

## N-channel 600 V, 0.175 $\Omega$ typ., 18 A MDmesh™ DM2 Power MOSFET in a TO-220FP package

Datasheet - production data

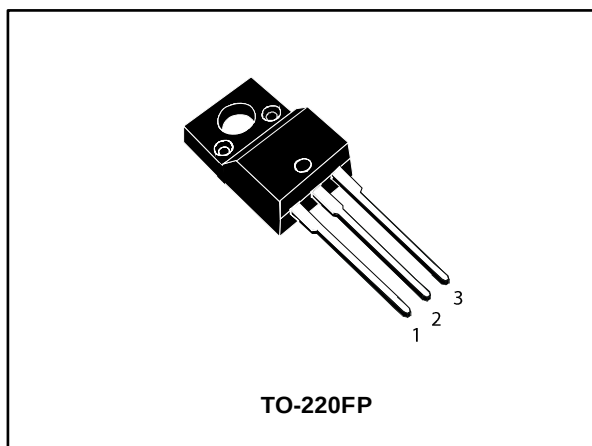
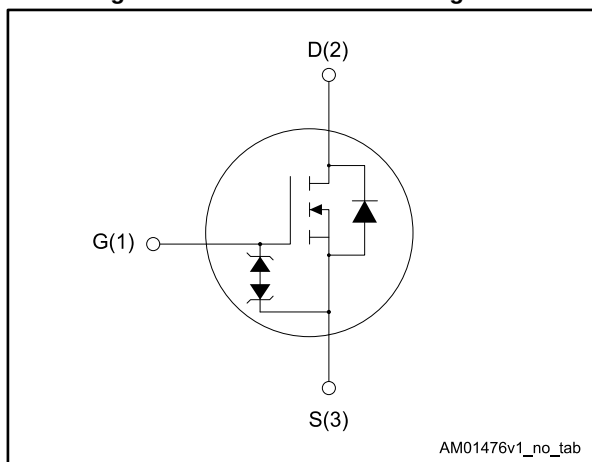


Figure 1: Internal schematic diagram



### Features

| Order code  | V <sub>DS</sub> @ T <sub>Jmax</sub> | R <sub>DS(on)</sub> max. | I <sub>D</sub> |
|-------------|-------------------------------------|--------------------------|----------------|
| STF24N60DM2 | 650 V                               | 0.200 $\Omega$           | 18 A           |

- Fast-recovery body diode
- Extremely low gate charge and input capacitance
- Low on-resistance
- 100% avalanche tested
- Extremely high dv/dt ruggedness
- Zener-protected

### Applications

- Switching applications

### Description

This high voltage N-channel Power MOSFET is part of the MDmesh™ DM2 fast recovery diode series. It offers very low recovery charge ( $Q_{rr}$ ) and time ( $t_{rr}$ ) combined with low  $R_{DS(on)}$ , rendering it suitable for the most demanding high efficiency converters and ideal for bridge topologies and ZVS phase-shift converters.

Table 1: Device summary

| Order code  | Marking  | Package  | Packing |
|-------------|----------|----------|---------|
| STF24N60DM2 | 24N60DM2 | TO-220FP | Tube    |

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## Contents

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# 1 Electrical ratings

Table 2: Absolute maximum ratings

| Symbol            | Parameter                                                                                                                             | Value      | Unit             |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------|------------|------------------|
| $V_{GS}$          | Gate-source voltage                                                                                                                   | $\pm 25$   | V                |
| $I_D^{(1)}$       | Drain current (continuous) at $T_C = 25\text{ }^\circ\text{C}$                                                                        | 18         | A                |
|                   | Drain current (continuous) at $T_C = 100\text{ }^\circ\text{C}$                                                                       | 11         |                  |
| $I_{DM}^{(2)(1)}$ | Drain current (pulsed)                                                                                                                | 72         | A                |
| $P_{TOT}$         | Total dissipation at $T_C = 25\text{ }^\circ\text{C}$                                                                                 | 30         | W                |
| $dv/dt^{(3)}$     | Peak diode recovery voltage slope                                                                                                     | 40         | V/ns             |
| $dv/dt^{(4)}$     | MOSFET $dv/dt$ ruggedness                                                                                                             | 50         |                  |
| $V_{ISO}$         | Insulation withstand voltage (RMS) from all three leads to external heat sink ( $t = 1\text{ s}$ ; $T_C = 25\text{ }^\circ\text{C}$ ) | 2500       | V                |
| $T_{stg}$         | Storage temperature range                                                                                                             | -55 to 150 | $^\circ\text{C}$ |
| $T_j$             | Max. operating junction temperature range                                                                                             |            |                  |

**Notes:**

(1) Limited by package.

