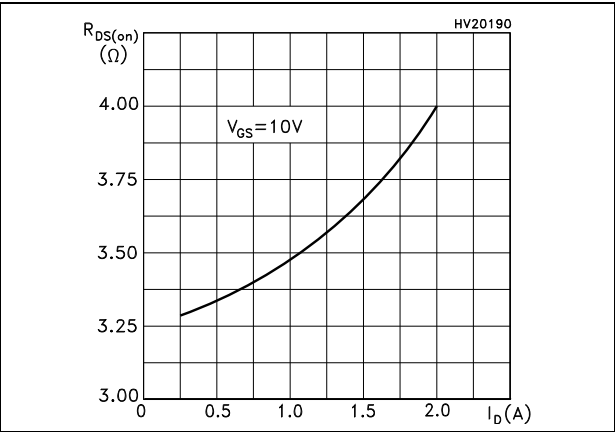


Figure 12. Gate charge vs gate-source voltage

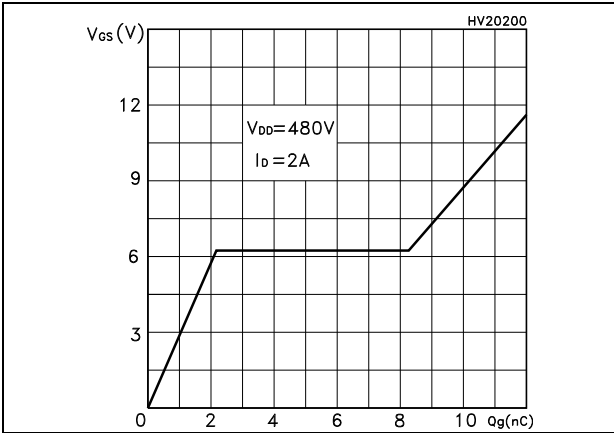


Figure 13. Capacitance variations

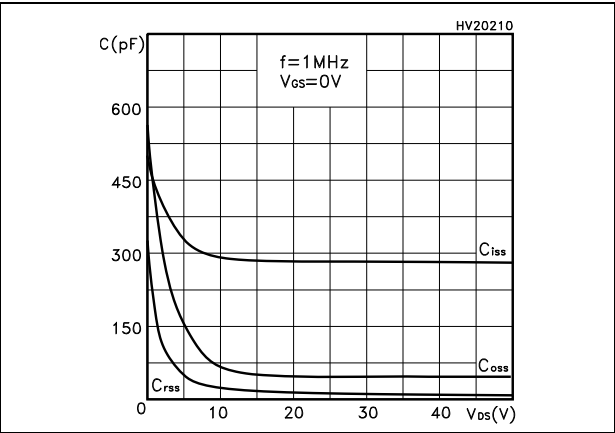


Figure 14. Normalized gate threshold voltage vs temperature

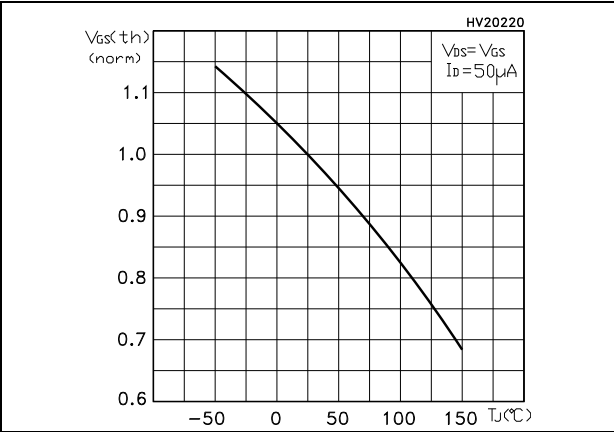


