

N-channel 950 V, 2  $\Omega$  typ., 3.5 A MDmesh™ K5  
Power MOSFETs in DPAK, TO-220FP, TO-220 and IPAK

Datasheet - production data

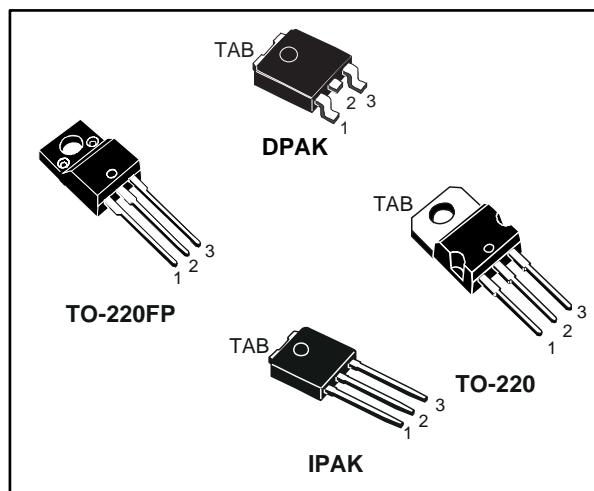
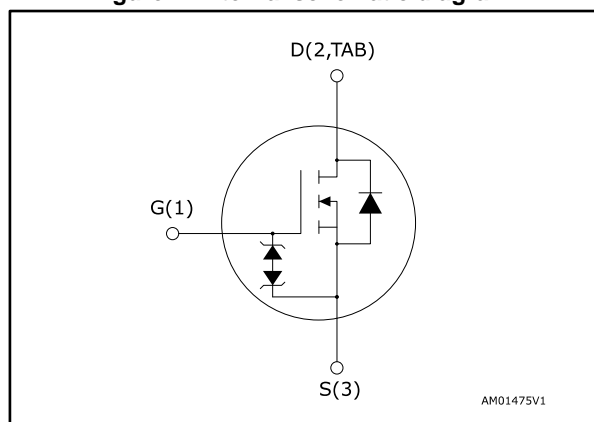


Figure 1: Internal schematic diagram



## Features

| Order code | V <sub>DS</sub> | R <sub>DS(on)</sub> max. | I <sub>D</sub> | P <sub>tot</sub> |
|------------|-----------------|--------------------------|----------------|------------------|
| STD5N95K5  | 950 V           | 2.5 $\Omega$             | 3.5 A          | 70 W             |
| STF5N95K5  |                 |                          |                | 25 W             |
| STP5N95K5  |                 |                          |                | 70 W             |
| STU5N95K5  |                 |                          |                | 70 W             |

- Industry's lowest R<sub>DS(on)</sub> x area
- Industry's best FoM (figure of merit)
- Ultra-low gate charge
- 100% avalanche tested
- Zener-protected

## Applications

- Switching applications

## Description

These very high voltage N-channel Power MOSFETs are designed using MDmesh™ K5 technology based on an innovative proprietary vertical structure. The result is a dramatic reduction in on-resistance and ultra-low gate charge for applications requiring superior power density and high efficiency.

Table 1: Device summary

| Order code | Marking | Package  | Packing       |
|------------|---------|----------|---------------|
| STD5N95K5  | 5N95K5  | DPAK     | Tape and reel |
| STF5N95K5  |         | TO-220FP | Tube          |
| STP5N95K5  |         | TO-220   |               |
| STU5N95K5  |         | IPAK     |               |

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# 1 Electrical ratings

Table 2: Absolute maximum ratings

| Symbol                         | Parameter  | Value              |                    | Unit |
|--------------------------------|--|--------------------|--------------------|------|
|                                |  | DPAK, TO-220, IPAK | TO-220FP           |      |
| V <sub>GS</sub>                | Gate-source voltage  | ±30                |                    | V    |
| I <sub>D</sub>                 | Drain current (continuous) at T <sub>C</sub> = 25 °C   | 3.5                | 3.5 <sup>(1)</sup> | A    |
| I <sub>D</sub>                 | Drain current (continuous) at T <sub>C</sub> = 100 °C  | 2.2                | 2.2 <sup>(1)</sup> | A    |
| I <sub>DM</sub> <sup>(2)</sup> | Drain current pulsed   | 14                 |                    | A    |
| P <sub>TOT</sub>               | Total dissipation at T <sub>C</sub> = 25 °C  | 70                 | 25                 | W    |
| dv/dt <sup>(3)</sup>           | Peak diode recovery voltage slope  | 4.5                |                    | V/ns |
| dv/dt <sup>(4)</sup>           | MOSFET dv/dt ruggedness  | 50                 |                    | V/ns |
| V <sub>ISO</sub>               | Insulation withstand voltage (RMS) from all three leads to external heat sink (t=1 s; T <sub>C</sub> =25 °C) |                    | 2500               | V    |
| T <sub>j</sub>                 | Operating junction temperature range   | -55 to 150         |                    | °C   |
| T <sub>stg</sub>               | Storage temperature range  |                    |                    |      |

**Notes:**

- <sup>(1)</sup>Limited by maximum junction temperature.
- <sup>(2)</sup>Pulse width limited by safe operating area.
- <sup>(3)</sup>I<sub>SD</sub> ≤ 3.5 A, di/dt ≤ 100 A/μs, V<sub>DS</sub> (peak) ≤ V<sub>(BR)DSS</sub>
- <sup>(4)</sup>V<sub>DS</sub> ≤ 640 V

Table 3: Thermal data

| Symbol                              | Parameter                           | Value |          |        |      | Unit |
|-------------------------------------|-------------------------------------|-------|----------|--------|------|------|
|                                     |                                     | DPAK  | TO-220FP | TO-220 | IPAK |      |
| R <sub>thj-case</sub>               | Thermal resistance junction-case    | 1.47  | 5        | 1.47   |      | °C/W |
| R <sub>thj-amb</sub>                | Thermal resistance junction-ambient |       | 62.5     |        | 100  | °C/W |
| R <sub>thj-pcb</sub> <sup>(1)</sup> | Thermal resistance junction-pcb     | 50    |          |        |      | °C/W |

**Notes:**

- <sup>(1)</sup>When mounted on 1 inch<sup>2</sup> FR-4, 2 Oz copper board

Table 4: Avalanche characteristics

| Symbol          | Parameter  | Value | Unit |
|-----------------|--|-------|------|
| I <sub>AR</sub> | Avalanche current, repetitive or not repetitive (pulse width limited by T <sub>jmax</sub> )                                | 1     | 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 V) | 70    | mJ   |

## 2 Electrical characteristics

$T_C = 25\text{ }^\circ\text{C}$  unless otherwise specified

**Table 5: On/off-state**

| Symbol        | Parameter                         | Test conditions  | Min. | Typ. | Max.     | Unit          |
|---------------|-----------------------------------|--|------|------|----------|---------------|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage    | $V_{GS} = 0\text{ V}$ , $I_D = 1\text{ mA}$  | 950  |      |          | V             |
| $I_{DSS}$     | Zero gate voltage drain current   | $V_{DS} = 950\text{ V}$ , $V_{GS} = 0\text{ V}$  |      |      | 1        | $\mu\text{A}$ |
|               |                                   | $V_{DS} = 950\text{ V}$ , $V_{GS} = 0\text{ V}$<br>$T_C = 125\text{ }^\circ\text{C}^{(1)}$ |      |      | 50       | $\mu\text{A}$ |
| $I_{GSS}$     | Gate body leakage current         | $V_{GS} = \pm 20\text{ V}$ , $V_{DS} = 0\text{ V}$   |      |      | $\pm 10$ | $\mu\text{A}$ |
| $V_{GS(th)}$  | 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 | $V_{GS} = 10\text{ V}$ , $I_D = 1.5\text{ A}$  |      | 2    | 2.5      | $\Omega$      |

**Notes:**

<sup>(1)</sup>Defined by design, not subject to production test.