(2) Pulse width is limited by safe operating area.

(3)  $I_{SD} \leq 18\text{ A}$ ,  $di/dt \leq 400\text{ A}/\mu\text{S}$ ,  $V_{DS(peak)} < V_{(BR)DSS}$ ,  $V_{DD} = 400\text{ V}$ .(4)  $V_{DS} \leq 480\text{ V}$ .

Table 3: Thermal data

| Symbol         | Parameter                                | Value | Unit                      |
|----------------|------------------------------------------|-------|---------------------------|
| $R_{thj-case}$ | Thermal resistance junction-case max.    | 4.2   | $^\circ\text{C}/\text{W}$ |
| $R_{thj-amb}$  | Thermal resistance junction-ambient max. | 62.5  |                           |

Table 4: Avalanche characteristics

| Symbol   | Parameter                                                                                                            | Value | Unit |
|----------|----------------------------------------------------------------------------------------------------------------------|-------|------|
| $I_{AR}$ | Avalanche current, repetitive or not repetitive (pulse width limited by $T_{Jmax}$ )                                 | 3.5   | A    |
| $E_{AS}$ | Single pulse avalanche energy (starting $T_J = 25\text{ }^\circ\text{C}$ , $I_D = I_{AR}$ ; $V_{DD} = 50\text{ V}$ ) | 180   | mJ   |

## 2 Electrical characteristics

(T<sub>case</sub> = 25 °C unless otherwise specified)

**Table 5: On /off states**

| Symbol               | Parameter                         | Test conditions                                                                        | Min. | Typ.  | Max.  | Unit |
|----------------------|-----------------------------------|----------------------------------------------------------------------------------------|------|-------|-------|------|
| V <sub>(BR)DSS</sub> | Drain-source breakdown voltage    | V <sub>GS</sub> = 0 V, I <sub>D</sub> = 1 mA                                           | 600  |       |       | V    |
| I <sub>DSS</sub>     | Zero gate voltage drain current   | V <sub>GS</sub> = 0 V, V <sub>DS</sub> = 600 V                                         |      |       | 1.5   | μA   |
|                      |                                   | V <sub>GS</sub> = 0 V, V <sub>DS</sub> = 600 V, T <sub>C</sub> = 125 °C <sup>(1)</sup> |      |       | 100   | μA   |
| I <sub>GSS</sub>     | Gate-body leakage current         | V <sub>DS</sub> = 0 V, V <sub>GS</sub> = ±25 V                                         |      |       | ±10   | μA   |
| V <sub>GS(th)</sub>  | Gate threshold voltage            | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250 μA                            | 3    | 4     | 5     | V    |
| R <sub>DS(on)</sub>  | Static drain-source on-resistance | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 9 A                                           |      | 0.175 | 0.200 | Ω    |

**Notes:**

<sup>(1)</sup>Defined by design, not subject to production test.

**Table 6: Dynamic**

| Symbol                              | Parameter                     | Test conditions                                                                                                                                     | Min. | Typ. | Max. | Unit |
|-------------------------------------|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|
| C <sub>iss</sub>                    | Input capacitance             | V <sub>DS</sub> = 100 V, f = 1 MHz, V <sub>GS</sub> = 0 V                                                                                           | -    | 1055 | -    | pF   |
| C <sub>oss</sub>                    | Output capacitance            |                                                                                                                                                     | -    | 56   | -    | pF   |
| C <sub>rss</sub>                    | Reverse transfer capacitance  |                                                                                                                                                     | -    | 2.4  | -    | pF   |
| C <sub>oss eq.</sub> <sup>(1)</sup> | Equivalent output capacitance | V <sub>DS</sub> = 0 to 480 V, V <sub>GS</sub> = 0 V                                                                                                 | -    | 259  | -    | pF   |
| R <sub>G</sub>                      | Intrinsic gate resistance     | f = 1 MHz, I <sub>D</sub> = 0 A                                                                                                                     | -    | 7    | -    | Ω    |
| Q <sub>g</sub>                      | Total gate charge             | V <sub>DD</sub> = 480 V, I <sub>D</sub> = 18 A, V <sub>GS</sub> = 10 V<br>(see <a href="#">Figure 15: "Test circuit for gate charge behavior"</a> ) | -    | 29   | -    | nC   |
| Q <sub>gs</sub>                     | Gate-source charge            |                                                                                                                                                     | -    | 6    | -    | nC   |
| Q <sub>gd</sub>                     | Gate-drain charge             |                                                                                                                                                     | -    | 12   | -    | nC   |

