

N-channel 600 V, 0.28  $\Omega$  typ., 11 A MDmesh™ II  
Power MOSFETs in D<sup>2</sup>PAK and DPAK packages

Datasheet — production data

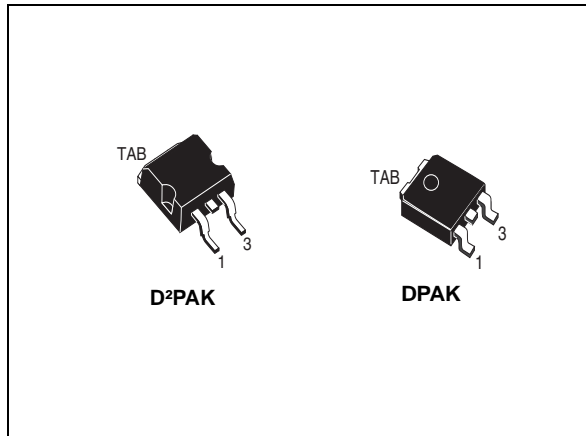
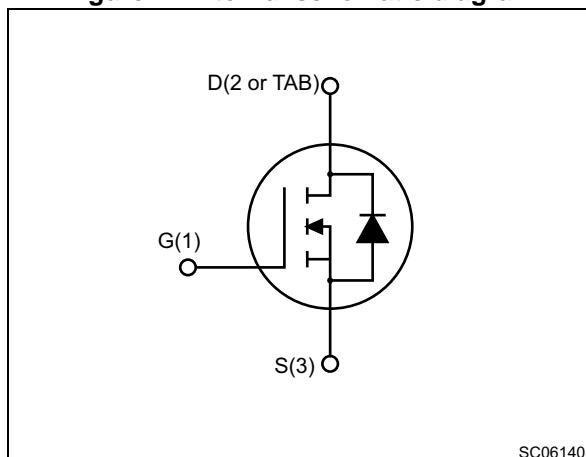


Figure 1. Internal schematic diagram



## Features

| Order code | V <sub>DS</sub> (@T <sub>jmax</sub> ) | R <sub>DS(on)</sub> max | I <sub>D</sub> |
|------------|---------------------------------------|-------------------------|----------------|
| STB13NM60N | 650 V                                 | 0.36 $\Omega$           | 11 A           |
| STD13NM60N |                                       |                         |                |

- 100% avalanche tested
- Low input capacitance and gate charge
- Low gate input resistance

## Applications

- Switching applications

## Description

These devices are N-channel Power MOSFETs developed using the second generation of MDmesh™ technology. This revolutionary Power MOSFET associates a vertical structure to the company's strip layout to yield one of the world's lowest on-resistance and gate charge. It is therefore suitable for the most demanding high efficiency converters.

Table 1. Device summary

| Order code | Marking | Packages           | Packaging     |
|------------|---------|--------------------|---------------|
| STB13NM60N | 13NM60N | D <sup>2</sup> PAK | Tape and reel |
| STD13NM60N |         | DPAK               |               |

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol         | Parameter   | Value       | Unit             |
|----------------|---|-------------|------------------|
| $V_{DS}$       | Drain-source voltage  | 600         | V                |
| $V_{GS}$       | Gate-source voltage   | $\pm 25$    | V                |
| $I_D$          | Drain current (continuous) at $T_C = 25\text{ }^\circ\text{C}$  | 11          | A                |
| $I_D$          | Drain current (continuous) at $T_C = 100\text{ }^\circ\text{C}$ | 6.93        | A                |
| $I_{DM}^{(1)}$ | Drain current (pulsed)  | 44          | A                |
| $P_{TOT}$      | Total dissipation at $T_C = 25\text{ }^\circ\text{C}$           | 90          | W                |
| $dv/dt^{(2)}$  | Peak diode recovery voltage slope                               | 15          | V/ns             |
| $T_{stg}$      | Storage temperature   | - 55 to 150 | $^\circ\text{C}$ |
| $T_j$          | Max. operating junction temperature                             | 150         | $^\circ\text{C}$ |

1. Pulse width limited by safe operating area

2.  $I_{SD} \leq 11\text{ A}$ ,  $di/dt \leq 400\text{ A}/\mu\text{s}$ ,  $V_{DS\text{ peak}} \leq V_{(BR)DSS}$ ,  $V_{DD} = 80\% V_{(BR)DSS}$ .

**Table 3. Thermal data**

| Symbol         | Parameter                            | Value              |      | Unit                      |
|----------------|--------------------------------------|--------------------|------|---------------------------|
|                |                                      | D <sup>2</sup> PAK | DPAK |                           |
| $R_{thj-case}$ | Thermal resistance junction-case max | 1.39               |      | $^\circ\text{C}/\text{W}$ |
| $R_{thj-pcb}$  | Thermal resistance junction-pcb max  | 30                 | 50   | $^\circ\text{C}/\text{W}$ |

**Table 4. Avalanche characteristics**

| Symbol   | Parameter  | Value | Unit |
|----------|--|-------|------|
| $I_{AS}$ | Avalanche current, repetitive or not-repetitive (pulse width limited by $T_j$ max)                             | 3.5   | A    |
| $E_{AS}$ | Single pulse avalanche energy (starting $T_j=25\text{ }^\circ\text{C}$ , $I_D=I_{AS}$ , $V_{DD}=50\text{ V}$ ) | 200   | 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    | $V_{GS} = 0, I_D = 1\text{ mA}$                          | 600  |      |           | V             |
| $I_{DSS}$     | Zero gate voltage drain current   | $V_{GS} = 0, V_{DS} = 600\text{ V}$                      |      |      | 1         | $\mu\text{A}$ |
|               |                                   | $V_{GS} = 0, V_{DS} = 600\text{ V}, T_C = 125\text{ °C}$ |      |      | 100       | $\mu\text{A}$ |
| $I_{GSS}$     | Gate-body leakage current         | $V_{DS} = 0, V_{GS} = \pm 25\text{ V}$                   |      |      | $\pm 0.1$ | $\mu\text{A}$ |
| $V_{GS(th)}$  | Gate threshold voltage            | $V_{DS} = V_{GS}, I_D = 250\text{ }\mu\text{A}$          | 2    | 3    | 4         | V             |
| $R_{DS(on)}$  | Static drain-source on-resistance | $V_{GS} = 10\text{ V}, I_D = 5.5\text{ A}$               |      | 0.28 | 0.36      | $\Omega$      |

