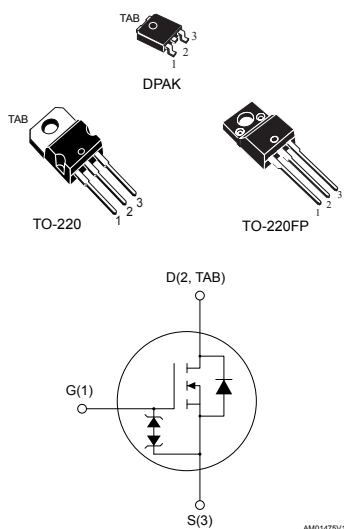


N-channel 600 V, 1.2  $\Omega$  typ., 5 A SuperMESH™ Power MOSFET in DPAK, TO-220 and TO-220FP packages



## Features

| Order codes | $V_{DS}$ @ $T_{jmax.}$ | $R_{DS(on)}$ max. | Package  |
|-------------|------------------------|-------------------|----------|
| STD5NK60ZT4 | 650 V                  | 1.6 $\Omega$      | DPAK     |
| STP5NK60Z   |                        |                   | TO-220   |
| STP5NK60ZFP |                        |                   | TO-220FP |

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

## Applications

- Switching applications

## Description

These high-voltage devices are Zener-protected N-channel Power MOSFETs developed using the SuperMESH™ technology by STMicroelectronics, an optimization of the well-established PowerMESH™. In addition to a significant reduction in on-resistance, these devices are designed to ensure a high level of dv/dt capability for the most demanding applications.

### Product status link

[STD4NK60ZT4](#)
[STP5NK60Z](#)
[STP5NK60ZFP](#)

# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

| Symbol                  | Parameter                                                                                                                               | Value        |                     | Unit               |
|-------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|--------------|---------------------|--------------------|
|                         |                                                                                                                                         | DPAK, TO-220 | TO-220FP            |                    |
| $V_{DS}$                | Drain-source voltage                                                                                                                    | 600          |                     | V                  |
| $V_{GS}$                | Gate-source voltage                                                                                                                     | $\pm 30$     |                     | V                  |
| $I_D$                   | Drain current (continuous) at $T_C = 25\text{ }^{\circ}\text{C}$                                                                        | 5            | 5 <sup>(1)</sup>    | A                  |
| $I_D$                   | Drain current (continuous) at $T_C = 100\text{ }^{\circ}\text{C}$                                                                       | 3.16         | 3.16 <sup>(1)</sup> | A                  |
| $I_{DM}$ <sup>(2)</sup> | Drain current (pulsed)                                                                                                                  | 20           | 20 <sup>(1)</sup>   | A                  |
| $P_{TOT}$               | Total dissipation at $T_C = 25\text{ }^{\circ}\text{C}$                                                                                 | 90           | 25                  | W                  |
| ESD                     | Gate-source human body model<br>( $R = 1.5\text{ k}\Omega$ , $C = 100\text{ pF}$ )                                                      | 3            |                     | kV                 |
| $V_{ISO}$               | Insulation withstand voltage (RMS) from all three leads to external heat-sink ( $t = 1\text{ s}$ , $T_C = 25\text{ }^{\circ}\text{C}$ ) |              | 2.5                 | kV                 |
| $dv/dt$ <sup>(3)</sup>  | Peak diode recovery voltage slope                                                                                                       | 4.5          |                     | V/ns               |
| $T_j$                   | Operating junction temperature range                                                                                                    | -55 to 150   |                     | $^{\circ}\text{C}$ |
| $T_{stg}$               | Storage temperature range                                                                                                               |              |                     |                    |

1. Limited by maximum junction temperature.

2. Pulse width limited by safe operating area.

3.  $I_{SD} \leq 5\text{ A}$ ,  $di/dt \leq 200\text{ A}/\mu\text{s}$ ,  $V_{DSpeak} \leq V_{(BR)DSS}$ ,  $V_{DD} = 80\% V_{(BR)DSS}$ .

**Table 2. Thermal data**

| Symbol                       | Parameter                           | Value |        |          | Unit                        |
|------------------------------|-------------------------------------|-------|--------|----------|-----------------------------|
|                              |                                     | DPAK  | TO-220 | TO-220FP |                             |
| $R_{thj-case}$               | Thermal resistance junction-case    | 1.39  |        | 5        | $^{\circ}\text{C}/\text{W}$ |
| $R_{thj-amb}$                | Thermal resistance junction-ambient |       | 62.5   |          | $^{\circ}\text{C}/\text{W}$ |
| $R_{thj-pcb}$ <sup>(1)</sup> | Thermal resistance junction-pcb     | 50    |        |          | $^{\circ}\text{C}/\text{W}$ |

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<br>(pulse width limited by $T_j$ Max)                                     | 5     | A    |
| $E_{AS}$ | Single pulse avalanche energy<br>(starting $T_j = 25\text{ }^{\circ}\text{C}$ , $I_D = I_{AR}$ , $V_{DD} = 50\text{ V}$ ) | 220   | mJ   |

## 2 Electrical characteristics

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

**Table 4. On/off states**

| Symbol        | Parameter                         | Test conditions                                                                                      | Min. | Typ. | Max.     | Unit          |
|---------------|-----------------------------------|------------------------------------------------------------------------------------------------------|------|------|----------|---------------|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage    | $I_D = 1\text{ mA}$ , $V_{GS} = 0\text{ V}$                                                          | 600  |      |          | V             |
| $I_{DSS}$     | Zero gate voltage drain current   | $V_{GS} = 0\text{ V}$ , $V_{DS} = 600\text{ V}$                                                      |      |      | 1        | $\mu\text{A}$ |
|               |                                   | $V_{GS} = 0\text{ V}$ , $V_{DS} = 600\text{ V}$ , $T_C = 125\text{ }^{\circ}\text{C}$ <sup>(1)</sup> |      |      | 50       | $\mu\text{A}$ |
| $I_{GSS}$     | Gate body leakage current         | $V_{DS} = 0\text{ V}$ , $V_{GS} = \pm 20\text{ V}$                                                   |      |      | $\pm 10$ | $\mu\text{A}$ |
| $V_{GS(th)}$  | 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 | $V_{GS} = 10\text{ V}$ , $I_D = 2.5\text{ A}$                                                        |      | 1.2  | 1.6      | $\Omega$      |

