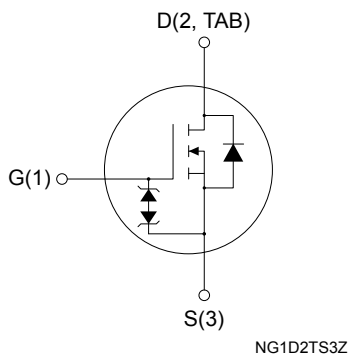
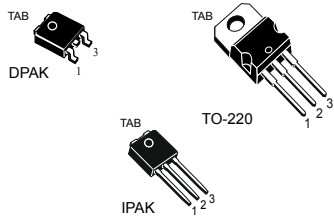


## N-channel 600 V, 1.3 $\Omega$ typ., 3.5 A, MDmesh™ M2 Power MOSFETs in DPAK, TO-220 and IPAK packages



### Features

| Order code | $V_{DS@T_{Jmax}}$ | $R_{DS(on) max.}$ | $I_D$ |
|------------|-------------------|-------------------|-------|
| STD5N60M2  | 650 V             | 1.4 $\Omega$      | 3.5 A |
| STP5N60M2  |                   |                   |       |
| STU5N60M2  |                   |                   |       |

- Extremely low gate charge
- Excellent output capacitance ( $C_{OSS}$ ) profile
- 100% avalanche tested
- Zener-protected

### Applications

- Switching applications

### Description

These devices are N-channel Power MOSFETs developed using the MDmesh™ M2 technology. Thanks to their strip layout and improved vertical structure, these devices exhibit low on-resistance and optimized switching characteristics, rendering them suitable for the most demanding high-efficiency converters.

#### Product status links

[STD5N60M2](#)
[STP5N60M2](#)
[STU5N60M2](#)

# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

| Symbol         | Parameter   | Value      | Unit             |
|----------------|---|------------|------------------|
| $V_{GS}$       | Gate-source voltage   | $\pm 25$   | V                |
| $I_D$          | Drain current (continuous) at $T_C = 25\text{ }^\circ\text{C}$  | 3.5        | A                |
|                | Drain current (continuous) at $T_C = 100\text{ }^\circ\text{C}$ | 2.2        |                  |
| $I_{DM}^{(1)}$ | Drain current (pulsed)  | 14         | A                |
| $P_{TOT}$      | Total dissipation at $T_C = 25\text{ }^\circ\text{C}$           | 45         | W                |
| $dv/dt^{(2)}$  | Peak diode recovery voltage slope                               | 15         | V/ns             |
| $dv/dt^{(3)}$  | MOSFET $dv/dt$ ruggedness                                       | 50         |                  |
| $T_{stg}$      | Storage temperature range                                       | -55 to 150 | $^\circ\text{C}$ |
| $T_j$          | Operating junction temperature range                            |            |                  |

1. Pulse width limited by safe operating area.
2.  $I_{SD} \leq 3.5\text{ A}$ ,  $di/dt \leq 400\text{ A}/\mu\text{s}$ ;  $V_{DS\text{ peak}} < V_{(BR)DSS}$ ,  $V_{DD} = 400\text{ V}$ .
3.  $V_{DS} \leq 480\text{ V}$ .

**Table 2. Thermal data**

| Symbol              | Parameter                           | Value |        |      | Unit                      |
|---------------------|-------------------------------------|-------|--------|------|---------------------------|
|                     |                                     | DPAK  | TO-220 | IPAK |                           |
| $R_{thj-case}$      | Thermal resistance junction-case    | 2.8   |        |      | $^\circ\text{C}/\text{W}$ |
| $R_{thj-pcb}^{(1)}$ | Thermal resistance junction-pcb     | 50    |        |      |                           |
| $R_{thj-amb}$       | Thermal resistance junction-ambient |       | 62.5   | 100  |                           |

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

**Table 3. Avalanche characteristics**

| Symbol   | Parameter  | Value | Unit |
|----------|--|-------|------|
| $I_{AR}$ | Avalanche current, repetitive or not repetitive <sup>(1)</sup> | 0.5   | A    |
| $E_{AS}$ | Single pulse avalanche energy <sup>(2)</sup>                   | 80    | mJ   |

1. Pulse width limited by  $T_{jmax}$
2. Starting  $T_j = 25\text{ }^\circ\text{C}$ ,  $I_D = I_{AR}$ ,  $V_{DD} = 50\text{ V}$

## 2 Electrical characteristics

( $T_{\text{case}} = 25\text{ }^{\circ}\text{C}$  unless otherwise specified)

**Table 4. On/off states**

| Symbol                      | Parameter                         | Test conditions  | Min. | Typ. | Max.     | Unit          |
|-----------------------------|-----------------------------------|--|------|------|----------|---------------|
| $V_{(\text{BR})\text{DSS}}$ | Drain-source breakdown voltage    | $V_{\text{GS}} = 0\text{ V}$ , $I_{\text{D}} = 1\text{ mA}$  | 600  |      |          | V             |
| $I_{\text{DSS}}$            | Zero gate voltage drain current   | $V_{\text{GS}} = 0\text{ V}$ , $V_{\text{DS}} = 600\text{ V}$  |      |      | 1        | $\mu\text{A}$ |
|                             |                                   | $V_{\text{GS}} = 0\text{ V}$ , $V_{\text{DS}} = 600\text{ V}$ ,<br>$T_{\text{C}} = 125\text{ }^{\circ}\text{C}$ <sup>(1)</sup> |      |      | 100      |               |
| $I_{\text{GSS}}$            | Gate-body leakage current         | $V_{\text{DS}} = 0\text{ V}$ , $V_{\text{GS}} = \pm 25\text{ V}$   |      |      | $\pm 10$ | $\mu\text{A}$ |
| $V_{\text{GS}(\text{th})}$  | Gate threshold voltage            | $V_{\text{DS}} = V_{\text{GS}}$ , $I_{\text{D}} = 250\text{ }\mu\text{A}$  | 2    | 3    | 4        | V             |
| $R_{\text{DS}(\text{on})}$  | Static drain-source on-resistance | $V_{\text{GS}} = 10\text{ V}$ , $I_{\text{D}} = 1.7\text{ A}$  |      | 1.3  | 1.4      | $\Omega$      |

