

## N-channel 650 V, 0.79 $\Omega$ typ., 5 A MDmesh M2 Power MOSFET in a TO-220FP ultra narrow leads package

Datasheet - production data

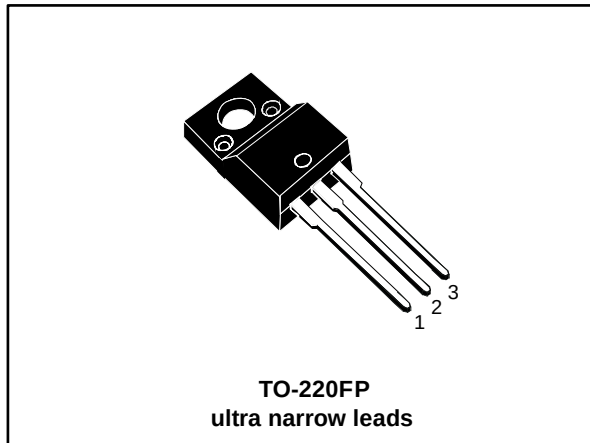
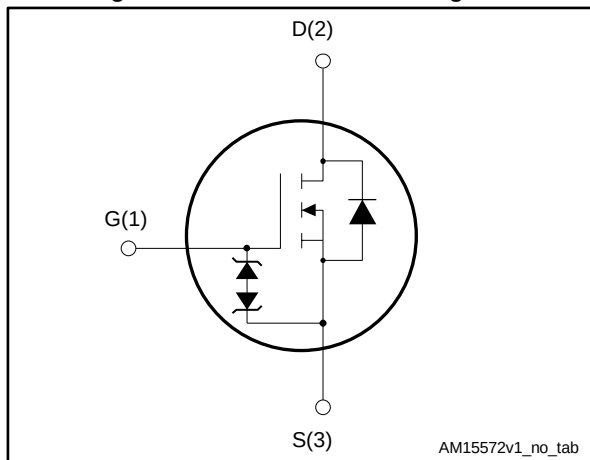


Figure 1: Internal schematic diagram



### Features

| Order code | V <sub>DS</sub> | R <sub>DS(on)</sub> max. | I <sub>D</sub> |
|------------|-----------------|--------------------------|----------------|
| STFU9N65M2 | 650 V           | 0.90 $\Omega$            | 5 A            |

- Extremely low gate charge
- Excellent output capacitance (C<sub>oss</sub>) profile
- 100% avalanche tested
- Zener-protected

### Applications

- Switching applications

### Description

This device is an N-channel Power MOSFET developed using MDmesh™ M2 technology. Thanks to its strip layout and an improved vertical structure, the device exhibits low on-resistance and optimized switching characteristics, rendering it suitable for the most demanding high efficiency converters.

Table 1: Device summary

| Order code | Marking | Package                     | Packing |
|------------|---------|-----------------------------|---------|
| STFU9N65M2 | 9N65M2  | TO-220FP ultra narrow leads | 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 $T_C = 25\text{ }^\circ\text{C}$                                                                 | 5           | A                |
| $I_D^{(1)}$    | Drain current (continuous) at $T_C = 100\text{ }^\circ\text{C}$                                                                | 3.2         | A                |
| $I_{DM}^{(2)}$ | Drain current pulsed                                                                                                           | 20          | A                |
| $P_{TOT}$      | Total dissipation at $T_C = 25\text{ }^\circ\text{C}$                                                                          | 20          | W                |
| $V_{ISO}$      | 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                |
| $dv/dt^{(3)}$  | Peak diode recovery voltage slope                                                                                              | 15          | V/ns             |
| $dv/dt^{(4)}$  | MOSFET $dv/dt$ ruggedness                                                                                                      | 50          |                  |
| $T_j$          | Operating junction temperature range                                                                                           | - 55 to 150 | $^\circ\text{C}$ |
| $T_{stg}$      | Storage temperature range                                                                                                      |             |                  |

**Notes:**

(1) Current limited by package.

(2) Pulse width limited by safe operating area.