**Notes:**

<sup>(1)</sup>C<sub>oss eq.</sub> is defined as a constant equivalent capacitance giving the same charging time as C<sub>oss</sub> when V<sub>DS</sub> increases from 0 to 80% V<sub>DSS</sub>.

Table 7: Switching times

| Symbol       | Parameter           | Test conditions                                                                                                                                                                                                                                 | Min. | Typ. | Max. | Unit |
|--------------|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|
| $t_{d(on)}$  | Turn-on delay time  | $V_{DD} = 300\text{ V}$ , $I_D = 9\text{ A}$<br>$R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$<br>(see <a href="#">Figure 14: "Test circuit for resistive load switching times"</a><br>and <a href="#">Figure 19: "Switching time waveform"</a> ) | -    | 15   | -    | ns   |
| $t_r$        | Rise time           |                                                                                                                                                                                                                                                 | -    | 8.7  | -    | ns   |
| $t_{d(off)}$ | Turn-off-delay time |                                                                                                                                                                                                                                                 | -    | 60   | -    | 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          |                                                                                                                                                                                                                                    | -    |      | 18   | A    |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |                                                                                                                                                                                                                                    | -    |      | 72   | A    |
| $V_{SD}^{(2)}$  | Forward on voltage            | $V_{GS} = 0\text{ V}$ , $I_{SD} = 18\text{ A}$                                                                                                                                                                                     | -    |      | 1.6  | V    |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 18\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ ,<br>$V_{DD} = 60\text{ V}$ (see <a href="#">Figure 16: "Test circuit for inductive load switching and diode recovery times"</a> )                                     | -    | 155  |      | ns   |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                                                                                                                    | -    | 956  |      | nC   |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                                                                                                                    | -    | 12.5 |      | A    |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 18\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ ,<br>$V_{DD} = 60\text{ V}$ , $T_J = 150\text{ }^\circ\text{C}$ (see <a href="#">Figure 16: "Test circuit for inductive load switching and diode recovery times"</a> ) | -    | 200  |      | ns   |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                                                                                                                    | -    | 1450 |      | nC   |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                                                                                                                    | -    | 13   |      | A    |

