

# STD10NM60N, STF10NM60N, STP10NM60N, STU10NM60N

N-channel 600 V, 0.53  $\Omega$  typ., 10 A MDmesh™ II Power MOSFET  
in DPAK, TO-220FP, TO-220 and IPAK packages

Datasheet - production data

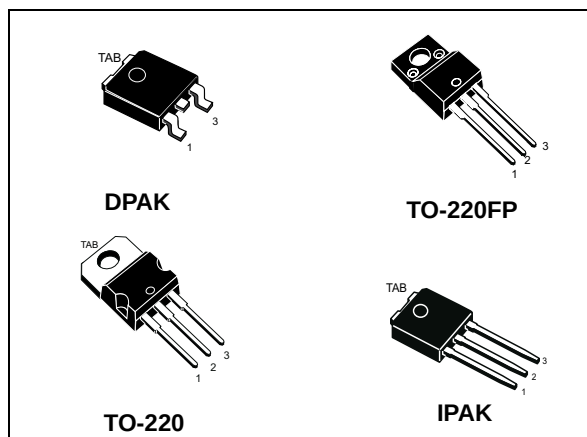
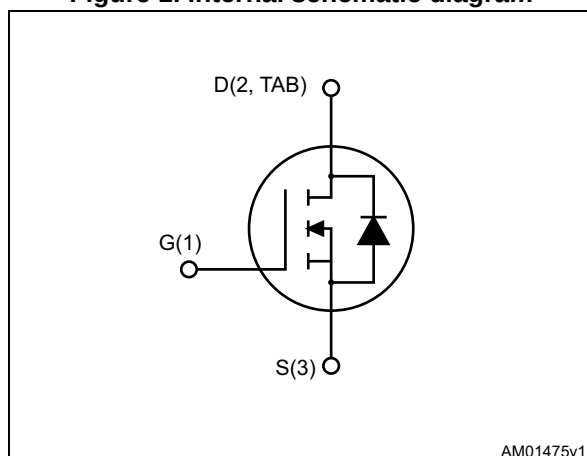


Figure 1. Internal schematic diagram



## Features

| Order code | $V_{DS} @ T_J$<br>max. | $R_{DS(on)}$<br>max. | $I_D$ | $P_{TOT}$ |
|------------|------------------------|----------------------|-------|-----------|
| STD10NM60N | 650 V                  | 0.55 $\Omega$        | 10 A  | 70 W      |
| STF10NM60N |                        |                      |       | 25 W      |
| STP10NM60N |                        |                      |       | 70 W      |
| STU10NM60N |                        |                      |       |           |

- 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 | Package  | Packing       |
|------------|---------|----------|---------------|
| STD10NM60N | 10NM60N | DPAK     | Tape and reel |
| STF10NM60N | 10NM60N | TO-220FP | Tube          |
| STP10NM60N | 10NM60N | TO-220   | Tube          |
| STU10NM60N | 10NM60N | IPAK     | Tube          |

## Contents

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# 1 Electrical ratings

Table 2. Absolute maximum ratings

| Symbol         | Parameter                                                                                                                                  | Value       |                   |      |      | Unit               |
|----------------|--------------------------------------------------------------------------------------------------------------------------------------------|-------------|-------------------|------|------|--------------------|
|                |                                                                                                                                            | TO-220      | TO-220FP          | IPAK | DPAK |                    |
| $V_{GS}$       | Gate- source voltage                                                                                                                       | $\pm 25$    |                   |      |      | V                  |
| $I_D$          | Drain current (continuous) at $T_C = 25\text{ }^{\circ}\text{C}$                                                                           | 10          | 10 <sup>(1)</sup> | 10   |      | A                  |
| $I_D$          | Drain current (continuous) at $T_C = 100\text{ }^{\circ}\text{C}$                                                                          | 5           | 5 <sup>(1)</sup>  | 5    |      | A                  |
| $I_{DM}^{(2)}$ | Drain current (pulsed)                                                                                                                     | 32          | 32 <sup>(1)</sup> | 32   |      | A                  |
| $P_{TOT}$      | Total dissipation at $T_C = 25\text{ }^{\circ}\text{C}$                                                                                    | 70          | 25                | 70   |      | W                  |
| $dv/dt^{(3)}$  | Peak diode recovery voltage slope                                                                                                          | 15          |                   |      |      | V/ns               |
| $V_{ISO}$      | Insulation withstand voltage (RMS) from all three leads to external heat sink<br>( $t = 1\text{ s}$ ; $T_C = 25\text{ }^{\circ}\text{C}$ ) |             | 2500              |      |      | V                  |
| $T_J$          | Operating junction temperature                                                                                                             | - 55 to 150 |                   |      |      | $^{\circ}\text{C}$ |
| $T_{stg}$      | Storage temperature                                                                                                                        |             |                   |      |      |                    |

1. Limited by maximum junction temperature.
2. Pulse width limited by safe operating area.
3.  $I_{SD} \leq 10\text{ A}$ ,  $di/dt \leq 400\text{ A}/\mu\text{s}$ ,  $V_{DS\text{ peak}} \leq V_{(BR)DSS}$ ,  $V_{DD} = 80\% V_{(BR)DSS}$ .

Table 3. Thermal data

| Symbol         | Parameter                                | Value  |          |      |      | Unit                        |
|----------------|------------------------------------------|--------|----------|------|------|-----------------------------|
|                |                                          | TO-220 | TO-220FP | IPAK | DPAK |                             |
| $R_{thj-case}$ | Thermal resistance junction-case max.    | 1.79   | 5        | 1.79 |      | $^{\circ}\text{C}/\text{W}$ |
| $R_{thj-amb}$  | Thermal resistance junction-ambient max. | 62.50  |          | 100  |      | $^{\circ}\text{C}/\text{W}$ |
| $R_{thj-pcb}$  | Thermal resistance junction-pcb max.     |        |          |      | 50   | $^{\circ}\text{C}/\text{W}$ |

Table 4. Avalanche characteristics

| Symbol   | Parameter                                                                                                                 | Value | Unit |
|----------|---------------------------------------------------------------------------------------------------------------------------|-------|------|
| $I_{AS}$ | Avalanche current, repetitive or not-repetitive<br>(pulse width limited by $T_J$ max.)                                    | 4     | A    |
| $E_{AS}$ | Single pulse avalanche energy<br>(starting $T_J = 25\text{ }^{\circ}\text{C}$ , $I_D = I_{AS}$ , $V_{DD} = 50\text{ V}$ ) | 200   | mJ   |

## 2 Electrical characteristics

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

**Table 5. On/off-states**

| Symbol                      | Parameter                                               | Test conditions                                                      | Min. | Typ. | Max.      | Unit          |
|-----------------------------|---------------------------------------------------------|----------------------------------------------------------------------|------|------|-----------|---------------|
| $V_{(\text{BR})\text{DSS}}$ | Drain-source breakdown voltage                          | $I_D = 1\text{ mA}$ , $V_{\text{GS}} = 0$                            | 600  |      |           | V             |
|                             |                                                         | $I_D = 1\text{ mA}$ , $V_{\text{GS}} = 0$ ,<br>$T_C = 150\text{ °C}$ |      | 650  |           |               |
| $I_{\text{DSS}}$            | Zero-gate voltage drain current ( $V_{\text{GS}} = 0$ ) | $V_{\text{DS}} = 600\text{ V}$                                       |      |      | 1         | $\mu\text{A}$ |
|                             |                                                         | $V_{\text{DS}} = 600\text{ V}$ , $T_C = 125\text{ °C}$               |      |      | 100       |               |
| $I_{\text{GSS}}$            | Gate-body leakage current ( $V_{\text{DS}} = 0$ )       | $V_{\text{GS}} = \pm 25\text{ V}$                                    |      |      | $\pm 100$ | nA            |
| $V_{\text{GS(th)}}$         | Gate threshold voltage                                  | $V_{\text{DS}} = V_{\text{GS}}$ , $I_D = 250\text{ }\mu\text{A}$     | 2    | 3    | 4         | V             |
| $R_{\text{DS(on)}}$         | Static drain-source on-resistance                       | $V_{\text{GS}} = 10\text{ V}$ , $I_D = 4\text{ A}$                   |      | 0.53 | 0.55      | $\Omega$      |