1. Defined by design, not subject to production test.

**Table 5. Dynamic**

| Symbol                     | Parameter                     | Test conditions   | Min. | Typ. | Max. | Unit        |
|----------------------------|-------------------------------|---|------|------|------|-------------|
| $C_{\text{iss}}$           | Input capacitance             | $V_{\text{DS}} = 100\text{ V}$ , $f = 1\text{ MHz}$ ,<br>$V_{\text{GS}} = 0\text{ V}$   | -    | 211  | -    | $\text{pF}$ |
| $C_{\text{oss}}$           | Output capacitance            |   | -    | 13   | -    |             |
| $C_{\text{riss}}$          | Reverse transfer capacitance  |   | -    | 0.75 | -    |             |
| $C_{\text{oss eq.}}^{(1)}$ | Equivalent output capacitance | $V_{\text{DS}} = 0\text{ to }480\text{ V}$ , $V_{\text{GS}} = 0\text{ V}$   | -    | 19.5 | -    | $\text{pF}$ |
| $R_{\text{G}}$             | Intrinsic gate resistance     | $f = 1\text{ MHz}$ open drain   | -    | 6.2  | -    | $\Omega$    |
| $Q_{\text{g}}$             | Total gate charge             | $V_{\text{DD}} = 480\text{ V}$ , $I_{\text{D}} = 3.5\text{ A}$ ,<br>$V_{\text{GS}} = 0\text{ to }10\text{ V}$<br>(see Figure 16. Test circuit for gate charge behavior) | -    | 8    | -    | $\text{nC}$ |
| $Q_{\text{gs}}$            | Gate-source charge            |   | -    | 1.6  | -    |             |
| $Q_{\text{gd}}$            | Gate-drain charge             |   | -    | 4.4  | -    |             |

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

**Table 6. Switching times**

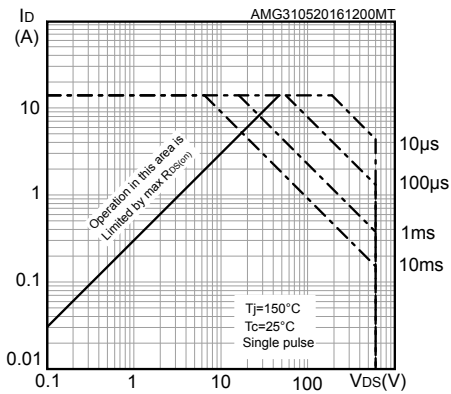
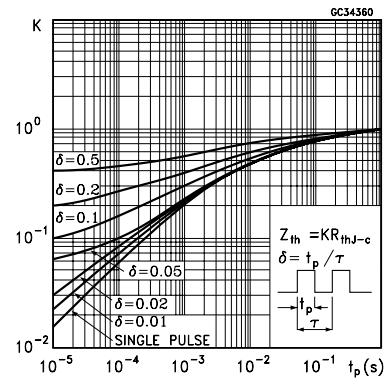
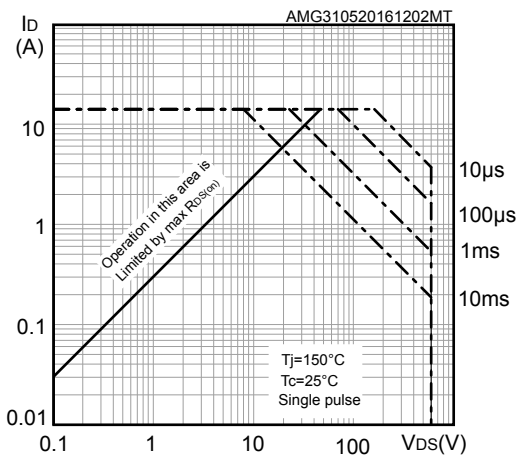
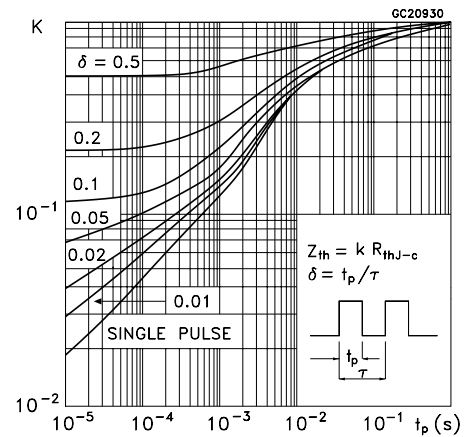
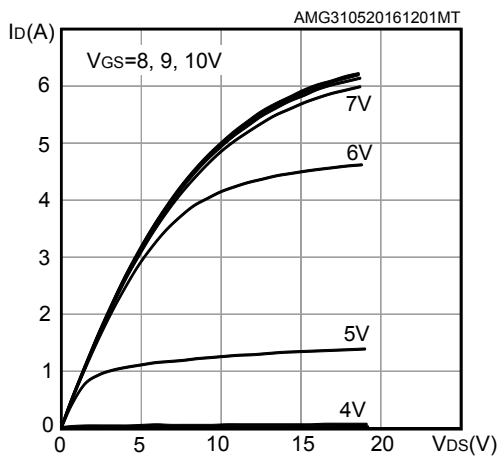
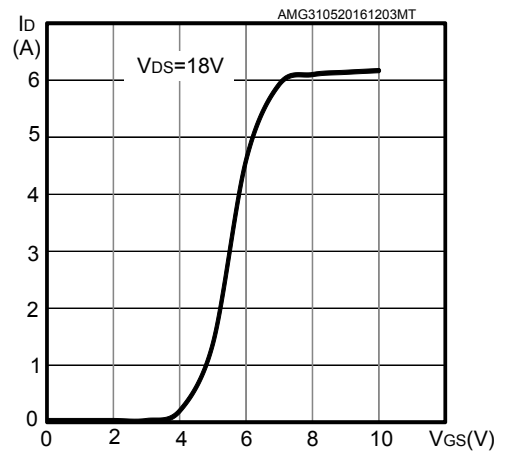
| Symbol                     | Parameter           | Test conditions   | Min. | Typ. | Max. | Unit        |
|----------------------------|---------------------|---|------|------|------|-------------|
| $t_{\text{d}(\text{on})}$  | Turn-on delay time  | $V_{\text{DD}} = 300\text{ V}$ , $I_{\text{D}} = 1.7\text{ A}$ ,<br>$R_{\text{G}} = 4.7\text{ }\Omega$ , $V_{\text{GS}} = 10\text{ V}$<br>(see Figure 15. Test circuit for resistive load switching times and Figure 20. Switching time waveform) | -    | 12   | -    | $\text{ns}$ |
| $t_{\text{r}}$             | Rise time           |   | -    | 3    | -    |             |
| $t_{\text{d}(\text{off})}$ | Turn-off delay time |   | -    | 70   | -    |             |
| $t_{\text{f}}$             | Fall time           |   | -    | 15   | -    |             |