Figure 15. Normalized on-resistance vs temperature

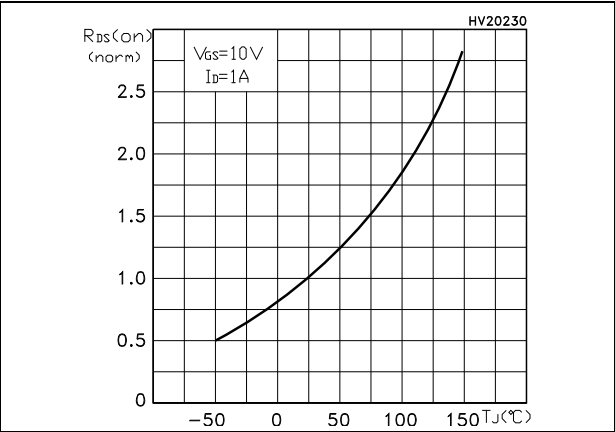


Figure 16. Source-drain diode forward characteristics

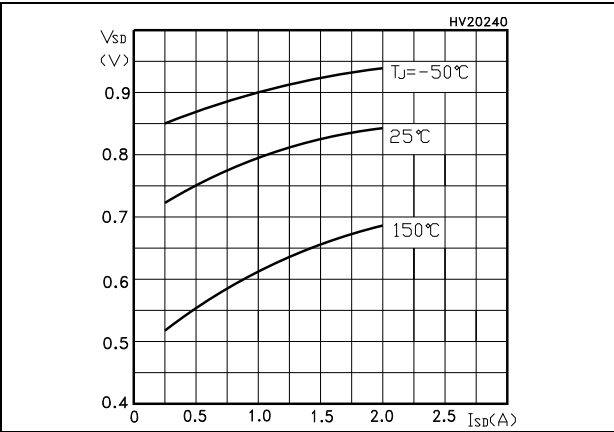
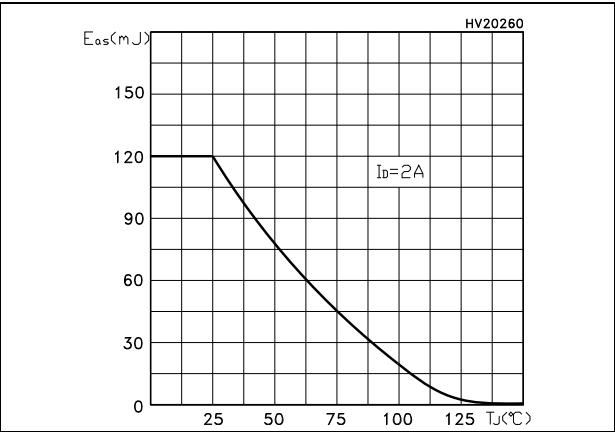


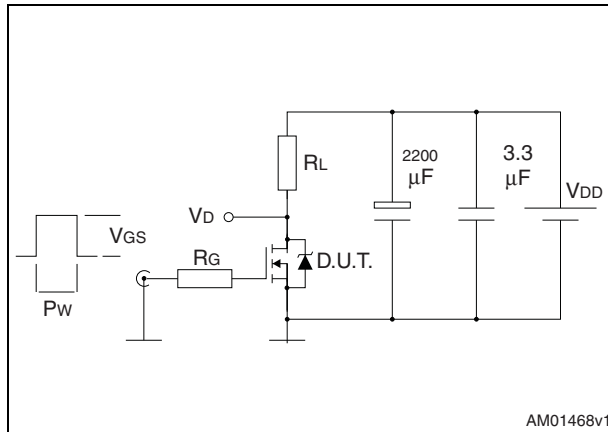
Figure 17. Maximum avalanche energy vs temperature