**Table 6. Dynamic**

| Symbol                    | Parameter                           | Test conditions                                                                                                            | Min. | Typ. | Max. | Unit     |
|---------------------------|-------------------------------------|----------------------------------------------------------------------------------------------------------------------------|------|------|------|----------|
| $C_{\text{iss}}$          | Input capacitance                   | $V_{\text{DS}} = 50\text{ V}$ , $f = 1\text{ MHz}$ ,<br>$V_{\text{GS}} = 0$                                                | -    | 540  | -    | pF       |
| $C_{\text{oss}}$          | Output capacitance                  |                                                                                                                            | -    | 44   | -    | pF       |
| $C_{\text{rss}}$          | Reverse transfer capacitance        |                                                                                                                            | -    | 1.2  | -    | pF       |
| $C_{\text{oss eq}}^{(1)}$ | Equivalent capacitance time related | $V_{\text{DS}} = 0\text{ to }480\text{ V}$ , $V_{\text{GS}} = 0$                                                           | -    | 110  | -    | pF       |
| $R_g$                     | Gate input resistance               | $f = 1\text{ MHz}$ open drain                                                                                              | -    | 6    | -    | $\Omega$ |
| $Q_g$                     | Total gate charge                   | $V_{\text{DD}} = 480\text{ V}$ , $I_D = 8\text{ A}$ ,<br>$V_{\text{GS}} = 10\text{ V}$<br>(see <a href="#">Figure 17</a> ) | -    | 19   | -    | nC       |
| $Q_{\text{gs}}$           | Gate-source charge                  |                                                                                                                            | -    | 3    | -    | nC       |
| $Q_{\text{gd}}$           | Gate-drain charge                   |                                                                                                                            | -    | 10   | -    | nC       |

1.  $C_{\text{oss eq}}$  time related 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 7. Switching times

| Symbol       | Parameter           | Test conditions                                                                                                                    | Min. | Typ. | Max. | Unit |
|--------------|---------------------|------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|
| $t_{d(on)}$  | Turn-on delay time  | $V_{DD} = 300\text{ V}$ , $I_D = 4\text{ A}$ ,<br>$R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$<br>(see <a href="#">Figure 16</a> ) | -    | 10   | -    | ns   |
| $t_r$        | Rise time           |                                                                                                                                    | -    | 12   | -    | ns   |
| $t_{d(off)}$ | Turn-off-delay time |                                                                                                                                    | -    | 32   | -    | ns   |
| $t_f$        | Fall time           |                                                                                                                                    | -    | 15   | -    | ns   |

Table 8. Source-drain diode

| Symbol          | Parameter                     | Test conditions                                                                                                                                              | Min. | Typ. | Max. | Unit          |
|-----------------|-------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|---------------|
| $I_{SD}$        | Source-drain current          |                                                                                                                                                              | -    |      | 8    | A             |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |                                                                                                                                                              |      |      | 32   |               |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD} = 8\text{ A}$ , $V_{GS} = 0$                                                                                                                         | -    |      | 1.3  | V             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 8\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$<br>$V_{DD} = 60\text{ V}$<br>(see <a href="#">Figure 18</a> )                                     | -    | 250  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                                              | -    | 2.12 |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                                              |      | 17   |      | A             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 8\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$<br>$V_{DD} = 60\text{ V}$ , $T_J = 150\text{ }^\circ\text{C}$<br>(see <a href="#">Figure 18</a> ) | -    | 315  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                                              |      | 2.6  |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                                              |      | 16.5 |      | A             |

