

P-channel -60 V, 0.13  $\Omega$  typ., -10 A STripFET™ F6  
Power MOSFETs in DPAK, TO-220FP, TO-220 and IPAK packages

Datasheet – production data

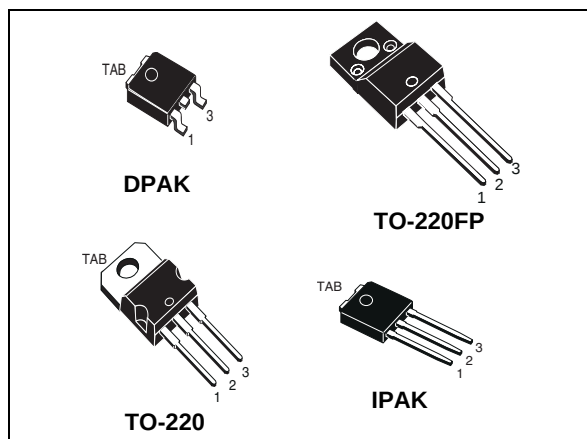
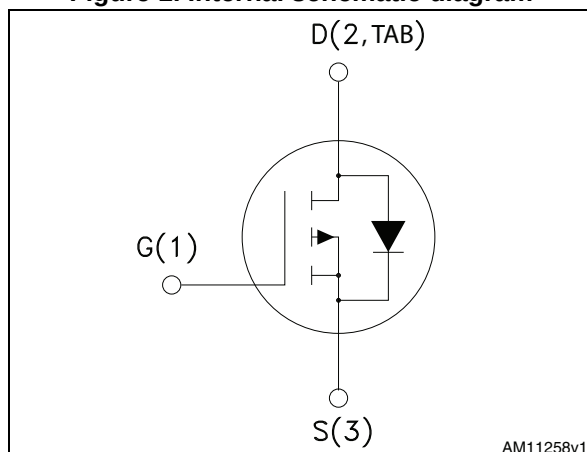


Figure 1. Internal schematic diagram



## Features

| Order codes | $V_{DS}$ | $R_{DS(on)}$ max | $I_D$ |
|-------------|----------|------------------|-------|
| STD10P6F6   | -60 V    | 0.16 $\Omega$    | -10 A |
| STF10P6F6   |          |                  |       |
| STP10P6F6   |          |                  |       |
| STU10P6F6   |          |                  |       |

- Very low on-resistance
- Very low gate charge
- High avalanche ruggedness
- Low gate drive power loss

## Applications

- Switching applications

## Description

These devices are P-channel Power MOSFETs developed using the STripFET™ F6 technology, with a new trench gate structure. The resulting Power MOSFETs exhibit very low  $R_{DS(on)}$  in all packages.

Table 1. Device summary

| Order codes | Marking | Package  | Packing       |
|-------------|---------|----------|---------------|
| STD10P6F6   | 10P6F6  | DPAK     | Tape and reel |
| STF10P6F6   |         | TO-220FP | Tube          |
| STP10P6F6   |         | TO-220   |               |
| STU10P6F6   |         | IPAK     |               |

## Contents

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# 1 Electrical ratings

Table 2. Absolute maximum ratings

| Symbol         | Parameter                                                                                                                                 | Value        |          |        | Unit               |
|----------------|-------------------------------------------------------------------------------------------------------------------------------------------|--------------|----------|--------|--------------------|
|                |                                                                                                                                           | DPAK<br>IPAK | TO-220FP | TO-220 |                    |
| $V_{DS}$       | Drain-source voltage                                                                                                                      | -60          |          |        | V                  |
| $V_{GS}$       | Gate-source voltage                                                                                                                       | $\pm 20$     |          |        | V                  |
| $I_D^{(1)}$    | Drain current (continuous) at $T_C = 25\text{ }^{\circ}\text{C}$                                                                          | -10          |          |        | A                  |
| $I_D$          | Drain current (continuous) at $T_C = 100\text{ }^{\circ}\text{C}$                                                                         | -7.2         |          |        | A                  |
| $I_{DM}^{(2)}$ | Drain current (pulsed)                                                                                                                    | -40          |          |        | A                  |
| $P_{TOT}$      | Total dissipation at $T_C = 25\text{ }^{\circ}\text{C}$                                                                                   | 35           | 20       | 30     | W                  |
| $E_{AS}$       | Single pulse avalanche energy<br>(starting $T_J=25\text{ }^{\circ}\text{C}$ , $I_D=-3\text{ A}$ , $V_{DD}=40\text{ V}$ )                  | 80           |          |        | mJ                 |
| $V_{ISO}$      | Insulation withstand voltage (RMS) from all<br>three leads to external heat sink<br>( $t=1\text{ s}$ ; $T_C=25\text{ }^{\circ}\text{C}$ ) |              | 2500     |        | V                  |
| $V_{DG}$       | Drain-gate voltage ( $V_{GS} = 0$ )                                                                                                       | -20          |          |        | V                  |
| $T_{stg}$      | Storage temperature                                                                                                                       | -55 to 175   |          |        | $^{\circ}\text{C}$ |
| $T_J$          | Max. operating junction temperature                                                                                                       | 175          |          |        | $^{\circ}\text{C}$ |

1. Limited by package
2. Pulse width limited by safe operating area

Table 3. Thermal data

| Symbol         | Parameter                                          | Value |      |          |        | Unit                 |
|----------------|----------------------------------------------------|-------|------|----------|--------|----------------------|
|                |                                                    | DPAK  | IPAK | TO-220FP | TO-220 |                      |
| $R_{thj-case}$ | Thermal resistance junction-case max               | 4.29  |      | 7.5      | 5      | $^{\circ}\text{C/W}$ |
| $R_{thj-amb}$  | Thermal resistance junction-ambient max            |       | 100  | 62.5     | 62.5   | $^{\circ}\text{C/W}$ |
| $R_{thj-pcb}$  | Thermal resistance junction-pcb max <sup>(1)</sup> | 50    |      |          |        | $^{\circ}\text{C/W}$ |

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

## 2 Electrical characteristics

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

**Table 4. Static**

| Symbol        | Parameter                                        | Test conditions                                         | Min. | Typ. | Max.      | Unit          |
|---------------|--------------------------------------------------|---------------------------------------------------------|------|------|-----------|---------------|
| $V_{(BR)DSS}$ | Drain-source breakdown Voltage                   | $I_D = -250\text{ }\mu\text{A}$ , $V_{GS} = 0\text{ V}$ | -60  |      |           | V             |
| $I_{DSS}$     | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = -60\text{ V}$                                 |      |      | -1        | $\mu\text{A}$ |
|               |                                                  | $V_{DS} = -60\text{ V}$ , $T_c = 125\text{ °C}$         |      |      | -10       | $\mu\text{A}$ |
| $I_{GSS}$     | Gate body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20\text{ V}$                              |      |      | $\pm 100$ | nA            |
| $V_{GS(th)}$  | Gate threshold voltage                           | $V_{DS} = V_{GS}$ , $I_D = -250\text{ }\mu\text{A}$     | -2   |      | -4        | V             |
| $R_{DS(on)}$  | Static drain-source on-resistance                | $V_{GS} = -10\text{ V}$ , $I_D = -5\text{ A}$           |      | 0.13 | 0.16      | $\Omega$      |