**Table 6: Dynamic**

| Symbol            | Parameter                             | Test conditions   | Min. | Typ. | Max. | Unit     |
|-------------------|---------------------------------------|---|------|------|------|----------|
| $C_{iss}$         | Input capacitance                     | $V_{DS} = 100\text{ V}$ , $f = 1\text{ MHz}$ ,<br>$V_{GS} = 0\text{ V}$   | -    | 220  | -    | pF       |
| $C_{oss}$         | Output capacitance                    |   | -    | 17   | -    | pF       |
| $C_{rss}$         | Reverse transfer capacitance          |   | -    | 1    | -    | pF       |
| $C_{o(tr)}^{(1)}$ | Equivalent capacitance time related   | $V_{GS} = 0\text{ V}$ ,<br>$V_{DS} = 0\text{ to }760\text{ V}$  | -    | 30   | -    | pF       |
| $C_{o(er)}^{(2)}$ | Equivalent capacitance energy related |   | -    | 11   | -    | pF       |
| $R_g$             | Intrinsic gate resistance             | $f = 1\text{ MHz}$ open drain   | -    | 17   | -    | $\Omega$ |
| $Q_g$             | Total gate charge                     | $V_{DD} = 760\text{ V}$ , $I_D = 3.5\text{ A}$<br>$V_{GS} = 10\text{ V}$<br>(see <a href="#">Figure 19: "Test circuit for gate charge behavior"</a> ) | -    | 12.5 | -    | nC       |
| $Q_{gs}$          | Gate-source charge                    |   | -    | 2    | -    | nC       |
| $Q_{gd}$          | Gate-drain charge                     |   | -    | 10   | -    | nC       |

**Notes:**

<sup>(1)</sup> $C_{o(tr)}$  is a constant capacitance value that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{DSS}$ .

<sup>(2)</sup> $C_{o(er)}$  is a constant capacitance value that gives the same stored energy as  $C_{oss}$  while  $V_{DS}$  is rising 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  | $V_{DD} = 475 \text{ V}$ , $I_D = 1.75 \text{ A}$ ,<br>$R_G = 4.7 \Omega$<br>$V_{GS} = 10 \text{ V}$<br>(see <a href="#">Figure 18: "Test circuit for resistive load switching times"</a><br>and <a href="#">Figure 23: "Switching time waveform"</a> ) | -    | 12   | -    | ns   |
| $t_r$        | Rise time           |   | -    | 16   | -    | ns   |
| $t_{d(off)}$ | Turn-off delay time |   | -    | 32   | -    | ns   |
| $t_f$        | Fall time           |   | -    | 25   | -    | ns   |

Table 8: Source-drain diode

| Symbol         | Parameter                     | Test conditions   | Min.   | Typ. | Max. | Unit          |
|----------------|-------------------------------|---|--|------|------|---------------|
| $I_{SD}$       | Source-drain current          |   | -  |      | 3.5  | A             |
| $I_{SDM}$      | Source-drain current (pulsed) |   | -  |      | 14   | A             |
| $V_{SD}^{(1)}$ | Forward on voltage            | $I_{SD} = 3.5 \text{ A}$ , $V_{GS} = 0 \text{ V}$   | -  |      | 1.5  | V             |
| $t_{rr}$       | Reverse recovery time         | $I_{SD} = 3.5 \text{ A}$ , $di/dt = 100 \text{ A}/\mu\text{s}$ ,<br>$V_{DD} = 60 \text{ V}$<br>(see <a href="#">Figure 20: "Test circuit for inductive load switching and diode recovery times"</a> ) | -  | 330  |      | ns            |
| $Q_{rr}$       | Reverse recovery charge       |   | -  | 2.2  |      | $\mu\text{C}$ |
| $I_{RRM}$      | Reverse recovery current      |   | -  | 13   |      | A             |
| $t_{rr}$       | Reverse recovery time         |   | $I_{SD} = 3.5 \text{ A}$ , $di/dt = 100 \text{ A}/\mu\text{s}$ ,<br>$V_{DD} = 60 \text{ V}$ , $T_j = 150 \text{ }^\circ\text{C}$<br>(see <a href="#">Figure 20: "Test circuit for inductive load switching and diode recovery times"</a> ) | -    | 525  |               |
| $Q_{rr}$       | Reverse recovery charge       | -   |  | 3.2  |      | $\mu\text{C}$ |
| $I_{RRM}$      | Reverse recovery current      | -   |  | 12   |      | A             |

**Notes:**

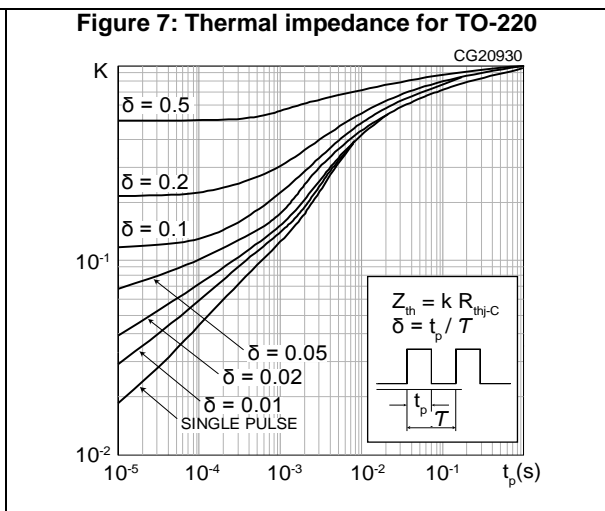
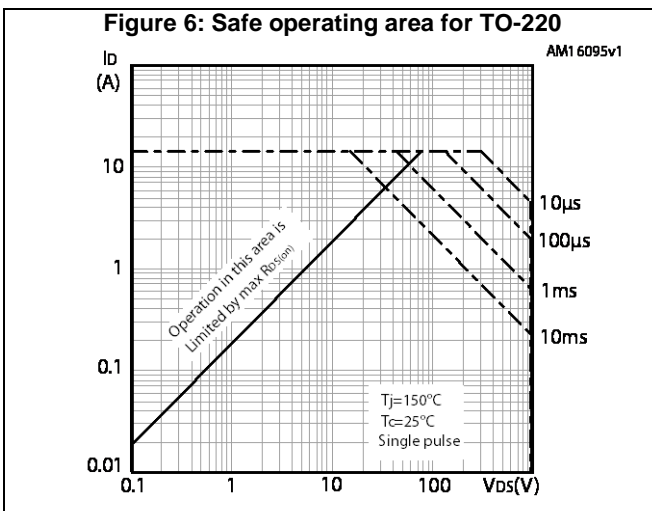
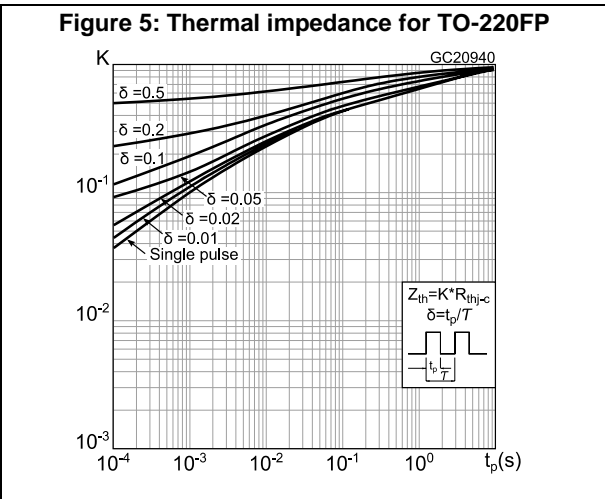
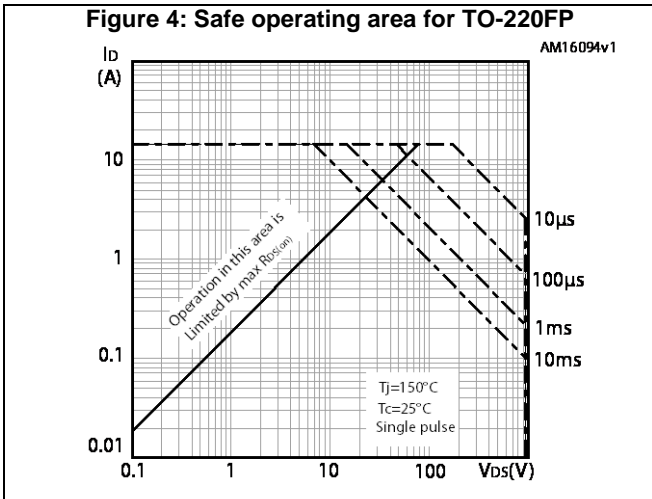
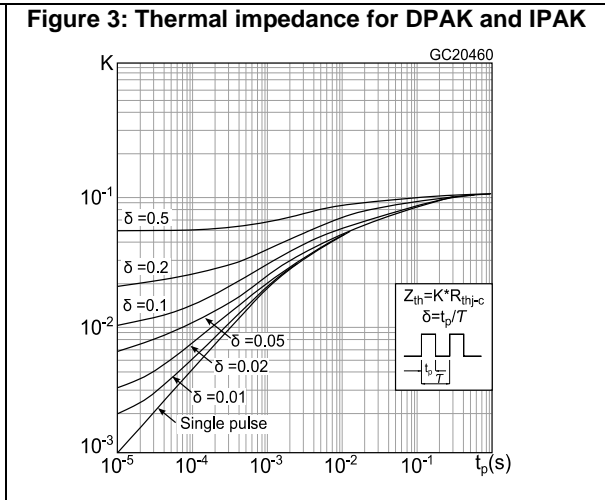
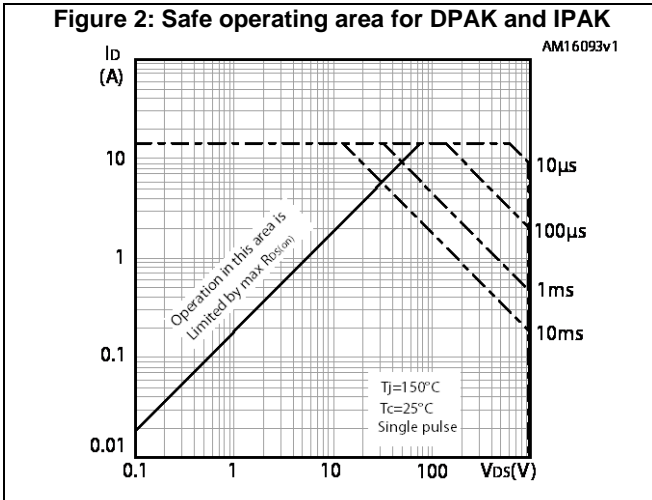
<sup>(1)</sup>Pulsed: pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%