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

## 2.1 Electrical characteristics (curves)

Figure 2. Safe operating area for TO-220

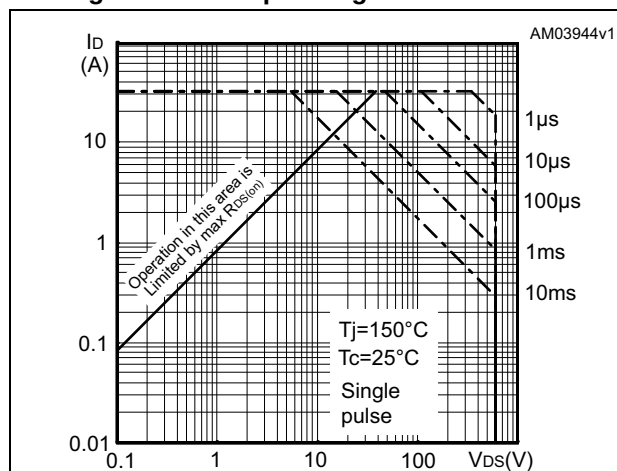


Figure 3. Thermal impedance for TO-220

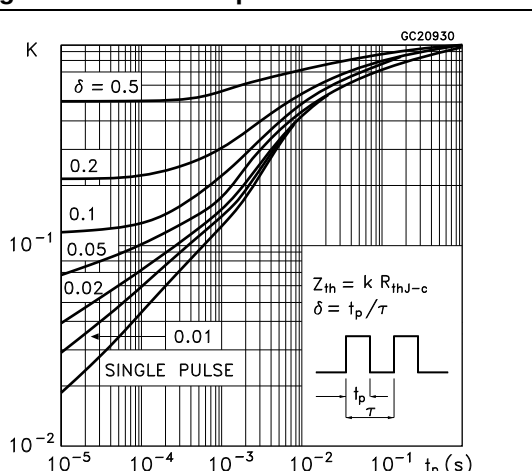


Figure 4. Safe operating area for TO-220FP

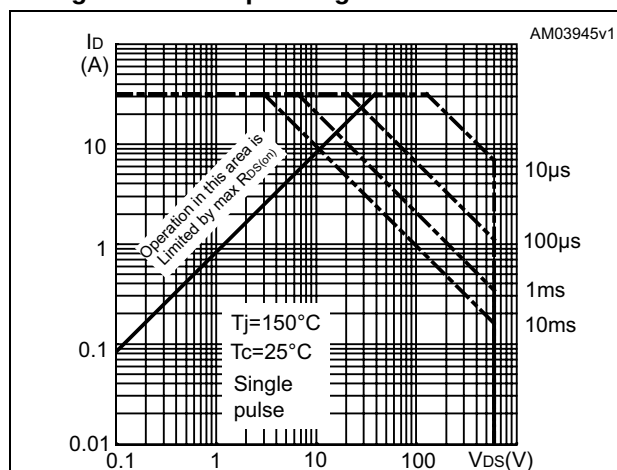


Figure 5. Thermal impedance for TO-220FP

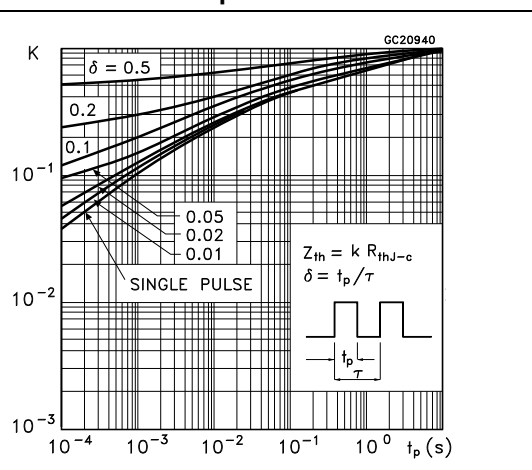


Figure 6. Safe operating area for DPAK, IPAK

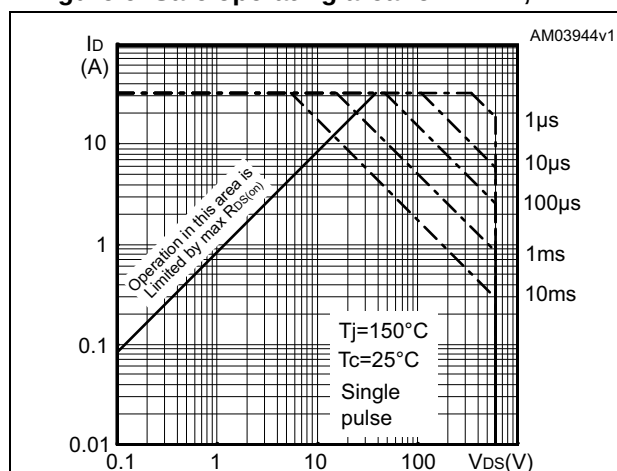


Figure 7. Thermal impedance for DPAK, IPAK

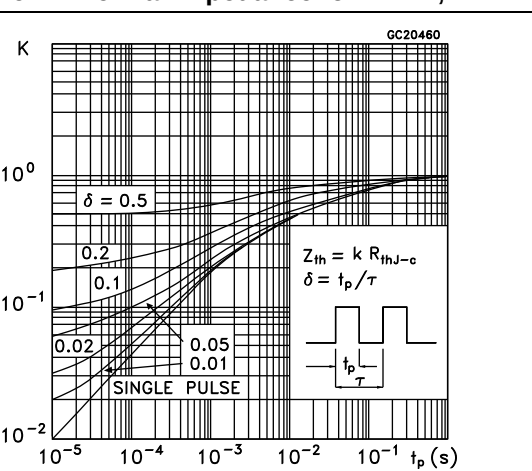


Figure 8. Output characteristics

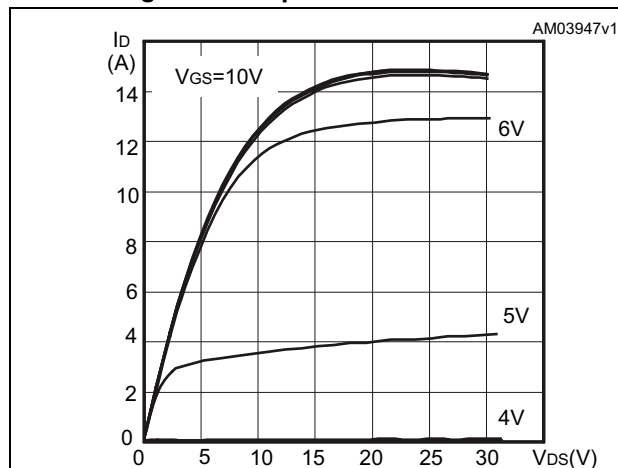


Figure 9. Transfer characteristics

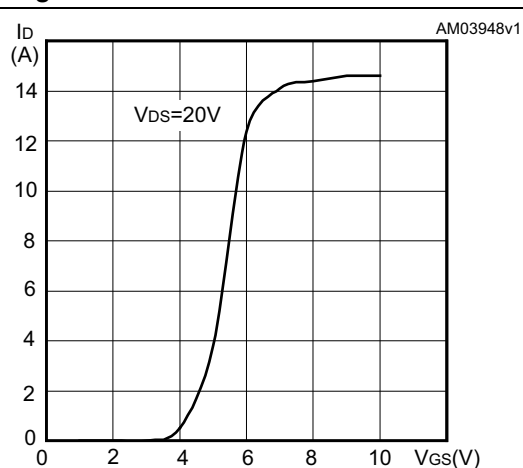
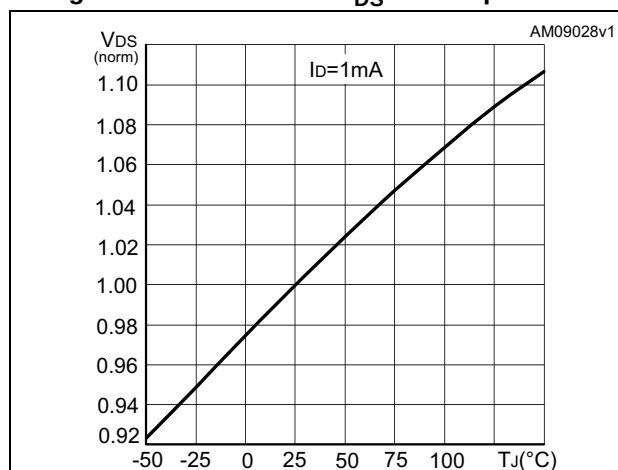
Figure 10. Normalized  $V_{DS}$  vs. temperature

Figure 11. Static drain-source on-resistance

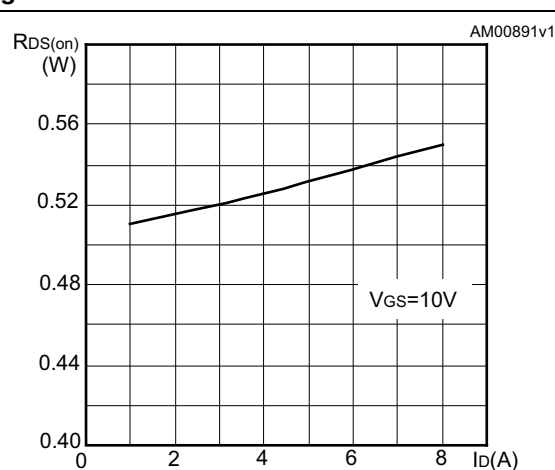


Figure 12. Gate charge vs. gate-source voltage

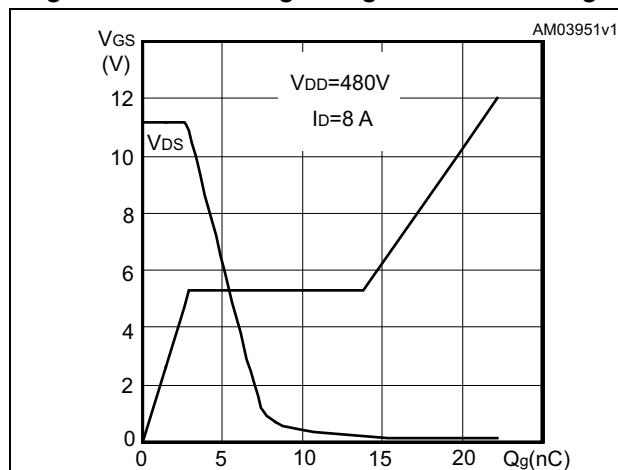


Figure 13. Capacitance variations

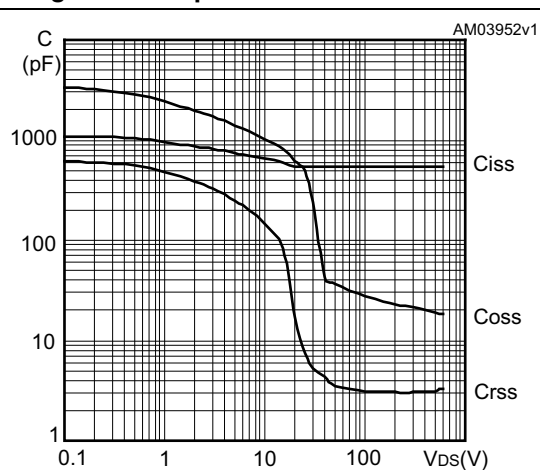


Figure 14. Normalized gate threshold voltage vs. temperature

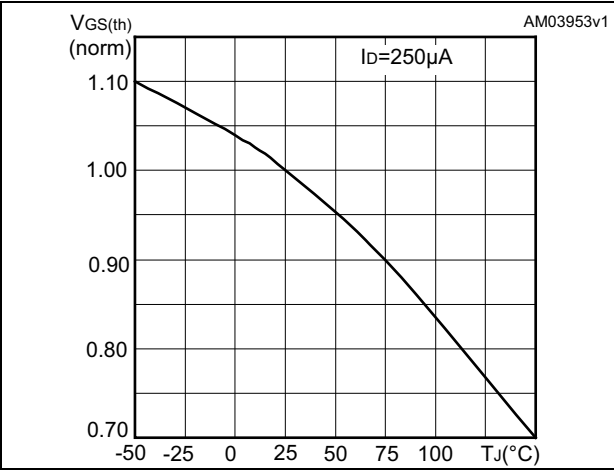
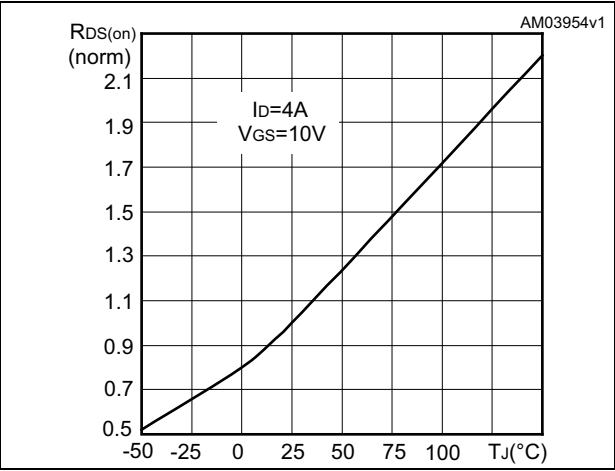