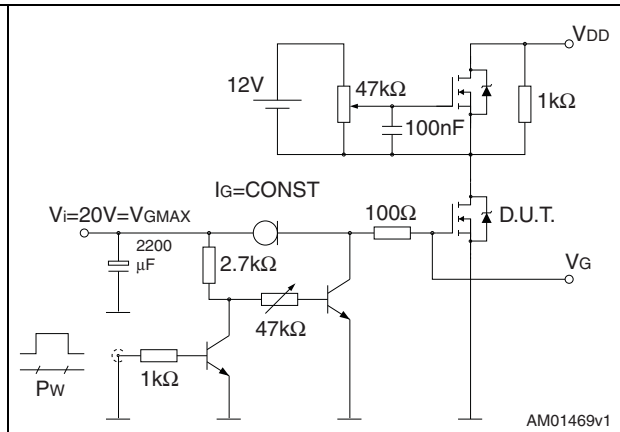


### 3 Test circuits

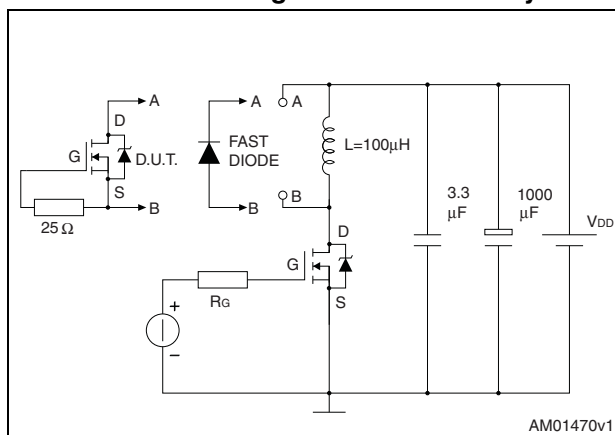
**Figure 18. Switching times test circuit for resistive load**



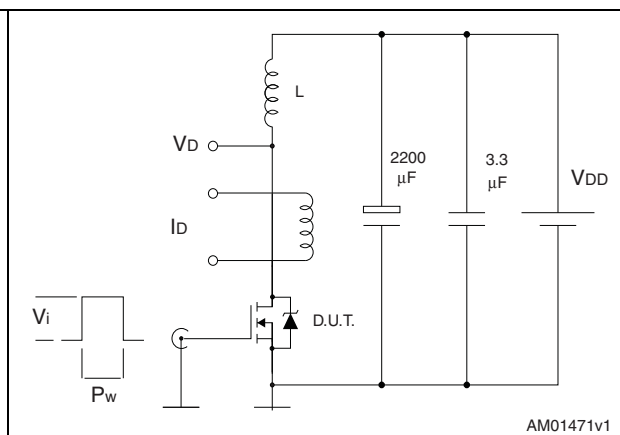
**Figure 19. Gate charge test circuit**



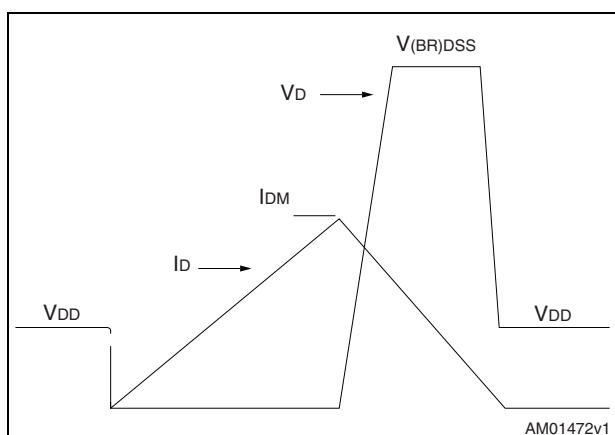
**Figure 20. Test circuit for inductive load switching and diode recovery times**



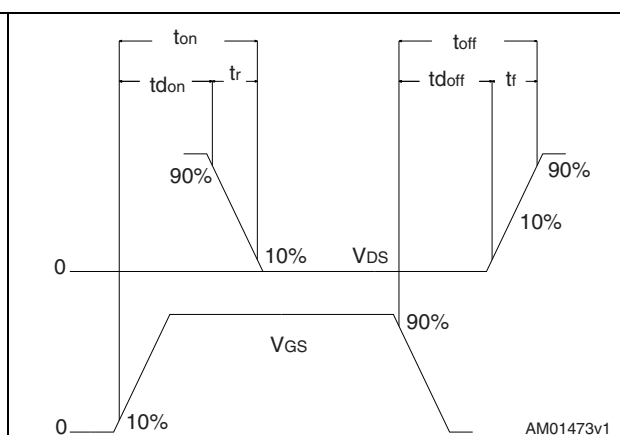
**Figure 21. Unclamped inductive load test circuit**



**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<sup>®</sup> packages, depending on their level of environmental compliance. ECOPACK<sup>®</sup> specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK is an ST trademark.