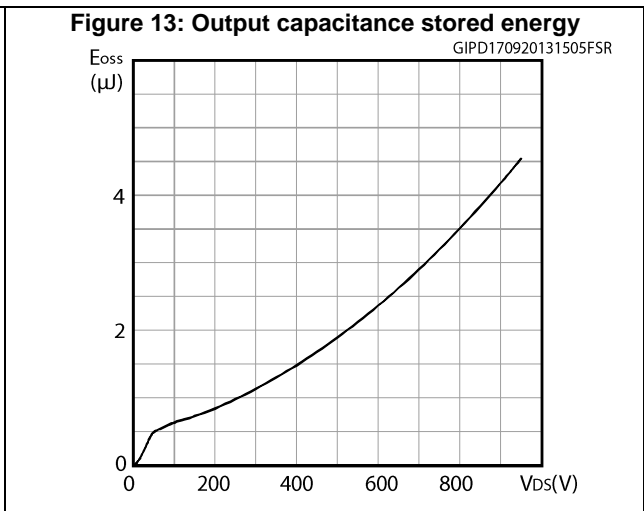
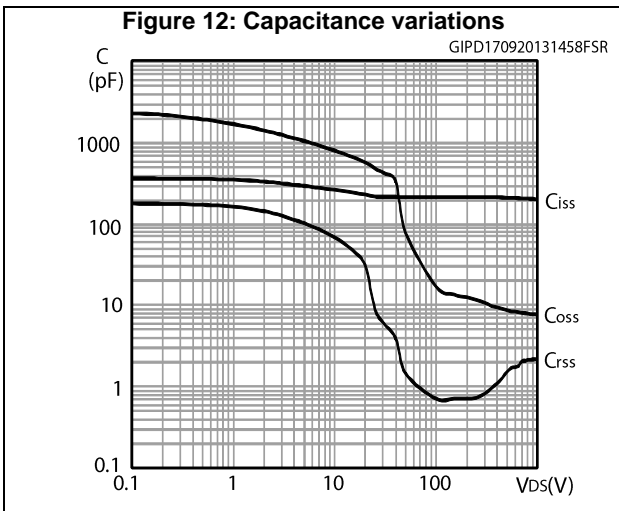
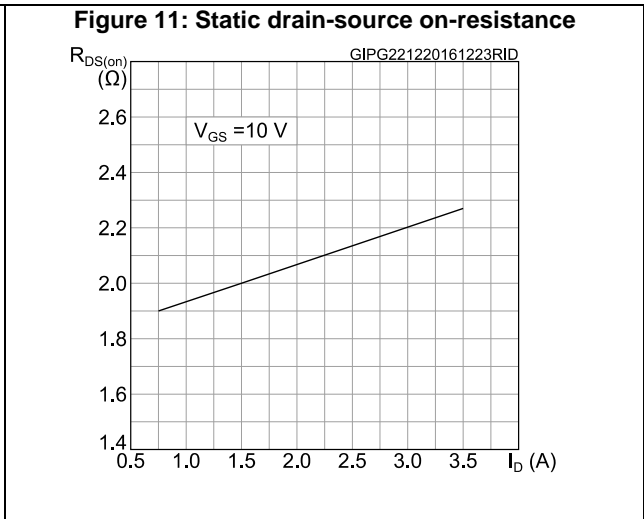
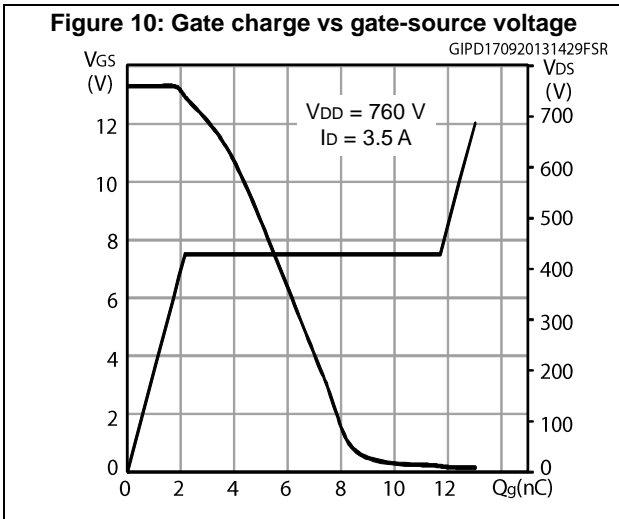
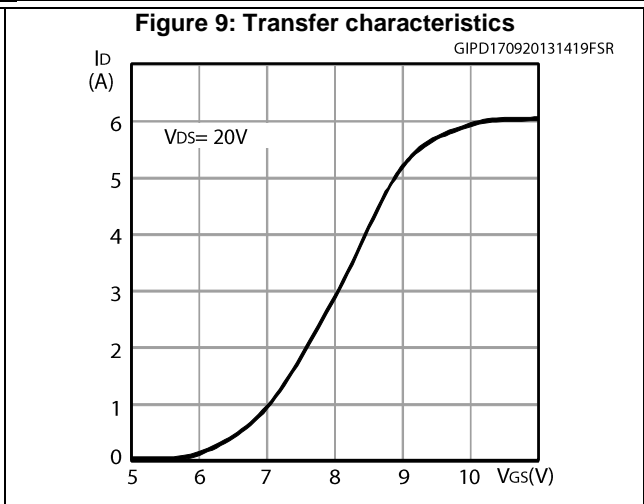
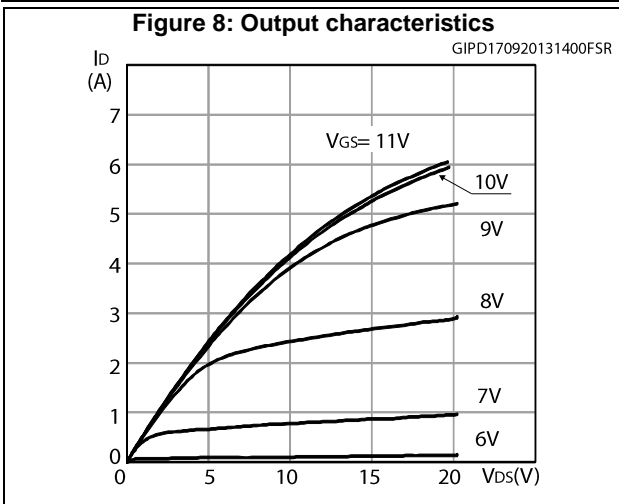
Table 9: Gate-source Zener diode