Figure 15. Normalized on-resistance vs. temperature



### 3 Test circuits

Figure 16. Switching times test circuit for resistive load

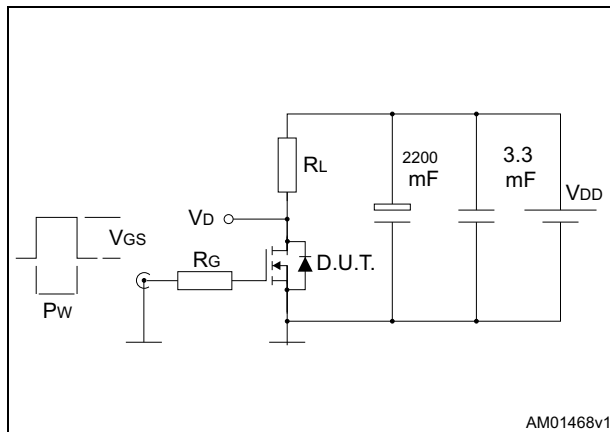


Figure 17. Gate charge test circuit

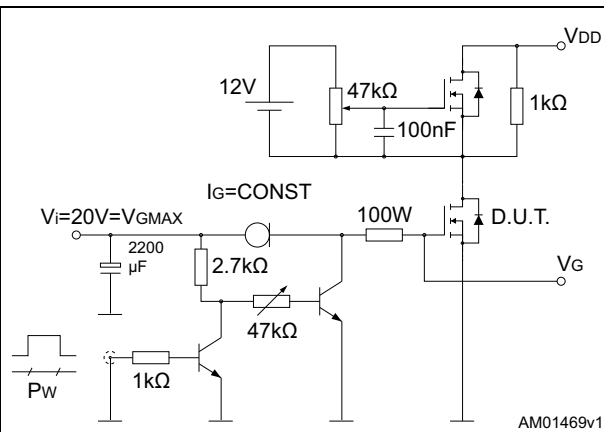


Figure 18. Test circuit for inductive load switching and diode recovery times

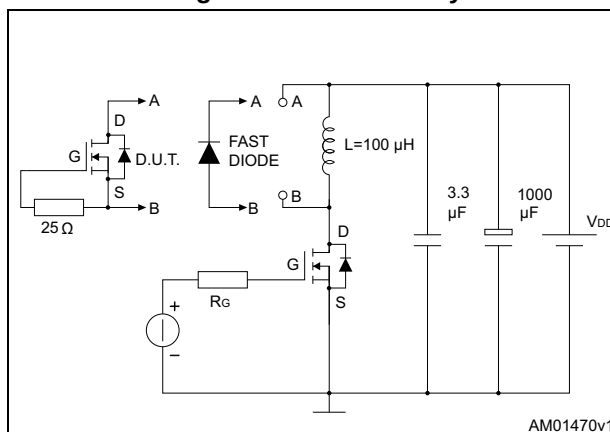


Figure 19. Unclamped inductive load test circuit

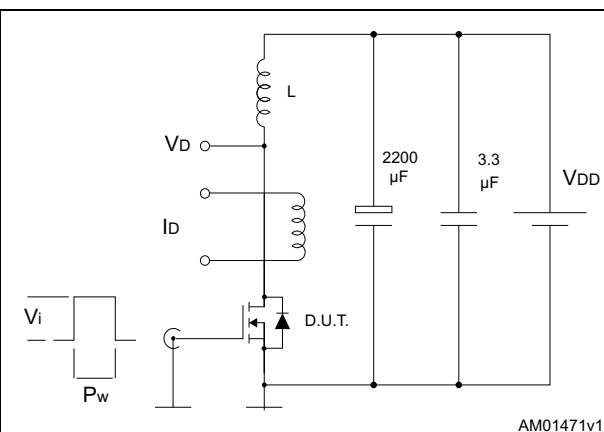


Figure 20. Unclamped inductive waveform

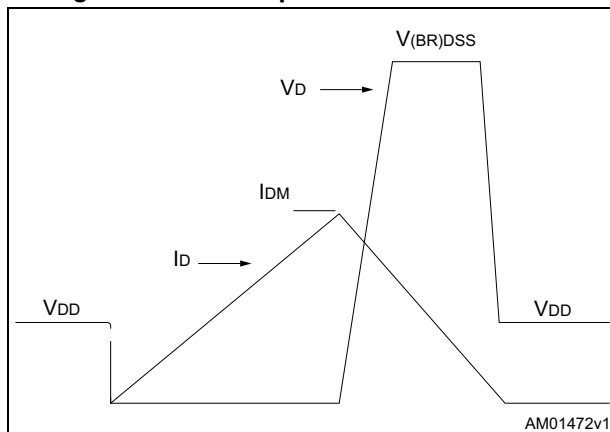
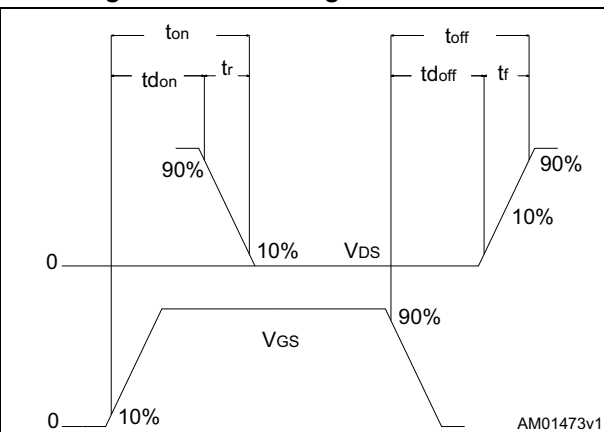


Figure 21. Switching time waveform



## 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 STD10NM60N, DPAK (TO-252) package information

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

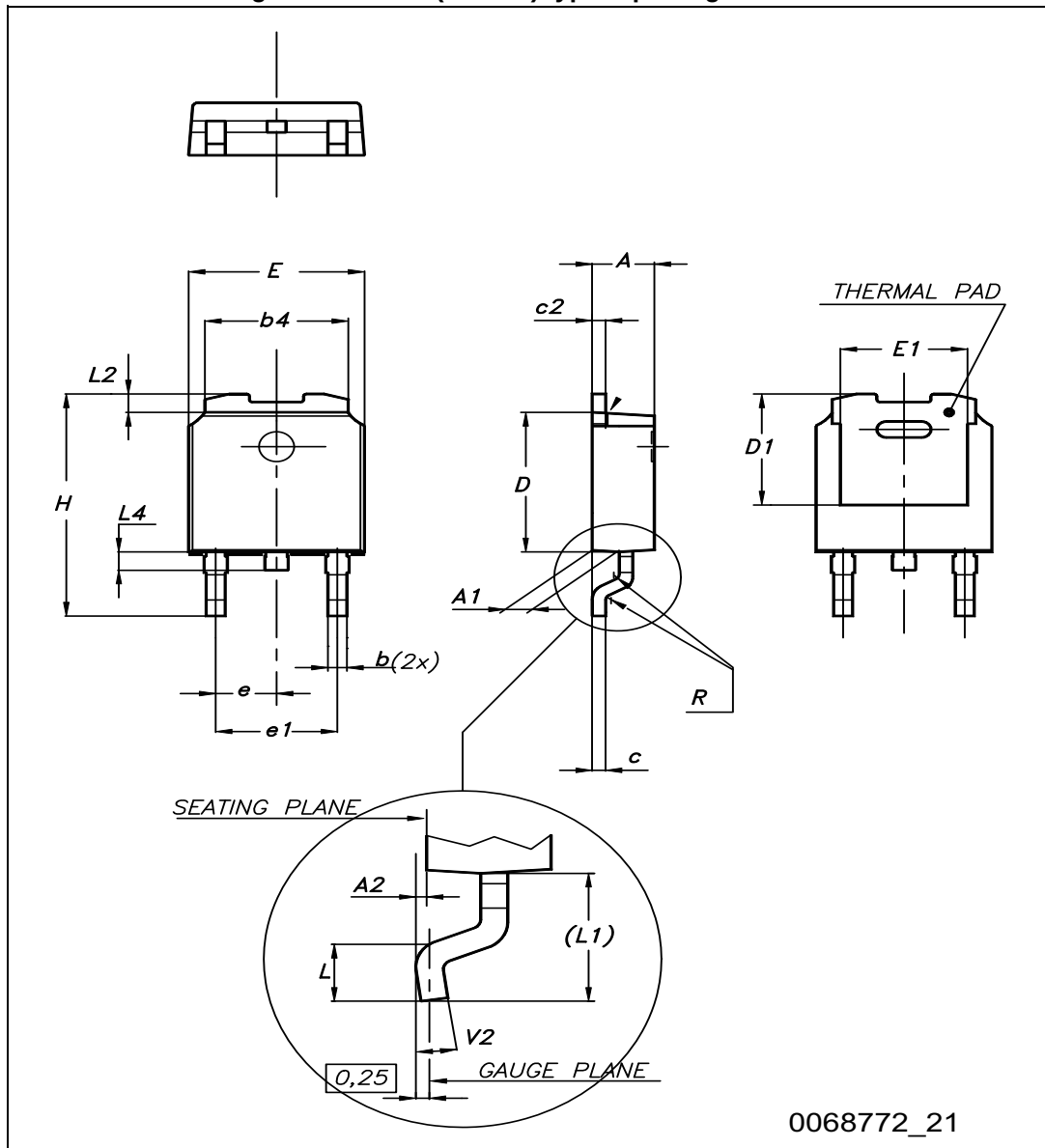


Table 9. DPAK (TO-252) type A mechanical data

| 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   | 4.60 | 4.70 | 4.80  |
| 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 23. DPAK (TO-252) type C2 outline