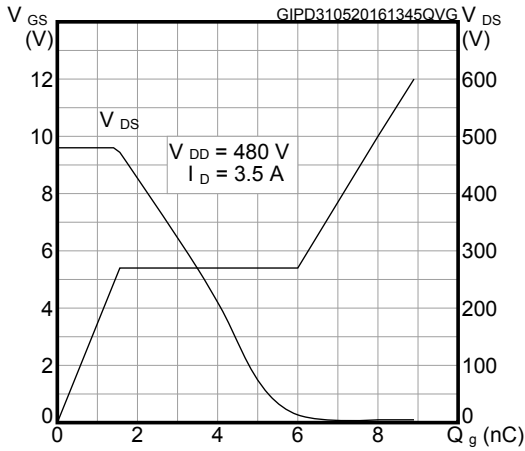
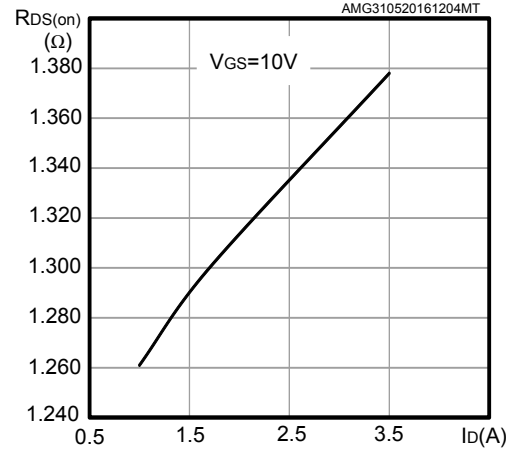
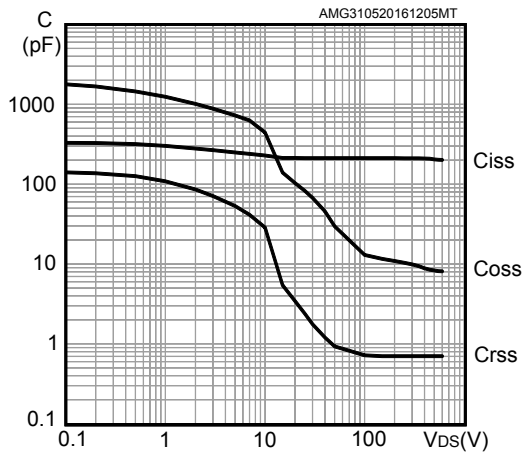
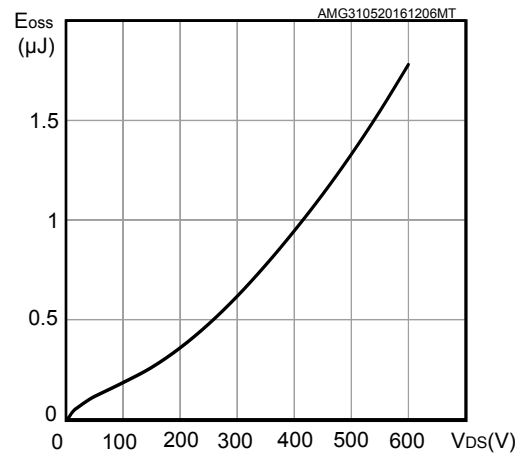
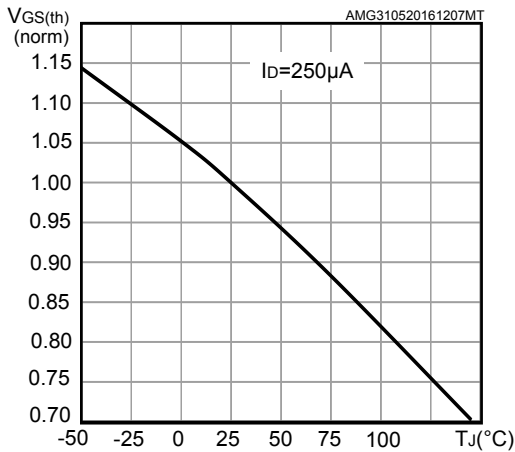
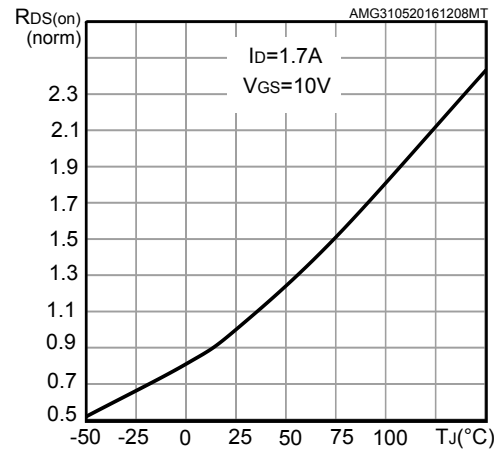
**Table 7. Source-drain diode**

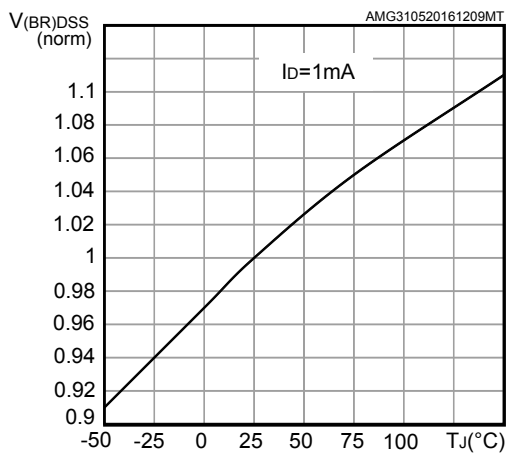
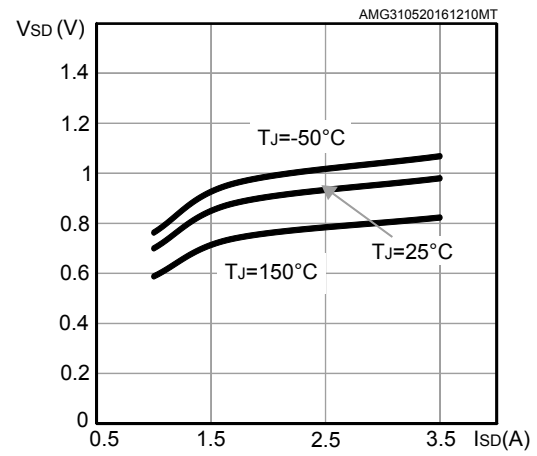
| Symbol          | Parameter                     | Test conditions  | Min.  | Typ. | Max. | Unit          |
|-----------------|-------------------------------|--|---|------|------|---------------|
| $I_{SD}$        | Source-drain current          |  | -   |      | 3.5  | A             |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |  | -   |      | 14   | A             |
| $V_{SD}^{(2)}$  | Forward on voltage            | $V_{GS} = 0\text{ V}$ , $I_{SD} = 3.5\text{ A}$  | -   |      | 1.6  | V             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 3.5\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ ,<br>$V_{DD} = 60\text{ V}$                                     | -   | 220  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |  | -   | 1.05 |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      | (see Figure 17. Test circuit for inductive load switching and diode recovery times)  | -   | 9.5  |      | A             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 3.5\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ ,<br>$V_{DD} = 60\text{ V}$ , $T_j = 150\text{ }^\circ\text{C}$ | -   | 314  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |  | -   | 1.5  |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |  | (see Figure 17. Test circuit for inductive load switching and diode recovery times) | -    | 9.5  |               |