**Table 5. Dynamic**

| Symbol    | Parameter                    | Test conditions                                                                                               | Min. | Typ. | Max. | Unit |
|-----------|------------------------------|---------------------------------------------------------------------------------------------------------------|------|------|------|------|
| $C_{iss}$ | Input capacitance            | $V_{DS} = -48\text{ V}$ , $f = 1\text{ MHz}$ ,<br>$V_{GS} = 0\text{ V}$                                       | -    | 340  | -    | pF   |
| $C_{oss}$ | Output capacitance           |                                                                                                               | -    | 40   | -    | pF   |
| $C_{rss}$ | Reverse transfer capacitance |                                                                                                               | -    | 20   | -    | pF   |
| $Q_g$     | Total gate charge            | $V_{DD} = -30\text{ V}$ , $I_D = -10\text{ A}$<br>$V_{GS} = -10\text{ V}$<br>(see <a href="#">Figure 16</a> ) | -    | 6.4  | -    | nC   |
| $Q_{gs}$  | Gate-source charge           |                                                                                                               | -    | 1.7  | -    | nC   |
| $Q_{gd}$  | Gate-drain charge            |                                                                                                               | -    | 1.7  | -    | nC   |

**Table 6. Switching on/off (inductive load)**

| Symbol       | Parameter           | Test conditions                                                                                                                            | Min. | Typ. | Max. | Unit |
|--------------|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|
| $t_{d(on)}$  | Turn-on delay time  | $V_{DD} = -48\text{ V}$ , $I_D = -5\text{ A}$ ,<br>$R_G = 4.7\text{ }\Omega$ , $V_{GS} = -10\text{ V}$<br>(see <a href="#">Figure 15</a> ) | -    | 64   | -    | ns   |
| $t_r$        | Rise time           |                                                                                                                                            | -    | 5.3  | -    | ns   |
| $t_{d(off)}$ | Turn-off delay time |                                                                                                                                            | -    | 14   | -    | ns   |
| $t_f$        | Fall time           |                                                                                                                                            | -    | 3.7  | -    | ns   |

Table 7. Source drain diode

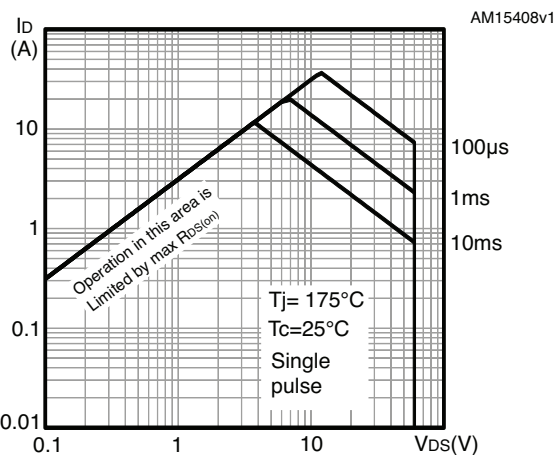
| Symbol          | Parameter                     | Test conditions                                                                                                                   | Min. | Typ. | Max. | Unit |
|-----------------|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|
| $I_{SD}$        | Source-drain current          |                                                                                                                                   | -    |      | -10  | A    |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |                                                                                                                                   | -    |      | -40  | A    |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD} = -5\text{ A}$ , $V_{GS} = 0\text{ V}$                                                                                    | -    |      | -1.1 | V    |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = -10\text{ A}$ ,<br>$di/dt = -100\text{ A}/\mu\text{s}$ ,<br>$V_{DD} = -48\text{ V}$<br>(see <a href="#">Figure 17</a> ) | -    | 20   |      | ns   |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                   | -    | 17.8 |      | nC   |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                   | -    | -1.8 |      | A    |

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

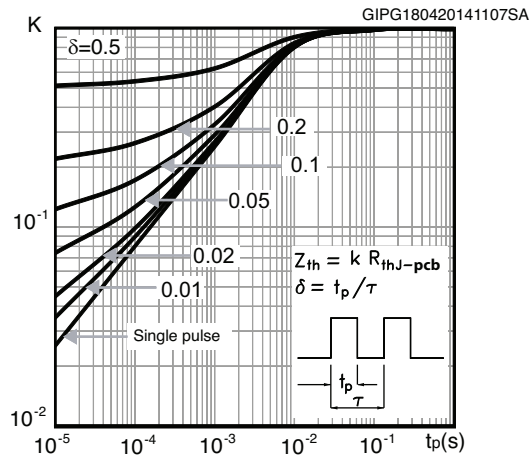
## 2.1 Electrical characteristics (curves)

Note: For the P-channel Power MOSFET, current and voltage polarities are reversed.

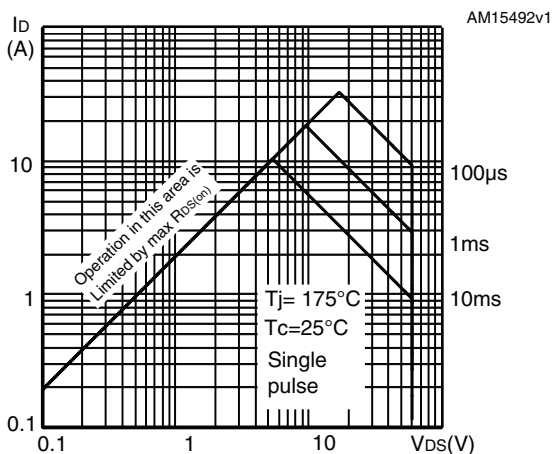
**Figure 2. Safe operating area for DPAK, TO-220 and IPAK**



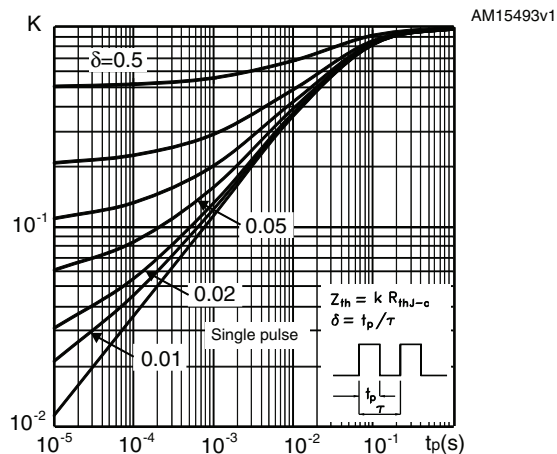
**Figure 3. Thermal impedance DPAK, TO-220 and IPAK**