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

**Table 5. Dynamic**

| Symbol                     | Parameter                     | Test conditions                                                                                                                             | Min. | Typ. | Max. | Unit |
|----------------------------|-------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|
| $C_{iss}$                  | Input capacitance             | $V_{DS} = 25\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GS} = 0\text{ V}$                                                                         | -    | 690  |      | pF   |
| $C_{oss}$                  | Output capacitance            |                                                                                                                                             |      | 90   |      |      |
| $C_{rss}$                  | Reverse transfer capacitance  |                                                                                                                                             |      | 20   |      |      |
| $C_{oss\text{ eq.}}^{(1)}$ | Equivalent output capacitance | $V_{DS} = 0\text{ to }480\text{ V}$ , $V_{GS} = 0\text{ V}$                                                                                 | -    | 40   |      | pF   |
| $Q_g$                      | Total gate charge             | $V_{DD} = 400\text{ V}$ , $I_D = 5\text{ A}$ , $V_{GS} = 0\text{ to }10\text{ V}$<br>(see Figure 16. Test circuit for gate charge behavior) | -    | 26   | 34   | nC   |
| $Q_{gs}$                   | Gate-source charge            |                                                                                                                                             |      | 6    |      |      |
| $Q_{gd}$                   | Gate-drain charge             |                                                                                                                                             |      | 14   |      |      |

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%  $V_{DSS}$ .

**Table 6. Switching times**

| Symbol               | Parameter             | Test conditions                                                                                                            | Min. | Typ. | Max. | Unit |
|----------------------|-----------------------|----------------------------------------------------------------------------------------------------------------------------|------|------|------|------|
| t <sub>d(on)</sub>   | Turn-on delay time    | V <sub>DD</sub> = 300 V, I <sub>D</sub> = 2.5 A,                                                                           | -    | 16   | -    | ns   |
| t <sub>r</sub>       | Rise time             | R <sub>G</sub> = 4.7 Ω, V <sub>GS</sub> = 10 V                                                                             |      | 25   |      |      |
| t <sub>d(off)</sub>  | Turn-off delay time   | (see Figure 15. Test circuit for resistive load switching times and Figure 20. Switching time waveform)                    |      | 36   |      |      |
| t <sub>f</sub>       | Fall time             |                                                                                                                            |      | 25   |      |      |
| t <sub>r(Voff)</sub> | Off-voltage rise time | V <sub>DD</sub> = 480 V, I <sub>D</sub> = 5 A,                                                                             |      | 12   |      |      |
| t <sub>f</sub>       | Fall time             | R <sub>G</sub> = 4.7 Ω, V <sub>GS</sub> = 10 V                                                                             |      | 10   |      |      |
| t <sub>c</sub>       | Cross-over time       | (see Figure 17. Test circuit for inductive load switching and diode recovery times and Figure 20. Switching time waveform) |      | 24   |      |      |

**Table 7. Source drain diode**

| Symbol          | Parameter                     | Test conditions                                                                                            | Min. | Typ. | Max. | Unit          |
|-----------------|-------------------------------|------------------------------------------------------------------------------------------------------------|------|------|------|---------------|
| $I_{SD}$        | Source-drain current          |                                                                                                            | -    |      | 5    | A             |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |                                                                                                            |      |      | 20   |               |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD} = 5\text{ A}$ , $V_{GS} = 0\text{ V}$                                                              | -    |      | 1.6  | V             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 5\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$                                                 | -    | 485  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       | $V_{DD} = 30\text{ V}$ (see Figure 17. Test circuit for inductive load switching and diode recovery times) |      | 2.7  |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                            |      | 11   |      | A             |