1. Pulse width is limited by safe operating area.

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

**2.1 Electrical characteristics (curves)**
**Figure 1. Safe operating area for DPAK and IPAK**

**Figure 2. Thermal impedance for DPAK and IPAK**

**Figure 3. Safe operating area for TO-220**

**Figure 4. Thermal impedance for TO-220**

**Figure 5. Output characteristics**

**Figure 6. Transfer characteristics**


**Figure 7. Gate charge vs gate-source voltage**

**Figure 8. Static drain-source on-resistance**

**Figure 9. Capacitance variations**

**Figure 10. Output capacitance stored energy**

**Figure 11. Normalized gate threshold voltage vs temperature**

**Figure 12. Normalized on-resistance vs temperature**


**Figure 13. Normalized  $V_{(BR)DSS}$  vs temperature**

**Figure 14. Source-drain diode forward characteristics**


### 3 Test circuits

**Figure 15. Test circuit for resistive load switching times**


AM01468v1

**Figure 16. Test circuit for gate charge behavior**


AM01469v1

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


AM01470v1

**Figure 18. Unclamped inductive load test circuit**


AM01471v1

**Figure 19. Unclamped inductive waveform**


AM01472v1

**Figure 20. Switching time waveform**

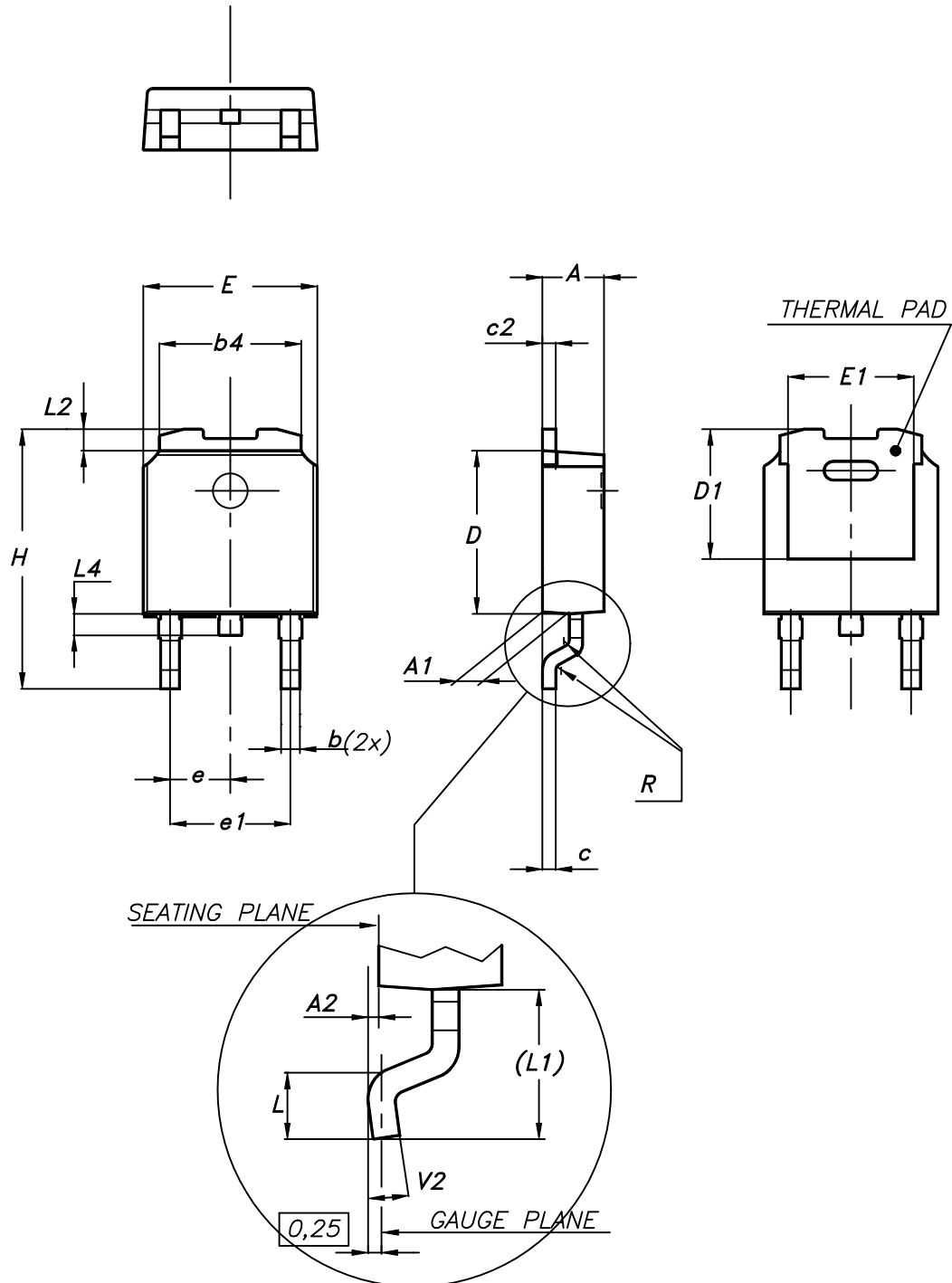

AM01473v1



## **4 Package information**

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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 21. DPAK (TO-252) type A2 package outline**