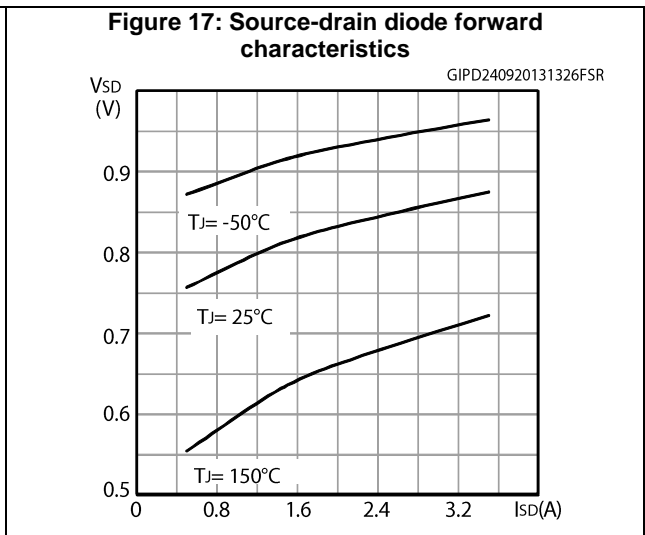
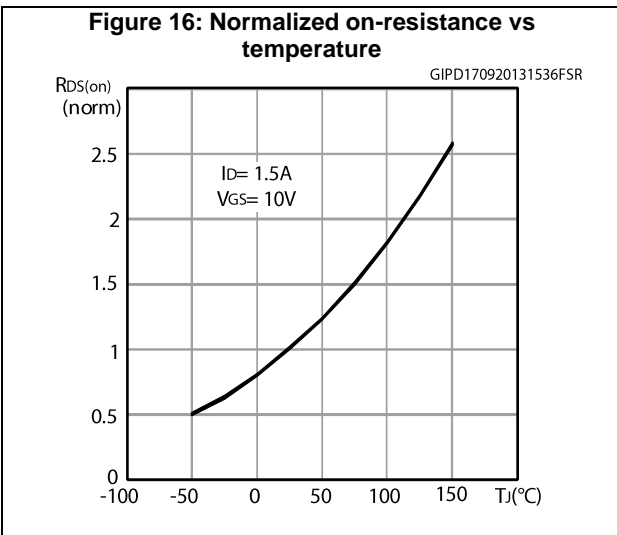
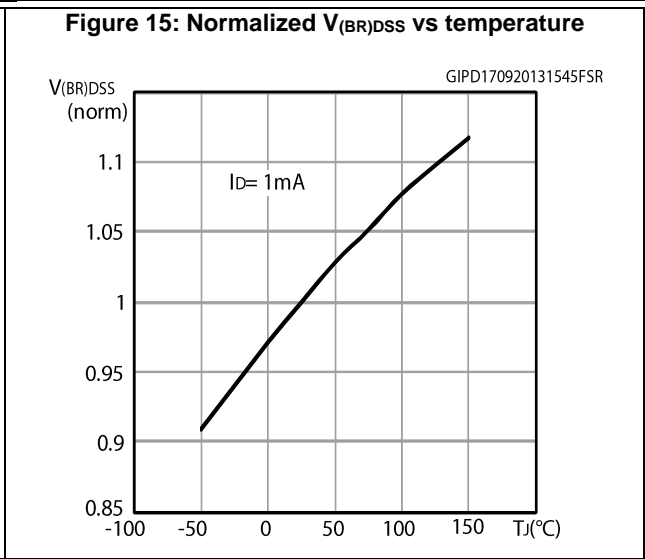
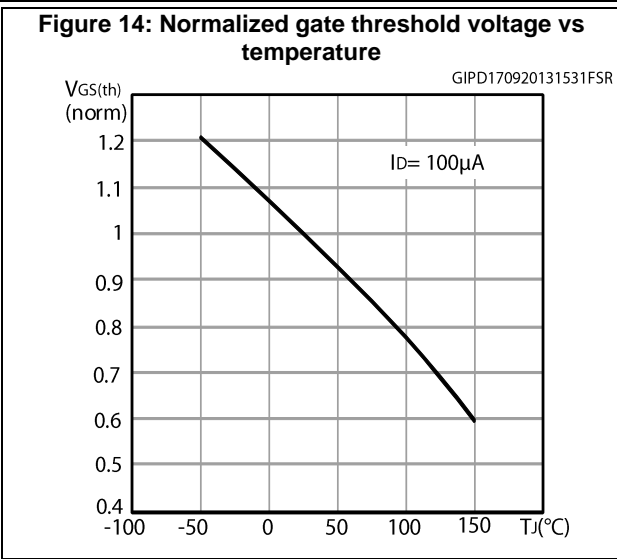
| Symbol        | Parameter                     | Test conditions                                   | Min | Typ. | Max | Unit |
|---------------|-------------------------------|---|-----|------|-----|------|
| $V_{(BR)GSO}$ | Gate-source breakdown voltage | $I_{GS} = \pm 1 \text{ mA}$ , $I_D = 0 \text{ A}$ | 30  | -    | -   | V    |

The built-in back-to-back Zener diodes are specifically designed to enhance the ESD performance of the device. The Zener voltage facilitates efficient and cost-effective device integrity protection, thus eliminating the need for additional external componentry.

## 2.1 Electrical characteristics (curves)



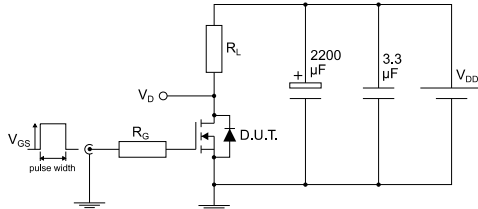






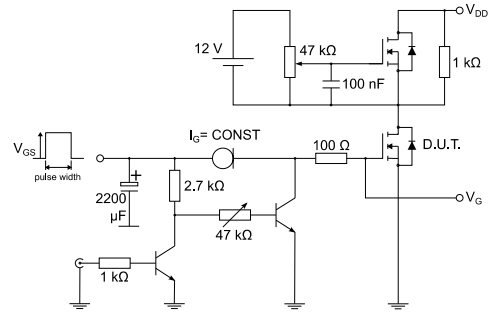
### 3 Test circuits

**Figure 18: Test circuit for resistive load switching times**



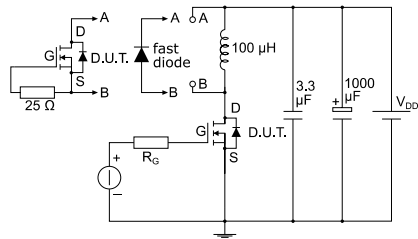
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**Figure 19: Test circuit for gate charge behavior**



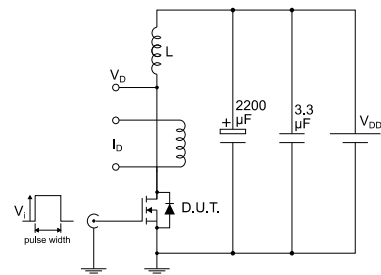
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**Figure 20: Test circuit for inductive load switching and diode recovery times**



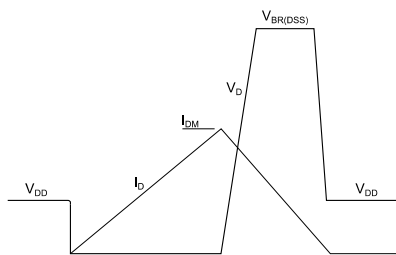
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**Figure 21: Unclamped inductive load test circuit**



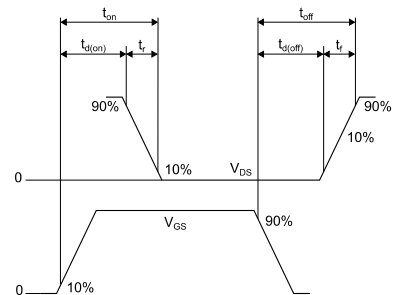
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**Figure 22: Unclamped inductive waveform**



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**Figure 23: Switching time waveform**



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## 4 Package information

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](http://www.st.com). ECOPACK® is an ST trademark.