**Notes:**

(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 2: Safe operating area

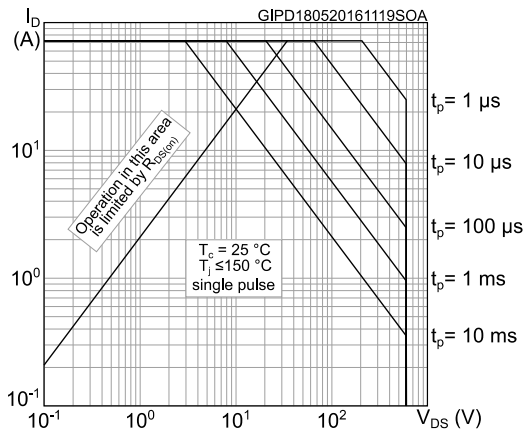


Figure 3: Thermal impedance

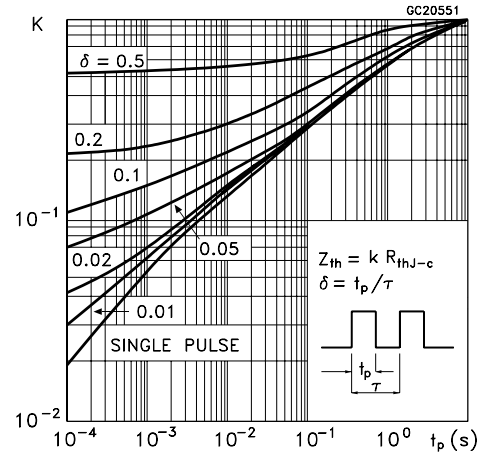


Figure 4: Output characteristics

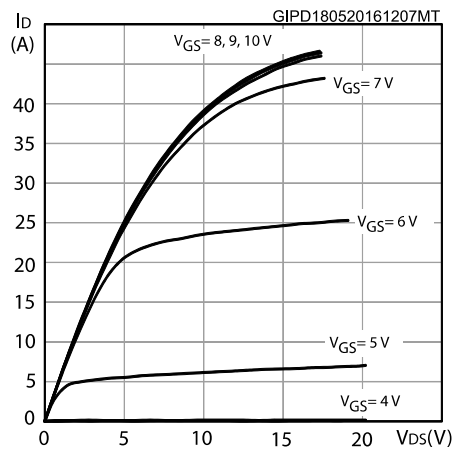


Figure 5: Transfer characteristics

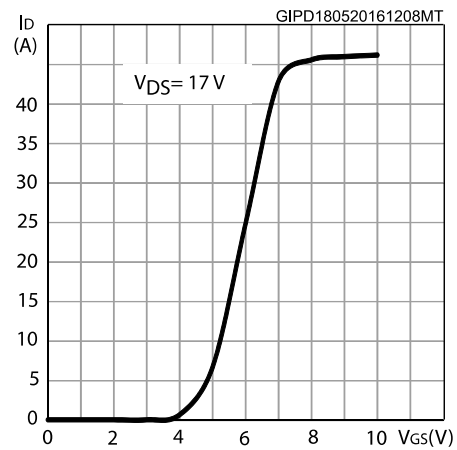


Figure 6: Gate charge vs gate-source voltage

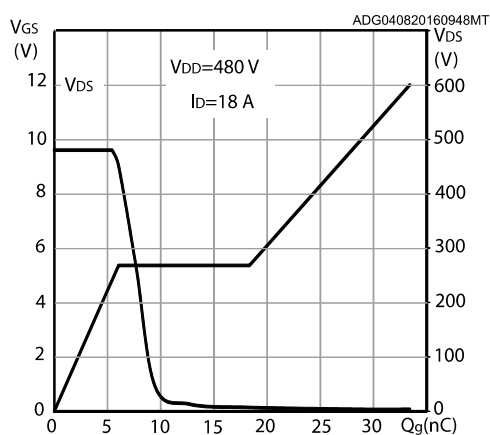


Figure 7: Static drain-source on-resistance