**Table 6. Dynamic**

| Symbol                     | Parameter                     | Test conditions   | Min. | Typ. | Max. | Unit     |
|----------------------------|-------------------------------|---|------|------|------|----------|
| $C_{iss}$                  | Input capacitance             | $V_{GS} = 0, V_{DS} = 50\text{ V}, f = 1\text{ MHz}$  | -    | 790  | -    | pF       |
| $C_{oss}$                  | Output capacitance            |   | -    | 60   | -    | pF       |
| $C_{rss}$                  | Reverse transfer capacitance  |   | -    | 3.6  | -    | pF       |
| $C_{oss\text{ eq.}}^{(1)}$ | Equivalent output capacitance | $V_{GS} = 0, V_{DS} = 0\text{ to }480\text{ V}$   | -    | 135  | -    | pF       |
| $Q_g$                      | Total gate charge             | $V_{DD} = 480\text{ V}, I_D = 11\text{ A}, V_{GS} = 10\text{ V},$<br><i>(see Figure 16)</i> | -    | 27   | -    | nC       |
| $Q_{gs}$                   | Gate-source charge            |   | -    | 4    | -    | nC       |
| $Q_{gd}$                   | Gate-drain charge             |   | -    | 14   | -    | nC       |
| $R_G$                      | Gate input resistance         | $f = 1\text{ MHz}$ open drain   | -    | 4.7  | -    | $\Omega$ |

1.  $C_{oss\text{ eq.}}$  is defined as a constant equivalent capacitance giving the same charging time as  $C_{oss}$  when  $V_{DS}$  increases from 0 to 80%  $V_{DS}$

**Table 7. Switching times**

| Symbol       | Parameter           | Test conditions  | Min. | Typ. | Max. | Unit |
|--------------|---------------------|--|------|------|------|------|
| $t_{d(on)}$  | Turn-on delay time  | $V_{DD} = 300\text{ V}, I_D = 5.5\text{ A}, R_G = 4.7\text{ }\Omega, V_{GS} = 10\text{ V}$<br><i>(see Figure 15)</i> | -    | 3    | -    | ns   |
| $t_r$        | Rise time           |  | -    | 8    | -    | ns   |
| $t_{d(off)}$ | Turn-off delay time |  | -    | 30   | -    | ns   |
| $t_f$        | Fall time           |  | -    | 10   | -    | ns   |

Table 8. Source drain diode

| Symbol          | Parameter                     | Test conditions  | Min | Typ. | Max. | Unit          |
|-----------------|-------------------------------|--|-----|------|------|---------------|
| $I_{SD}$        | Source-drain current          |  | -   |      | 11   | A             |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |  | -   |      | 44   | A             |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD} = 11 \text{ A}, V_{GS} = 0$  | -   |      | 1.5  | V             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 11 \text{ A}, di/dt = 100 \text{ A}/\mu\text{s}$<br>$V_{DD} = 100 \text{ V}$<br><i>(see Figure 17)</i>                                   | -   | 230  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |  | -   | 2    |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |  | -   | 18   |      | A             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 11 \text{ A}, di/dt = 100 \text{ A}/\mu\text{s}$<br>$V_{DD} = 100 \text{ V}, T_j = 150 \text{ }^\circ\text{C}$<br><i>(see Figure 17)</i> | -   | 290  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |  | -   | 2.5  |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |  | -   | 17   |      | 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 D<sup>2</sup>PAK