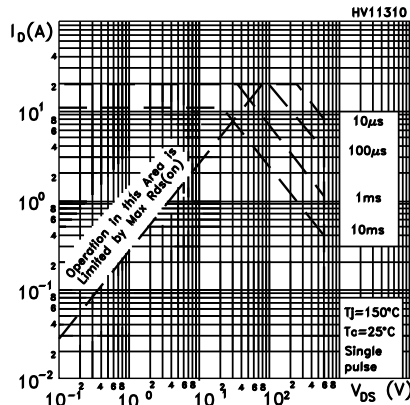
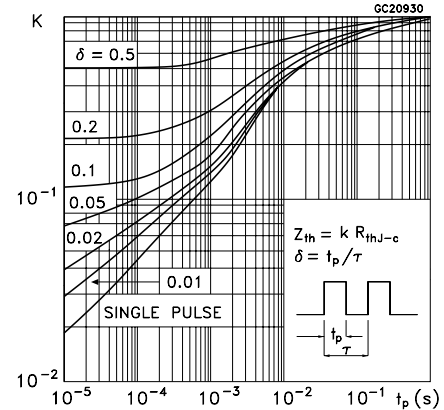
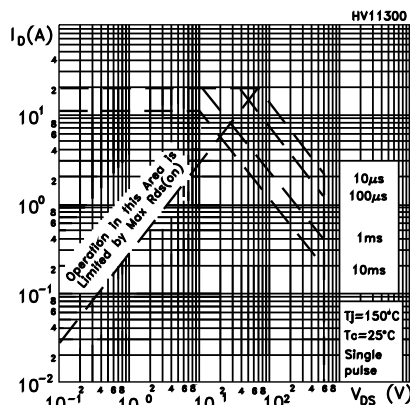
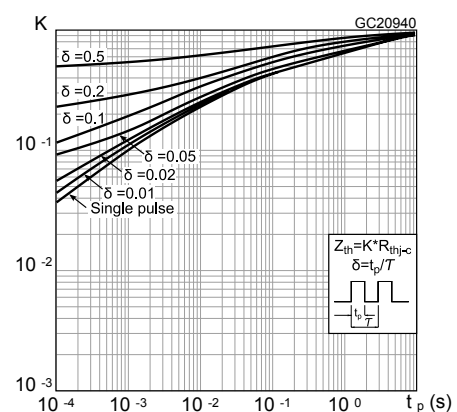
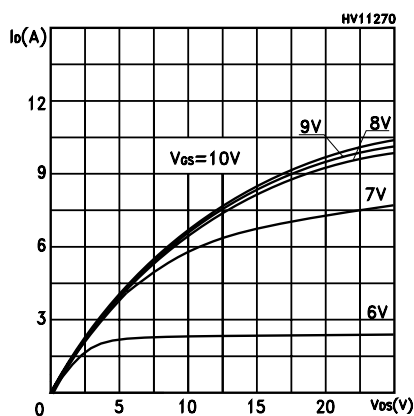
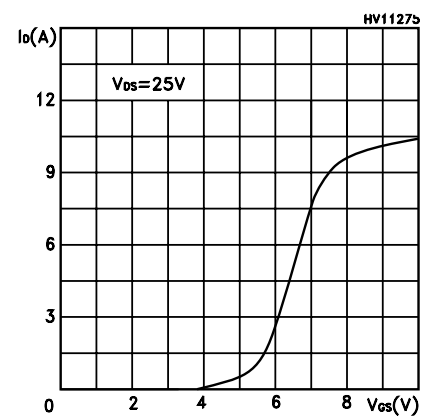
1. Pulse width limited by safe operating area.
2. Pulsed: pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%.

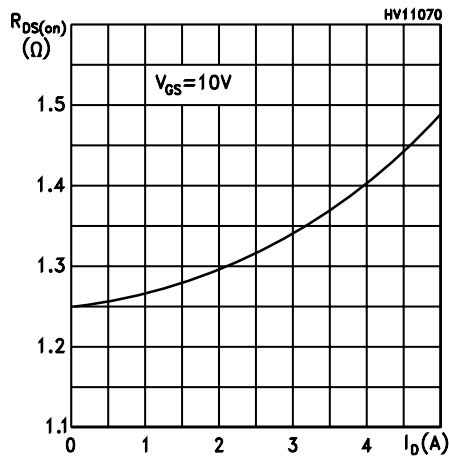
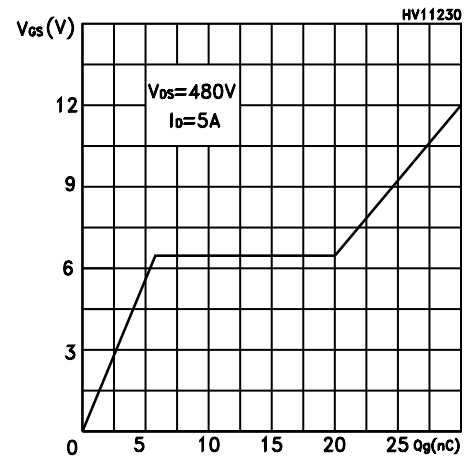
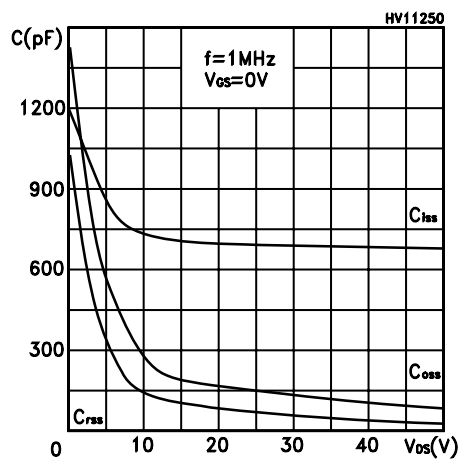
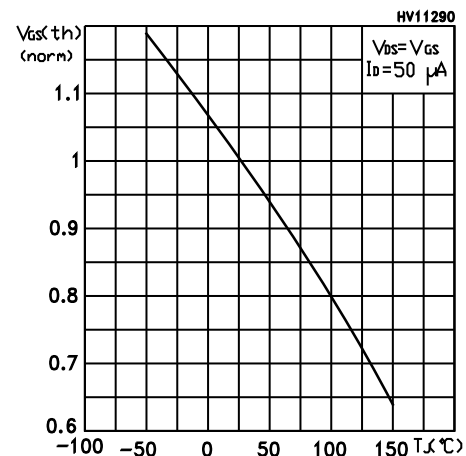
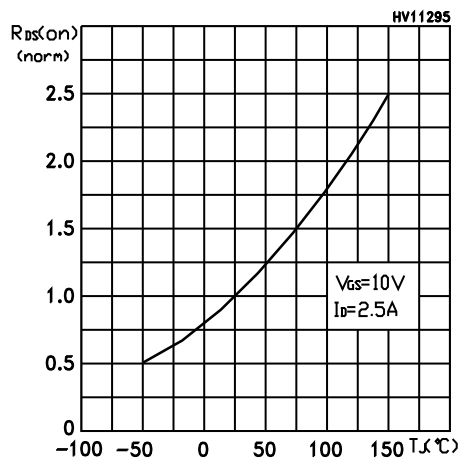
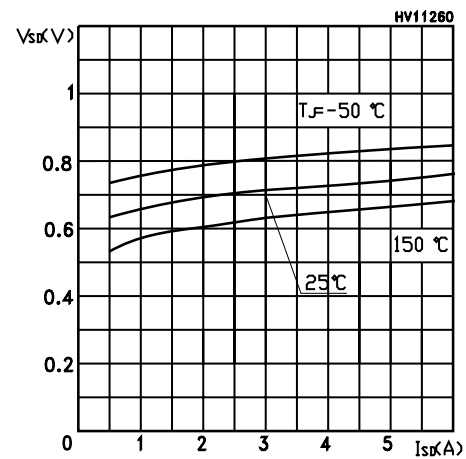
**Table 8. Gate-Source Zener Diode**