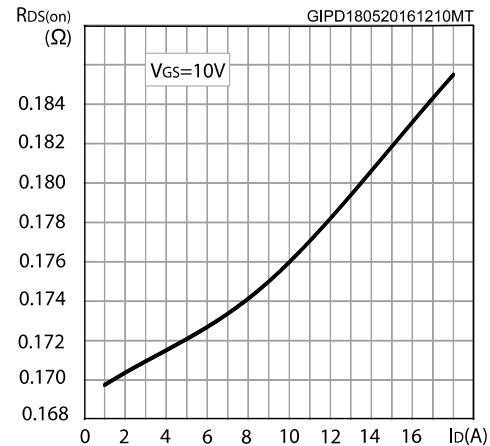


Figure 8: Capacitance variations

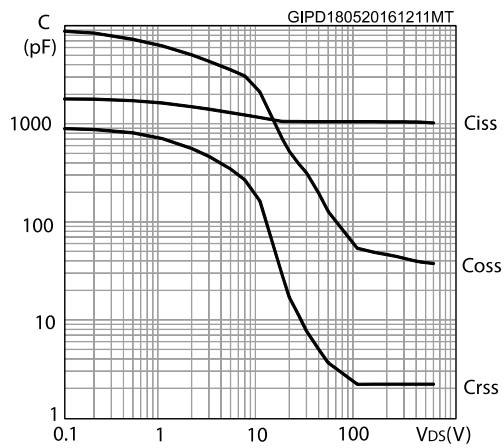


Figure 9: Output capacitance stored energy

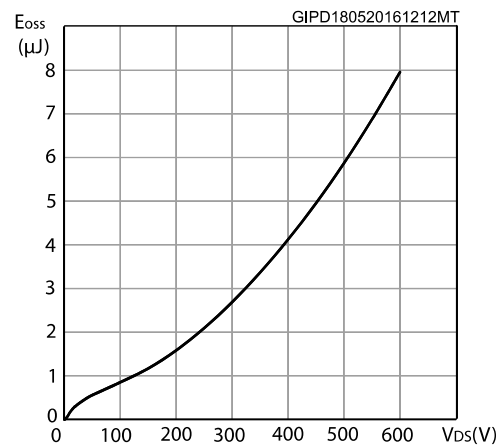


Figure 10: Normalized gate threshold voltage vs temperature

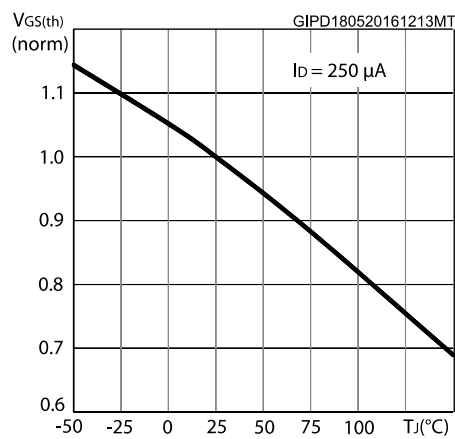


Figure 11: Normalized on-resistance vs temperature

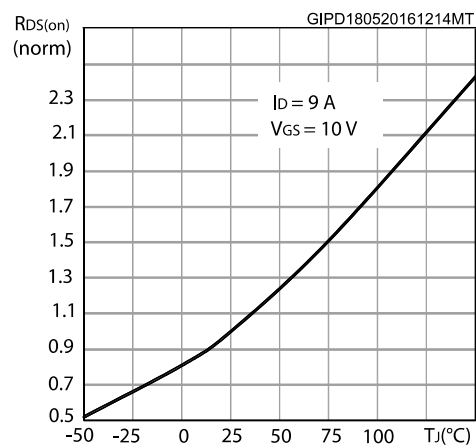
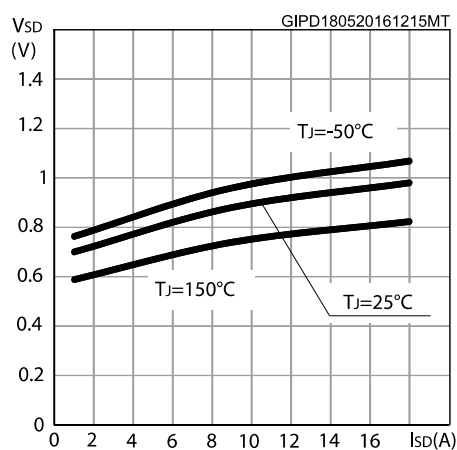
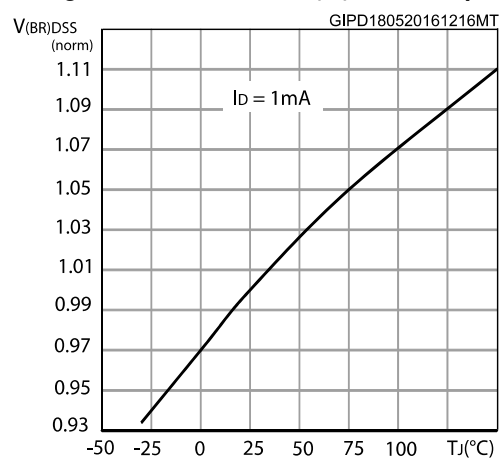