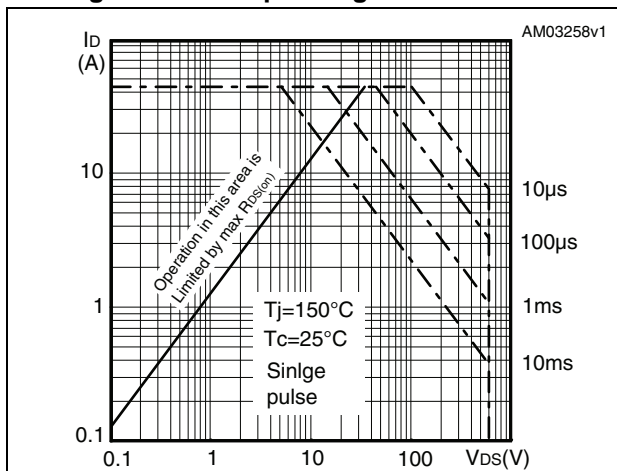


Figure 3. Thermal impedance for D<sup>2</sup>PAK

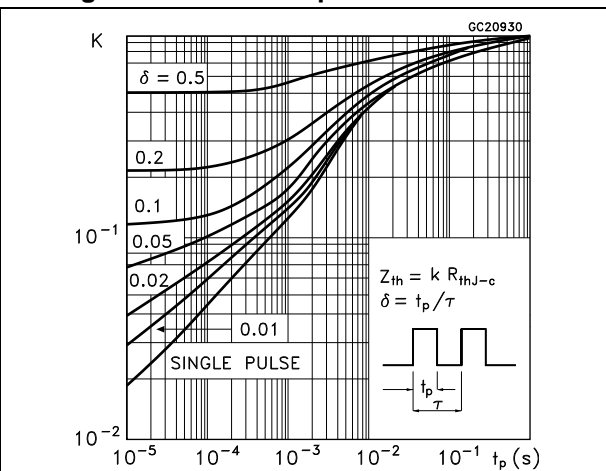


Figure 4. Safe operating area for DPAK

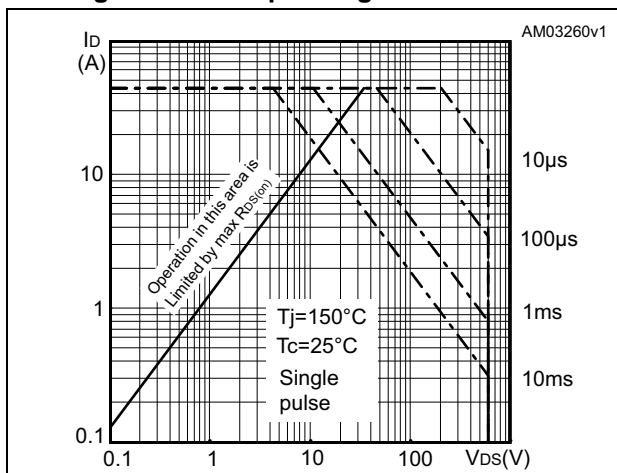


Figure 5. Thermal impedance for DPAK

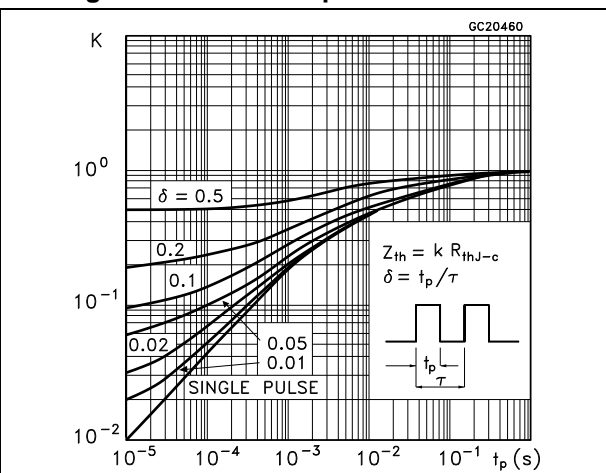


Figure 6. Output characteristics

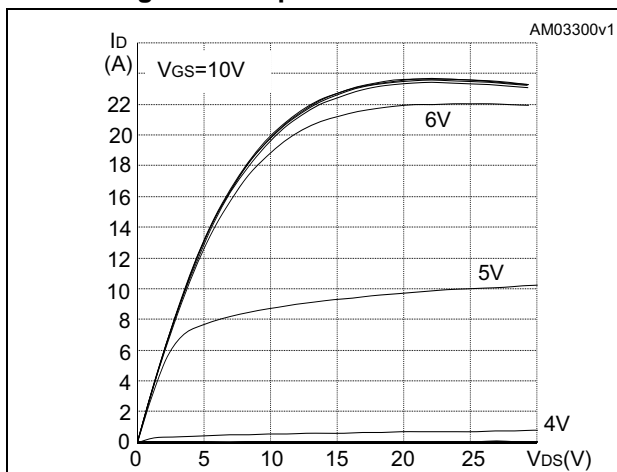


Figure 7. Transfer characteristics

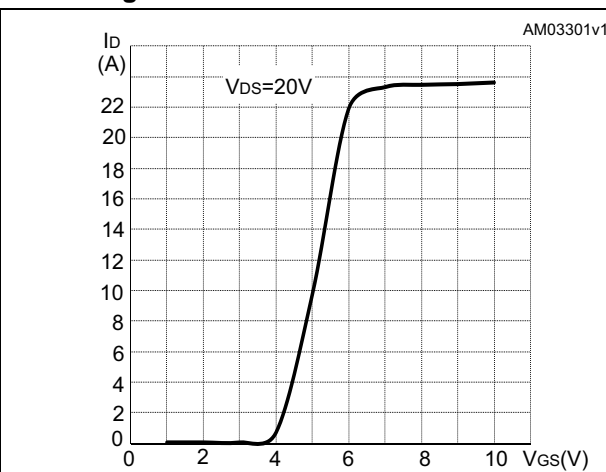


Figure 8. Normalized  $V_{(BR)DSS}$  vs temperature