(3)  $I_{SD} \leq 5\text{ A}$ ,  $di/dt \leq 400\text{ A}/\mu\text{s}$ ,  $V_{DS}(\text{peak}) \leq V_{(BR)DSS}$ ,  $V_{DD} = 400\text{ V}$ (4)  $V_{DS} \leq 520\text{ V}$ 

Table 3: Thermal data

| Symbol         | Parameter                           | Value | Unit                      |
|----------------|-------------------------------------|-------|---------------------------|
| $R_{thj-case}$ | Thermal resistance junction-case    | 6.25  | $^\circ\text{C}/\text{W}$ |
| $R_{thj-amb}$  | Thermal resistance junction-ambient | 62.5  | $^\circ\text{C}/\text{W}$ |

Table 4: Avalanche characteristics

| Symbol   | Parameter                                                                                                            | Value | Unit |
|----------|----------------------------------------------------------------------------------------------------------------------|-------|------|
| $I_{AR}$ | Avalanche current, repetitive or not repetitive (pulse width limited by $T_{jmax}$ )                                 | 1     | A    |
| $E_{AS}$ | Single pulse avalanche energy (starting $T_j = 25\text{ }^\circ\text{C}$ , $I_D = I_{AR}$ , $V_{DD} = 50\text{ V}$ ) | 105   | 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                                           | 650  |      |      | V    |
| I <sub>DSS</sub>     | Zero gate voltage drain current   | V <sub>GS</sub> = 0 V, V <sub>DS</sub> = 650 V                                         |      |      | 1    | μA   |
|                      |                                   | V <sub>GS</sub> = 0 V, V <sub>DS</sub> = 650 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                            | 2    | 3    | 4    | V    |
| R <sub>DS(on)</sub>  | Static drain-source on-resistance | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 2.5 A                                         |      | 0.79 | 0.90 | 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>GS</sub> = 0 V, V <sub>DS</sub> = 100 V, f = 1 MHz                                                                                            | -    | 315  | -    | pF   |
| C <sub>oss</sub>                   | Output capacitance            |                                                                                                                                                      | -    | 18   | -    | pF   |
| C <sub>rss</sub>                   | Reverse transfer capacitance  |                                                                                                                                                      | -    | 1    | -    | pF   |
| C <sub>oss eq</sub> <sup>(1)</sup> | Equivalent output capacitance | V <sub>DS</sub> = 0 V to 520 V, V <sub>GS</sub> = 0 V                                                                                                | -    | 109  | -    | pF   |
| R <sub>G</sub>                     | Intrinsic gate resistance     | f = 1 MHz, I <sub>D</sub> = 0 A                                                                                                                      | -    | 6.6  | -    | Ω    |
| Q <sub>g</sub>                     | Total gate charge             | V <sub>DD</sub> = 520 V, I <sub>D</sub> = 5 A<br>V <sub>GS</sub> = 10 V<br>(see <a href="#">Figure 15: "Test circuit for gate charge behavior"</a> ) | -    | 10   | -    | nC   |
| Q <sub>gs</sub>                    | Gate-source charge            |                                                                                                                                                      | -    | 2.5  | -    | nC   |
| Q <sub>gd</sub>                    | Gate-drain charge             |                                                                                                                                                      | -    | 5    | -    | 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 <sub>d(on)</sub>  | Turn-on delay time  | V <sub>DD</sub> = 325 V, I <sub>D</sub> = 2.5 A, R <sub>G</sub> = 4.7 Ω<br>V <sub>GS</sub> = 10 V<br>(see <a href="#">Figure 14: "Test circuit for resistive load switching times"</a> and <a href="#">Figure 19: "Switching time waveform"</a> ) | -    | 7.5  | -    | ns   |
| t <sub>r</sub>      | Rise time           |                                                                                                                                                                                                                                                   | -    | 6.6  | -    | ns   |
| t <sub>d(off)</sub> | Turn-off delay time |                                                                                                                                                                                                                                                   | -    | 22.5 | -    | ns   |
| t <sub>f</sub>      | Fall time           |                                                                                                                                                                                                                                                   | -    | 18   | -    | ns   |