Table 9. 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 24. IPAK (TO-251) drawing

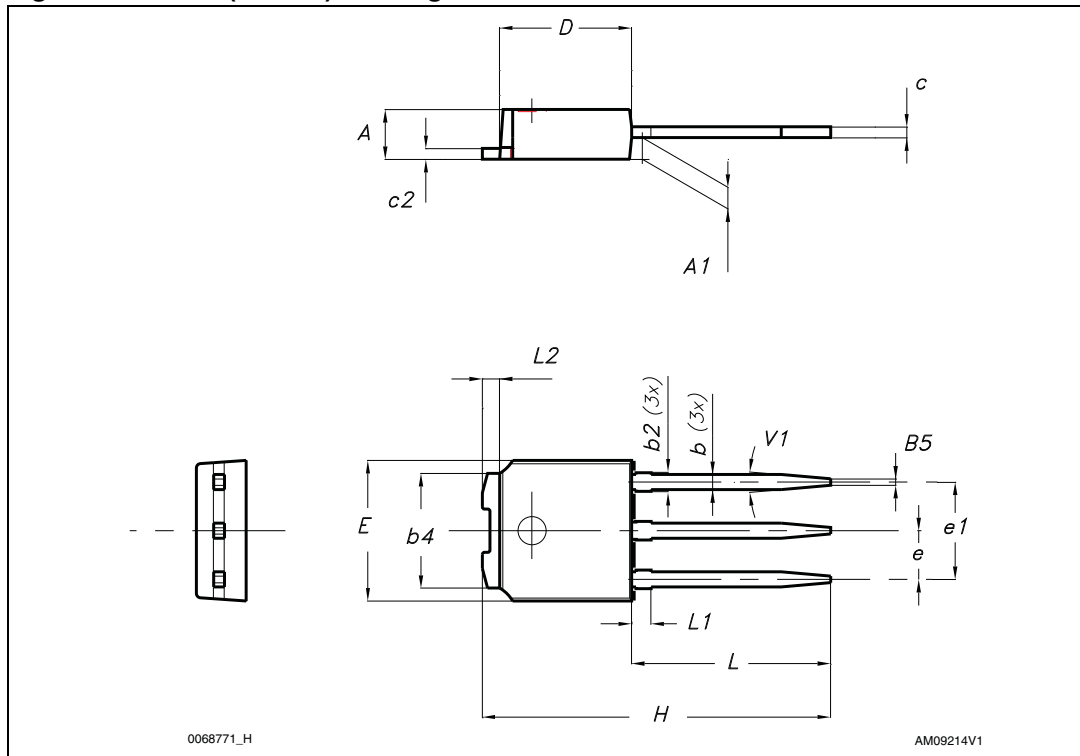
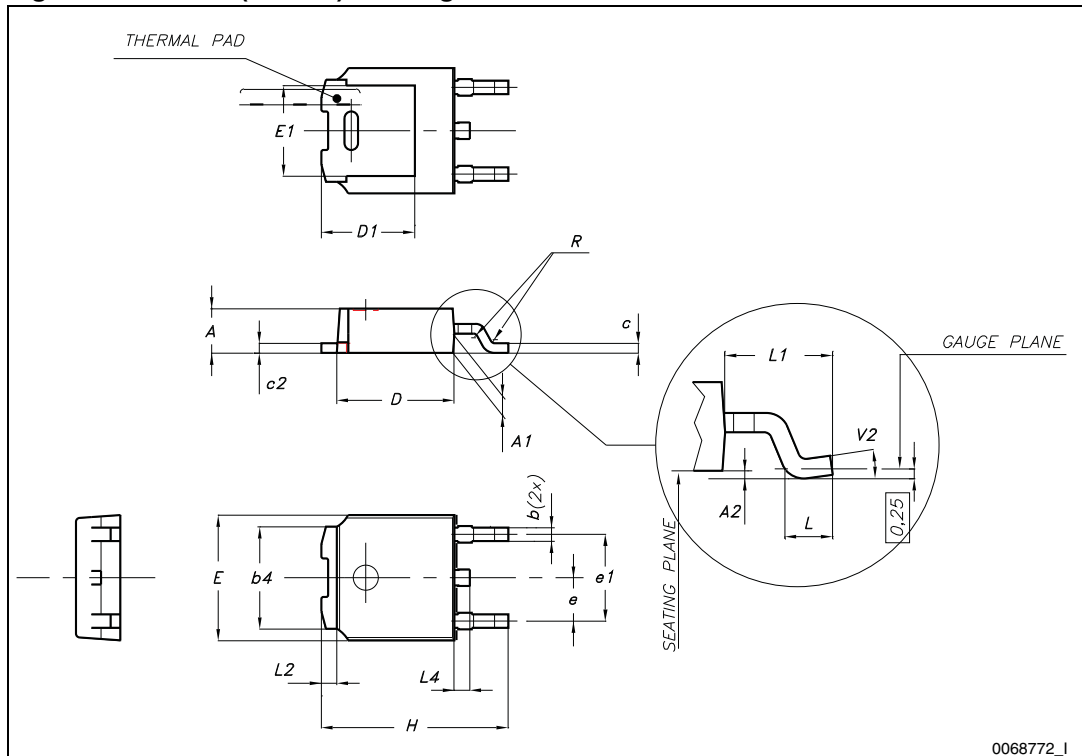
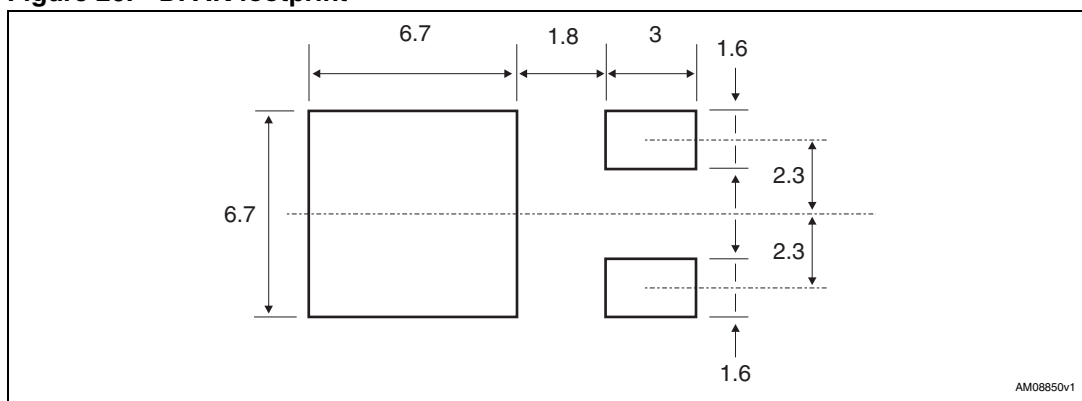