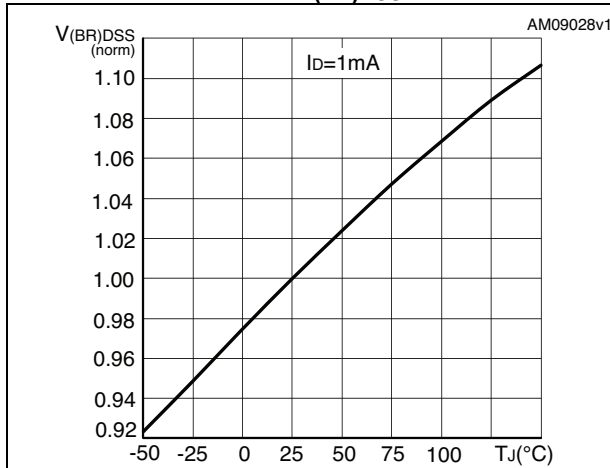


Figure 9. Static drain-source on-resistance

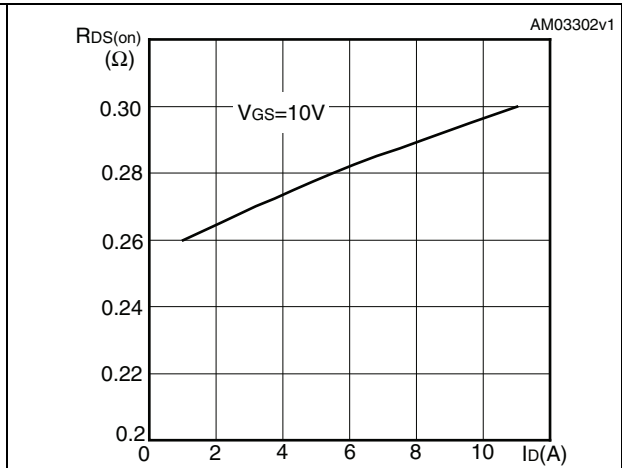


Figure 10. Gate charge vs gate-source voltage

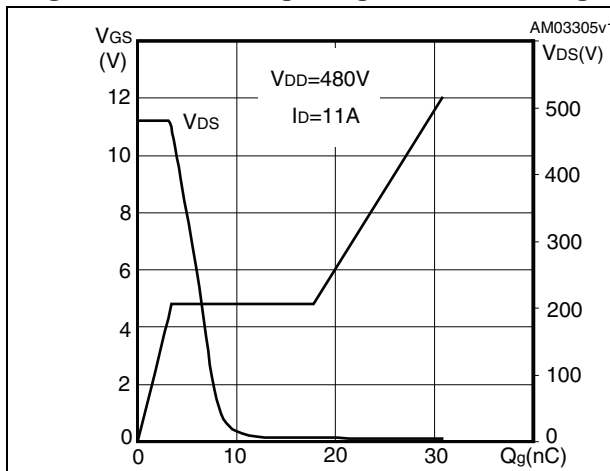


Figure 11. Capacitance variations

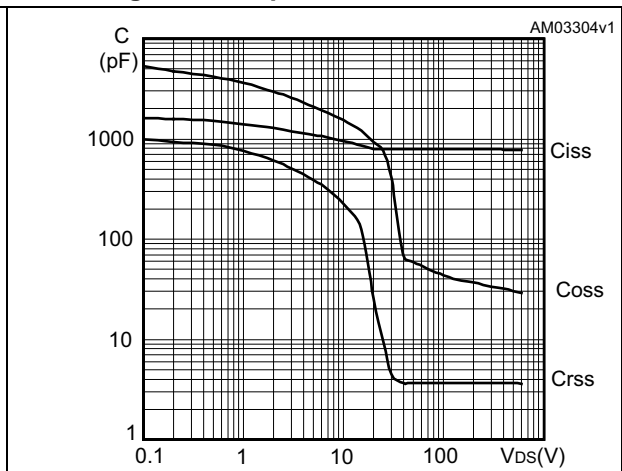


Figure 12. Normalized gate threshold voltage vs temperature

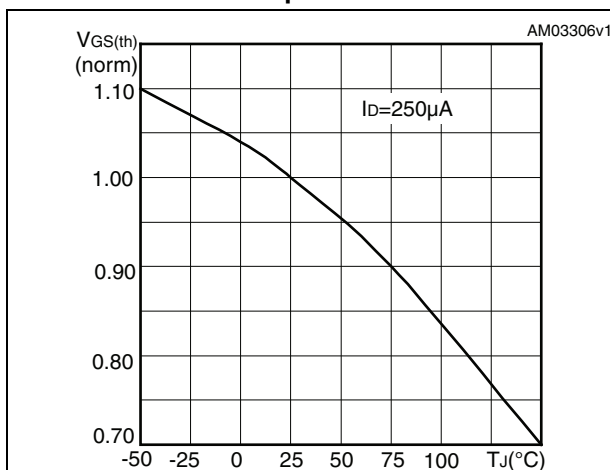


Figure 13. Normalized on-resistance vs temperature

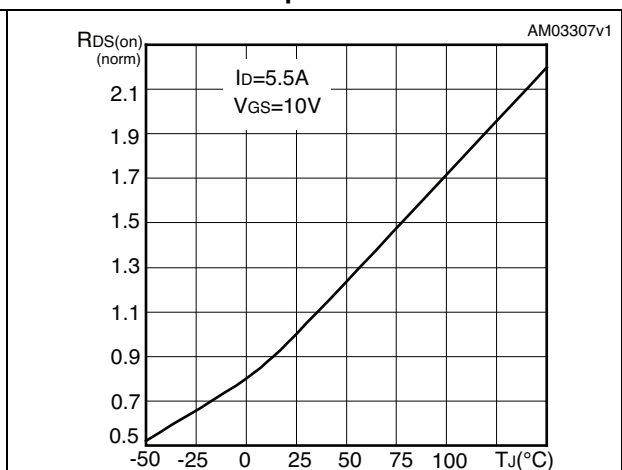
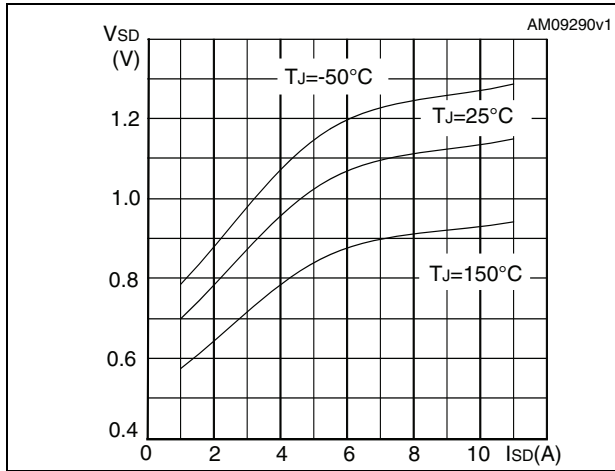