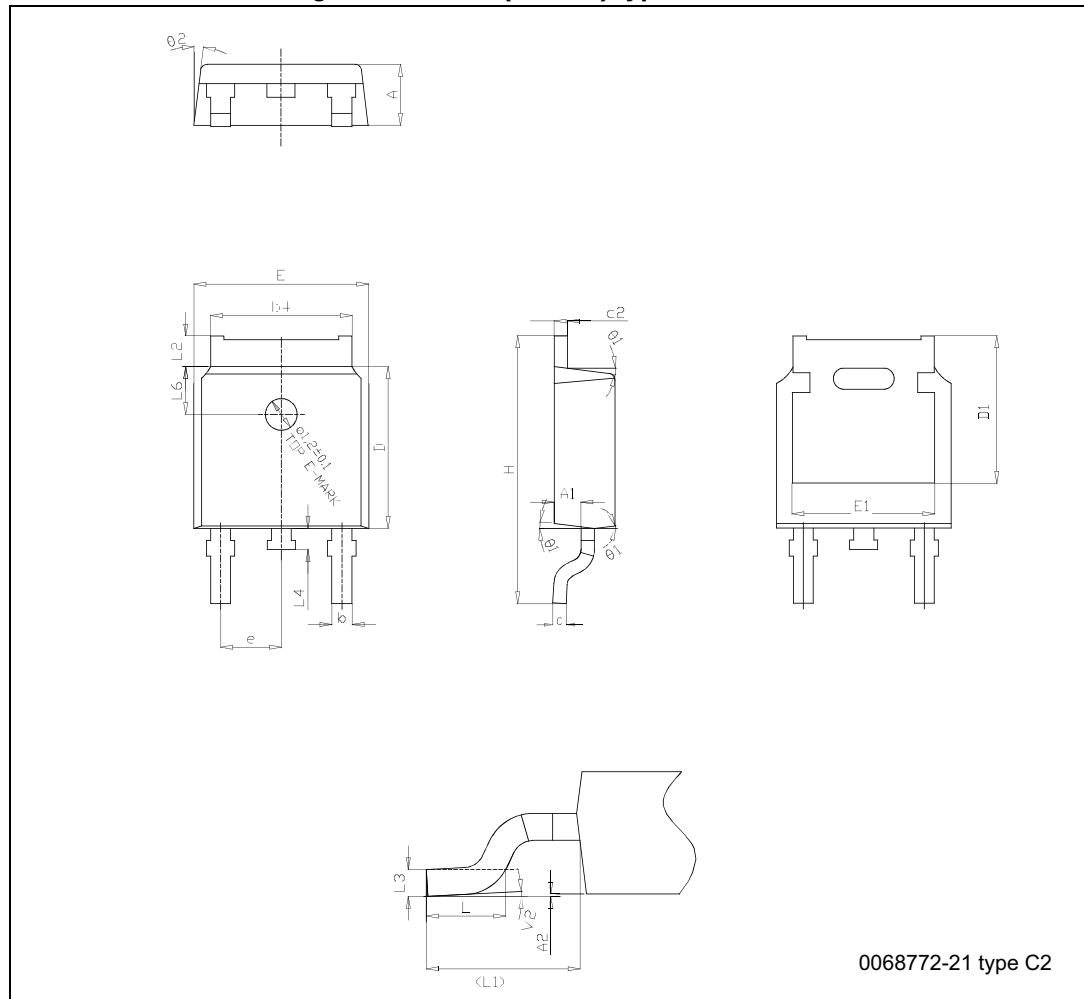


Table 10. DPAK (TO-252) type C2 package mechanical data

| 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   | 5.10     |       | 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 24. DPAK (TO-252) type E package outline

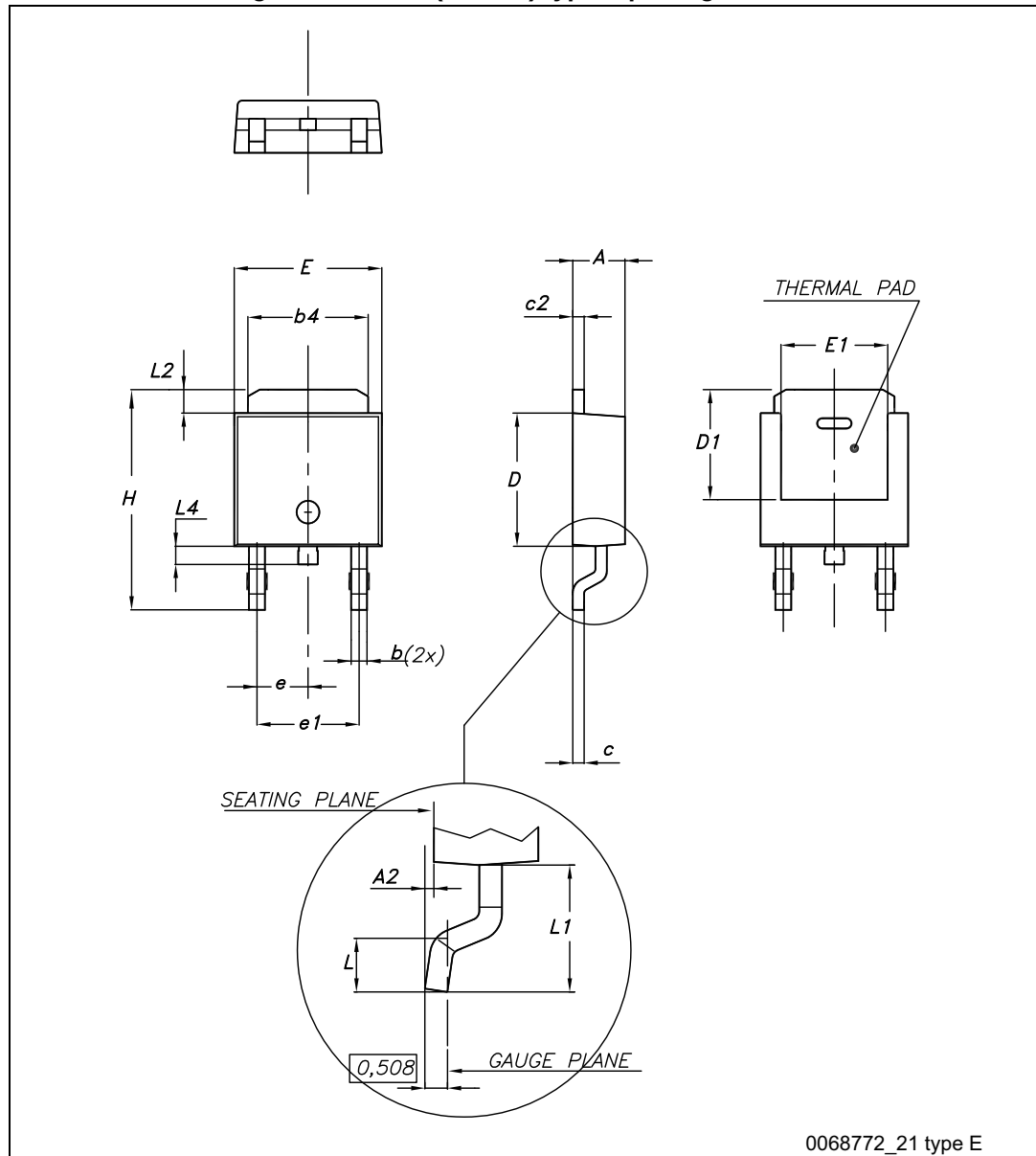
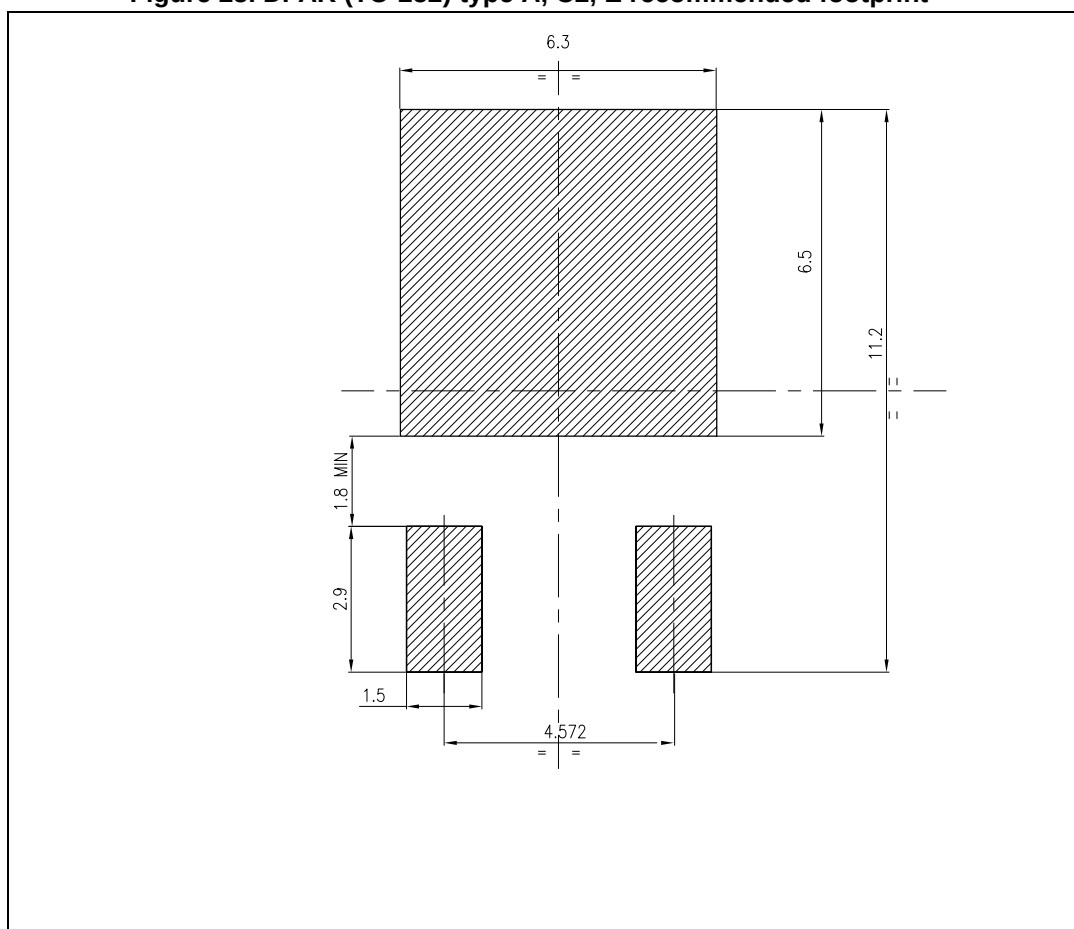