Table 10. DPAK (TO-252) mechanical data

| 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 25. DPAK (TO-252) drawing

Figure 26. DPAK footprint<sup>(a)</sup>

a. All dimensions are in millimeters

Table 11. 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 27. TO-220FP drawing

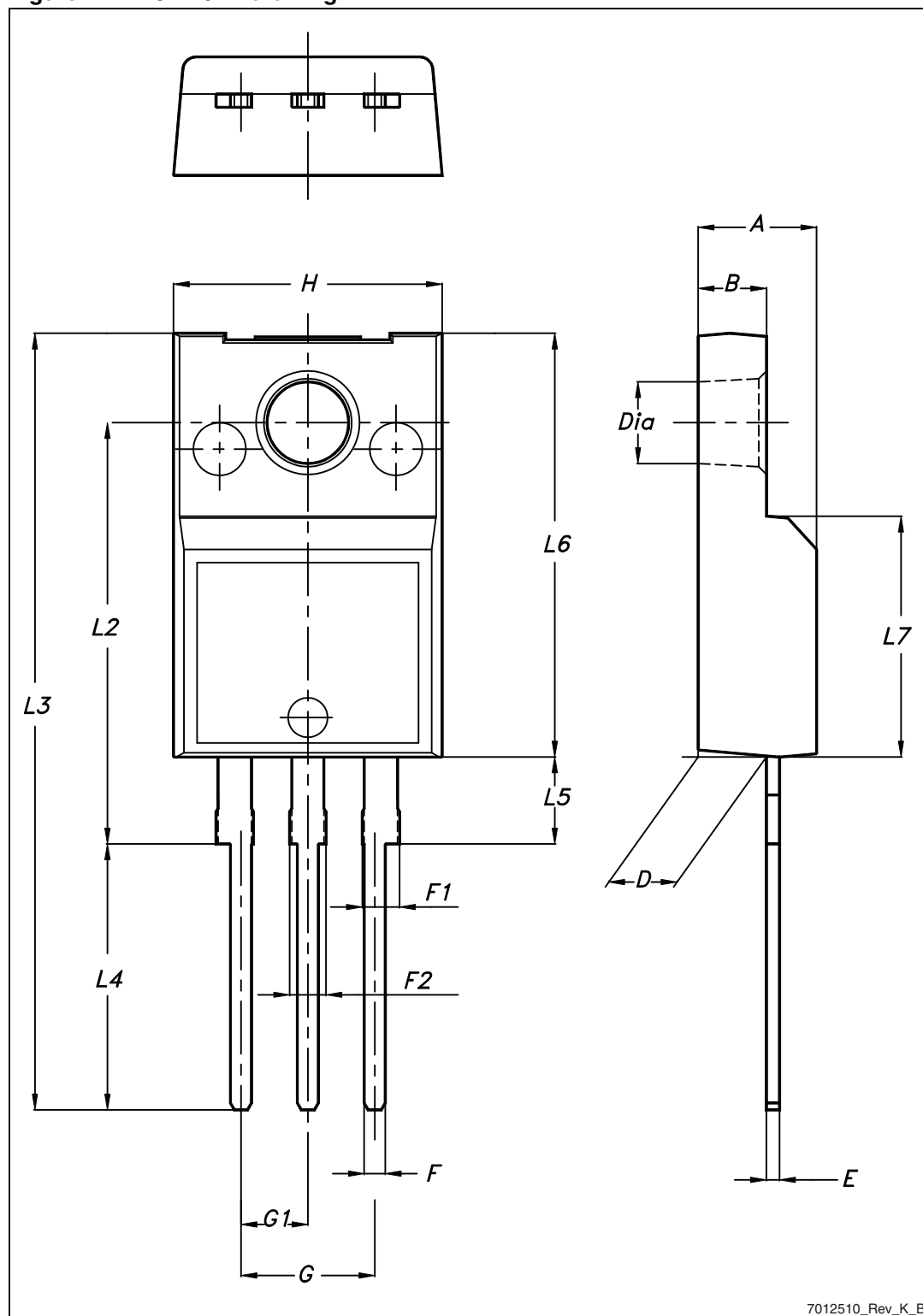
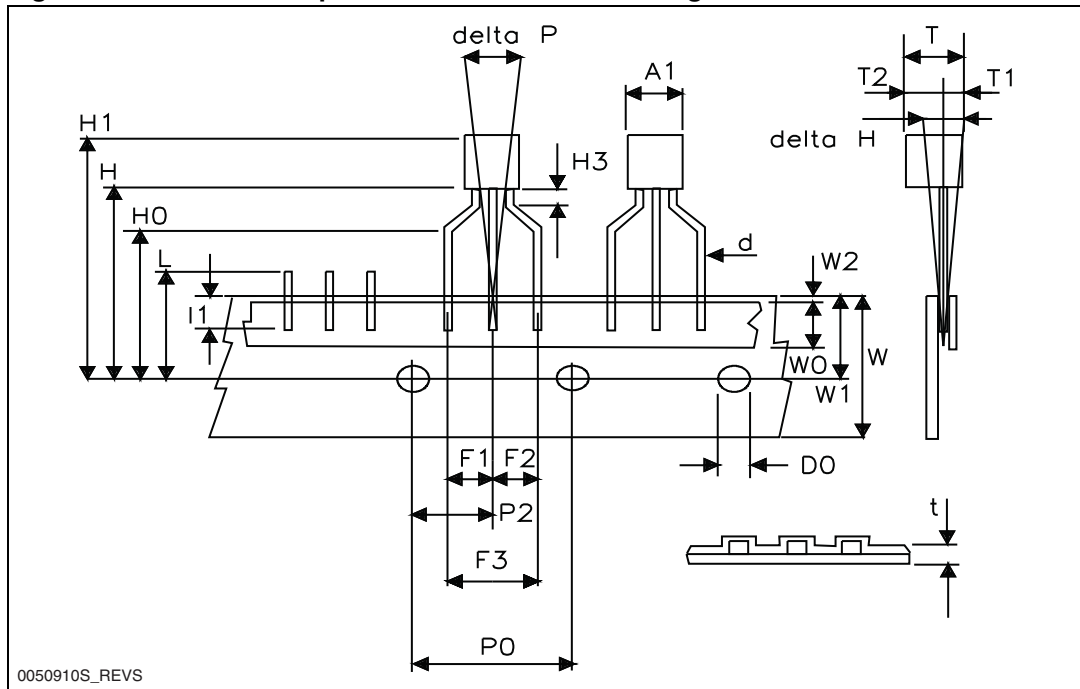