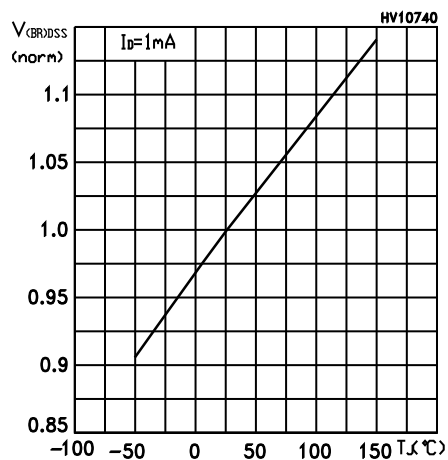
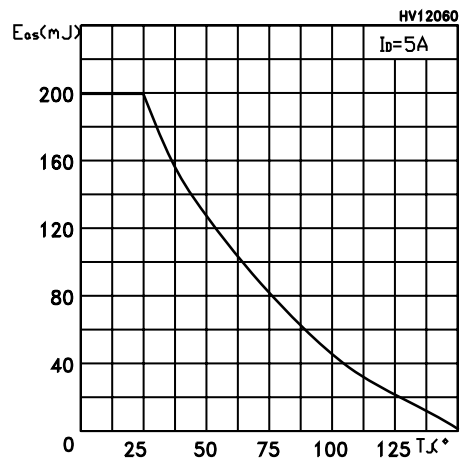
| Symbol        | Parameter                     | Test conditions                                 | Min. | Typ. | Max. | Unit |
|---------------|-------------------------------|-------------------------------------------------|------|------|------|------|
| $V_{(BR)GSO}$ | Gate-source breakdown voltage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

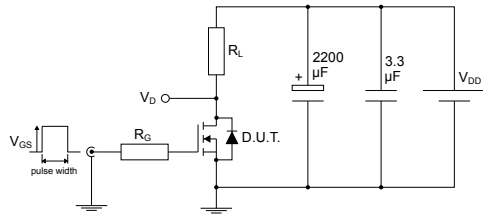
## 2.1 Electrical characteristics curves

**Figure 1. Safe operating area for DPAK and TO-220**

**Figure 2. Thermal impedance for DPAK and TO-220**

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

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

**Figure 5. Output characteristics**

**Figure 6. Transfer characteristics**


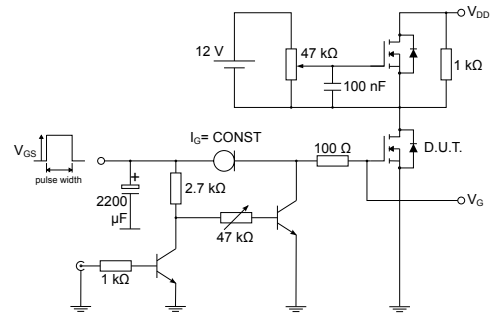
**Figure 7. Static drain-source on resistance**

**Figure 8. Gate charge vs gate-source voltage**

**Figure 9. Capacitance variations**

**Figure 10. Normalized gate threshold voltage vs temperature**

**Figure 11. Normalized on resistance vs temperature**

**Figure 12. Source-drain diode forward characteristic**


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

**Figure 14. Maximum avalanche energy vs temperature**


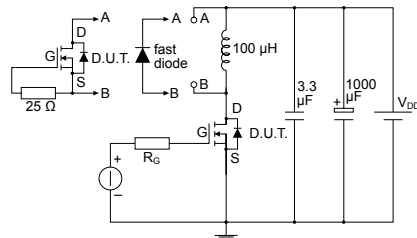
### 3 Test circuits

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


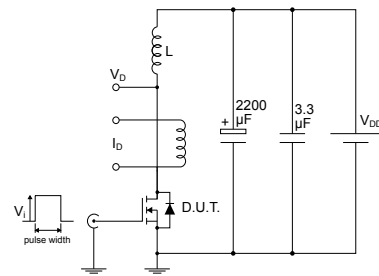
AM01468v1

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


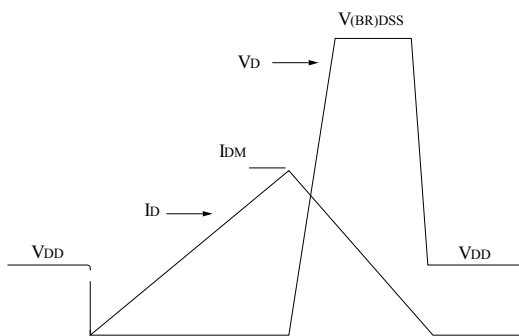
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**Figure 17. Test circuit for inductive load switching and diode recovery times**


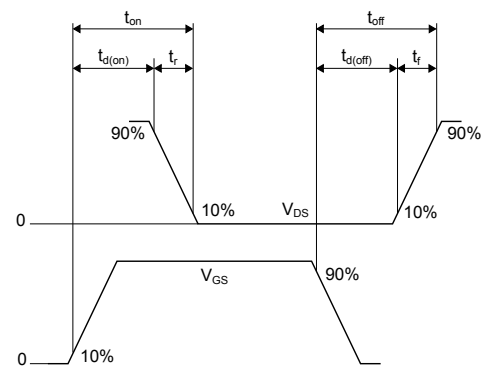
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**Figure 18. Unclamped inductive load test circuit**