Table 8: 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) |                                                                                                                                                                                                                                       | -    |      | 10   | A             |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD} = 5\text{ A}$ , $V_{GS} = 0\text{ V}$                                                                                                                                                                                         | -    |      | 1.6  | V             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 5\text{ A}$ , $V_{DD} = 60\text{ V}$<br>$di/dt = 100\text{ A}/\mu\text{s}$ ,<br>(see <a href="#">Figure 16: "Test circuit for inductive load switching and diode recovery times"</a> )                                      | -    | 276  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                                                                                                                       | -    | 1.7  |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                                                                                                                       | -    | 12.5 |      | A             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 5\text{ A}$ , $V_{DD} = 60\text{ V}$<br>$di/dt = 100\text{ A}/\mu\text{s}$ ,<br>$T_j = 150\text{ }^\circ\text{C}$<br>(see <a href="#">Figure 16: "Test circuit for inductive load switching and diode recovery times"</a> ) | -    | 312  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                                                                                                                       | -    | 1.9  |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                                                                                                                       | -    | 12.4 |      | A             |

**Notes:**

<sup>(1)</sup>Pulse width limited by safe operating area.

<sup>(2)</sup>Pulsed: pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5 %.

## 2.1 Electrical characteristics (curves)

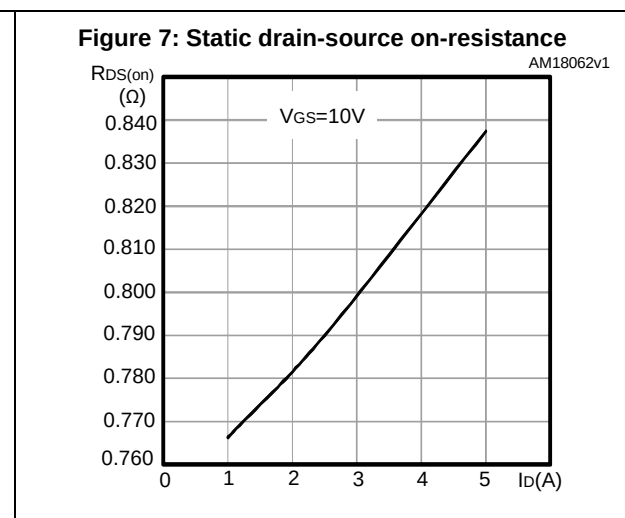
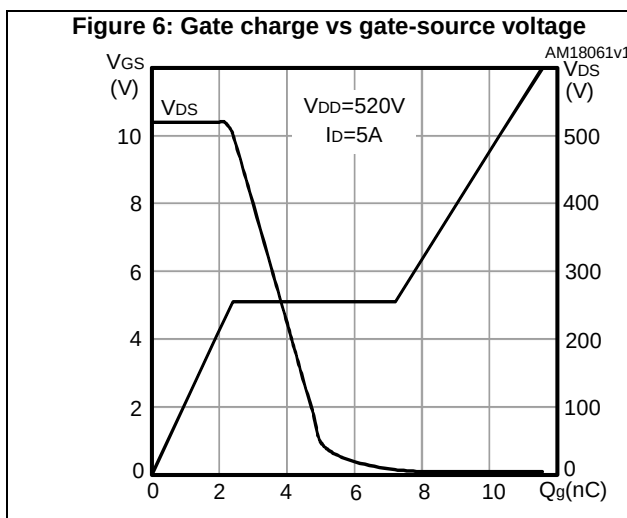
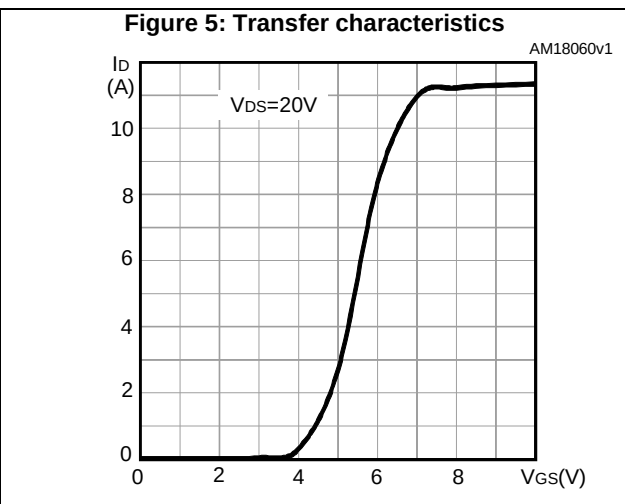
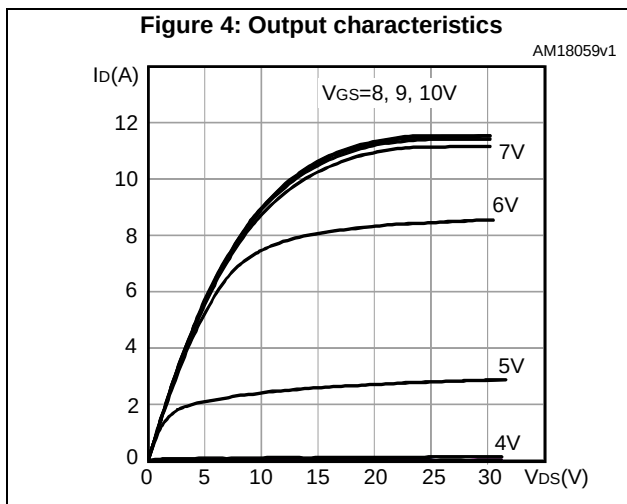
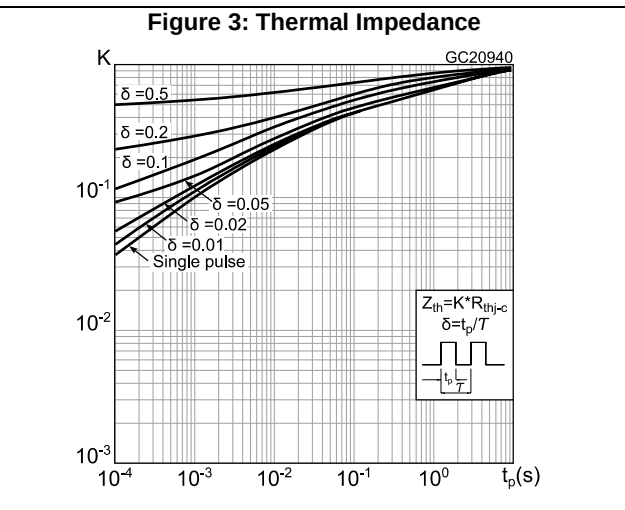
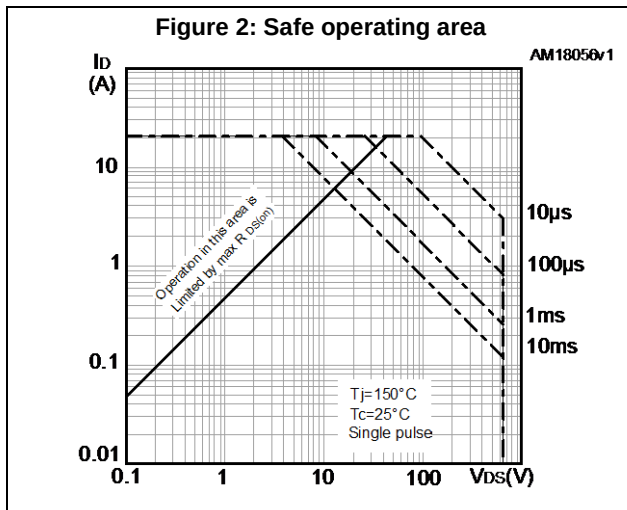