Table 12. TO-92 ammpack mechanical data

| Dim.    | mm    |       |       |
|---------|-------|-------|-------|
|         | Min.  | Typ.  | Max.  |
| A1      |       |       | 4.80  |
| T       |       |       | 3.80  |
| T1      |       |       | 1.60  |
| T2      |       |       | 2.30  |
| d       |       |       | 0.48  |
| P0      | 12.50 | 12.70 | 12.90 |
| P2      | 5.65  | 6.35  | 7.05  |
| F1, F2  | 2.44  | 2.54  | 2.94  |
| F3      | 4.98  | 5.08  | 5.48  |
| delta H | -2.00 |       | 2.00  |
| W       | 17.50 | 18.00 | 19.00 |
| W0      | 5.70  | 6.00  | 6.30  |
| W1      | 8.50  | 9.00  | 9.25  |
| W2      |       |       | 0.50  |
| H       | 18.50 |       | 20.50 |
| H3      | 0.5   | 1     | 1.5   |
| H0      | 15.50 | 16.00 | 16.50 |
| H1      |       |       | 25.00 |
| D0      | 3.80  | 4.00  | 4.20  |
| t       |       |       | 0.90  |
| L       |       |       | 11.00 |
| I1      | 3.00  |       |       |
| delta P | -1.00 |       | 1.00  |