AM01471v1

**Figure 19. Unclamped inductive waveform**


AM01472v1

**Figure 20. Switching time waveform**


AM01473v1

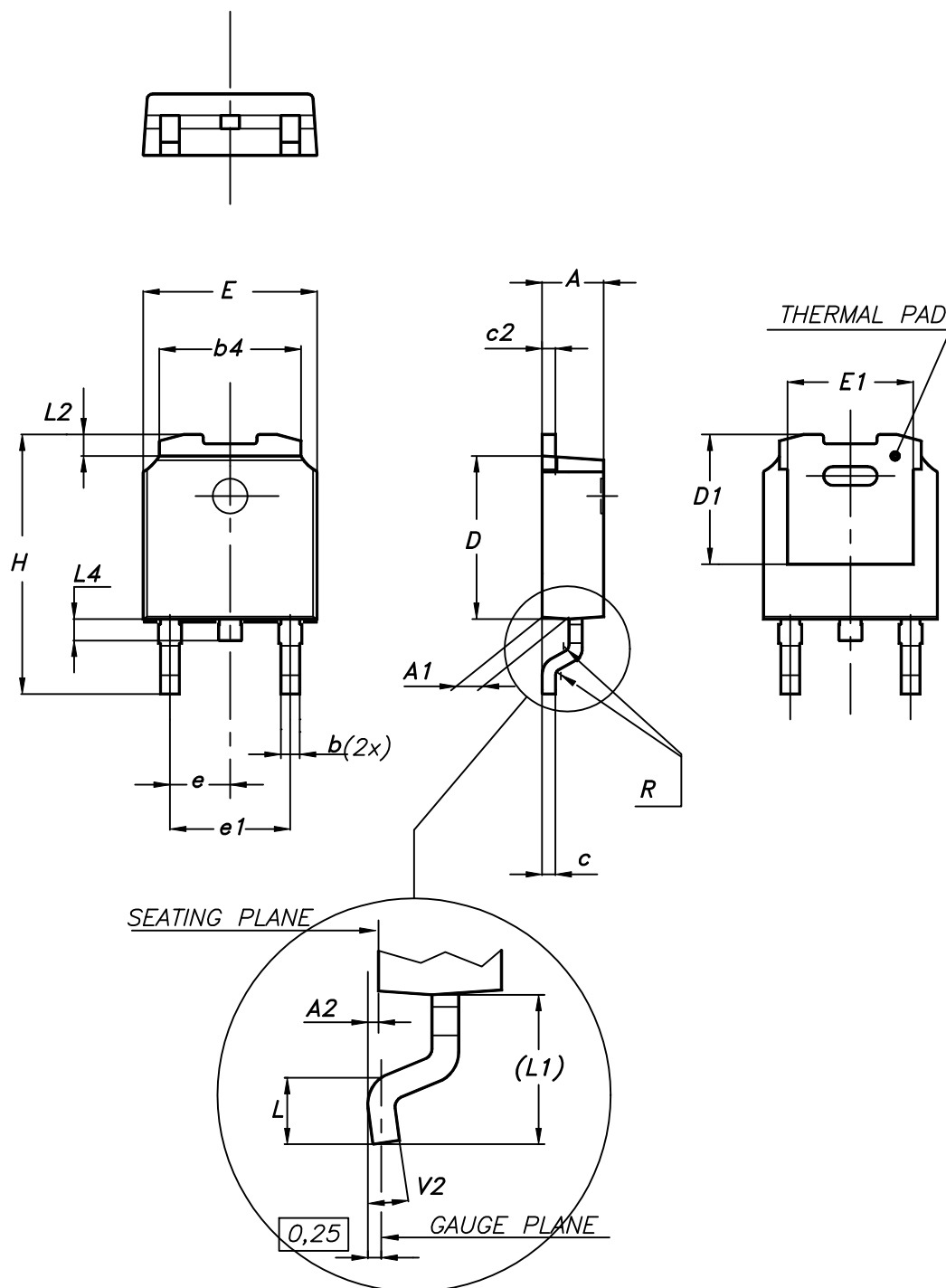
## 4 Package information

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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