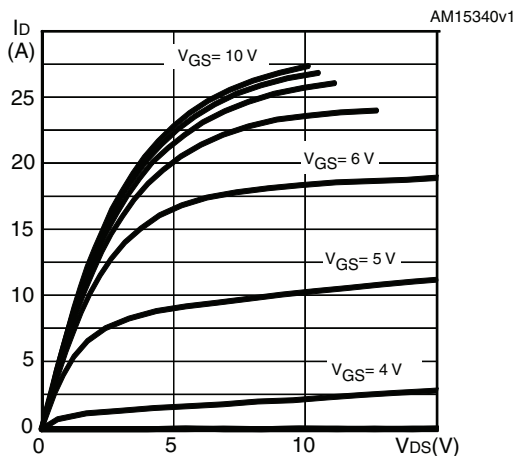
**Figure 4. Safe operating area for TO-220FP**



**Figure 5. Thermal impedance for TO-220FP**



**Figure 6. Output characteristics**



**Figure 7. Transfer characteristics**

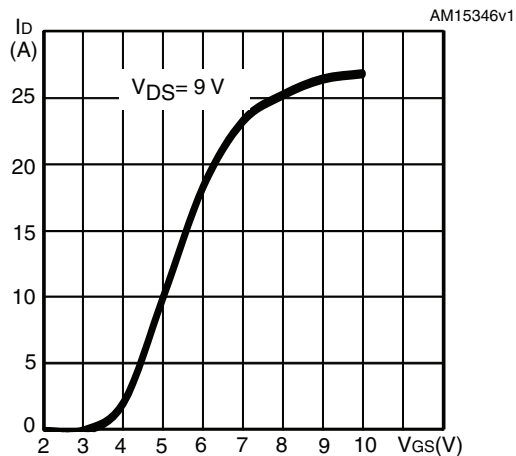


Figure 8. Gate charge vs gate-source voltage

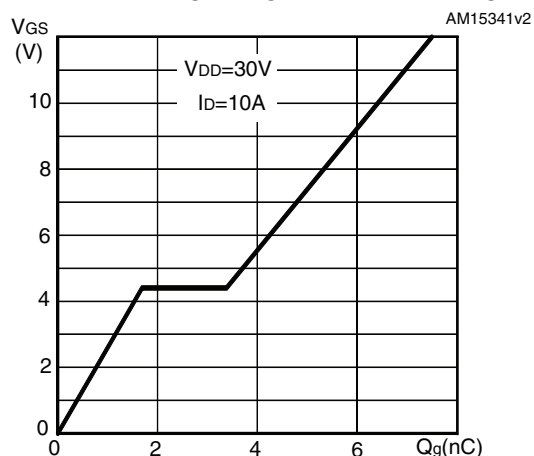


Figure 9. Static drain-source on-resistance

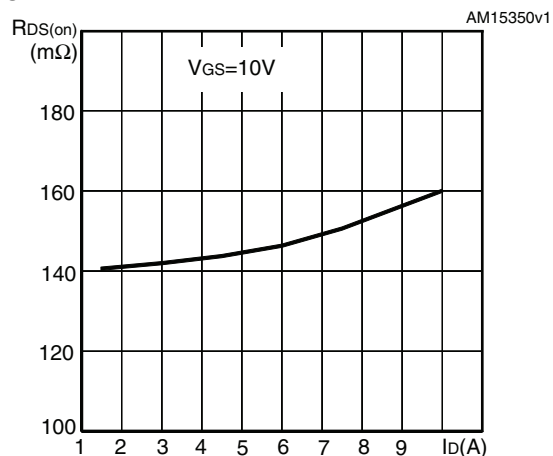


Figure 10. Capacitance variations

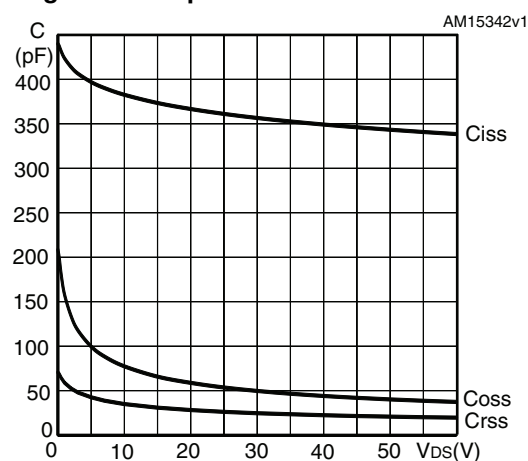
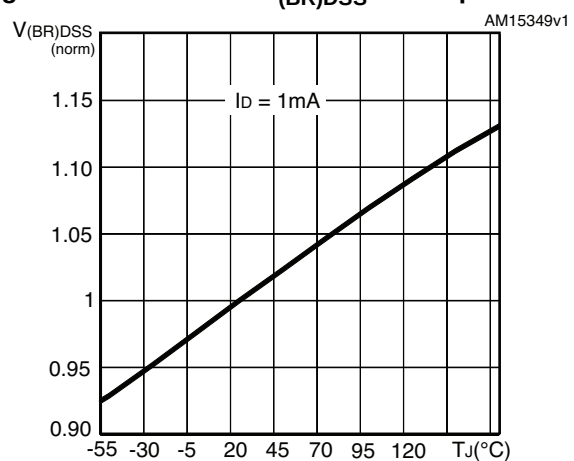
Figure 11. Normalized  $V_{(BR)DSS}$  vs temperature

Figure 12. Normalized gate threshold voltage vs temperature

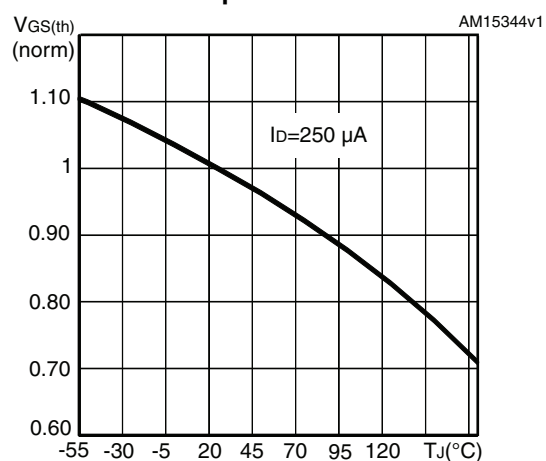
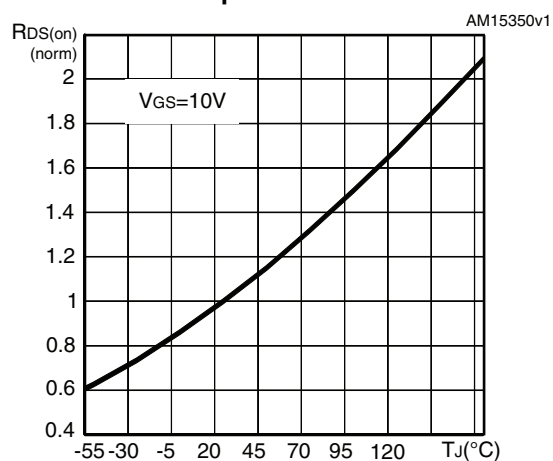
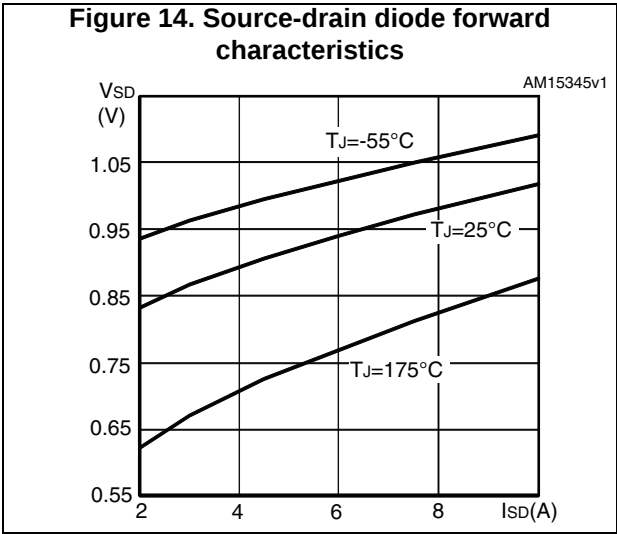