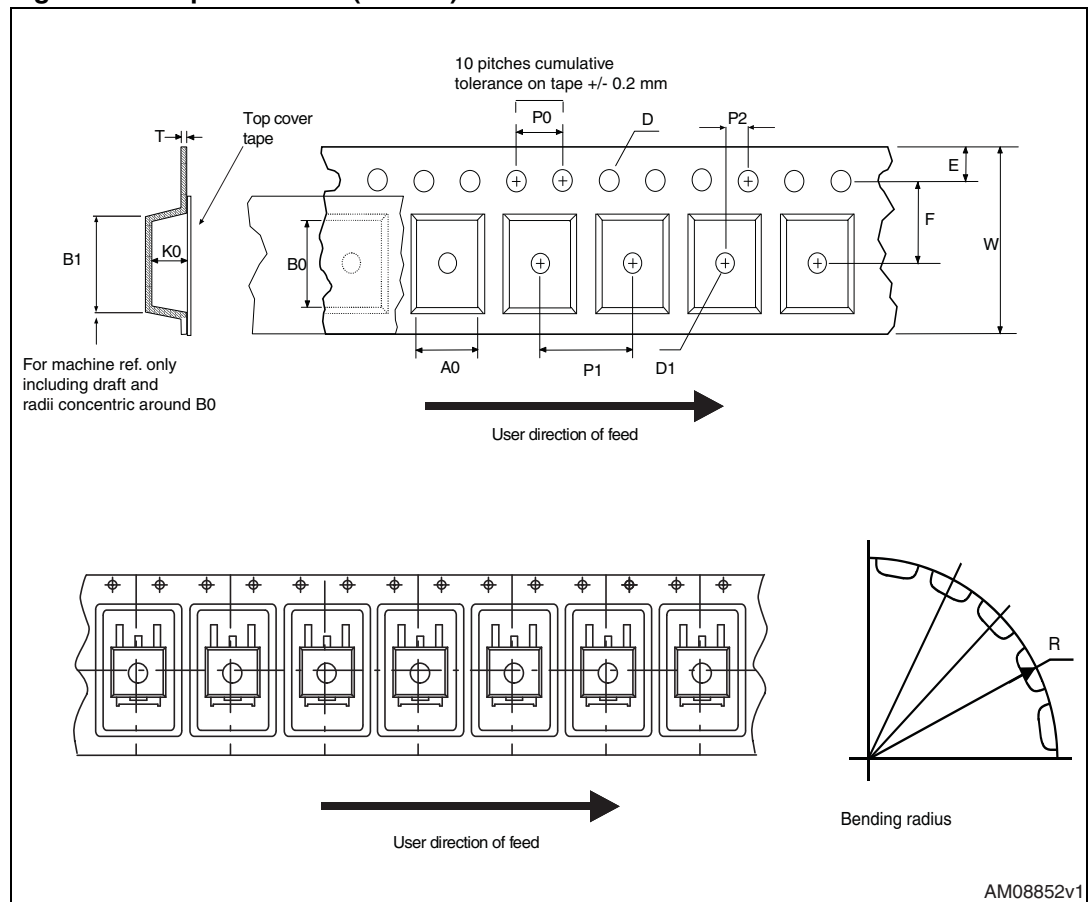
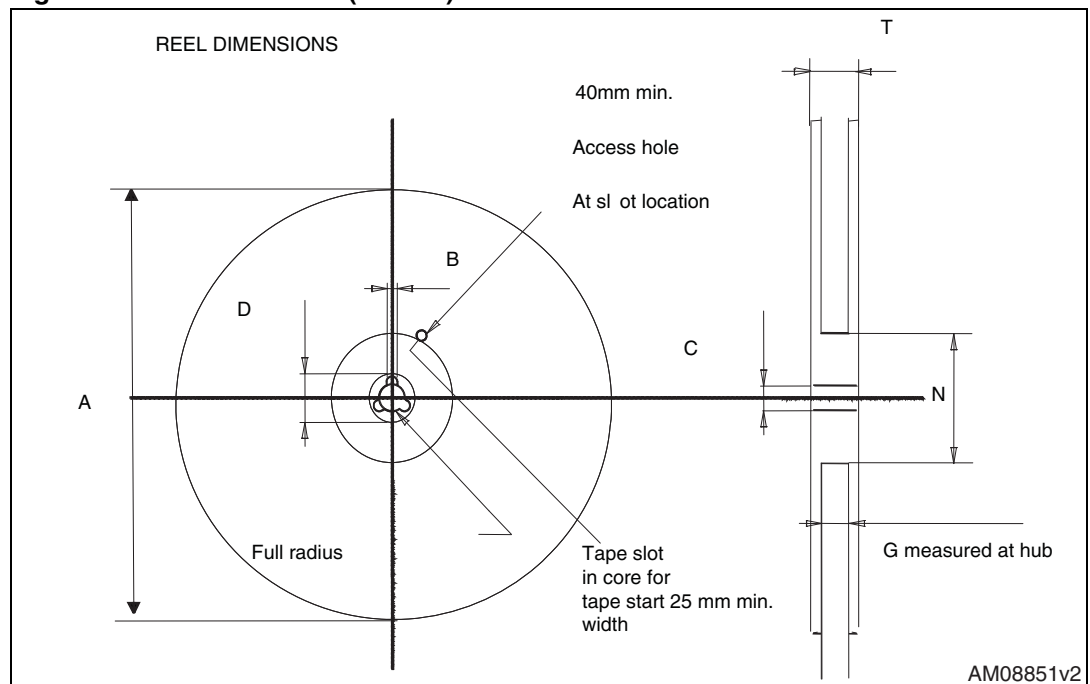
Figure 28. TO-92 ammopack mechanical data drawing



## 5 Packaging mechanical data

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 |           |      |      |

**Figure 29. Tape for DPAK (TO-252)****Figure 30. Reel for DPAK (TO-252)**

## 6 Revision history

Table 14. Document revision history

| Date        | Revision | Changes                                                                |
|-------------|----------|------------------------------------------------------------------------|
| 09-Mar-2004 | 1        | First release                                                          |
| 23-Mar-2004 | 2        | Modified title                                                         |
| 02-Apr-2005 | 3        | Added new section: <a href="#">Electrical characteristics (curves)</a> |
| 06-Mar-2006 | 4        | Inserted DPAK. The document has been reformatted                       |
| 25-May-2012 | 5        | Corrected unit in <a href="#">Table 5: On/off states</a>               |

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