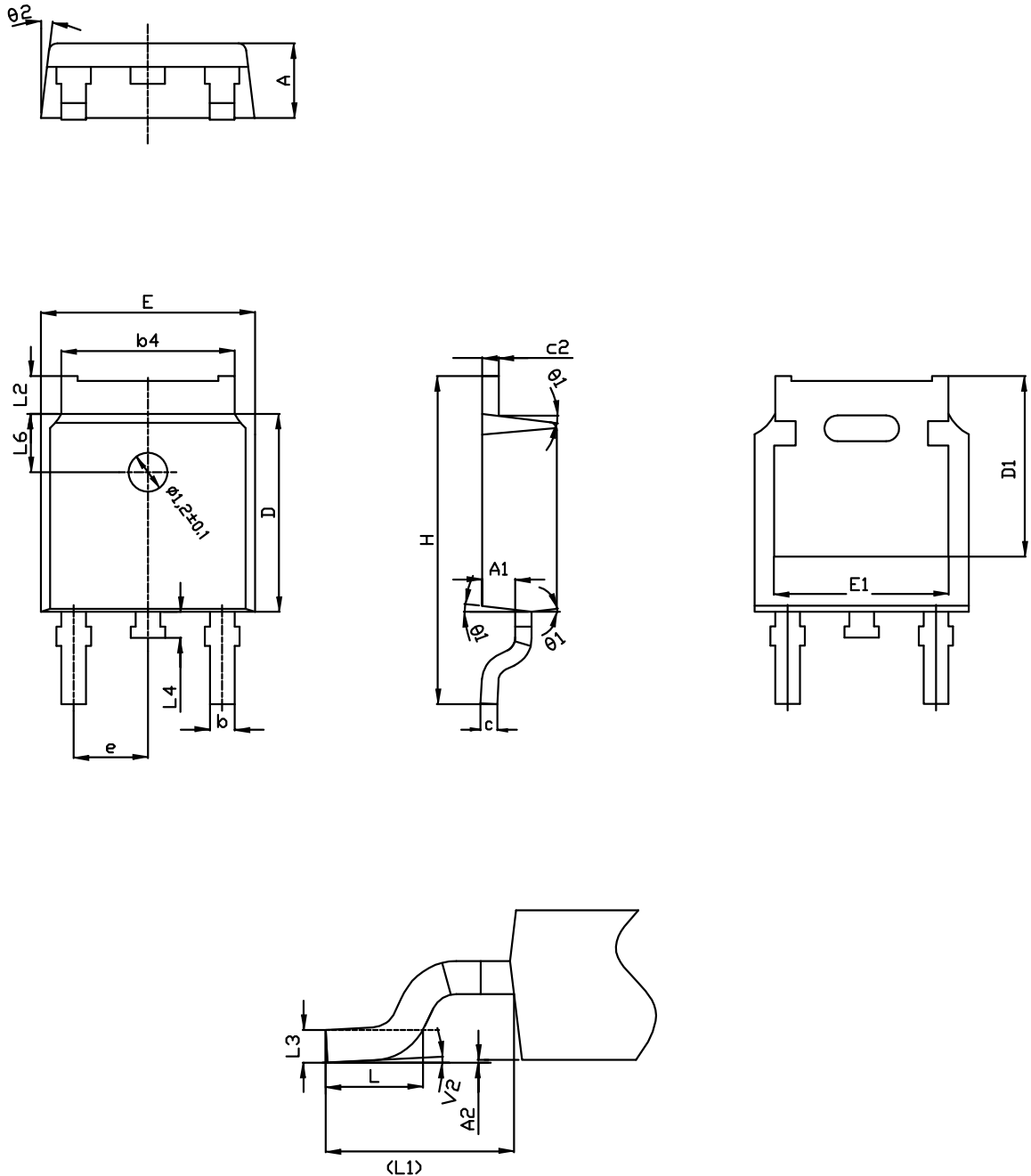
0068772\_type-A2\_rev25

**Table 8. 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    | 2.159 | 2.286 | 2.413 |
| e1   | 4.445 | 4.572 | 4.699 |
| 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°    |