Figure 14. Source-drain diode forward characteristics





### 3 Test circuits

Figure 15. Switching times test circuit for resistive load



Figure 16. Gate charge test circuit



Figure 17. Test circuit for inductive load switching and diode recovery times

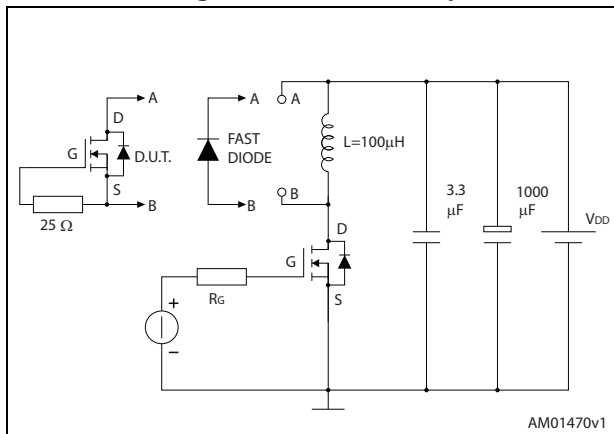


Figure 18. Unclamped inductive load test circuit

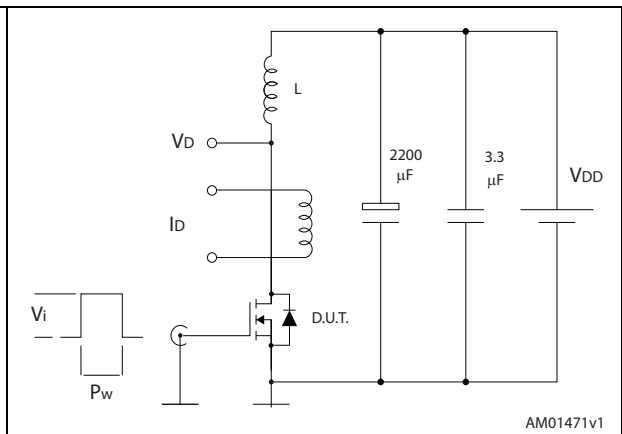


Figure 19. Unclamped inductive waveform



Figure 20. Switching time waveform



## 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 D<sup>2</sup>PAK package information

Figure 21. D<sup>2</sup>PAK (TO-263) type A package outline