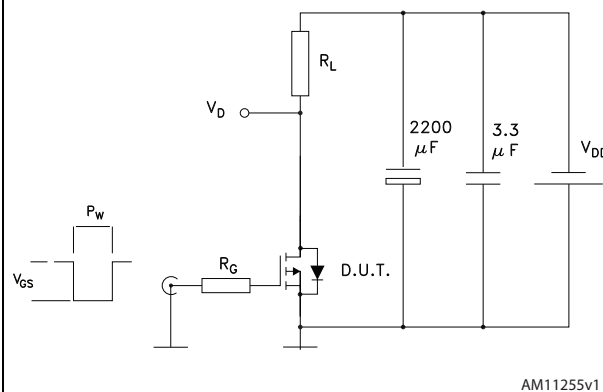
Figure 13. Normalized on-resistance vs temperature



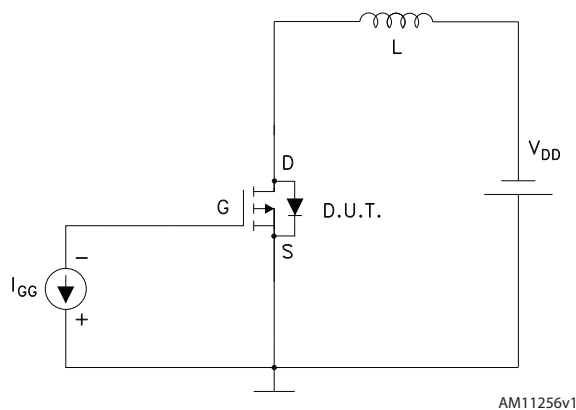


### 3 Test circuits

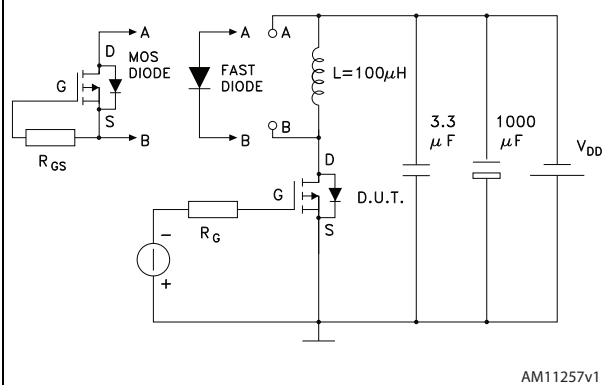
**Figure 15. Switching times test circuit for resistive load**