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

Figure 22. DPAK (TO-252) type C2 package outline



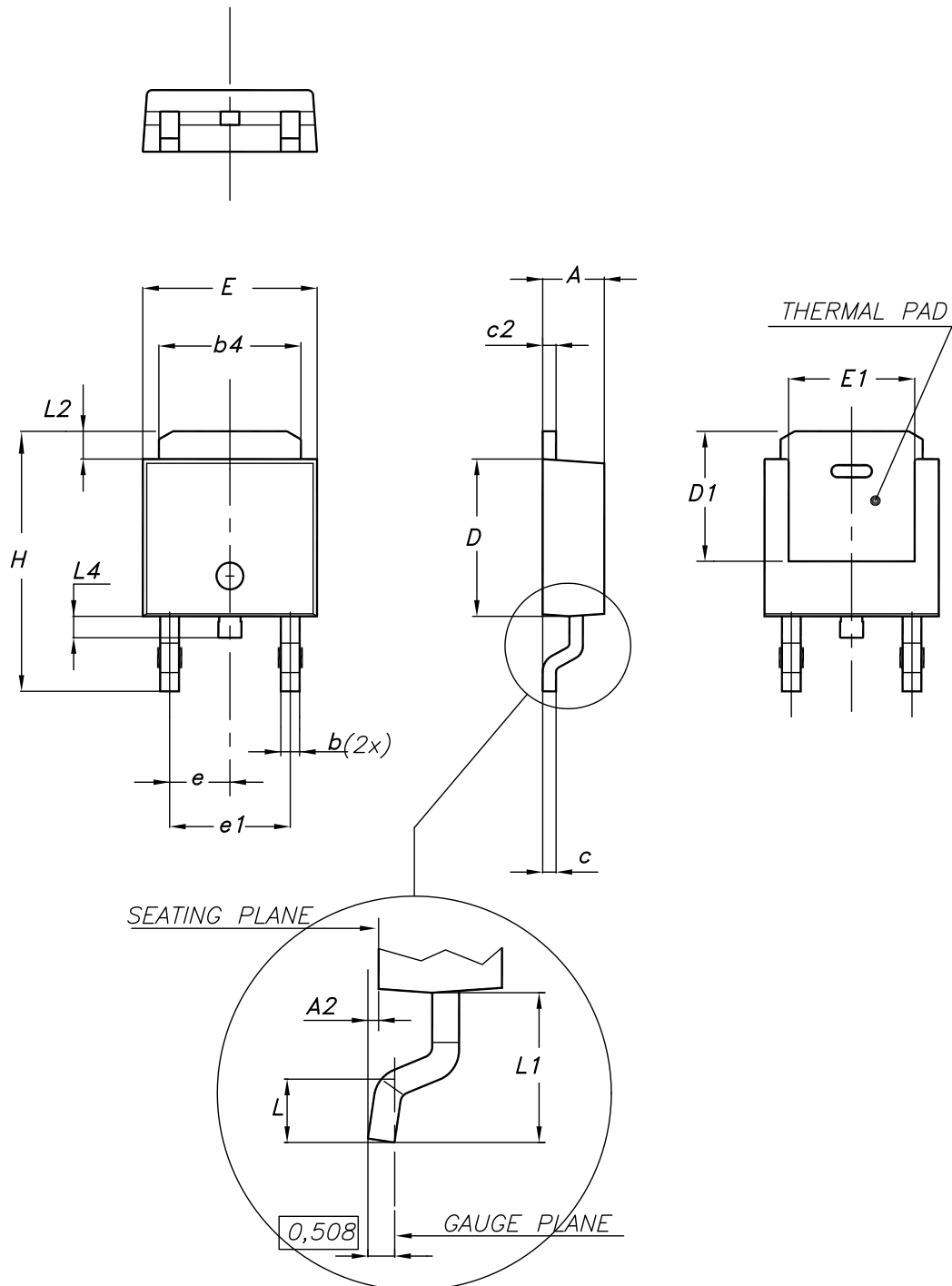
0068772\_C2\_25

**Table 9. 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°    |

### 4.3 DPAK (TO-252) type E package information

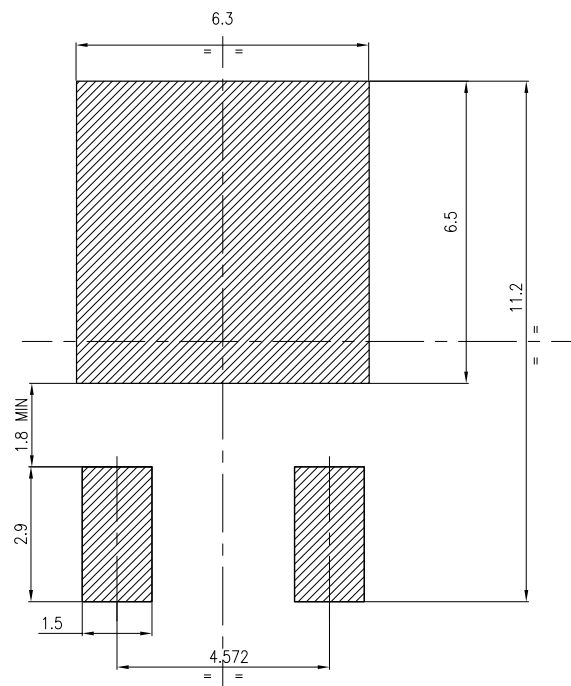
Figure 23. DPAK (TO-252) type E package outline



0068772\_type-E\_rev.25

**Table 10. DPAK (TO-252) type E mechanical data**

| Dim. | mm   |       |       |
|------|------|-------|-------|
|      | Min. | Typ.  | Max.  |
| A    | 2.18 |       | 2.39  |
| A2   |      |       | 0.13  |
| b    | 0.65 |       | 0.884 |
| b4   | 4.95 |       | 5.46  |
| c    | 0.46 |       | 0.61  |
| c2   | 0.46 |       | 0.60  |
| D    | 5.97 |       | 6.22  |
| D1   | 5.21 |       |       |
| E    | 6.35 |       | 6.73  |
| E1   | 4.32 |       |       |
| e    |      | 2.286 |       |
| e1   |      | 4.572 |       |
| H    | 9.94 |       | 10.34 |
| L    | 1.50 |       | 1.78  |
| L1   |      | 2.74  |       |
| L2   | 0.89 |       | 1.27  |
| L4   |      |       | 1.02  |

**Figure 24. DPAK (TO-252) recommended footprint (dimensions are in mm)**


FP\_0068772\_25

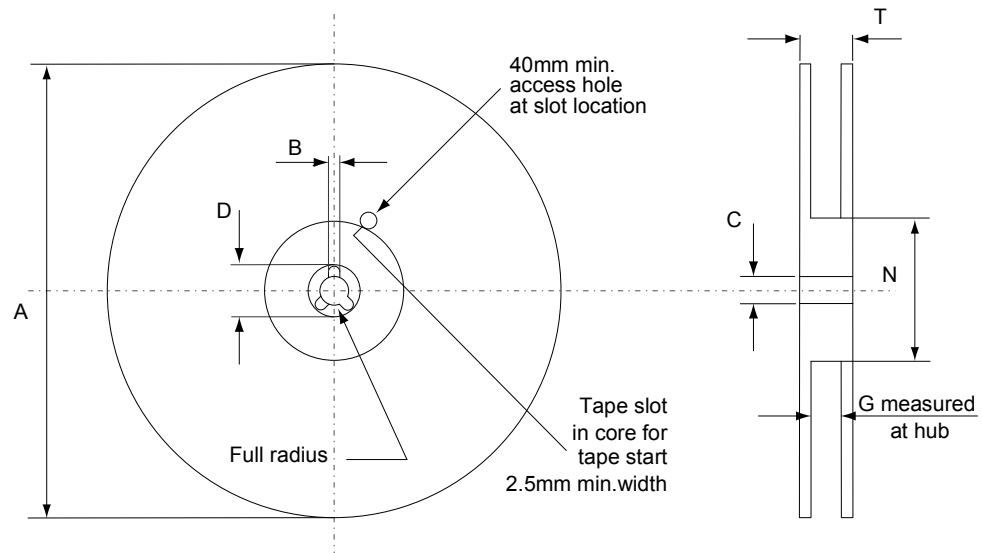
### 4.4 DPAK (TO-252) packing information