Table 11. DPAK (TO-252) type E mechanical data

| 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 25. DPAK (TO-252) type A, C2, E recommended footprint (a)



a. All dimensions are in millimeters

## 4.2 STF10NM60N, TO-220FP package information

Figure 26. TO-220FP package outline

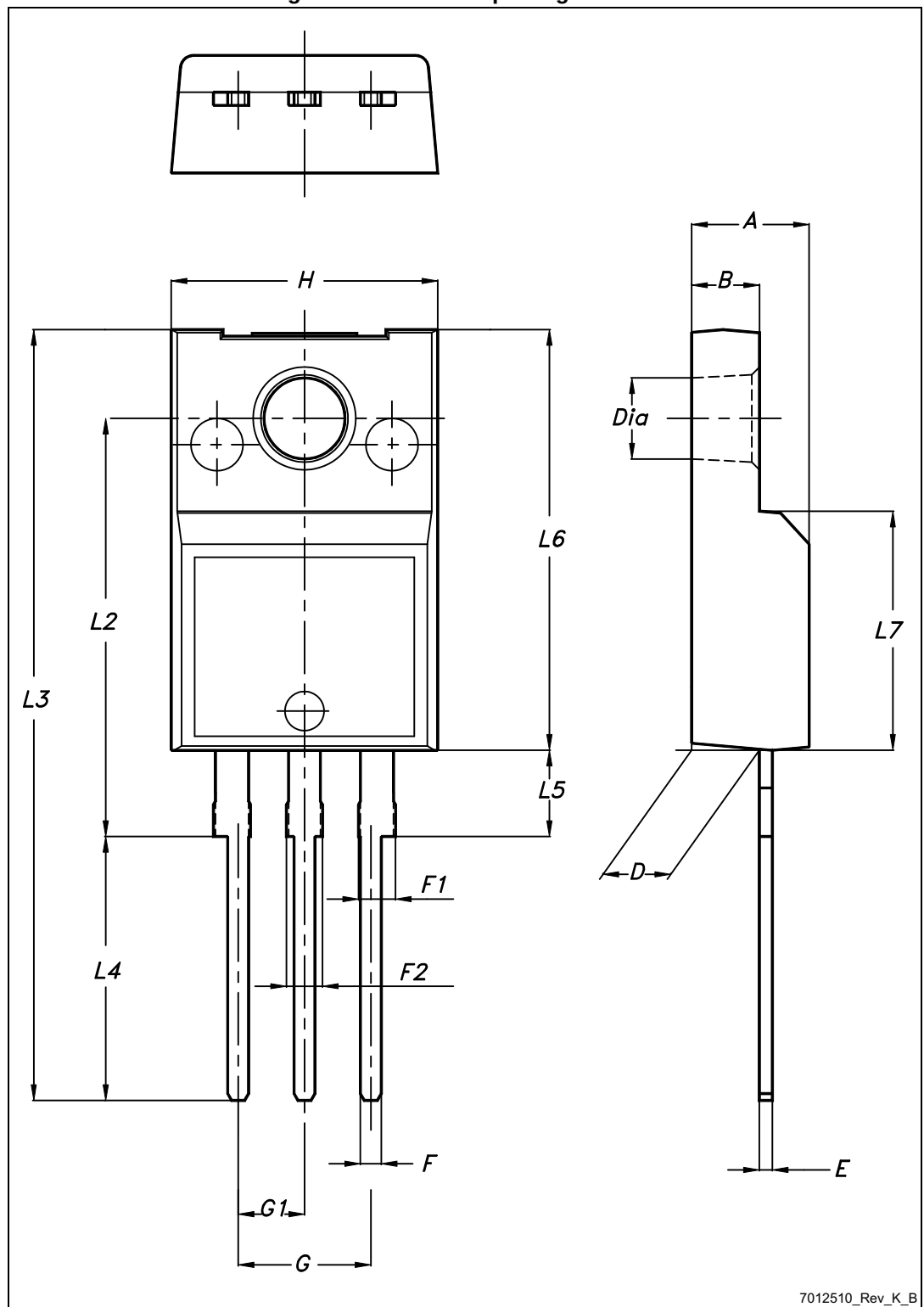


Table 12. TO-220FP package mechanical data

| 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  |

### 4.3 STP10NM60N, TO-220 package information

Figure 27. TO-220 type A package outline

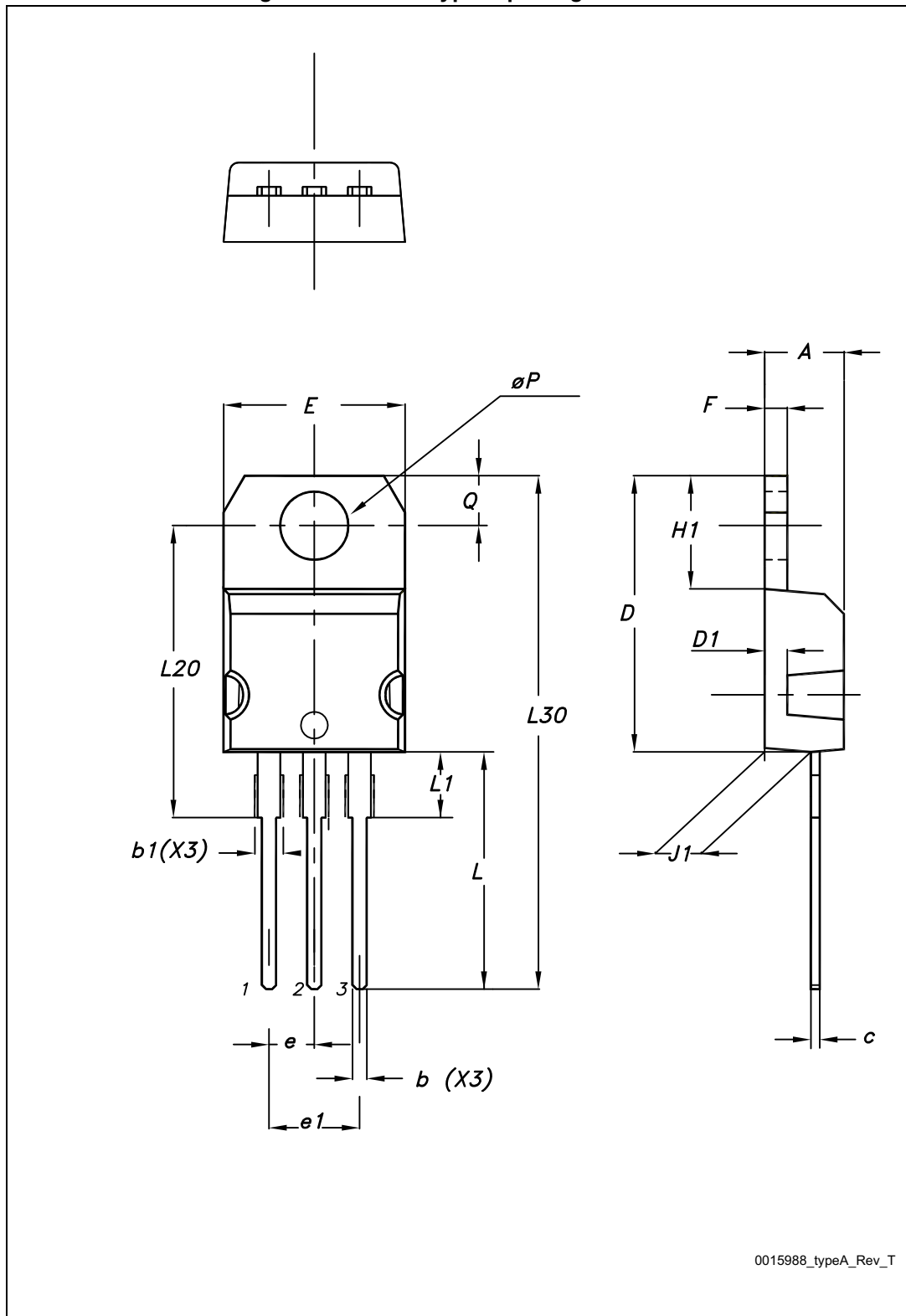


Table 13. TO-220 type A mechanical data

| Dim. | mm    |       |       |
|------|-------|-------|-------|
|      | Min.  | Typ.  | Max.  |
| A    | 4.40  |       | 4.60  |
| b    | 0.61  |       | 0.88  |
| b1   | 1.14  |       | 1.70  |
| c    | 0.48  |       | 0.70  |
| D    | 15.25 |       | 15.75 |
| D1   |       | 1.27  |       |
| E    | 10    |       | 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    |       | 14    |
| L1   | 3.50  |       | 3.93  |
| L20  |       | 16.40 |       |
| L30  |       | 28.90 |       |
| øP   | 3.75  |       | 3.85  |
| Q    | 2.65  |       | 2.95  |