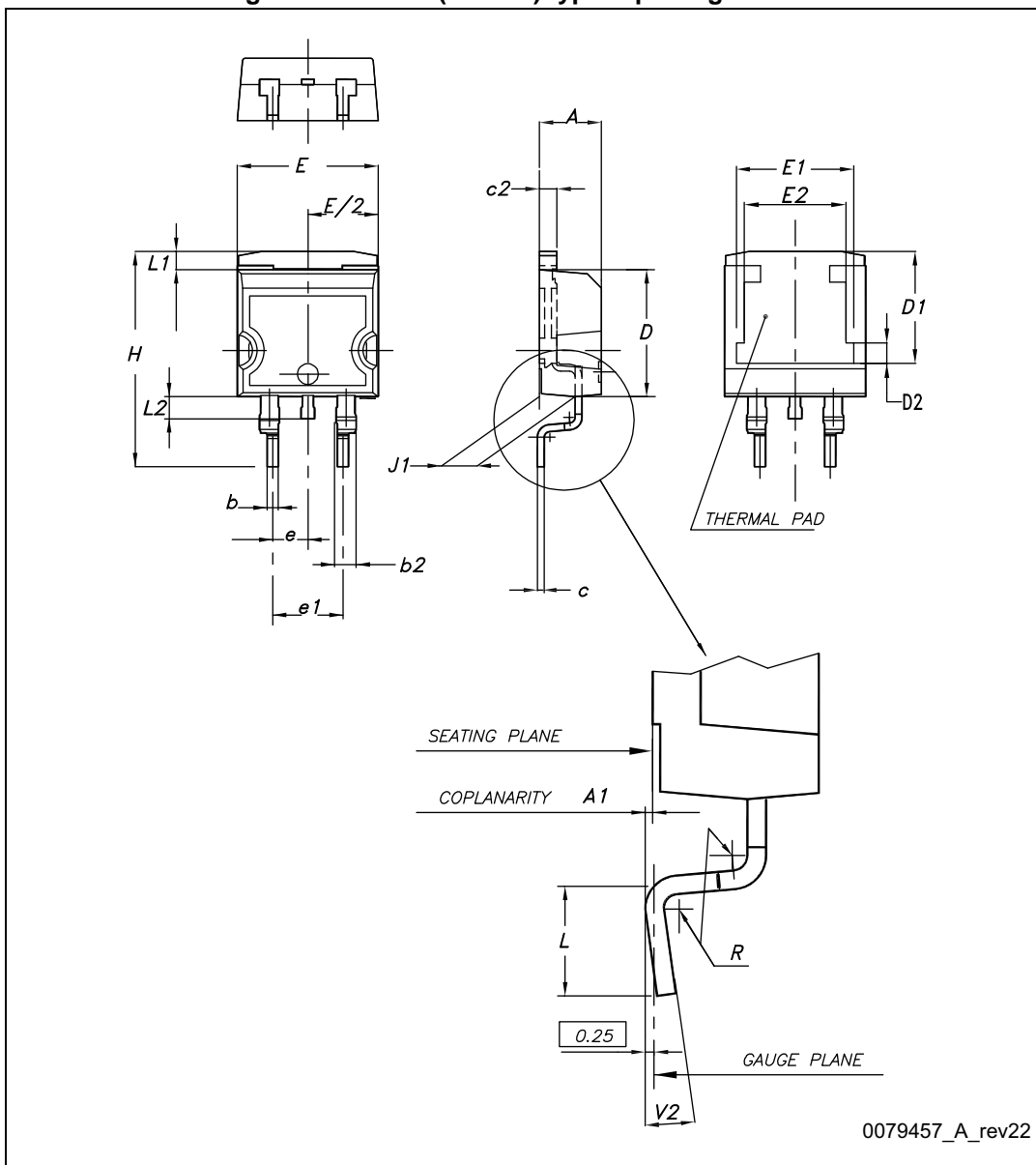


Table 9. D<sup>2</sup>PAK (TO-263) type A package mechanical data

| 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 | 7.75 | 8.00  |
| D2   | 1.10 | 1.30 | 1.50  |
| E    | 10   |      | 10.40 |
| E1   | 8.50 | 8.70 | 8.90  |
| E2   | 6.85 | 7.05 | 7.25  |
| 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 22. D<sup>2</sup>PAK (TO-263) type B package outline

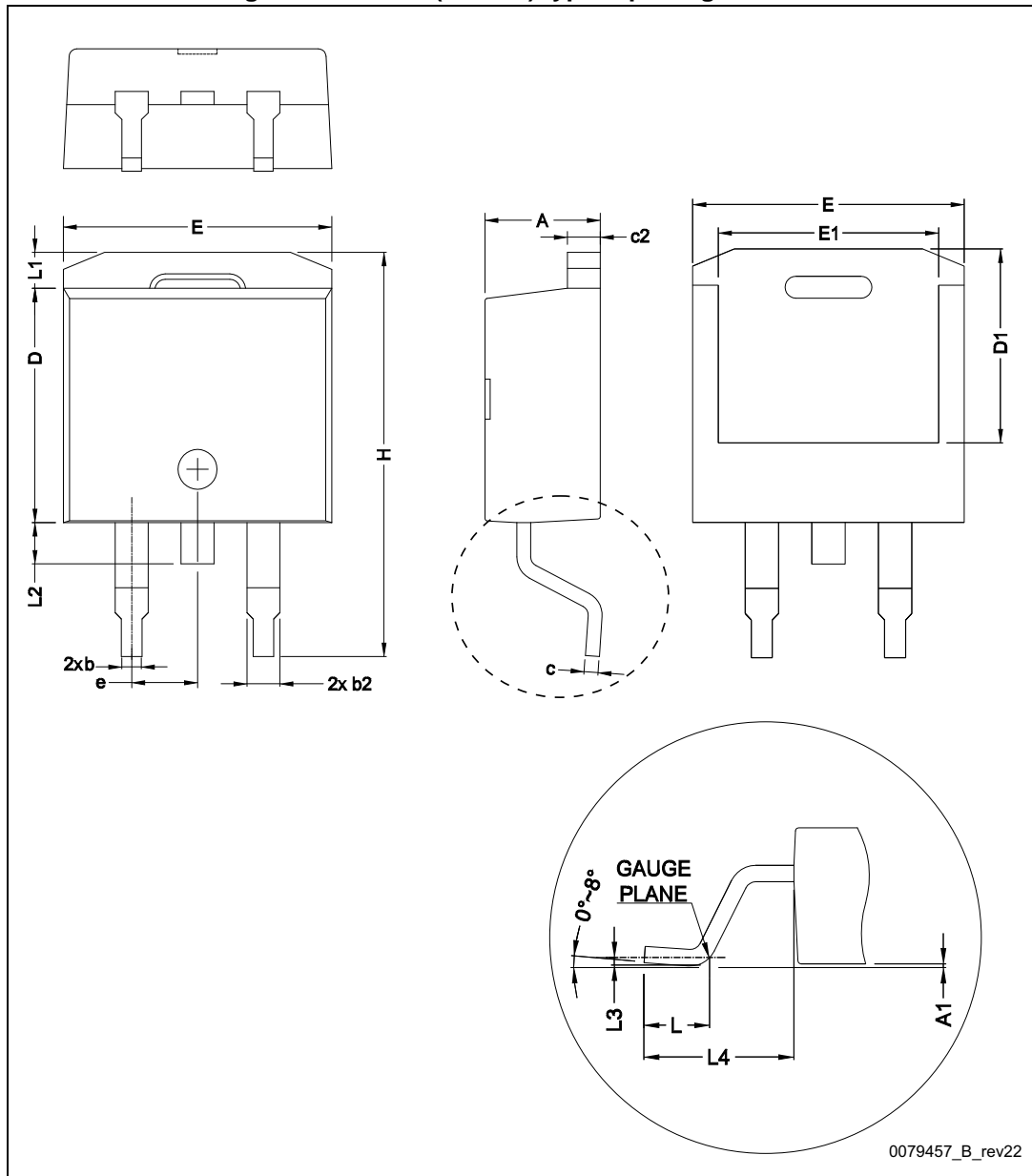
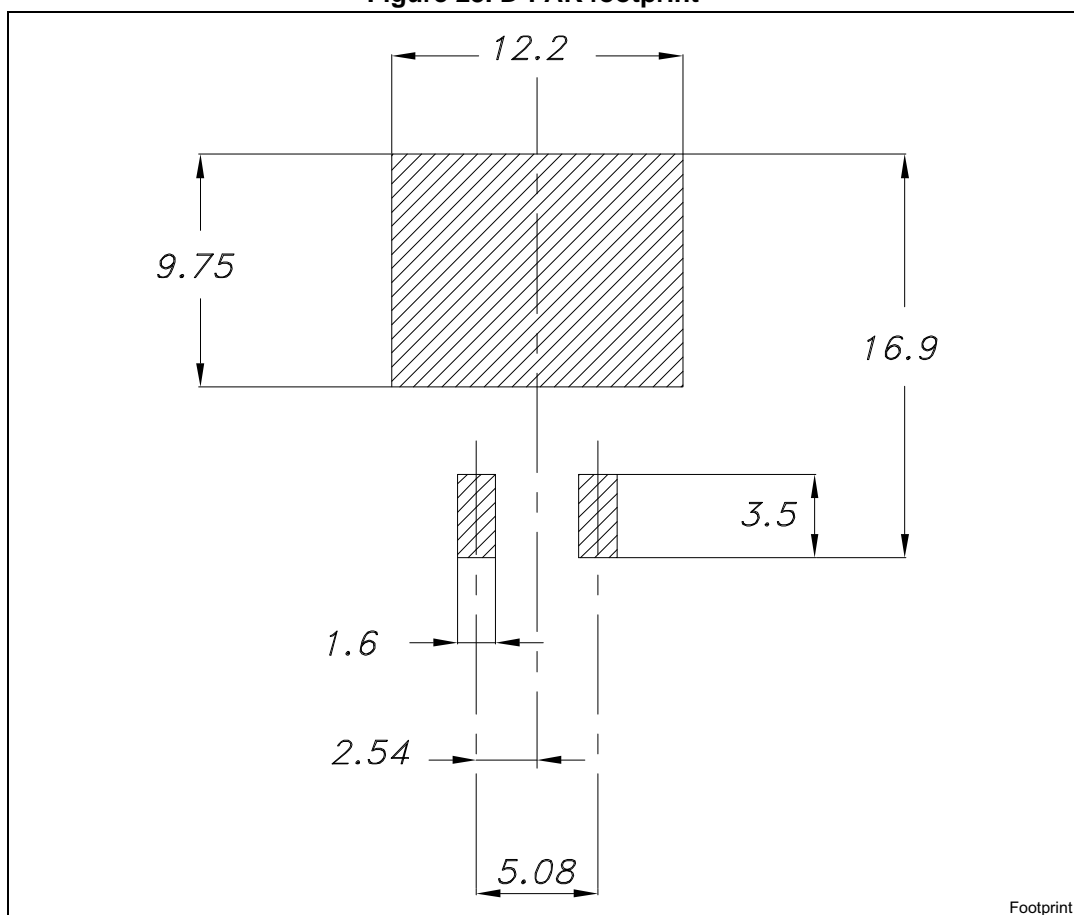