Figure 8: Capacitance variations

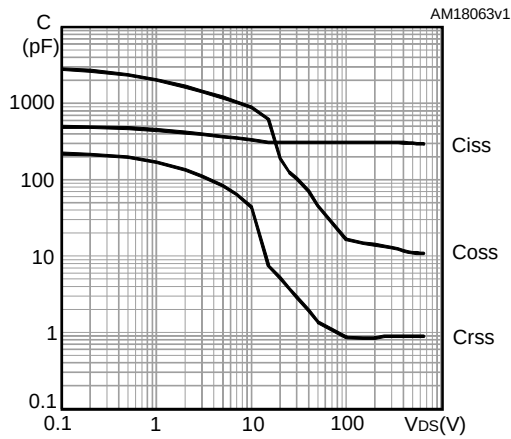


Figure 9: Output capacitance stored energy

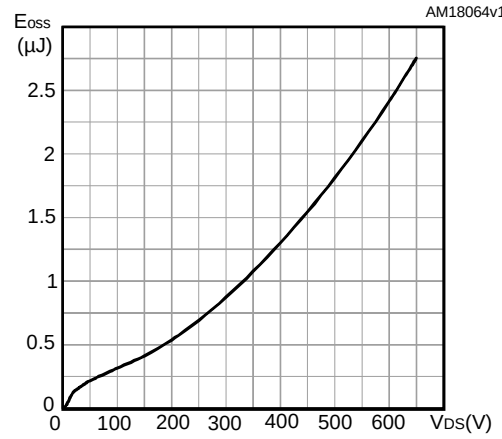


Figure 10: Normalized gate threshold voltage vs temperature

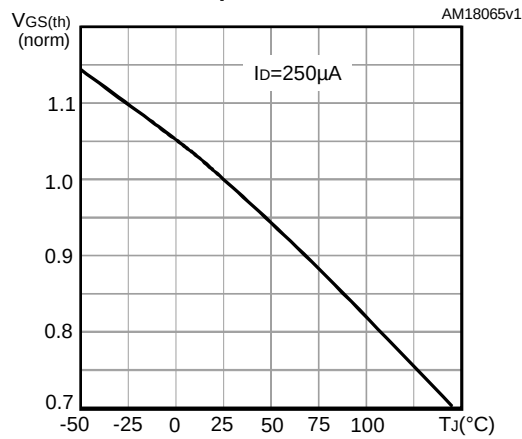


Figure 11: Normalized on-resistance vs temperature

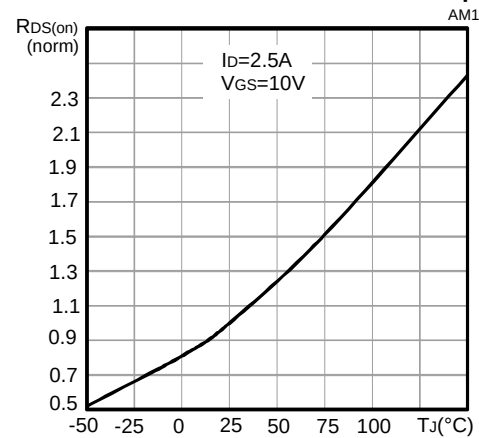


Figure 12: Normalized V(BR)DSS vs temperature

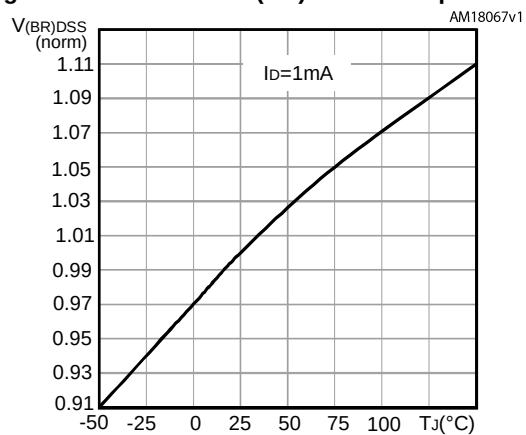
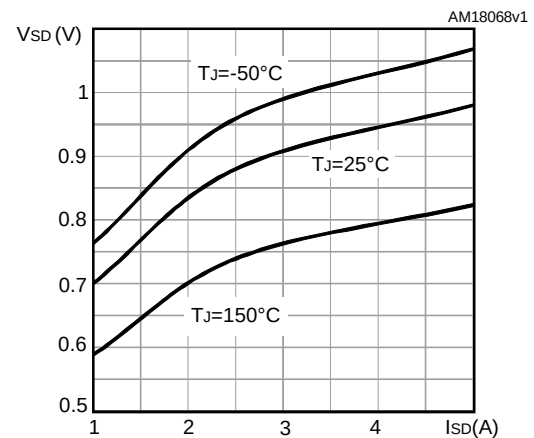
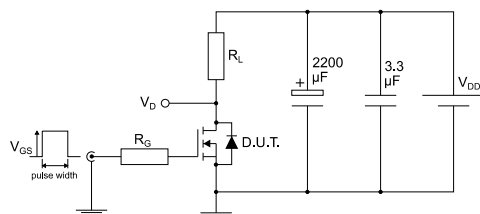