#### 4.4 STU10NM60N, IPAK (TO-251)

Figure 28. IPAK (TO-251) type A outline

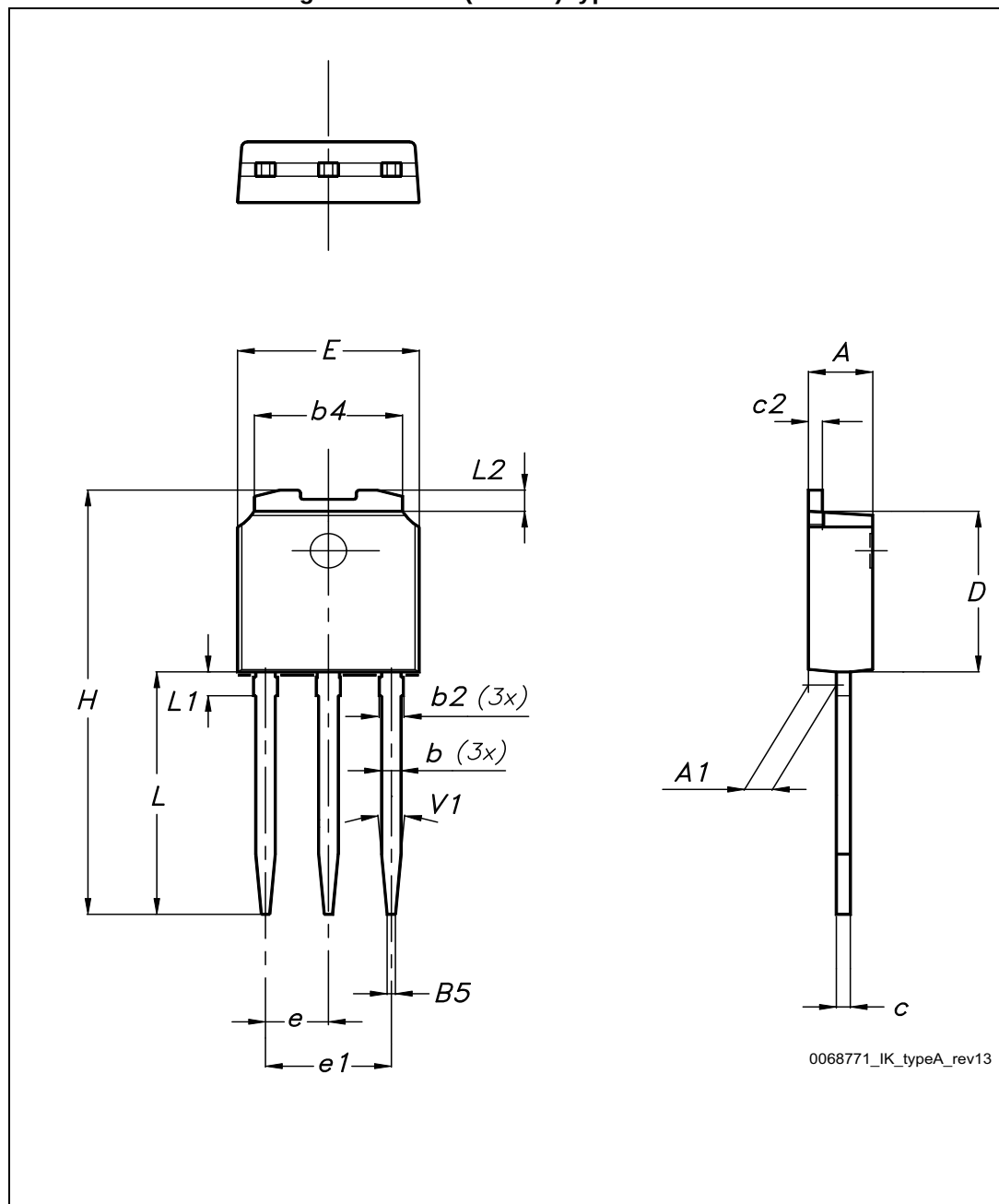


Table 14. IPAK (TO-251) type A mechanical data

| 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°   |      |

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

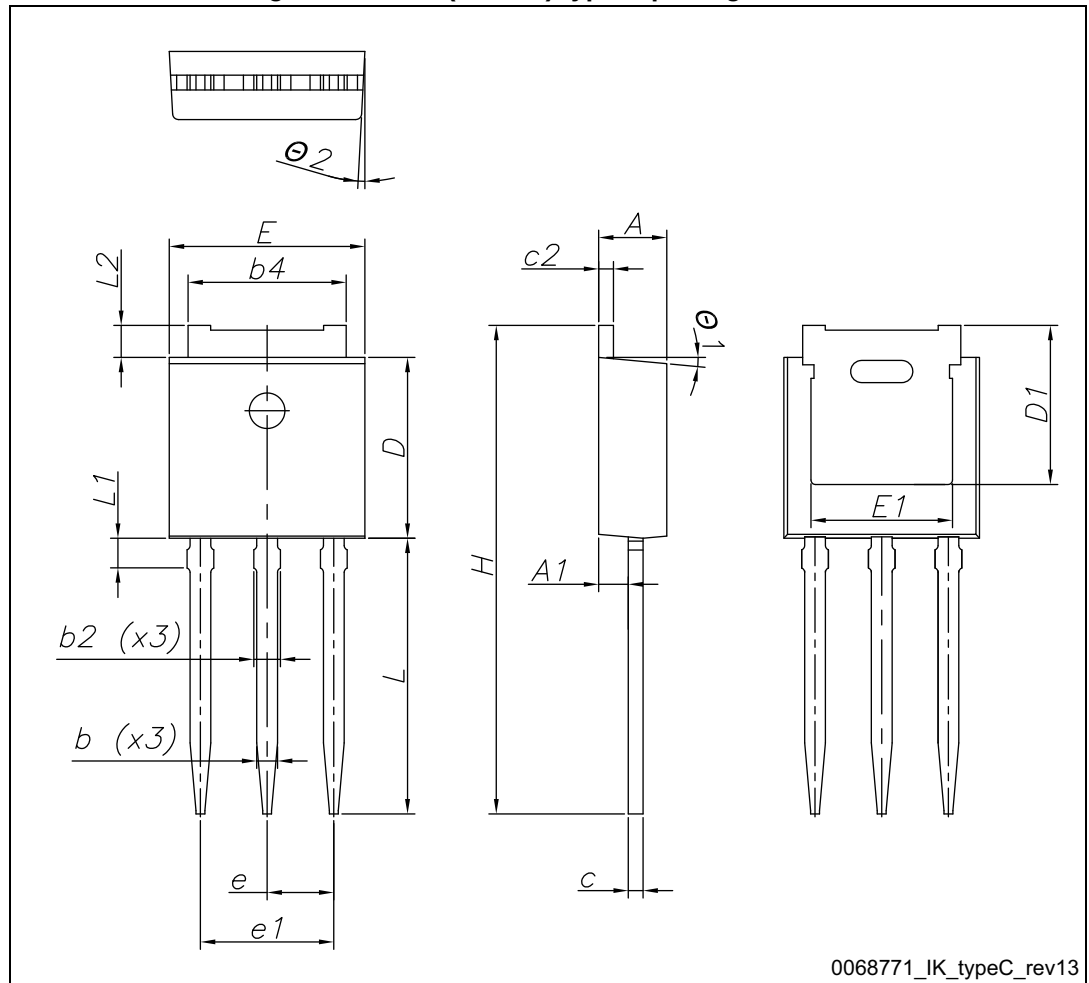


Table 15. IPAK (TO-251) type C package mechanical data

| 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   | 0.90  | 1.00  | 1.20  |
| L2   | 0.90  | 1.08  | 1.25  |
| Θ1   | 3°    | 5°    | 7°    |
| Θ2   | 1°    | 3°    | 5°    |

5 Packing information

Figure 30. Tape for DPAK (TO-252)

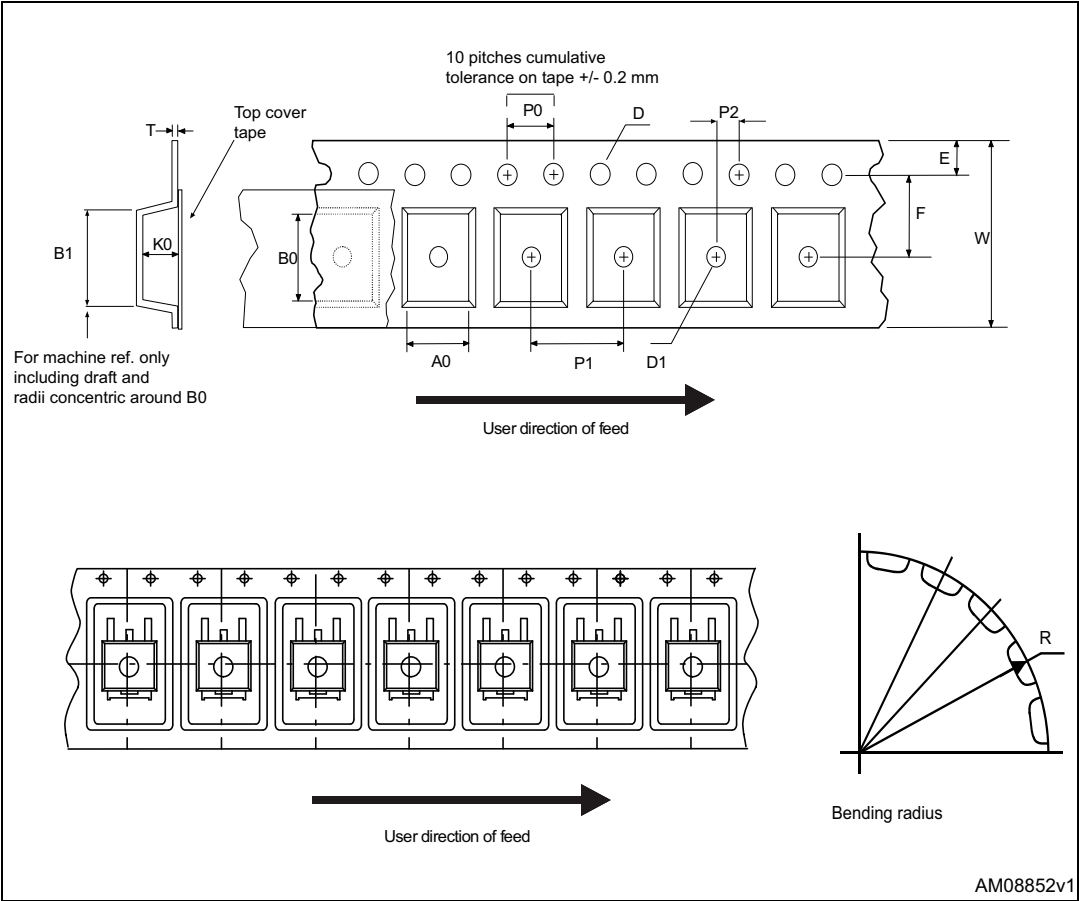


Figure 31. Reel for DPAK (TO-252)

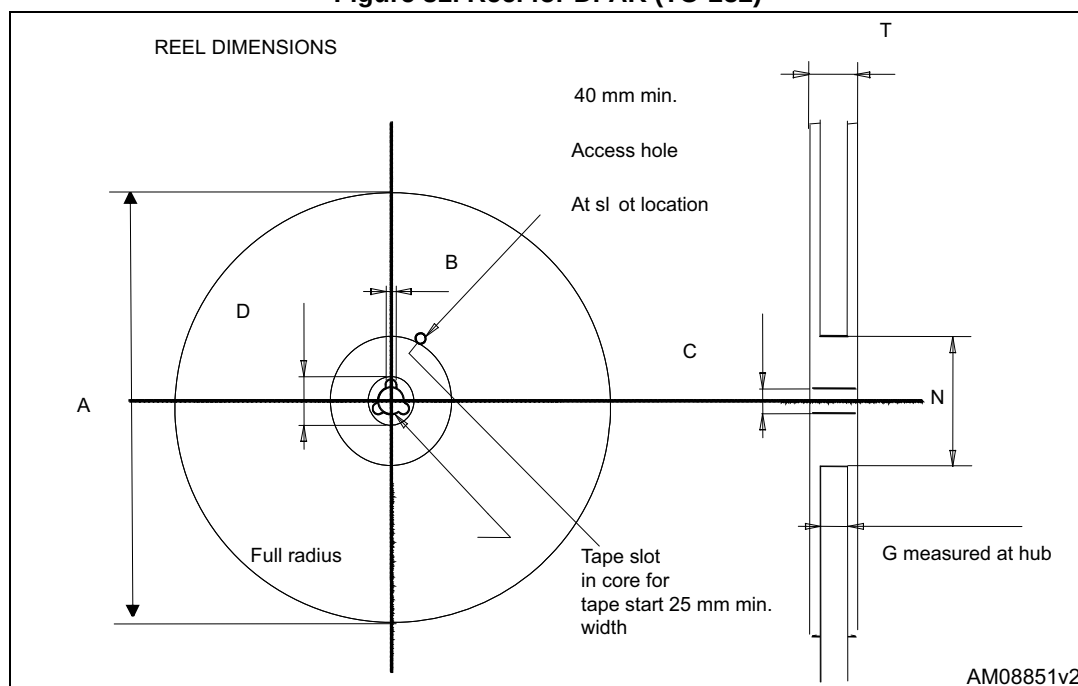


Table 16. DPAK (TO-252) tape and reel mechanical data

| 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 quantity |      | 2500 |
| P1   | 7.9  | 8.1  | Bulk quantity |      | 2500 |
| P2   | 1.9  | 2.1  |               |      |      |
| R    | 40   |      |               |      |      |
| T    | 0.25 | 0.35 |               |      |      |
| W    | 15.7 | 16.3 |               |      |      |

## 6 Revision history

**Table 17. Document revision history**

| Date        | Revision | Changes                                                                           |
|-------------|----------|-----------------------------------------------------------------------------------|
| 04-Dec-2015 | 1        | First release. Part numbers previously included in the datasheet with DocID15764. |

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