Figure 12: Source-drain diode forward characteristics

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

### 3 Test circuits

**Figure 14: Test circuit for resistive load switching times**



**Figure 15: Test circuit for gate charge behavior**



**Figure 16: Test circuit for inductive load switching and diode recovery times**



**Figure 17: Unclamped inductive load test circuit**



**Figure 18: Unclamped inductive waveform**



**Figure 19: 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 TO-220FP package information

Figure 20: TO-220FP package outline

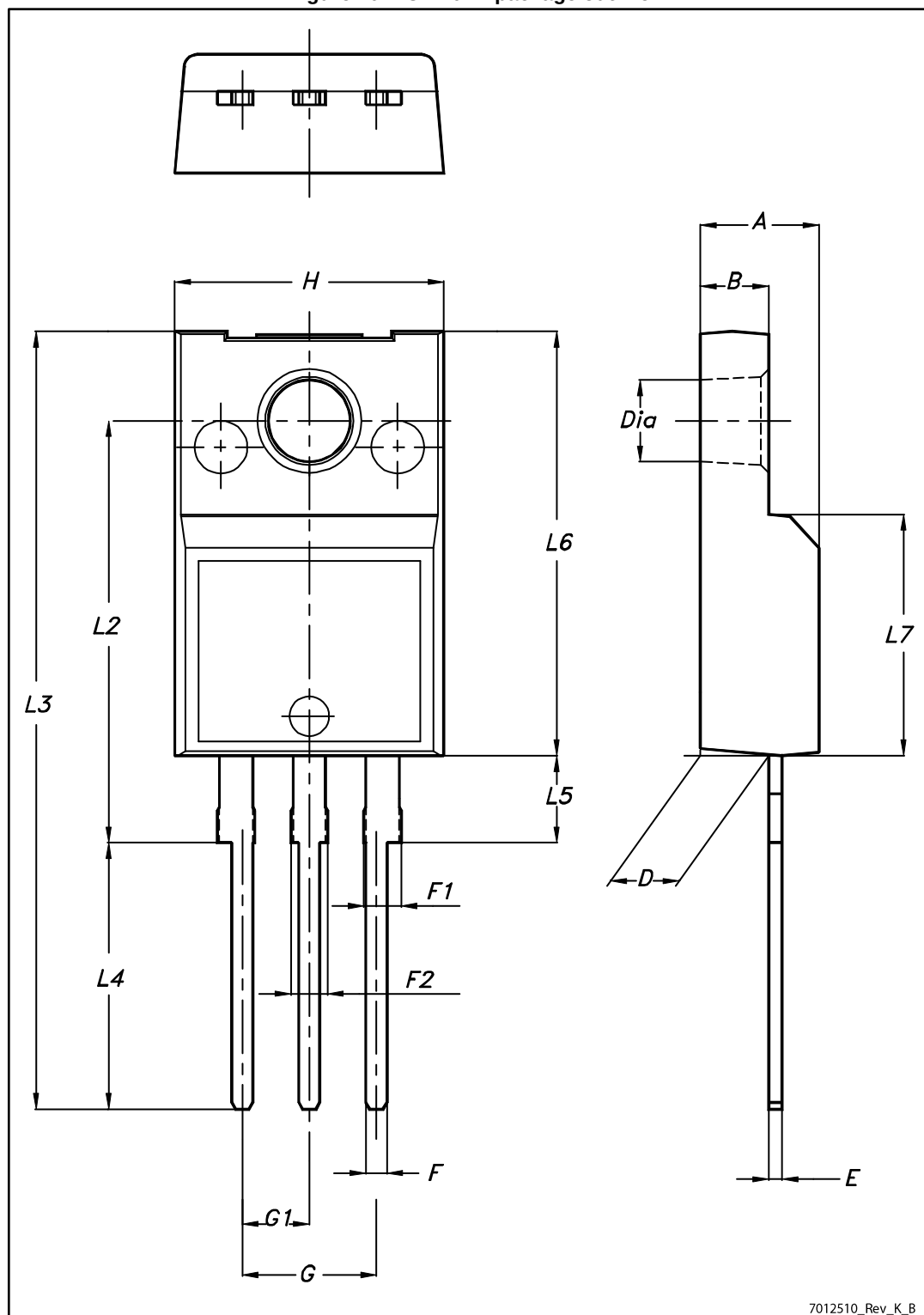


Table 9: TO-220FP package mechanical data

| 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 Revision history

**Table 10: Document revision history**

| Date        | Revision | Changes                                                                                                                                                                                                                                                                                        |
|-------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 12-Nov-2013 | 1        | First release.                                                                                                                                                                                                                                                                                 |
| 21-Jan-2014 | 2        | <ul style="list-style-type: none"><li>– Modified: <math>dv/dt</math> value in Table 2</li><li>– Modified: <math>I_{AR}</math> value in Table 4</li><li>– Modified: <math>I_{DSS}</math> and <math>V_{GS(th)}</math> in Table 5</li><li>– Minor text changes</li></ul>                          |
| 03-Mar-2014 | 3        | <ul style="list-style-type: none"><li>– Modified: Figure 1</li><li>– Modified: <math>P_{TOT}</math> value and note 1 in Table 2</li><li>– Modified: <math>R_{thj-case}</math> value in Table 3</li><li>– Modified: <math>I_{AR}</math> value in Table 4</li><li>– Minor text changes</li></ul> |
| 05-Mar-2015 | 4        | <ul style="list-style-type: none"><li>– Document status promoted from preliminary to production data.</li><li>– Updated title, features and description in cover page.</li></ul>                                                                                                               |
| 20-Sep-2016 | 5        | Updated <a href="#">Figure 2: "Safe operating area"</a> .<br>Minor text changes                                                                                                                                                                                                                |

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