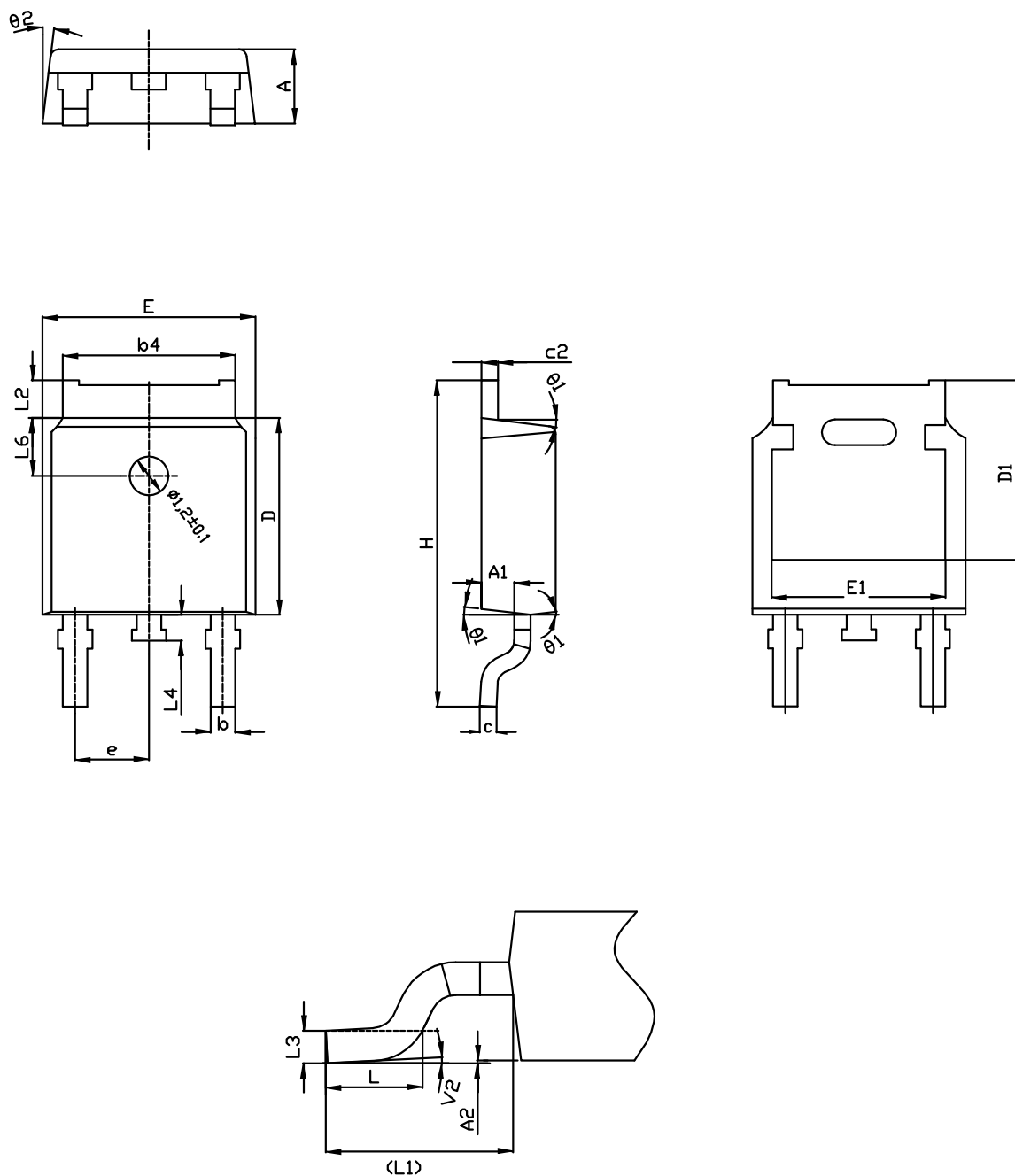
0068772\_type-A2\_rev25

**Table 9. 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

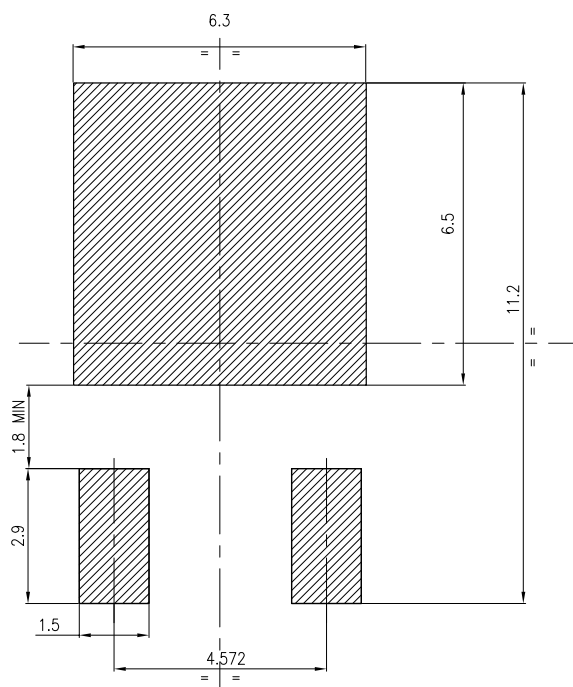


0068772\_C2\_25

**Table 10. 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°    |

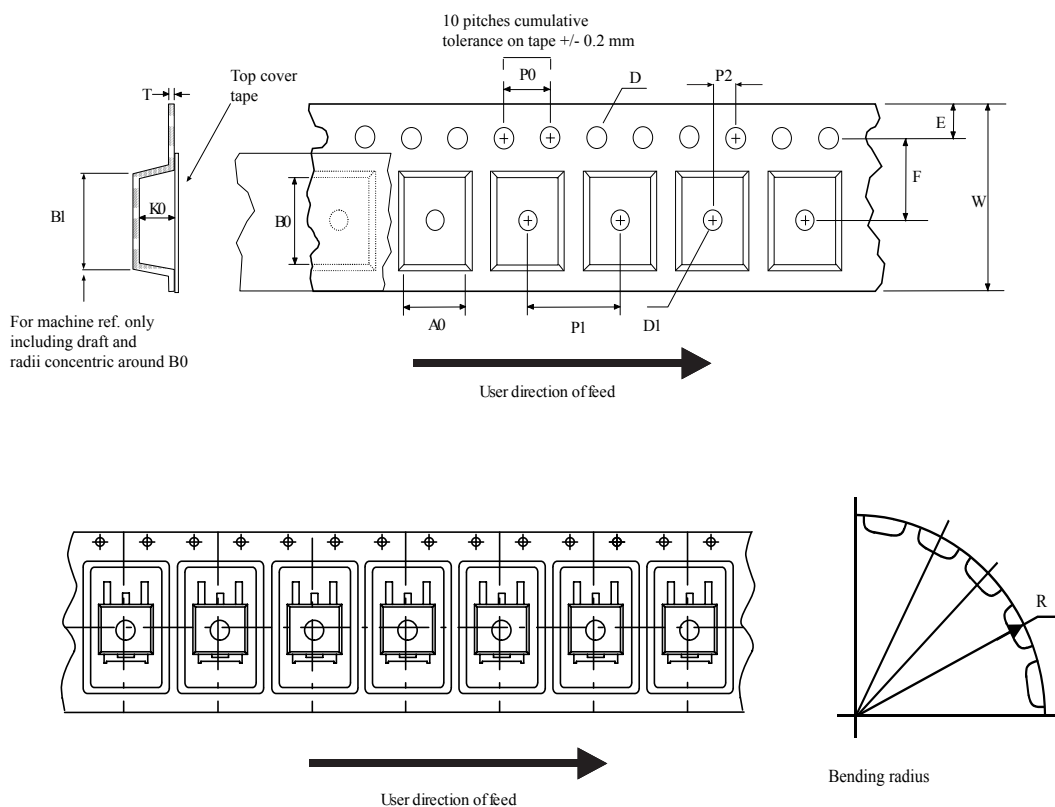
**Figure 23. DPAK (TO-252) recommended footprint (dimensions are in mm)**