Table 10. D<sup>2</sup>PAK (TO-263) type B package mechanical data

| Dim. | mm   |      |       |
|------|------|------|-------|
|      | Min. | Typ. | Max.  |
| A    | 4.36 |      | 4.60  |
| A1   | 0    |      | 0.25  |
| b    | 0.70 |      | 0.93  |
| b2   | 1.14 |      | 1.70  |
| c    | 0.38 |      | 0.694 |
| c1   | 0.38 |      | 0.534 |
| c2   | 1.19 |      | 1.36  |
| D    | 8.6  |      | 9.35  |
| D1   | 6.9  |      |       |
| E    | 10   |      | 10.55 |
| E1   | 8.1  |      |       |
| e    |      | 2.54 |       |
| H    | 15   |      | 15.85 |
| L    | 1.9  |      | 2.79  |
| L1   |      |      | 1.65  |
| L2   |      |      | 1.78  |
| L3   |      | 0.25 |       |
| L4   | 4.78 |      | 5.28  |

Figure 23. D<sup>2</sup>PAK footprint<sup>(a)</sup>



Footprint

a. All dimension are in millimeters

### 4.2 DPAK package information

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

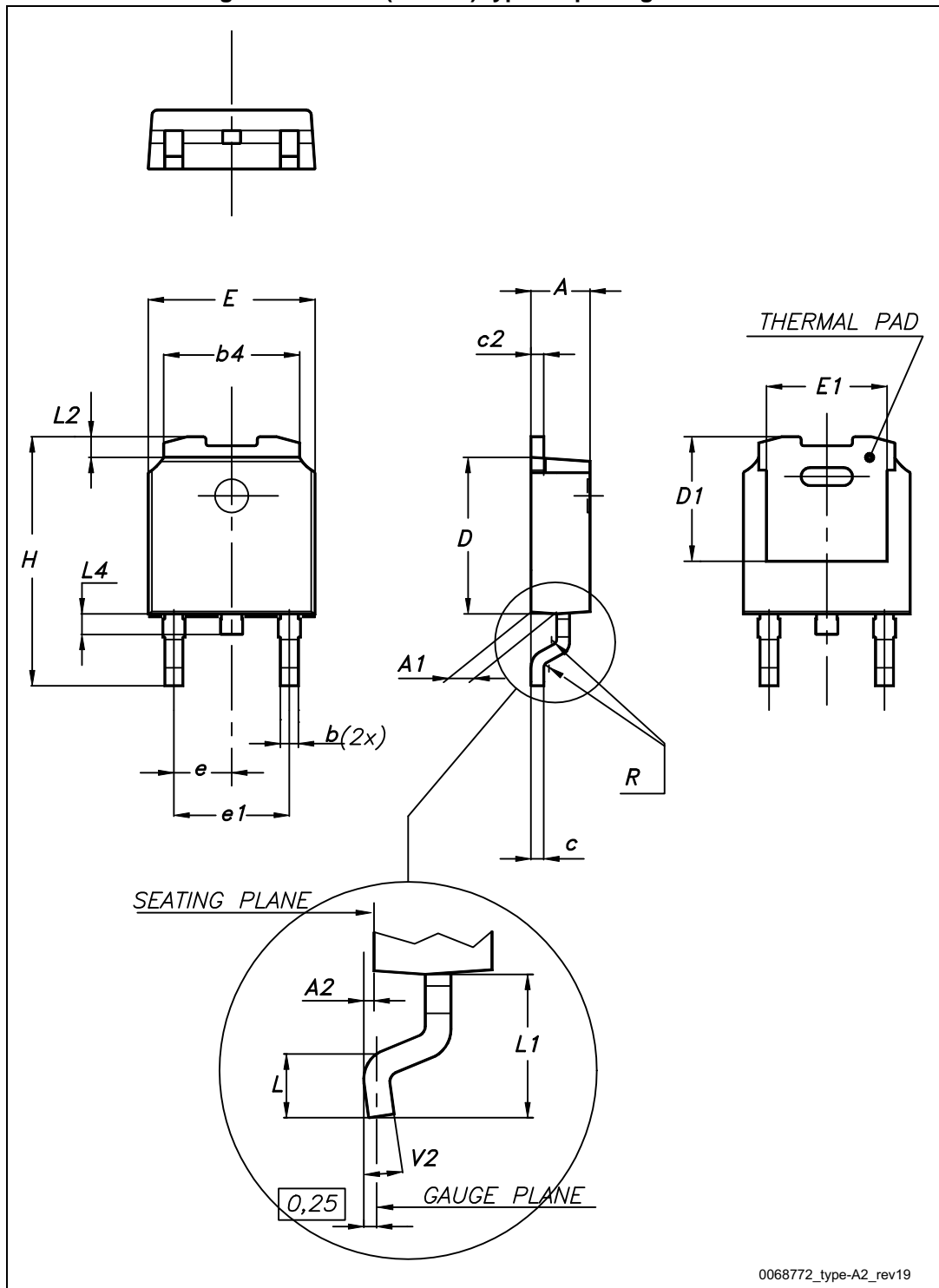


Table 11. DPAK (TO-252) type A2 package mechanical data

| 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 C2 outline

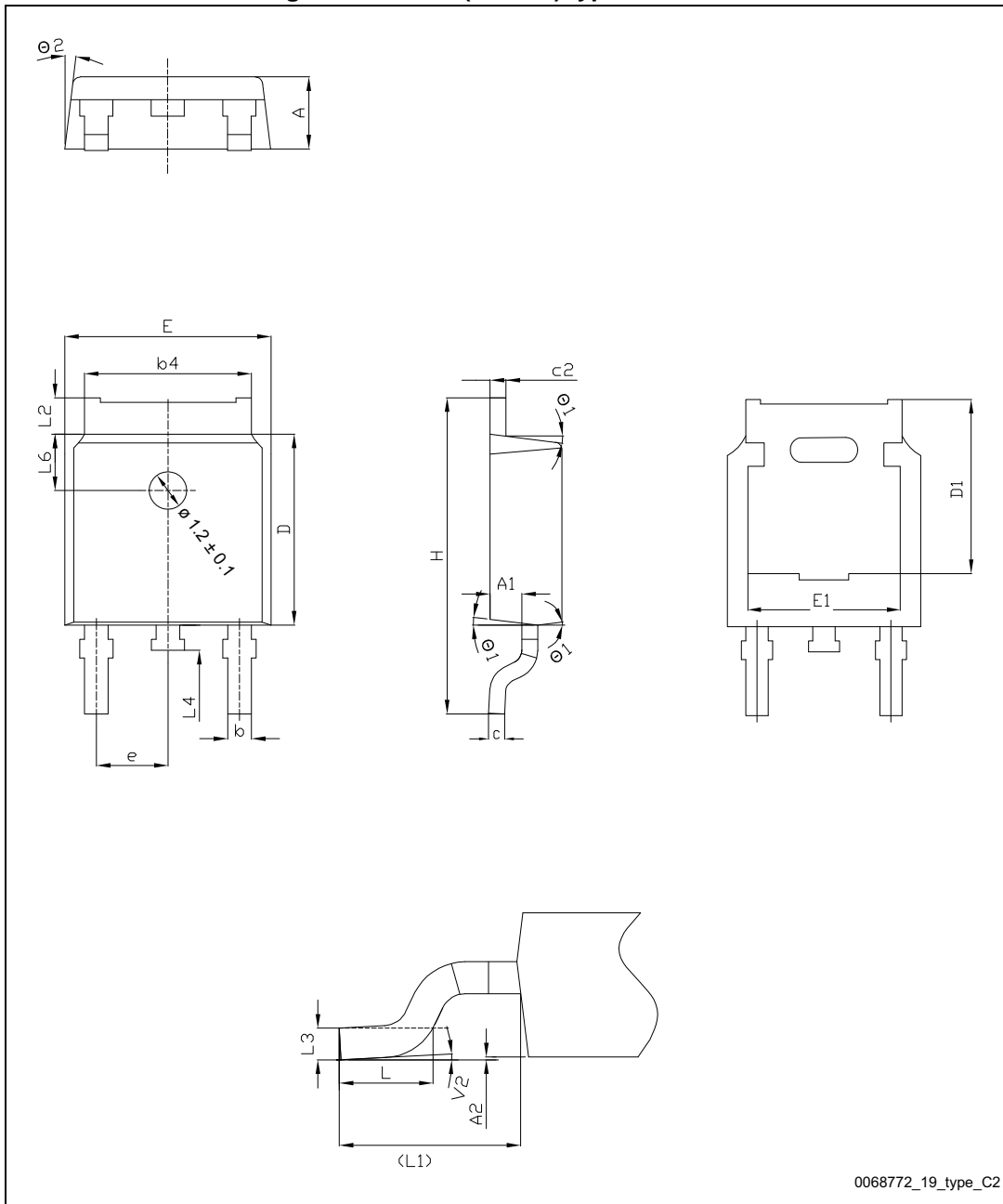
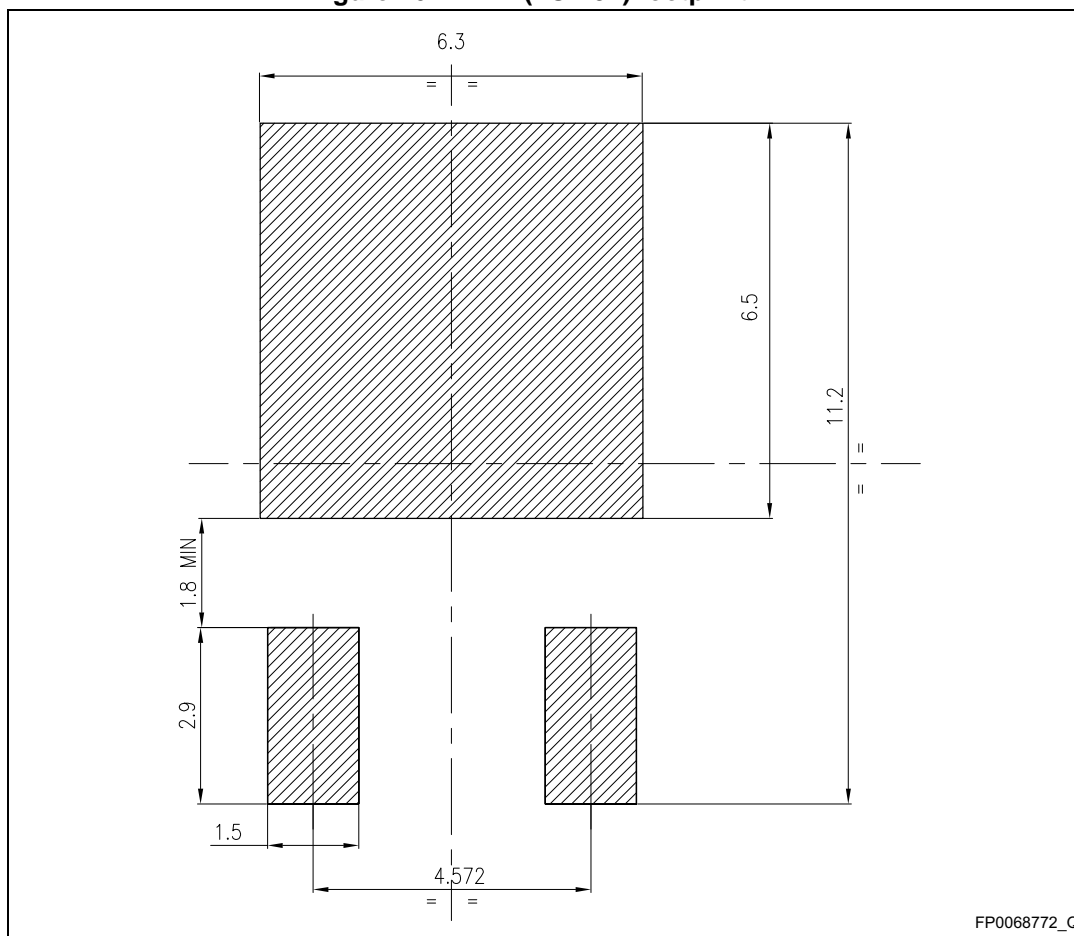