**Figure 16. Gate charge test circuit**



**Figure 17. Test circuit for diode recovery behaviour**



## 4 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK® is an ST trademark.

## 4.1 DPAK package information

**Figure 18. DPAK (TO-252) type C package outline**

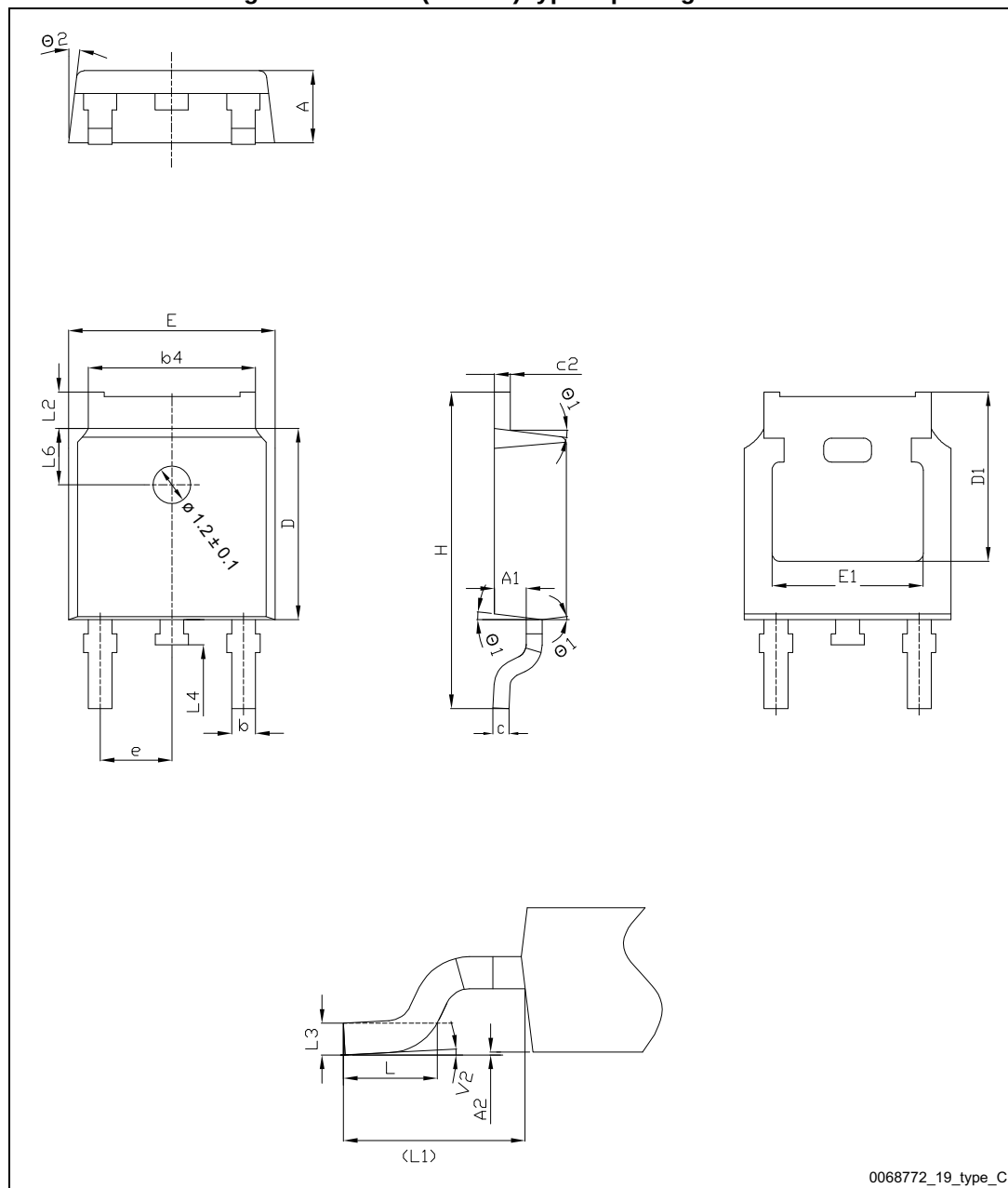
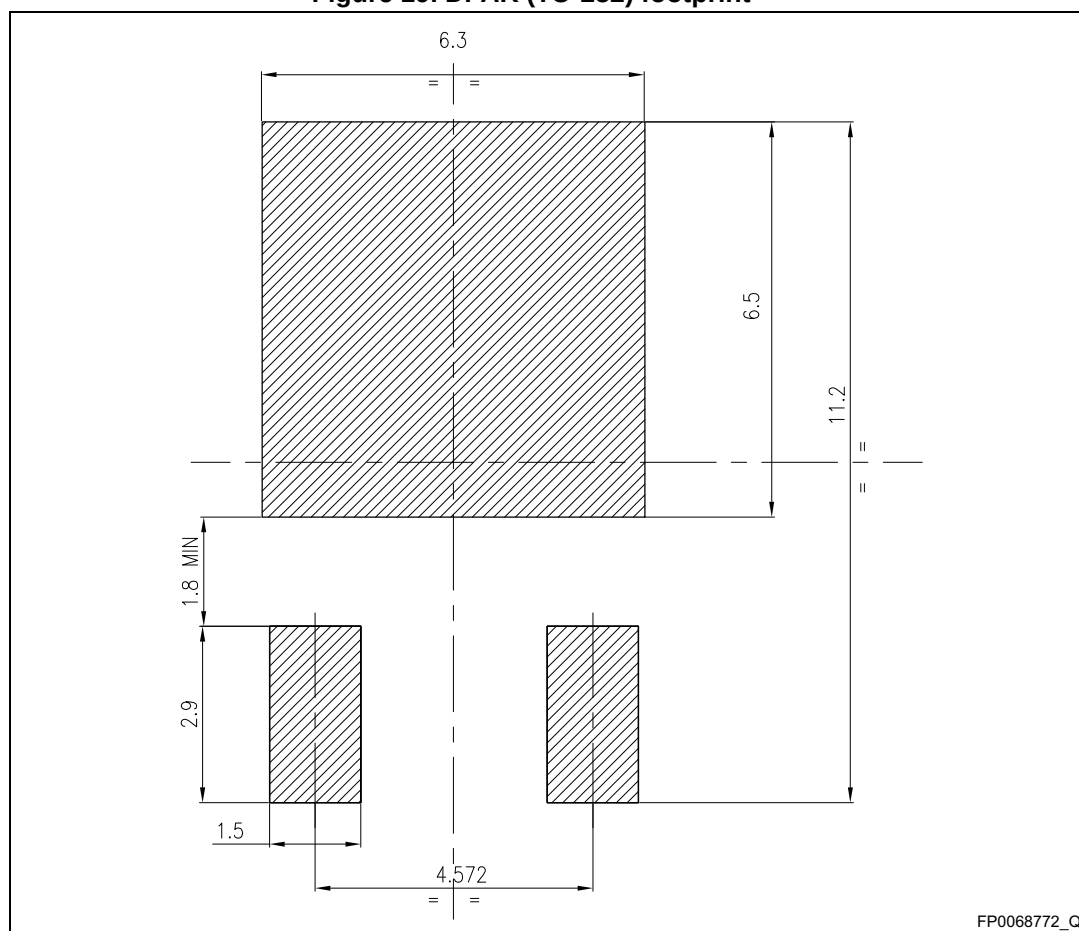


Table 8. DPAK (TO-252) type C package mechanical data

| 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  |
| e    | 2.186    | 2.286 | 2.386 |
| E1   | 4.70     |       |       |
| 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 |       |       |
| Ø1   | 5°       | 7°    | 9°    |
| Ø2   | 5°       | 7°    | 9°    |
| V2   | 0°       |       | 8°    |

Figure 19. DPAK (TO-252) footprint (a)



a. All dimensions are in millimeters

## 4.2 DPAK packing information

Figure 20. Tape for DPAK (TO-252)

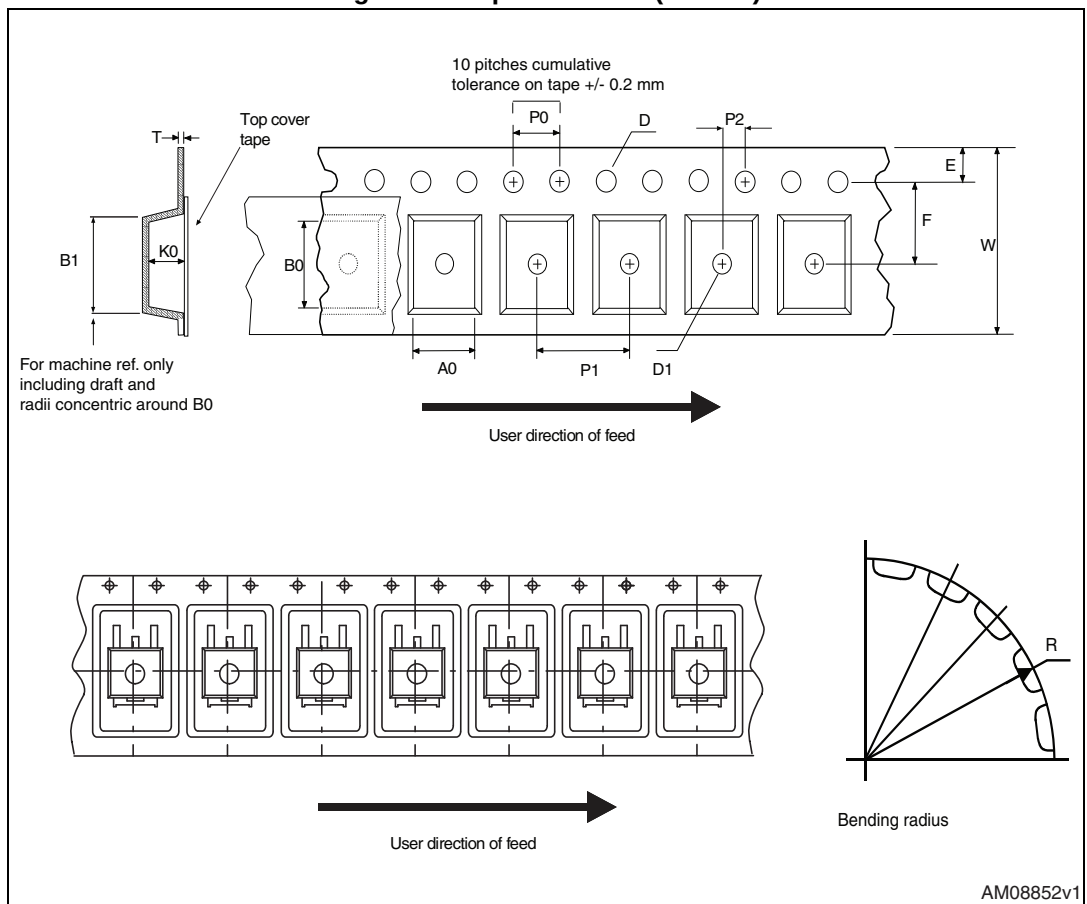


Figure 21. Reel for DPAK (TO-252)