Figure 13: Source-drain diode forward characteristics



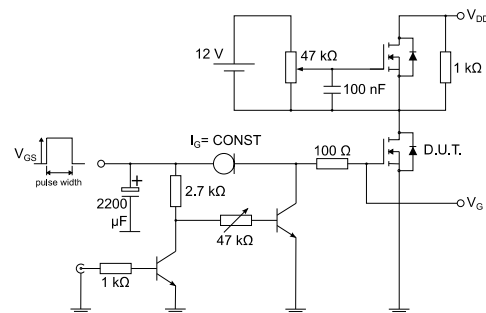
### 3 Test circuits

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



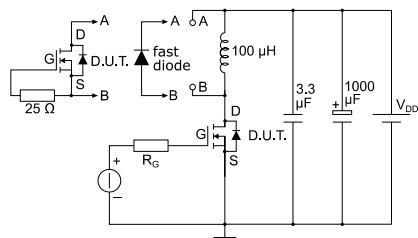
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**Figure 15: Test circuit for gate charge behavior**



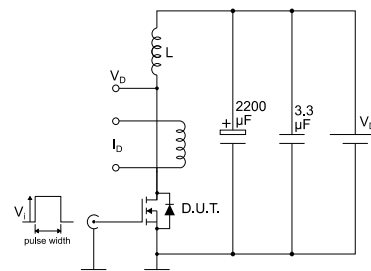
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**Figure 16: Test circuit for inductive load switching and diode recovery times**



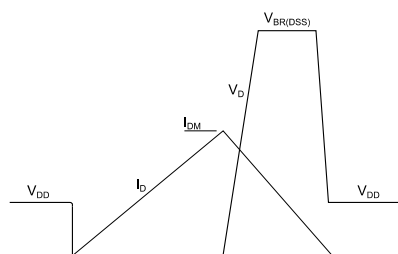
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**Figure 17: Unclamped inductive load test circuit**