### 4.1 DPAK (TO-252) type A2 package information

Figure 24: DPAK (TO-252) type A2 package outline

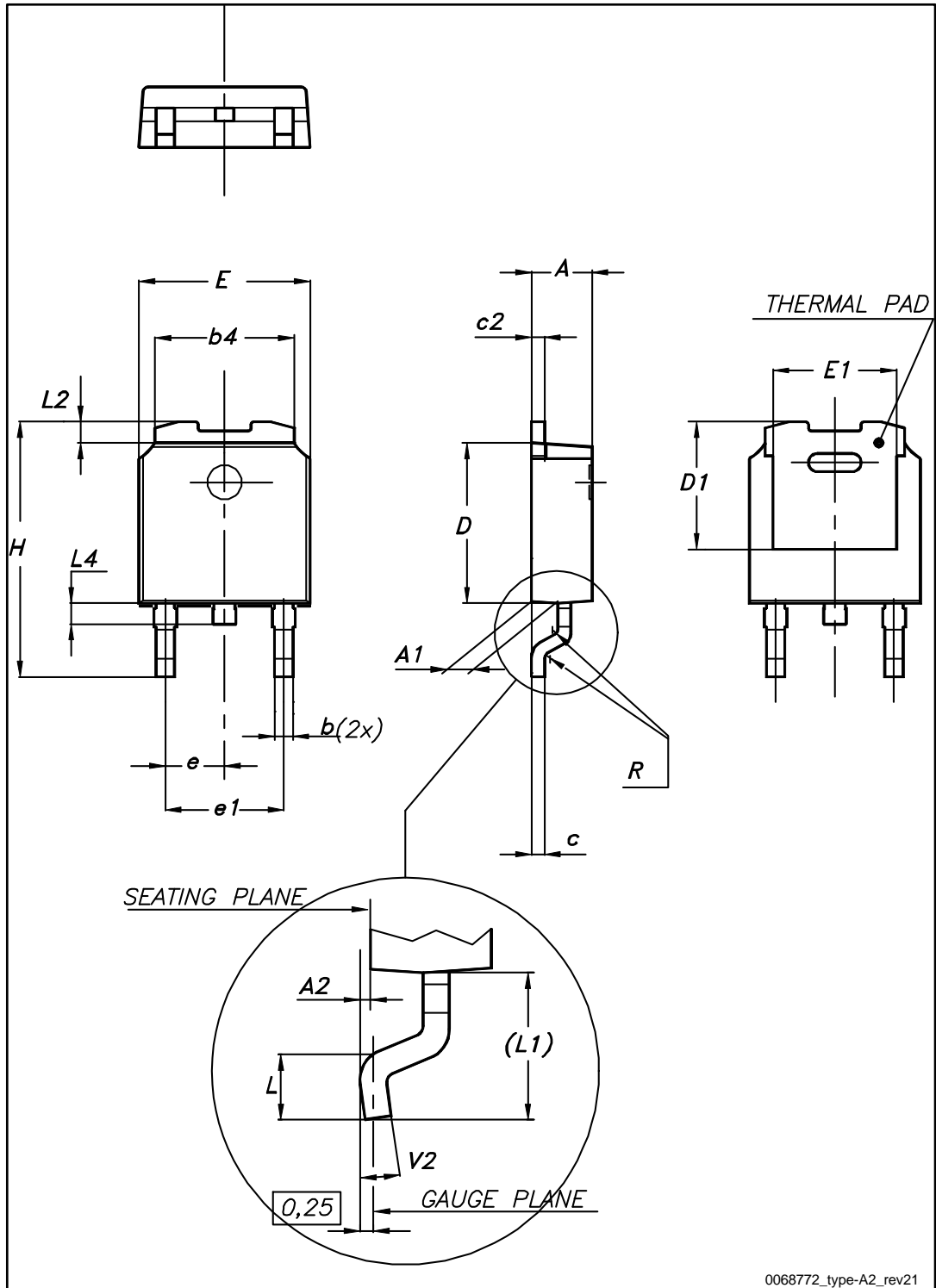
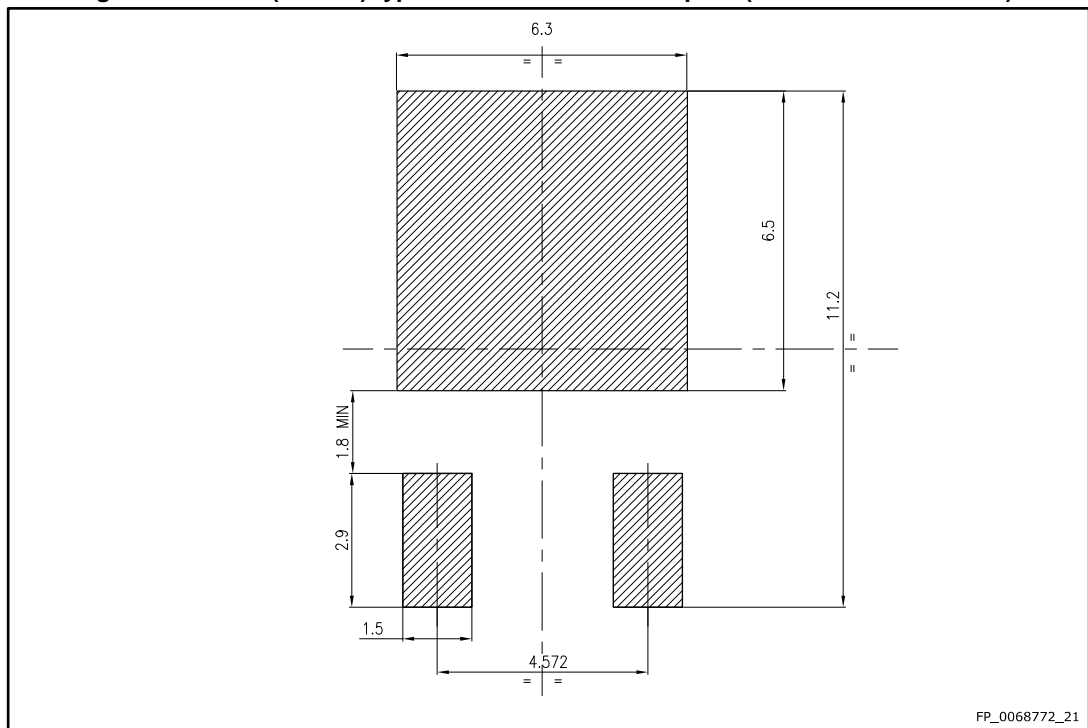


Table 10: DPAK (TO-252) type A2 mechanical data

| 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   | 4.95 | 5.10 | 5.25  |
| E    | 6.40 |      | 6.60  |
| E1   | 5.10 | 5.20 | 5.30  |
| e    | 2.16 | 2.28 | 2.40  |
| e1   | 4.40 |      | 4.60  |
| H    | 9.35 |      | 10.10 |
| L    | 1.00 |      | 1.50  |
| L1   | 2.60 | 2.80 | 3.00  |
| L2   | 0.65 | 0.80 | 0.95  |
| L4   | 0.60 |      | 1.00  |
| R    |      | 0.20 |       |
| V2   | 0°   |      | 8°    |

Figure 25: DPAK (TO-252) type A2 recommended footprint (dimensions are in mm)