Table 12. DPAK (TO-252) type C2 package mechanical data

| 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   | 5.25     | -     | -     |
| E    | 6.50     | 6.60  | 6.70  |
| E1   | 5.20     | -     | -     |
| 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 26. DPAK (TO-252) footprint (b)



b. All dimensions are in millimeters

# 5 Packing information

Figure 27. Tape

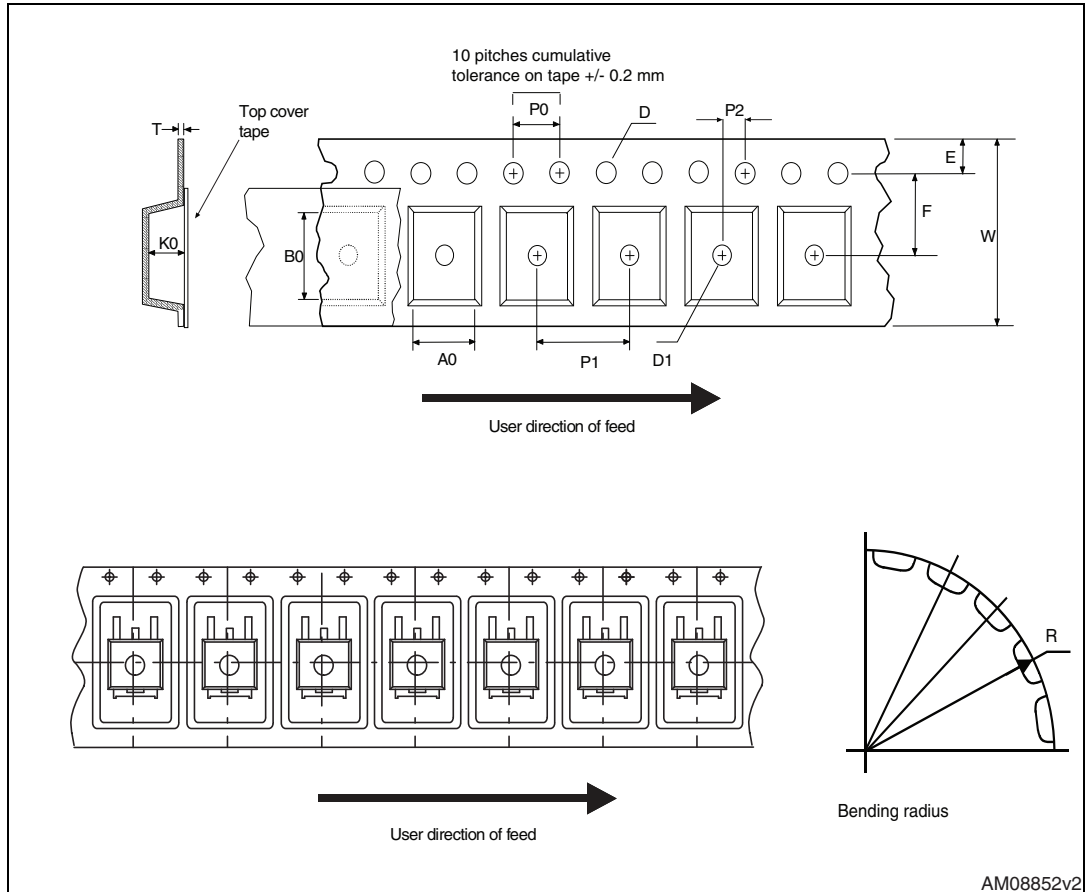


Figure 28. Reel

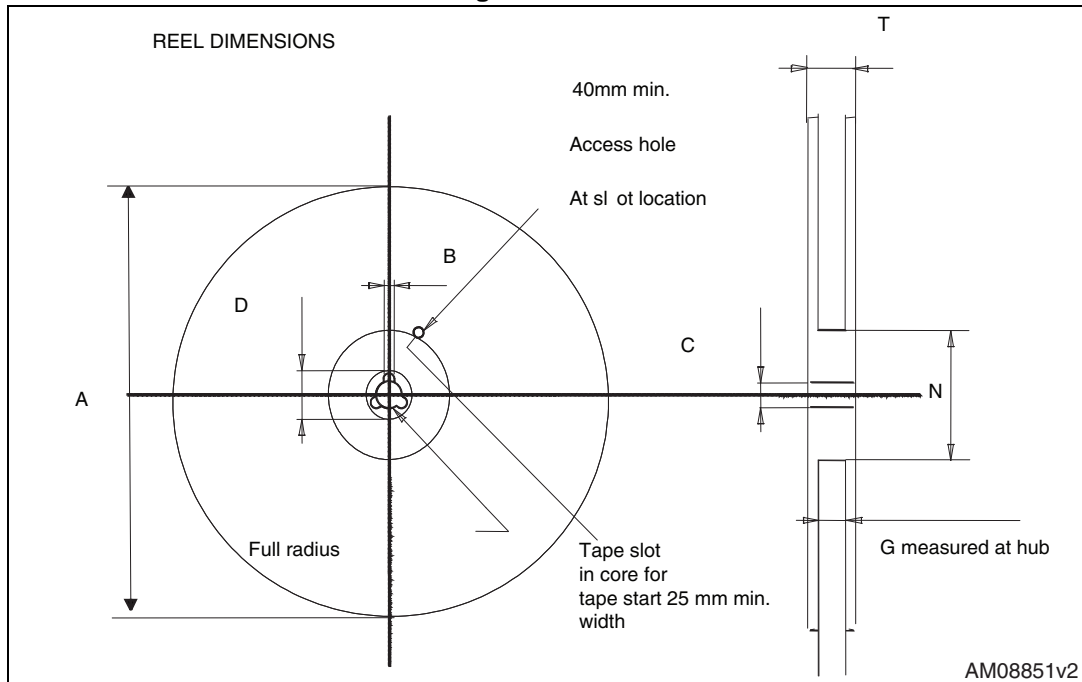


Table 13. D<sup>2</sup>PAK (TO-263) tape and reel mechanical data

| 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 |          |      |      |

Table 14. 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 15. Document revision history

| Date        | Revision | Changes  |
|-------------|----------|--|
| 18-Dec-2012 | 1        | First release  |
| 10-Jul-2014 | 2        | – Updated: <a href="#">Section 3: Test circuits</a><br>– Updated: <a href="#">Section 4: Package information</a><br>– Minor text changes |
| 19-Jun-2015 | 3        | – Updated <a href="#">4: Package information</a><br>– Minor text changes   |

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