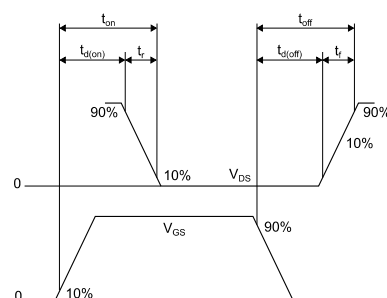
AM01471v1

**Figure 18: Unclamped inductive waveform**



AM01472v1

**Figure 19: Switching time waveform**



AM01473v1



## 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 ultra narrow leads package information

Figure 20: TO-220FP ultra narrow leads package outline

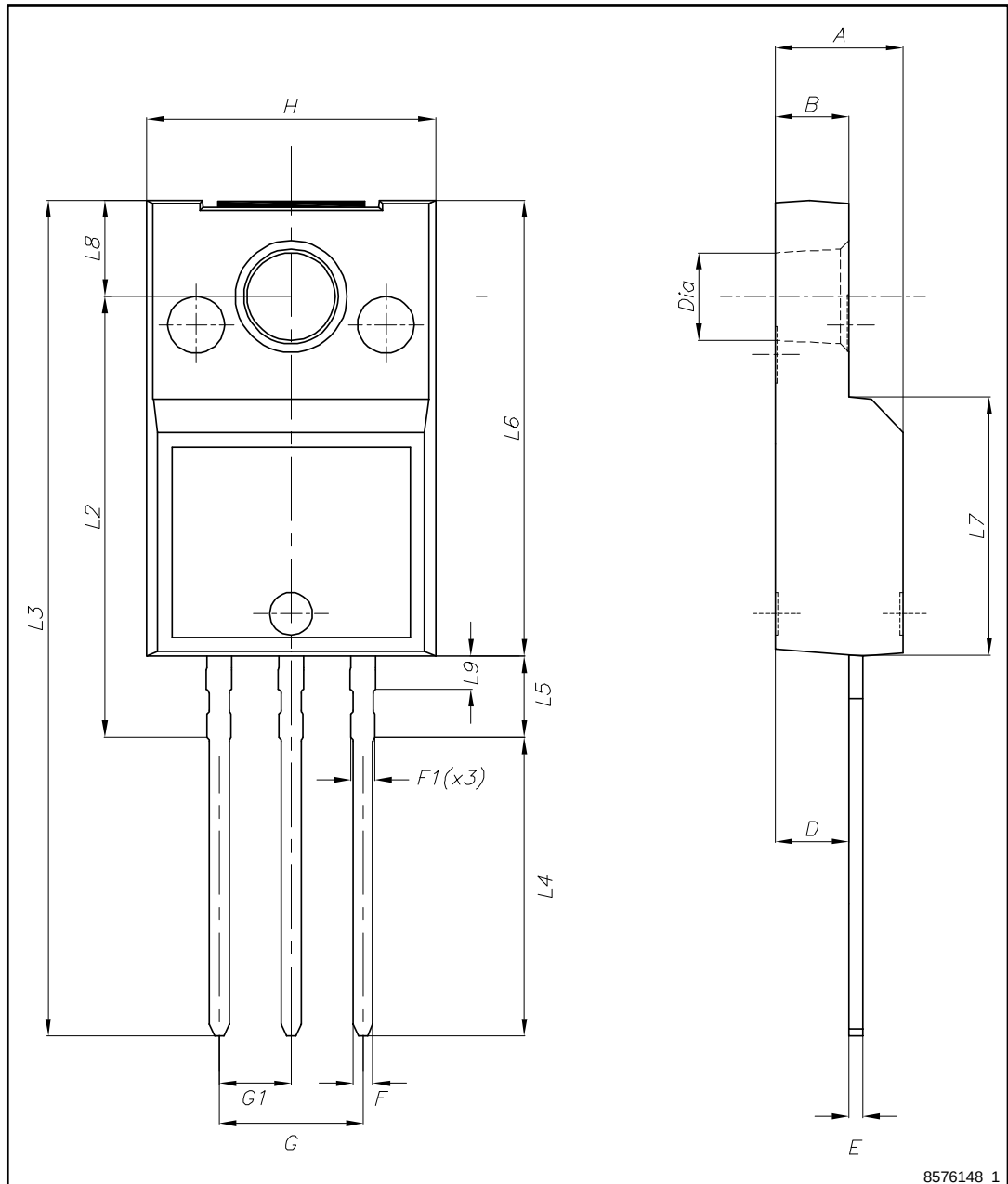


Table 9: TO-220FP ultra narrow leads mechanical data

| Dim. | mm    |      |       |
|------|-------|------|-------|
|      | Min.  | Typ. | Max.  |
| A    | 4.40  |      | 4.60  |
| B    | 2.50  |      | 2.70  |
| D    | 2.50  |      | 2.75  |
| E    | 0.45  |      | 0.60  |
| F    | 0.65  |      | 0.75  |
| F1   | -     |      | 0.90  |
| G    | 4.95  |      | 5.20  |
| G1   | 2.40  | 2.54 | 2.70  |
| H    | 10.00 |      | 10.40 |
| L2   | 15.10 |      | 15.90 |
| L3   | 28.50 |      | 30.50 |
| L4   | 10.20 |      | 11.00 |
| L5   | 2.50  |      | 3.10  |
| L6   | 15.60 |      | 16.40 |
| L7   | 9.00  |      | 9.30  |
| L8   | 3.20  |      | 3.60  |
| L9   | -     |      | 1.30  |
| Dia. | 3.00  |      | 3.20  |

## 5 Revision history

Table 10: Document revision history

| Date        | Revision | Changes                                                      |
|-------------|----------|--------------------------------------------------------------|
| 04-Aug-2016 | 1        | First release.                                               |
| 08-Sep-2016 | 2        | Document status updated from preliminary to production data. |

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