## 4.2 DPAK (TO-252) type C2 package information

Figure 26: DPAK (TO-252) type C2 package outline

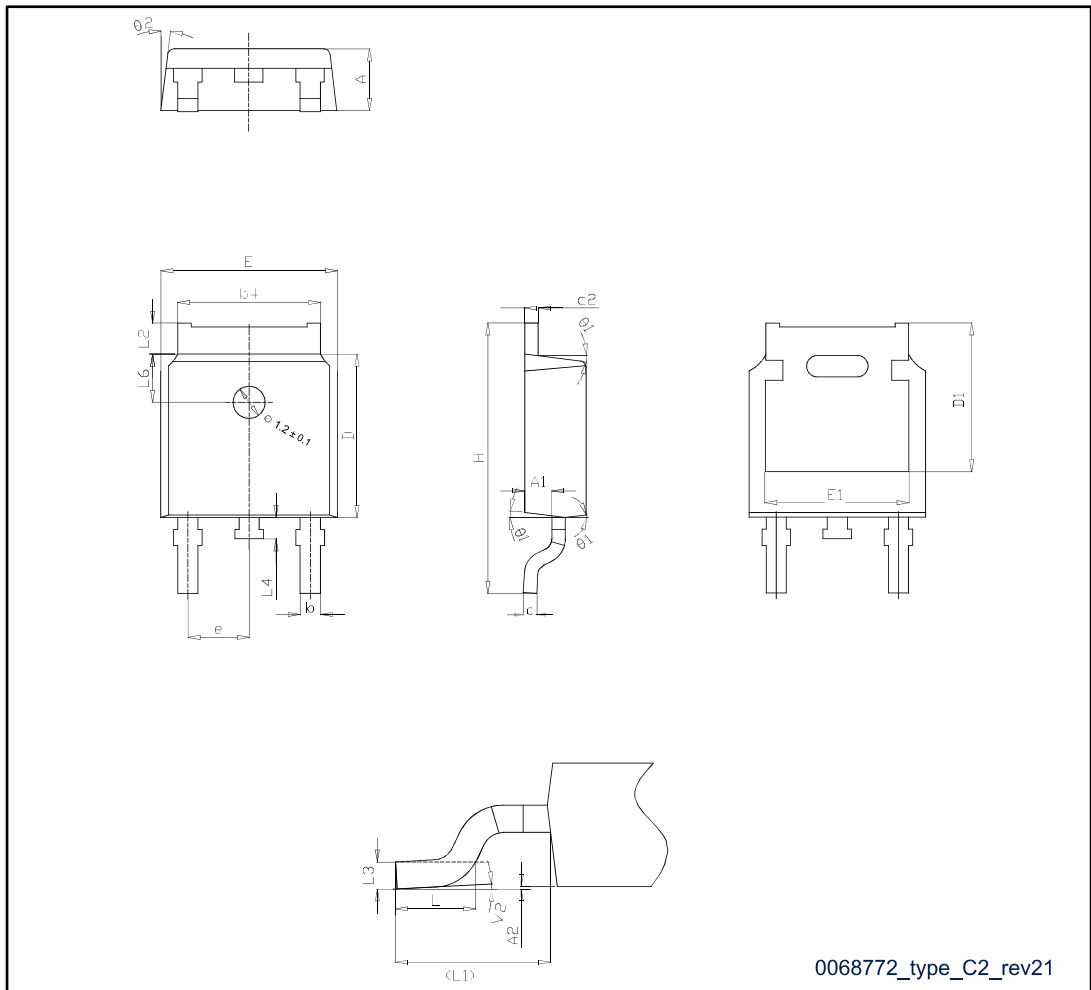
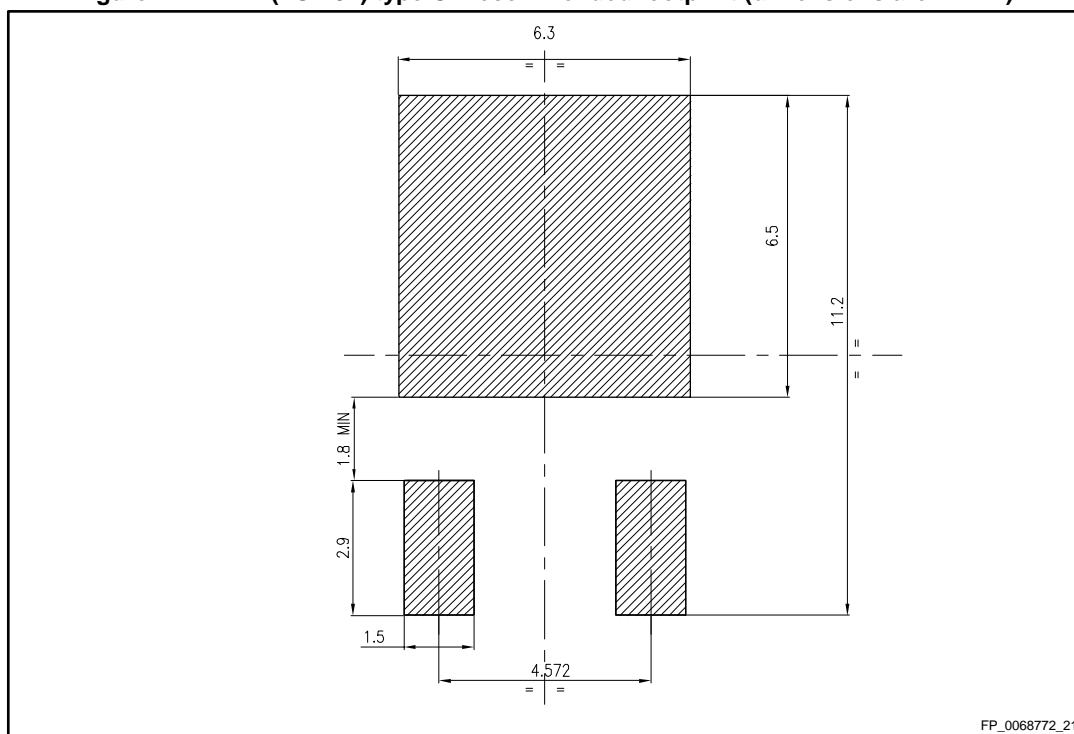


Table 11: DPAK (TO-252) type C2 mechanical data

| Dim. | mm       |       |       |
|------|----------|-------|-------|
|      | Min.     | Typ.  | Max.  |
| A    | 2.20     | 2.30  | 2.38  |
| A1   | 0.90     | 1.01  | 1.10  |
| A2   | 0.00     |       | 0.10  |
| b    | 0.72     |       | 0.85  |
| b4   | 5.13     | 5.33  | 5.46  |
| c    | 0.47     |       | 0.60  |
| c2   | 0.47     |       | 0.60  |
| D    | 6.00     | 6.10  | 6.20  |
| D1   | 5.10     |       | 5.60  |
| E    | 6.50     | 6.60  | 6.70  |
| E1   | 5.20     |       | 5.50  |
| e    | 2.186    | 2.286 | 2.386 |
| H    | 9.80     | 10.10 | 10.40 |
| L    | 1.40     | 1.50  | 1.70  |
| L1   | 2.90 REF |       |       |
| L2   | 0.90     |       | 1.25  |
| L3   | 0.51 BSC |       |       |
| L4   | 0.60     | 0.80  | 1.00  |
| L6   | 1.80 BSC |       |       |
| θ1   | 5°       | 7°    | 9°    |
| θ2   | 5°       | 7°    | 9°    |
| V2   | 0°       |       | 8°    |

Figure 27: DPAK (TO-252) type C2 recommended footprint (dimensions are in mm)