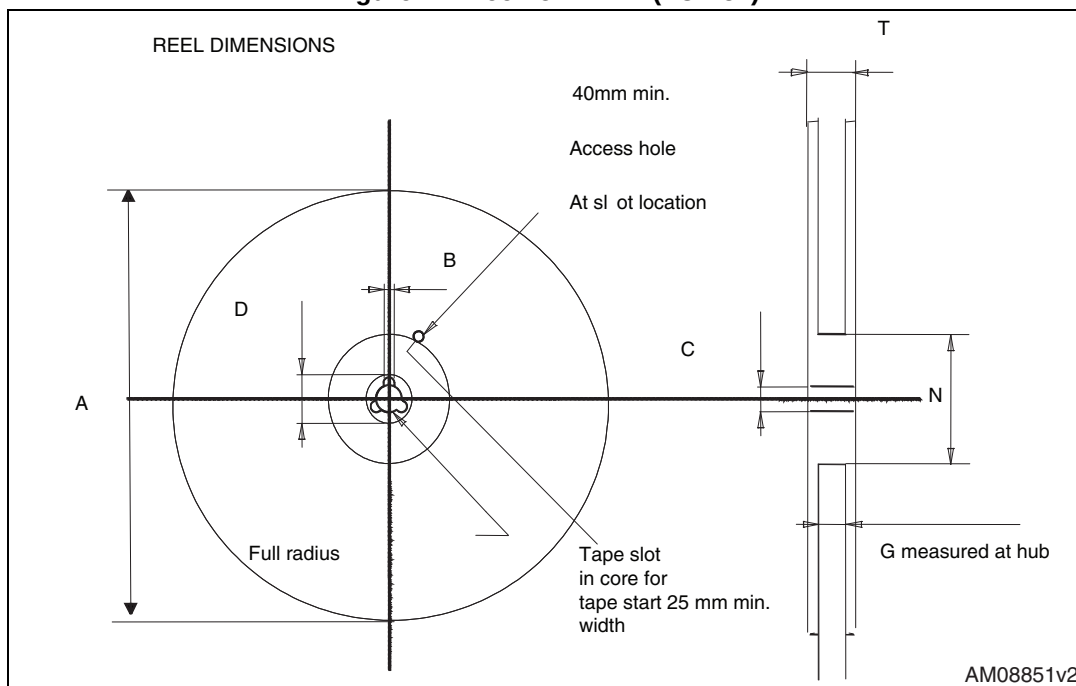


Table 9. DPAK (TO-252) tape and reel mechanical data

| 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 |           |      |      |