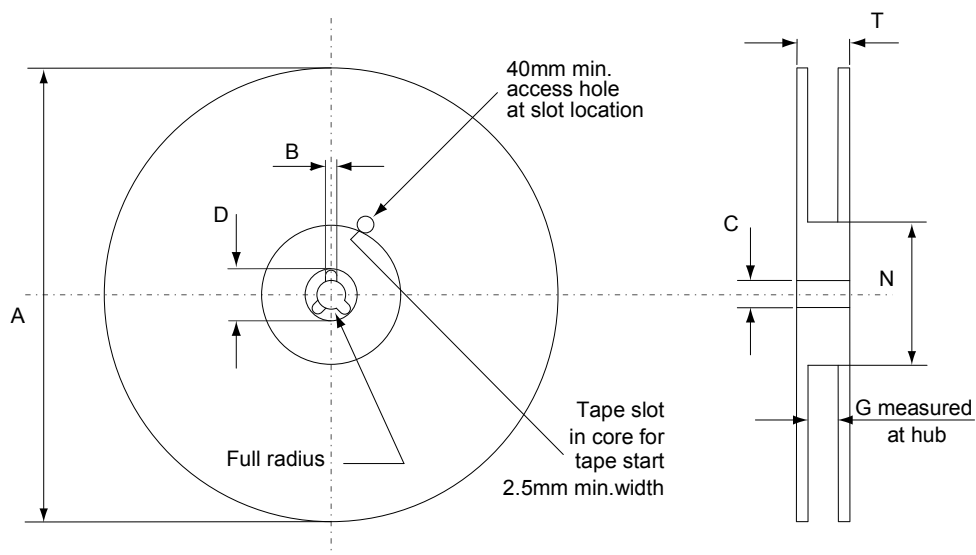
FP\_0068772\_25

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

**Figure 24. DPAK (TO-252) tape outline**



AM08852v1

**Figure 25. DPAK (TO-252) reel outline**


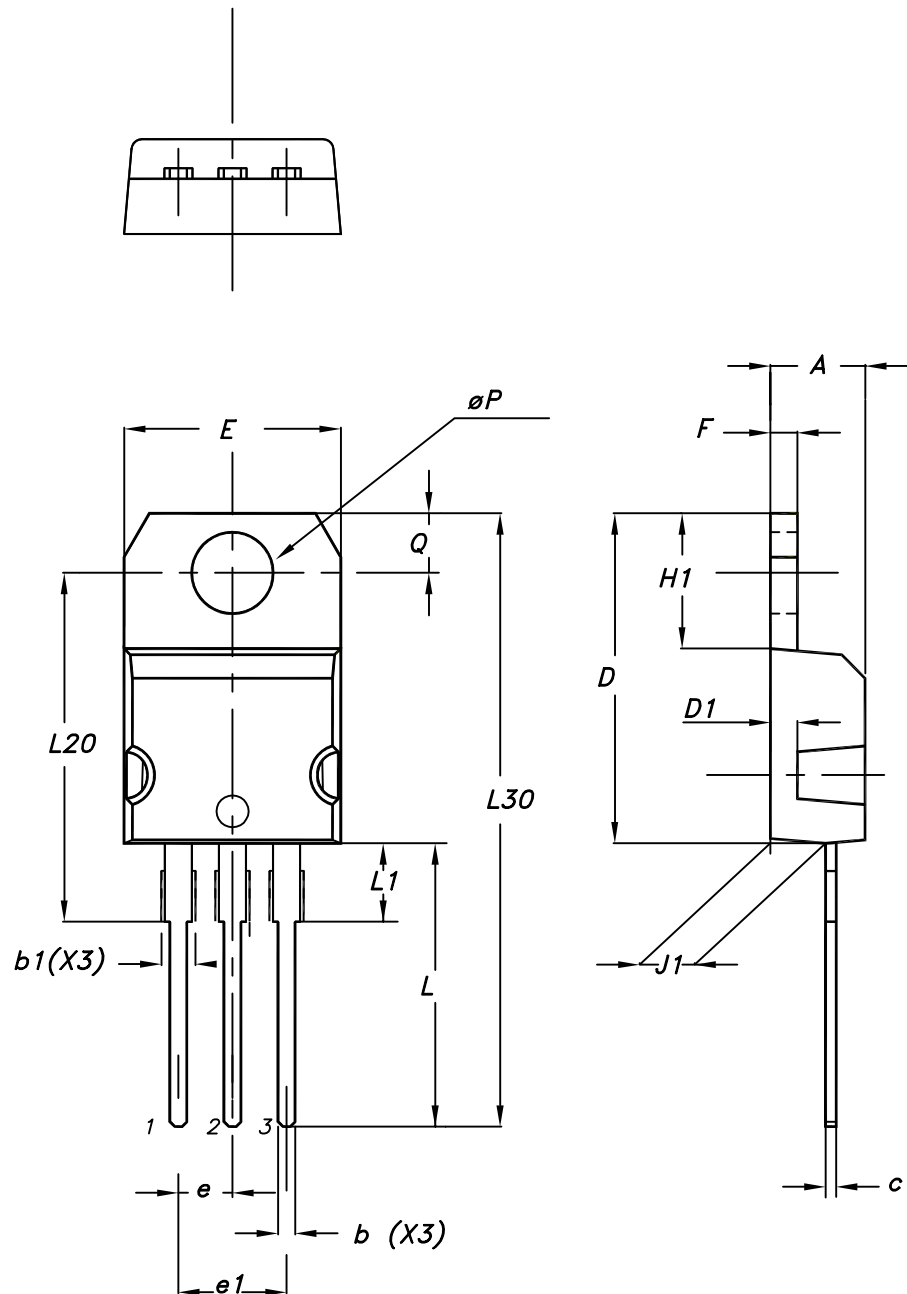
AM06038v1

**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 |           |      |      |

#### 4.4 TO-220 type A package information

Figure 26. TO-220 type A package outline



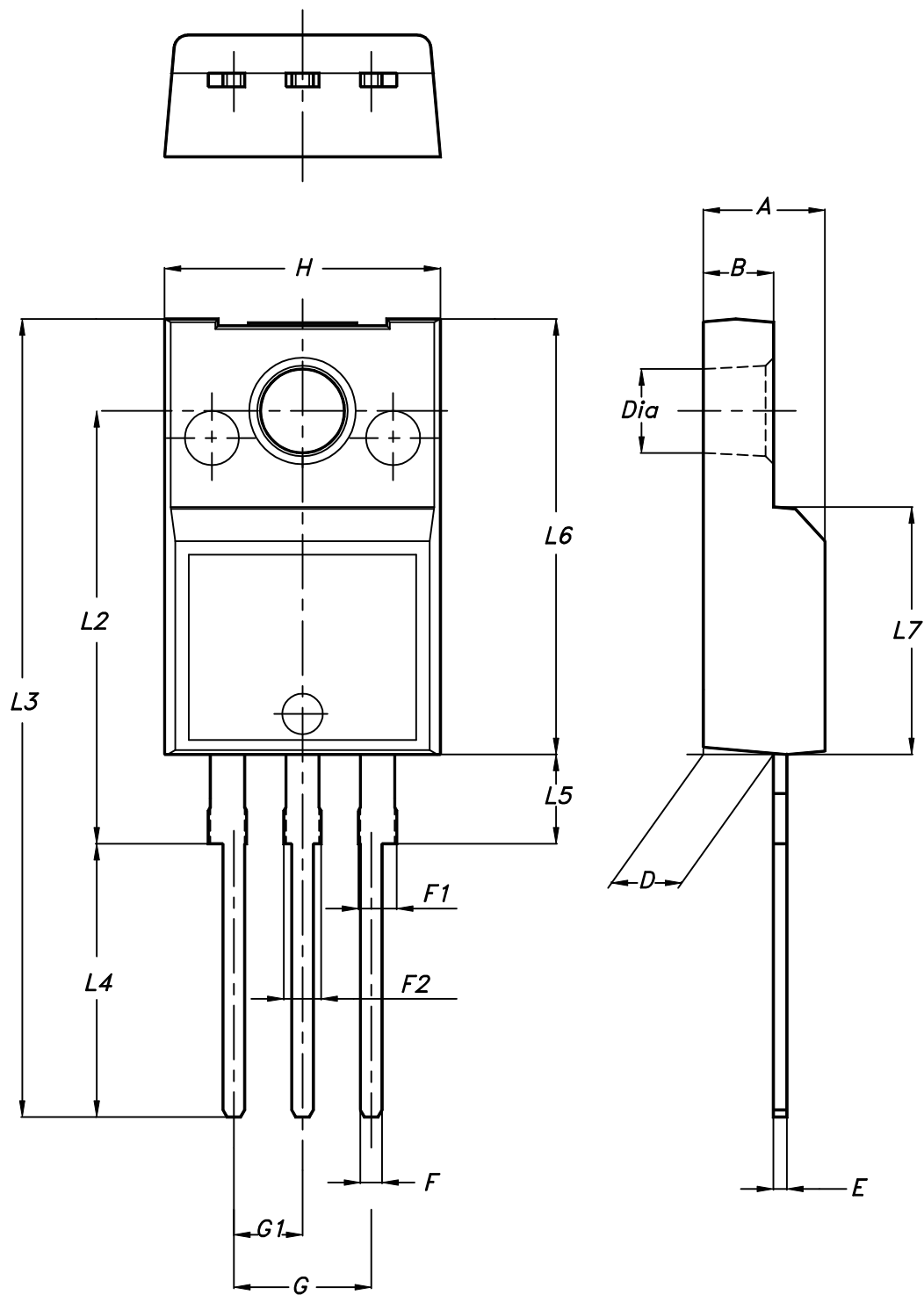
0015988\_typeA\_Rev\_21

**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  |

## 4.5 TO-220FP package information

Figure 27. TO-220FP package outline



7012510\_Rev\_12\_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  |

## 5 Ordering information

**Table 14. Order codes**

| Order code  | Marking   | Package  | Packing       |
|-------------|-----------|----------|---------------|
| STD5NK60ZT4 | D5NK60Z   | DPAK     | Tape and reel |
| STP5NK60Z   | P5NK60Z   | TO-220   | Tube          |
| STP5NK60ZFP | P5NK60ZFP | TO-220FP | Tube          |

## Revision history

**Table 15. Document revision history**

| Date        | Version | Changes                                                                                                                                                                       |
|-------------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 05-Apr-2005 | 1       | First issue                                                                                                                                                                   |
| 29-Apr-2005 | 2       | Modified value in Table 7.                                                                                                                                                    |
| 06-Sep-2005 | 3       | Inserted Ecopack indication                                                                                                                                                   |
| 14-Oct-2005 | 4       | Modified value on Table 1                                                                                                                                                     |
| 28-Oct-2005 | 5       | Tape & Reel info added                                                                                                                                                        |
| 14-Nov-2005 | 6       | Modified value on Table 6                                                                                                                                                     |
| 15-Dec-2005 | 7       | Various corrections                                                                                                                                                           |
| 22-Aug-2018 | 8       | Removed maturity status indication from cover page. The document status is production data.<br>Updated <a href="#">Section 4 Package information</a> .<br>Minor text changes. |

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