### 4.3 DPAK (TO-252) packing information

Figure 28: DPAK (TO-252) tape outline

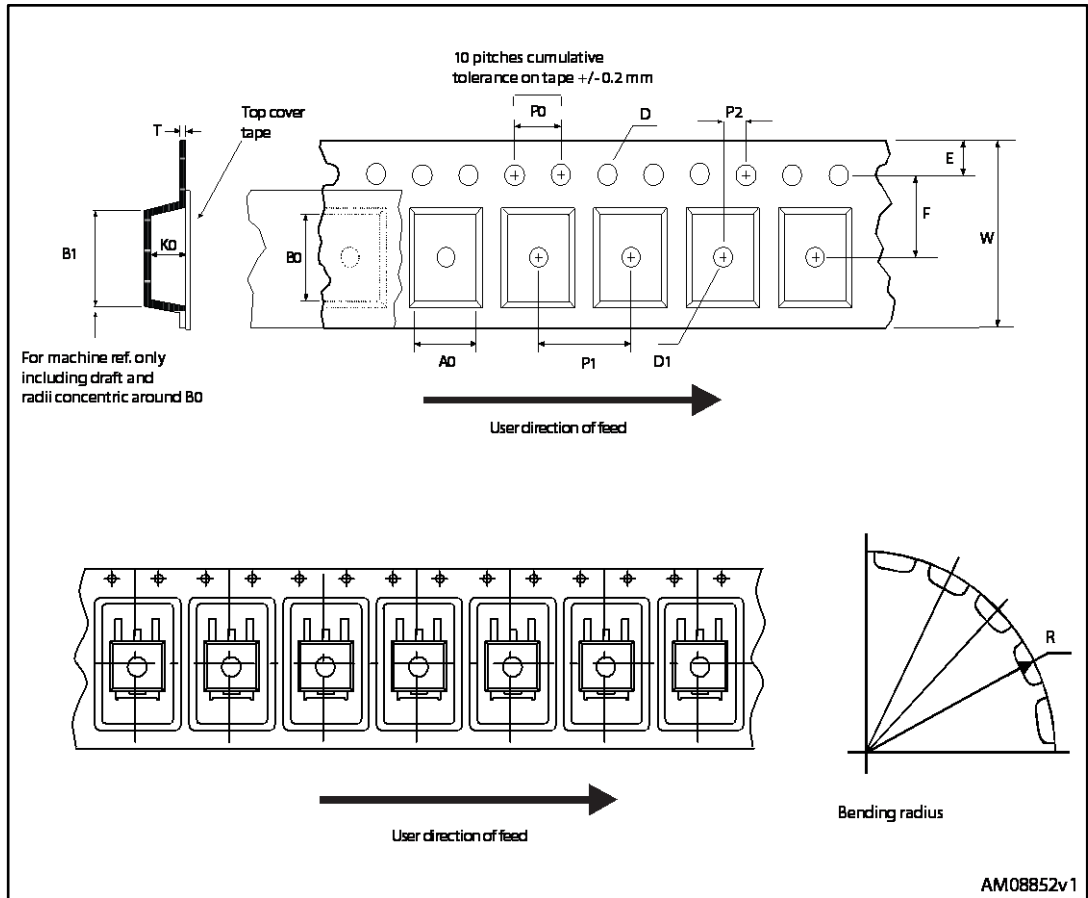
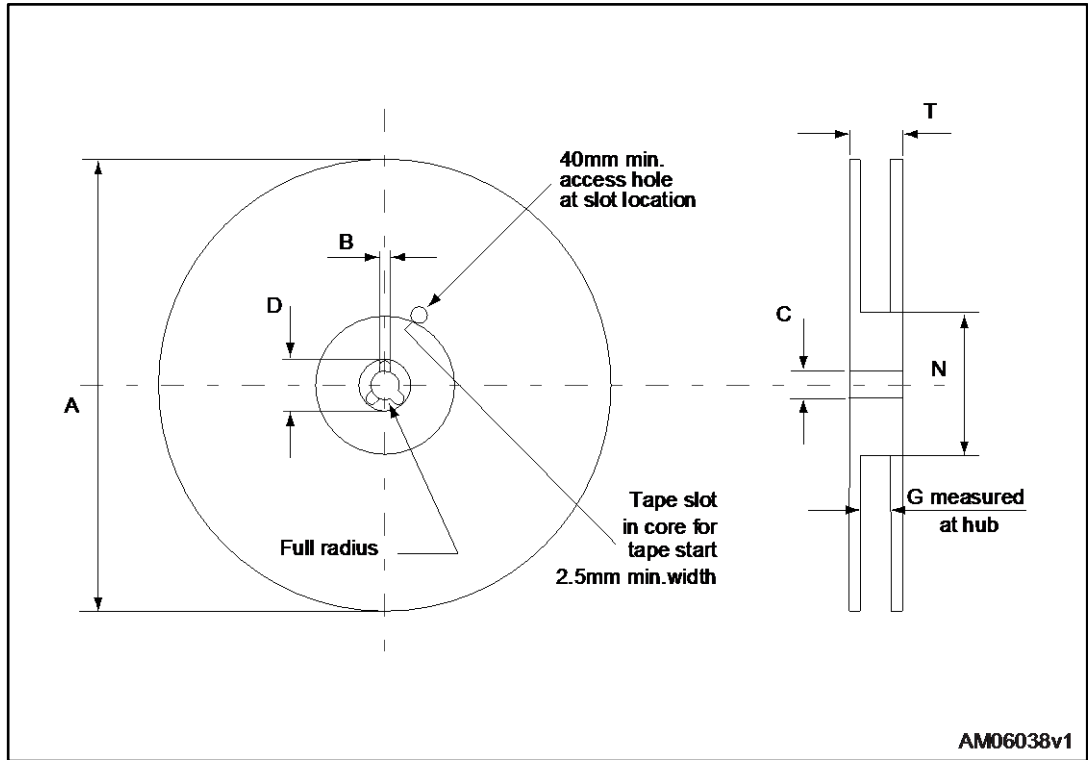


Figure 29: DPAK (TO-252) reel outline



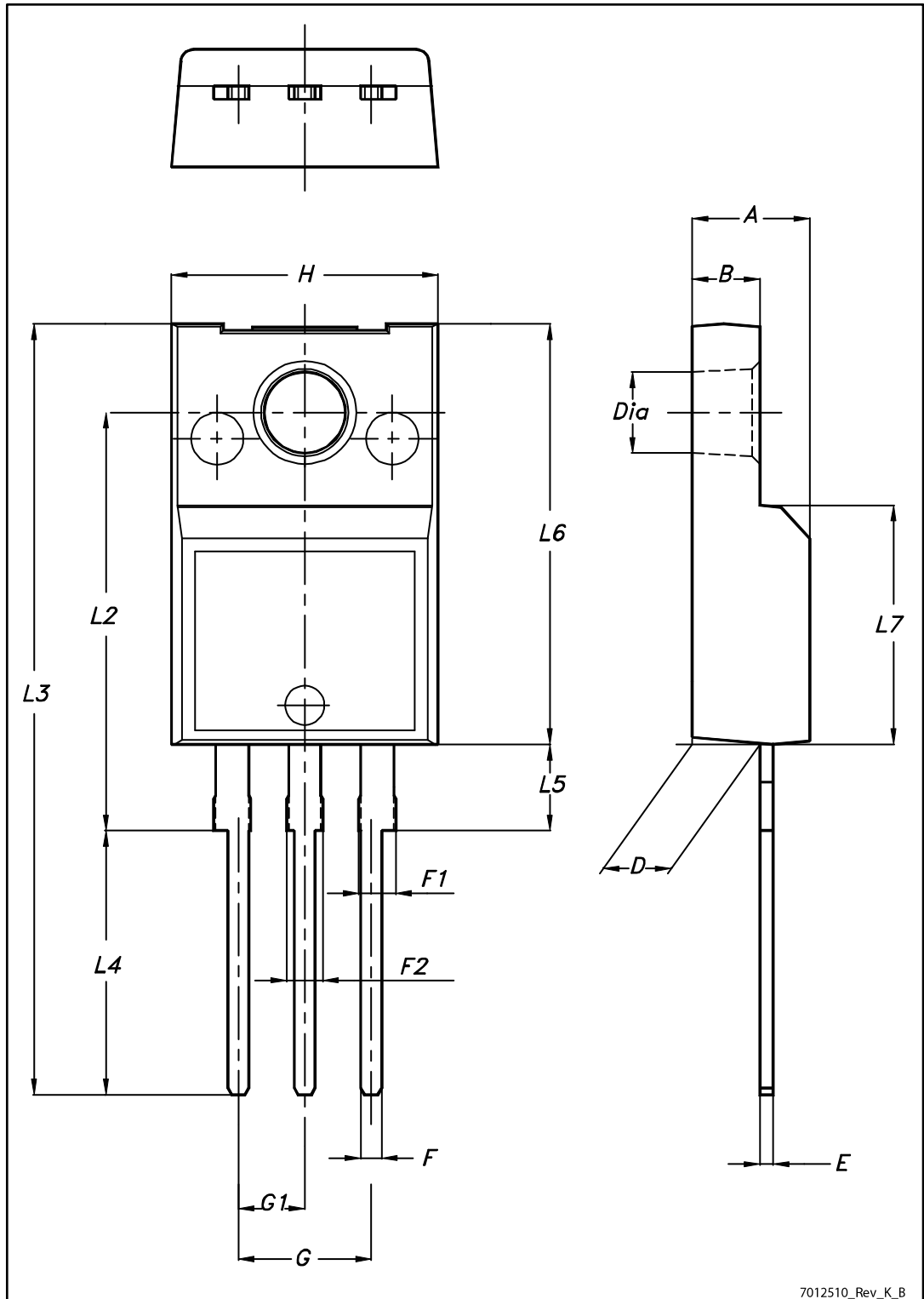
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Table 12: DPAK (TO-252) tape and reel mechanical data

| 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 |           |      |      |