### 4.3 TO-220FP package information

Figure 22. TO-220FP package outline

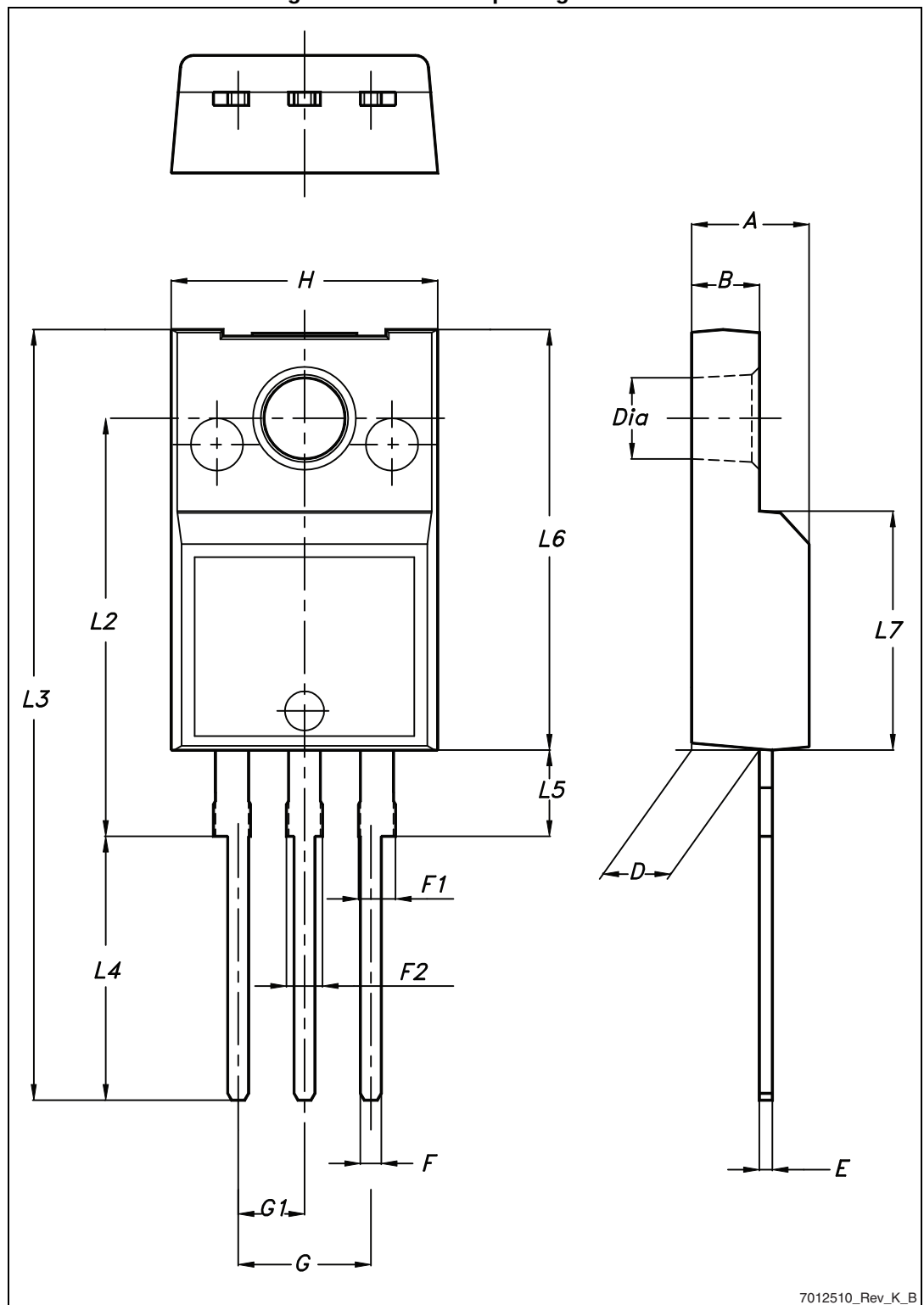


Table 10. TO-220FP mechanical data

| 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  |

#### 4.4 TO-220 package information

Figure 23. TO-220 type A package outline

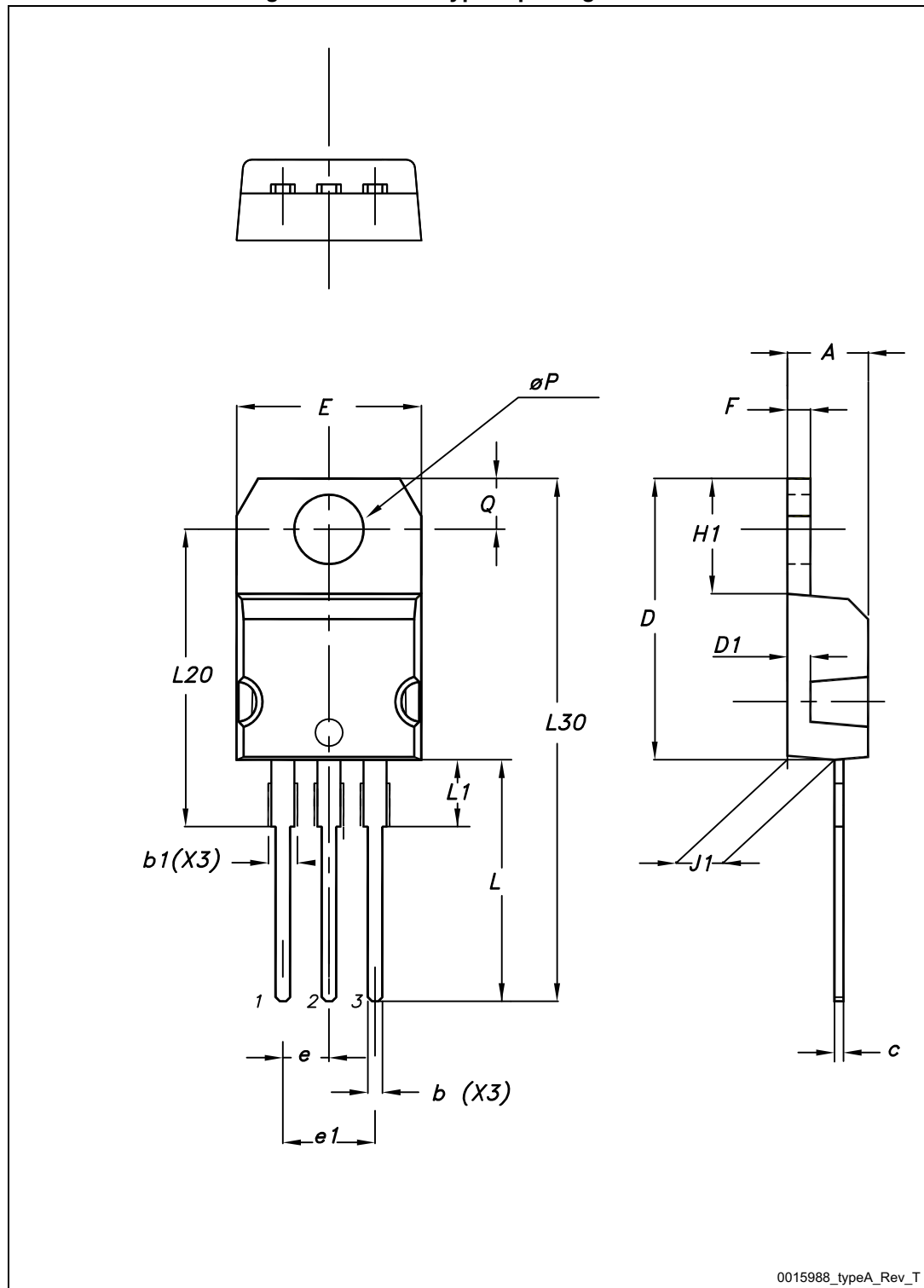


Table 11. TO-220 type A mechanical data

| 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  |

## 4.5 IPAK package information

Figure 24. IPAK (TO-251) type A package outline

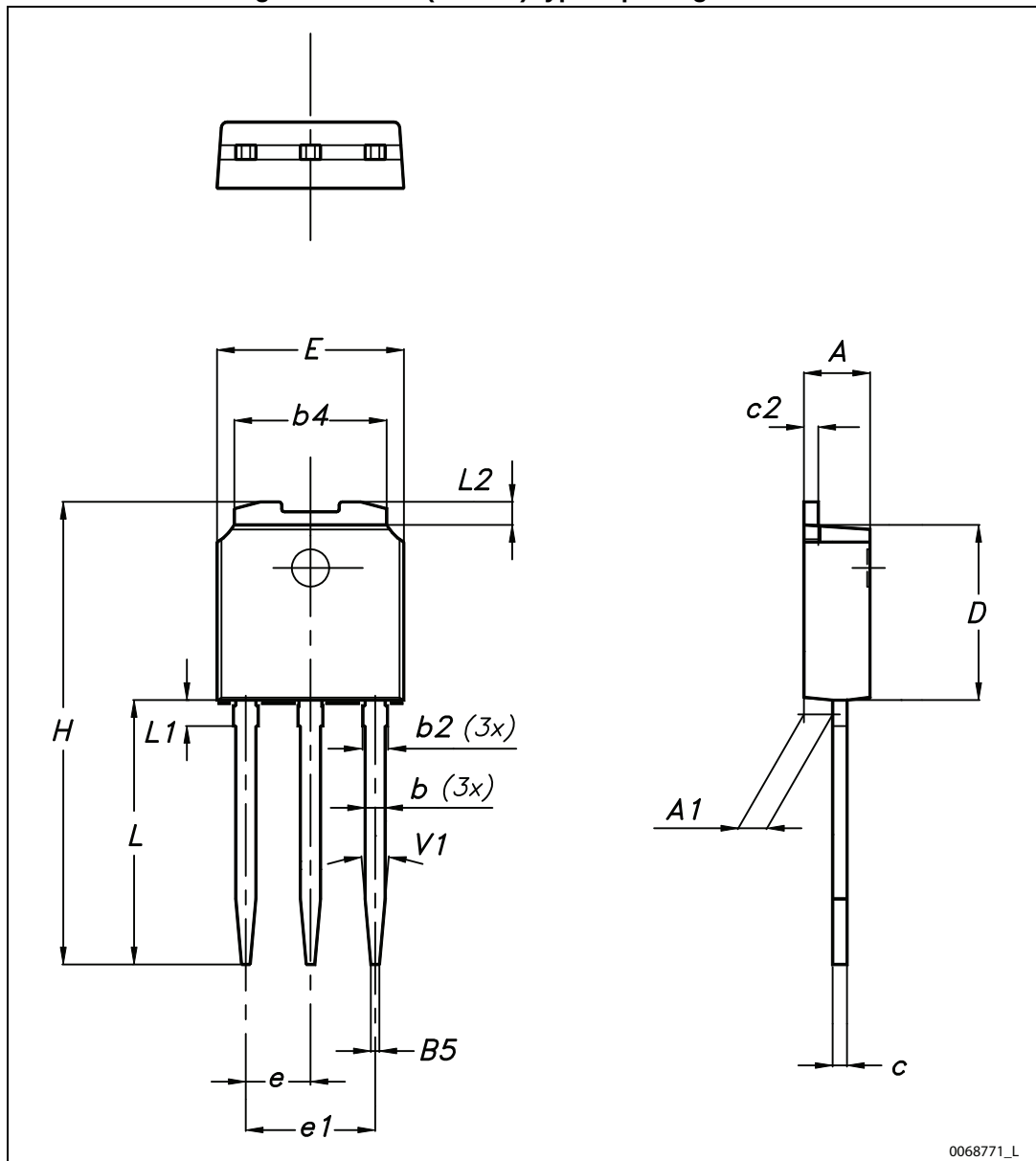


Table 12. IPAK (TO-251) type A mechanical data

| 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 25. IPAK (TO-251) type C package outline

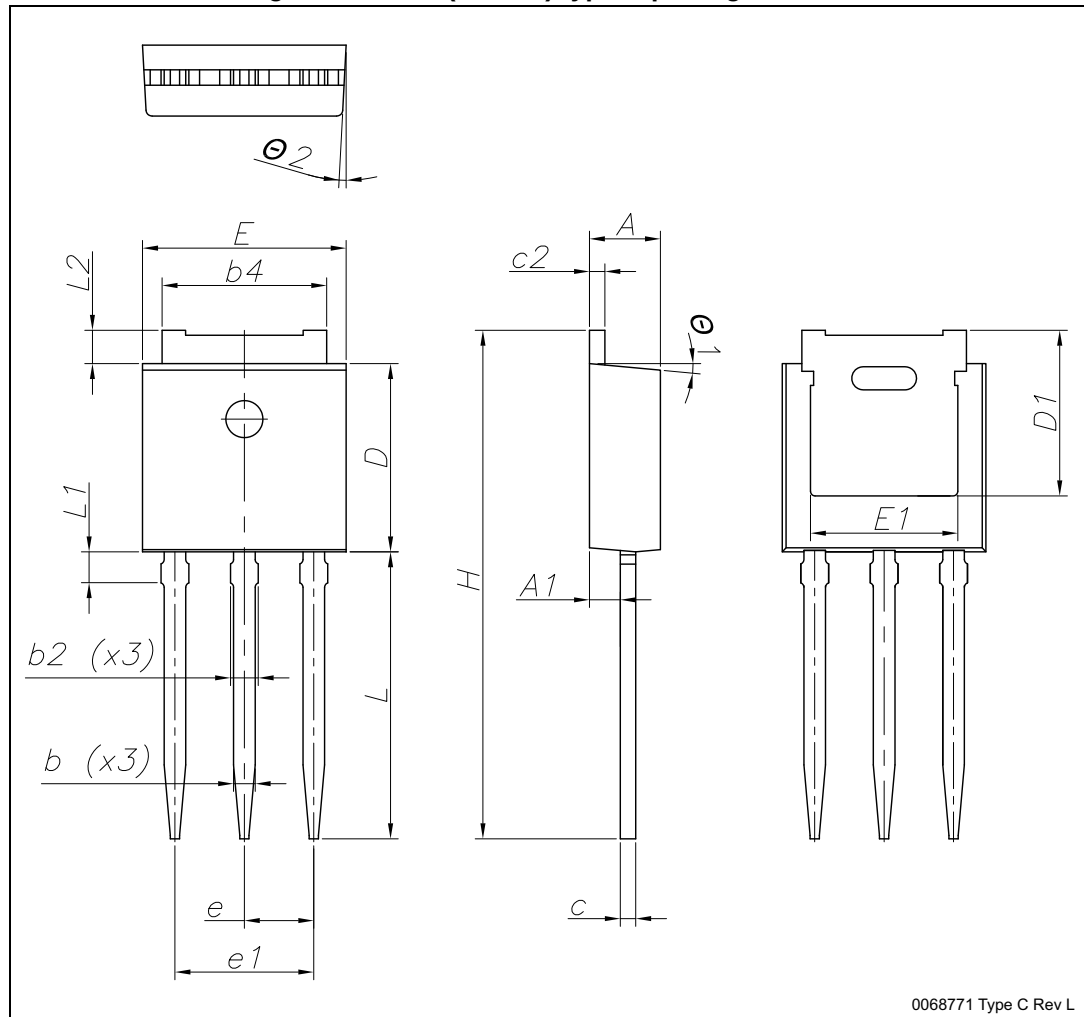


Table 13. IPAK (TO-251) type C mechanical data

| 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 Revision history

**Table 14. Document revision history**

| Date        | Revision | Changes                                                                                                                                                                                                                                                                                                                                                                     |
|-------------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 10-May-2012 | 1        | First release.                                                                                                                                                                                                                                                                                                                                                              |