Figure 25. DPAK (TO-252) tape outline



AM08852v1

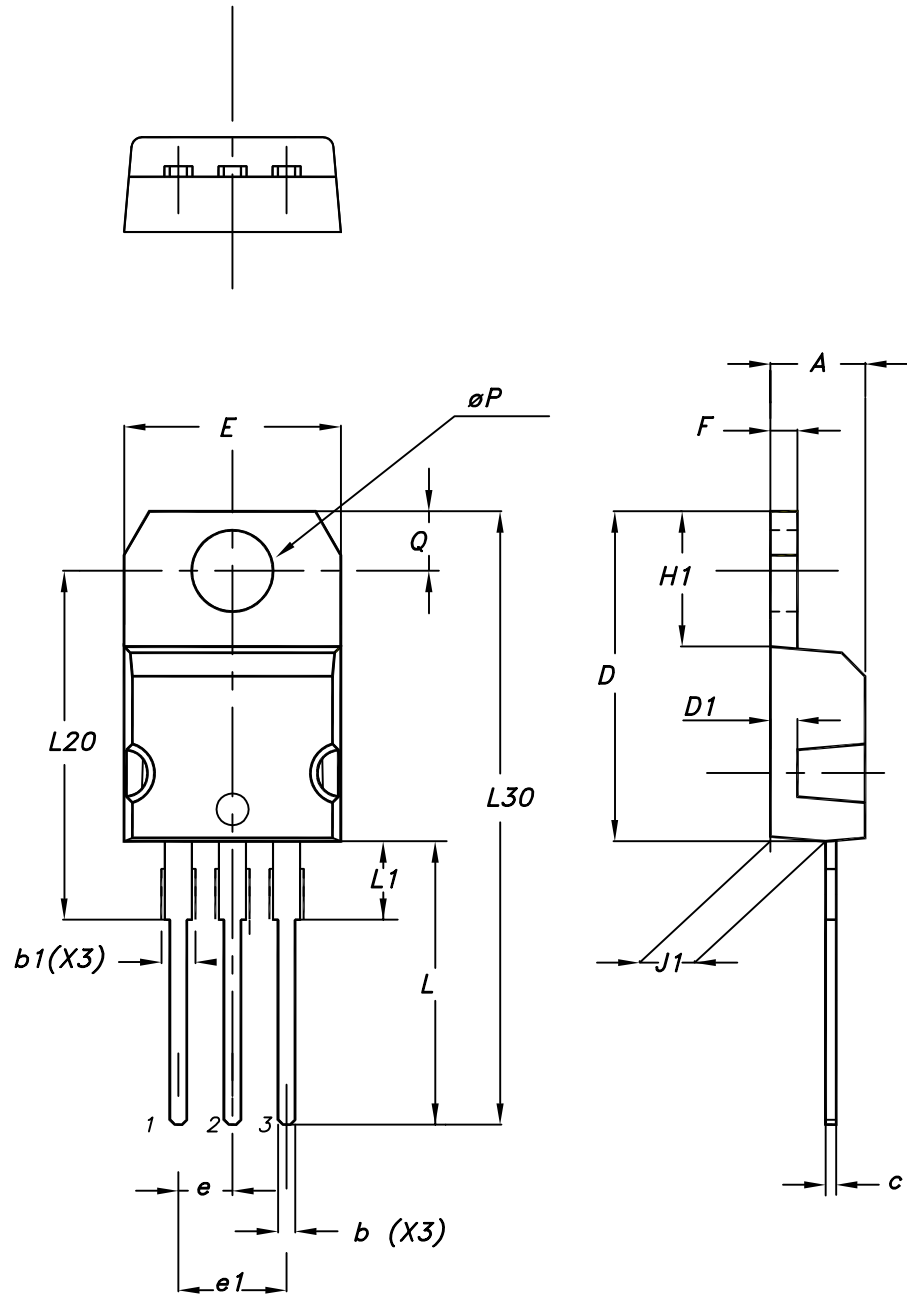


**Figure 26. DPAK (TO-252) reel outline**


AM06038v1

**Table 11. 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 |           |      |      |

**4.5 TO-220 type A package information**
**Figure 27. TO-220 type A package outline**


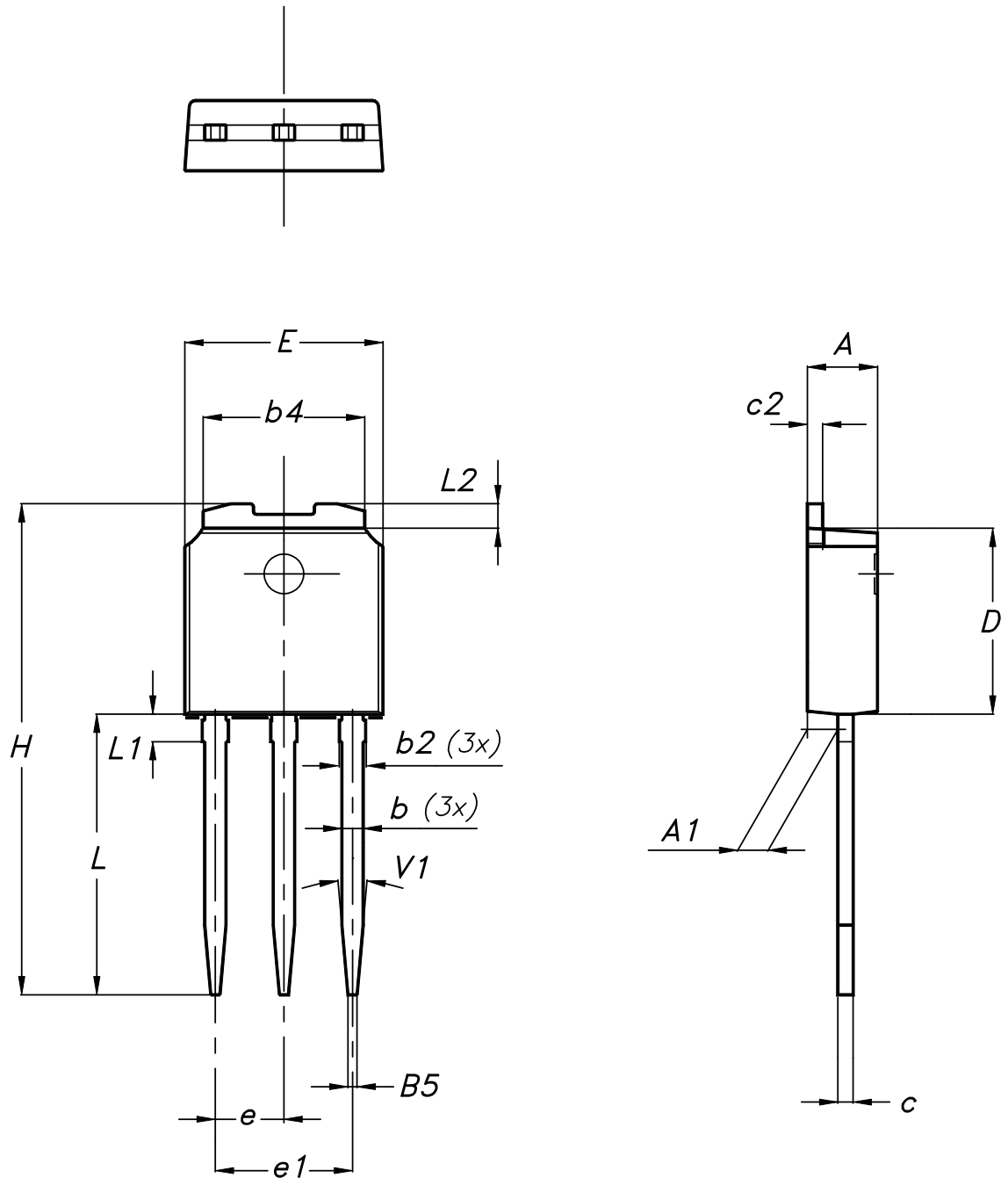
0015988\_typeA\_Rev\_21

**Table 12. TO-220 type A package 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 28. IPAK (TO-251) type A package outline