### 4.4 TO-220FP package information

Figure 30: TO-220FP package outline



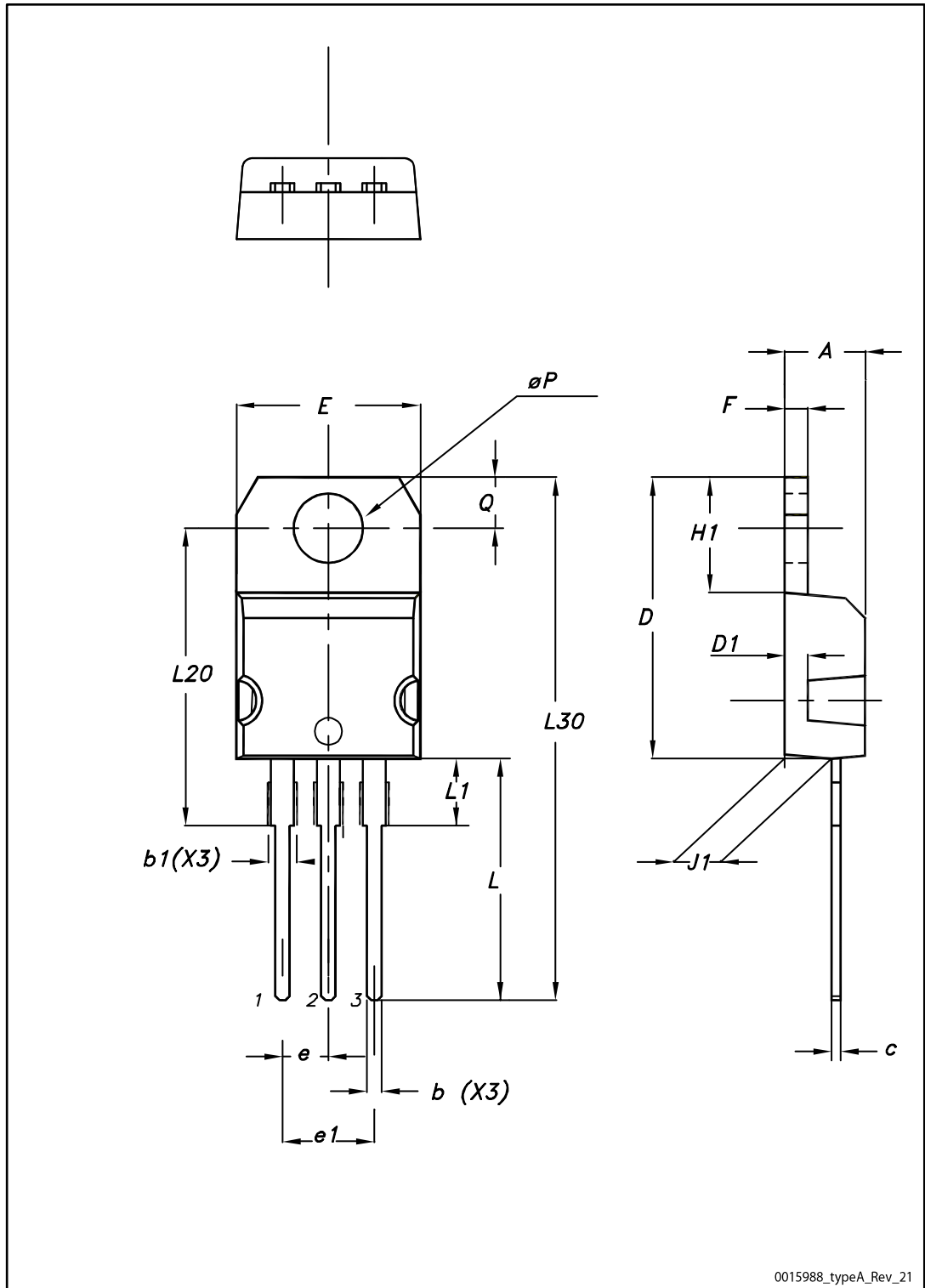
7012510\_Rev\_K\_B

Table 13: TO-220FP package 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  |

### 4.5 TO-220 type A package information

Figure 31: TO-220 type A package outline



0015988\_typeA\_Rev\_21

Table 14: TO-220 type A mechanical data

| Dim. | mm    |       |       |
|------|-------|-------|-------|
|      | Min.  | Typ.  | Max.  |
| A    | 4.40  |       | 4.60  |
| b    | 0.61  |       | 0.88  |
| b1   | 1.14  |       | 1.55  |
| c    | 0.48  |       | 0.70  |
| D    | 15.25 |       | 15.75 |
| D1   |       | 1.27  |       |
| E    | 10.00 |       | 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    | 13.00 |       | 14.00 |
| L1   | 3.50  |       | 3.93  |
| L20  |       | 16.40 |       |
| L30  |       | 28.90 |       |
| øP   | 3.75  |       | 3.85  |
| Q    | 2.65  |       | 2.95  |

### 4.6 IPAK (TO-251) type A package information

Figure 32: IPAK (TO-251) type A package outline

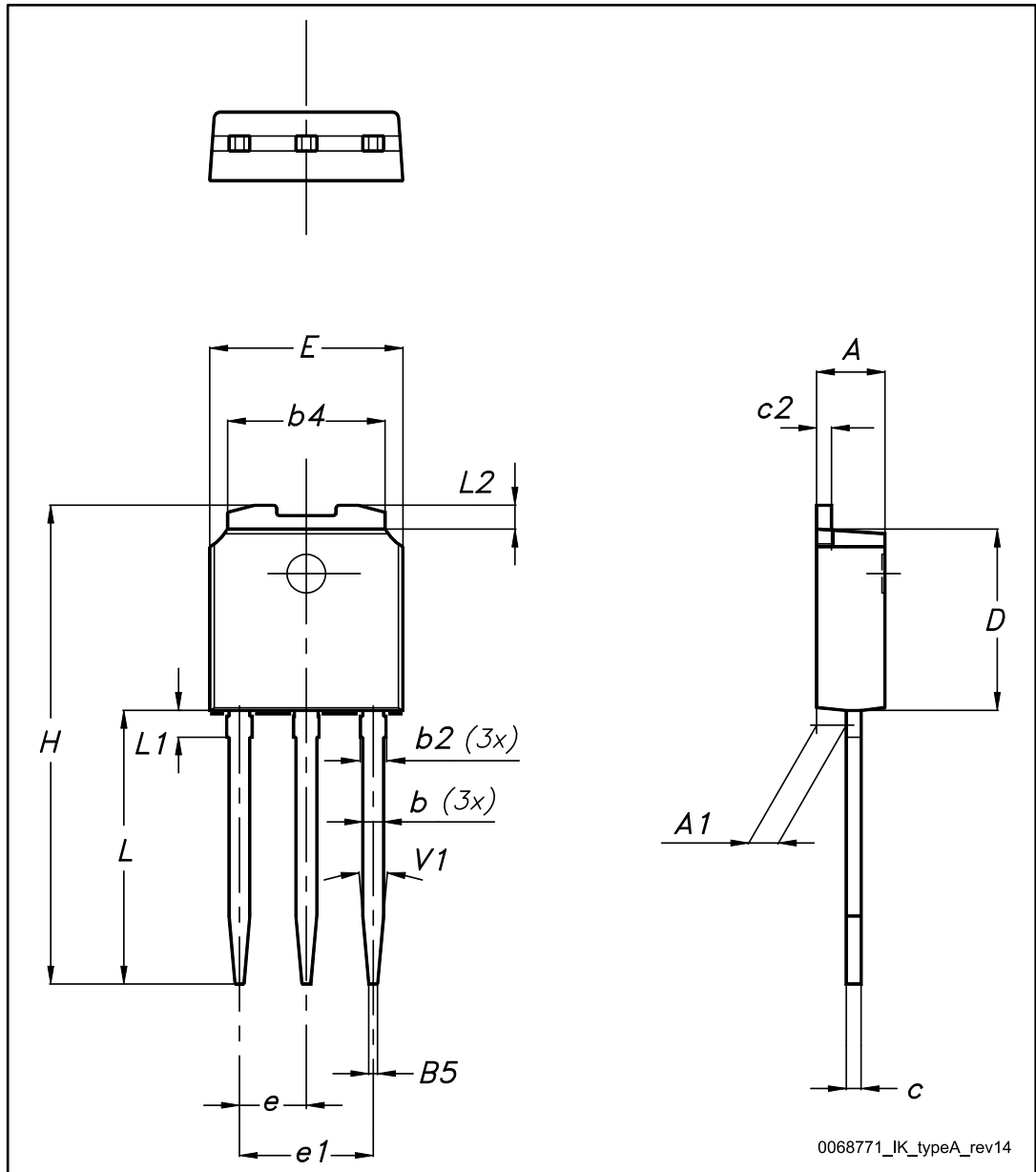


Table 15: IPAK (TO-251) type A package mechanical data

| 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 Revision history

Table 16: Document revision history

| Date        | Revision | Changes   |
|-------------|----------|---|
| 08-May-2013 | 1        | First release.  |
| 18-Sep-2013 | 2        | Document status promoted from preliminary to production data.<br>Added <i>Section 2.1: Electrical characteristics (curves)</i> .<br>Updated DPAK mechanical data.   |
| 25-Sep-2013 | 3        | Inserted <i>Figure 17: Source-drain diode forward characteristics</i> .   |
| 04-Jan-2017 | 4        | Added IPAK package.<br>Modified title, features and description on cover page.<br>Modified <i>Table 2: "Absolute maximum ratings"</i> , <i>Table 3: "Thermal data"</i> , <i>Table 5: "On/off-state"</i> .<br>Modified <i>Figure 11: "Static drain-source on-resistance"</i> .<br>Updated <i>Section 4: "Package information"</i> .<br>Minor text changes. |

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