| 20-Jun-2012 | 2        | Updated title on the cover page.<br>Updated all parameter values in <a href="#">Table 5</a> , <a href="#">Table 6</a> and <a href="#">Figure 1</a> .                                                                                                                                                                                                                        |
| 17-May-2013 | 3        | <ul style="list-style-type: none"> <li>– Added: TO-220FP and IPAK packages</li> <li>– Updated: <math>R_{DS(on)}</math> value in cover page, <math>R_{thj-case}</math> values, <a href="#">Table 5</a>, <a href="#">6</a> and <a href="#">7</a> typical values</li> <li>– Updated mechanical data only for DPAK in <a href="#">Section 4: Package information</a></li> </ul> |
| 24-Apr-2014 | 4        | <ul style="list-style-type: none"> <li>– Updated: <a href="#">Figure 2</a> and <a href="#">3</a></li> <li>– Updated: <a href="#">Section 4.1: DPAK package information</a> and <a href="#">Section 4.4: TO-220 package information</a></li> <li>– Minor text changes</li> </ul>                                                                                             |
| 27-Jul-2015 | 5        | <ul style="list-style-type: none"> <li>– All voltage and current polarities inverted</li> <li>– Added: note in <a href="#">Section 2.1: Electrical characteristics (curves)</a></li> <li>– Updated: <a href="#">Section 4.1</a> and <a href="#">Section 4.5</a></li> <li>– Text and formatting changes throughout document</li> </ul>                                       |

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