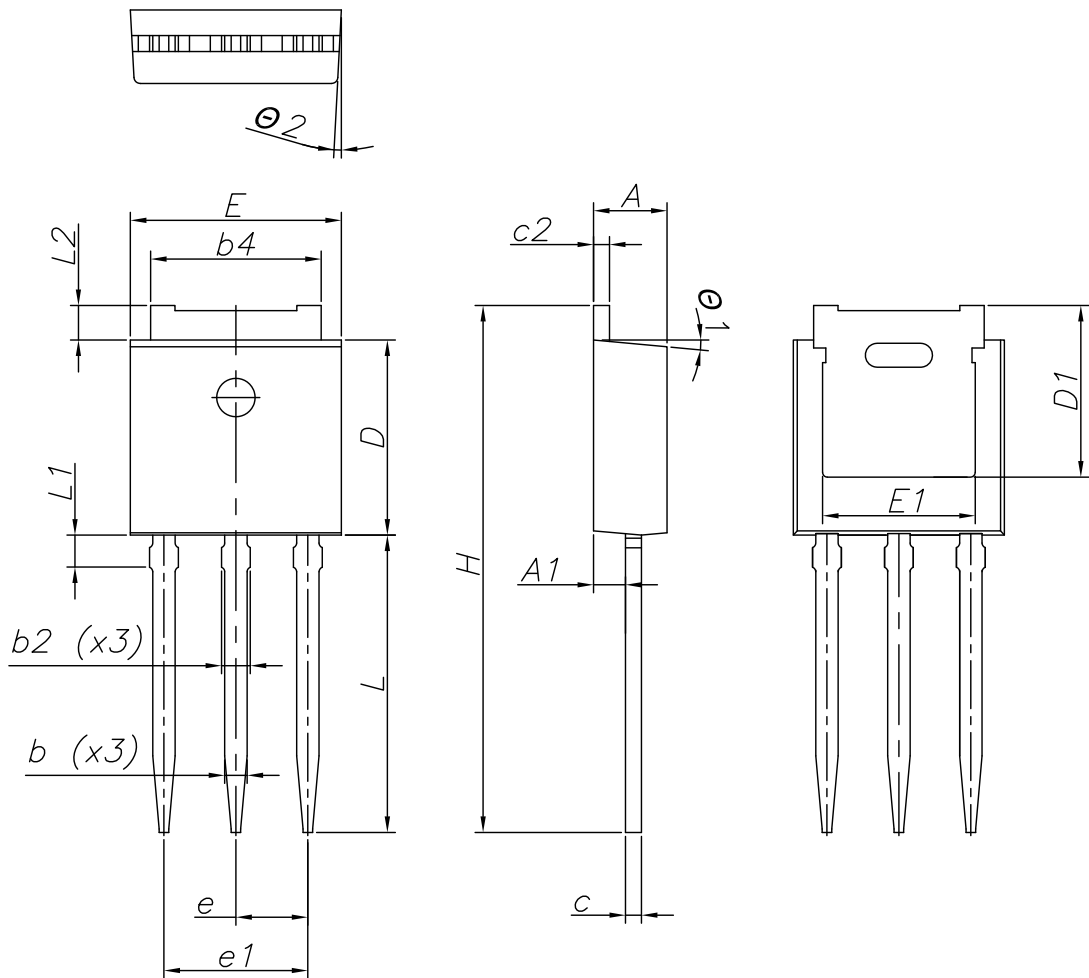
0068771\_IK\_typeA\_rev14

**Table 13. 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°   |      |

### 4.7 IPAK (TO-251) type C package information

Figure 29. IPAK (TO-251) type C package outline



0068771\_IK\_typeC\_rev14

**Table 14. IPAK (TO-251) type C package mechanical data**

| Dim. | mm    |       |       |
|------|-------|-------|-------|
|      | Min.  | Typ.  | Max.  |
| A    | 2.20  | 2.30  | 2.35  |
| A1   | 0.90  | 1.00  | 1.10  |
| b    | 0.66  |       | 0.79  |
| b2   |       |       | 0.90  |
| b4   | 5.23  | 5.33  | 5.43  |
| c    | 0.46  |       | 0.59  |
| c2   | 0.46  |       | 0.59  |
| D    | 6.00  | 6.10  | 6.20  |
| D1   | 5.20  | 5.37  | 5.55  |
| E    | 6.50  | 6.60  | 6.70  |
| E1   | 4.60  | 4.78  | 4.95  |
| e    | 2.20  | 2.25  | 2.30  |
| e1   | 4.40  | 4.50  | 4.60  |
| H    | 16.18 | 16.48 | 16.78 |
| L    | 9.00  | 9.30  | 9.60  |
| L1   | 0.80  | 1.00  | 1.20  |
| L2   | 0.90  | 1.08  | 1.25  |
| θ1   | 3°    | 5°    | 7°    |
| θ2   | 1°    | 3°    | 5°    |

## 5 Ordering information

**Table 15. Ordering information**

| Order code | Marking | Package | Packing       |
|------------|---------|---------|---------------|
| STD5N60M2  | 5N60M2  | DPAK    | Tape and reel |
| STP5N60M2  |         | TO-220  | Tube          |
| STU5N60M2  |         | IPAK    |               |



## Revision history

**Table 16. Document revision history**

| Date        | Revision | Changes  |
|-------------|----------|--|
| 30-Sep-2013 | 1        | First release.   |
| 20-Mar-2014 | 2        | <ul style="list-style-type: none"> <li>– Modified: ID, IDM and note 2 values in Table 2</li> <li>– Modified: the entire values in Table 4</li> <li>– Modified: RDS(on) typical and ID values in Table 5</li> <li>– Modified: the entire typical values, ISD and ISDM in Table 6, 7 and 8</li> <li>– Updated: Section 4.1: DPAK, STD5N60M2</li> <li>– Minor text changes</li> </ul> |
| 08-Jun-2016 | 3        | <p>Updated title, features, applications and description in cover page. Updated <i>Section 1: "Electrical ratings"</i>, <i>Table 6: "Dynamic"</i> and <i>Section 2.1: "Electrical characteristics (curves)"</i>.</p> <p>Updated IPAK C</p> <p>Minor text changes</p>   |
| 16-Jun-2016 | 4        | <p>Updated <i>Figure 1: "Internal schematic diagram"</i>.</p> <p>Updated <i>Table 7: "Switching times"</i> and <i>Table 8: "Source-drain diode"</i>.</p> <p>Minor text changes.</p>  |
| 01-Oct-2018 | 5        | <p>Updated <a href="#">Section 4 Package information</a>.</p> <p>Minor text changes</p>  |

## Contents

|            |   |           |
|------------|---|-----------|
| <b>1</b>   | <b>Electrical ratings</b> .....                 | <b>2</b>  |
| <b>2</b>   | <b>Electrical characteristics</b> .....         | <b>3</b>  |
| <b>2.1</b> | Electrical characteristics (curves) .....       | 5         |
| <b>3</b>   | <b>Test circuits</b> .....                      | <b>8</b>  |
| <b>4</b>   | <b>Package information</b> .....                | <b>9</b>  |
| <b>4.1</b> | DPAK (TO-252) type A2 package information ..... | 9         |
| <b>4.2</b> | DPAK (TO-252) type C2 package information ..... | 11        |
| <b>4.3</b> | DPAK (TO-252) type E package information .....  | 13        |
| <b>4.4</b> | DPAK (TO-252) packing information .....         | 15        |
| <b>4.5</b> | TO-220 type A package information .....         | 17        |
| <b>4.6</b> | IPAK (TO-251) type A package information .....  | 19        |
| <b>4.7</b> | IPAK (TO-251) type C package information .....  | 21        |
| <b>5</b>   | <b>Ordering information</b> .....               | <b>24</b> |
|            | <b>Revision history</b> .....                   | <b>25</b> |

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