



# STF20N65M5, STFI20N65M5

N-channel 650 V, 0.160  $\Omega$  typ., 18 A MDmesh™ V Power MOSFET in TO-220FP and I<sup>2</sup>PAKFP packages

Datasheet — production data

## Features

| Order codes | V <sub>DS</sub> @ T <sub>Jmax</sub> | R <sub>DS(on)</sub> max | I <sub>D</sub> |
|-------------|-------------------------------------|-------------------------|----------------|
| STF20N65M5  | 710 V                               | 0.19 $\Omega$           | 18 A           |
| STFI20N65M5 |                                     |                         |                |

- Worldwide best R<sub>DS(on)</sub> \* area
- Higher V<sub>DSS</sub> rating and high dv/dt capability
- Excellent switching performance
- 100% avalanche tested

## Applications

- Switching applications

## Description

These devices are N-channel MDmesh™ V Power MOSFETs based on an innovative proprietary vertical process technology, which is combined with STMicroelectronics' well-known PowerMESH™ horizontal layout structure. The resulting product has extremely low on-resistance, which is unmatched among silicon-based Power MOSFETs, making it especially suitable for applications which require superior power density and outstanding efficiency.

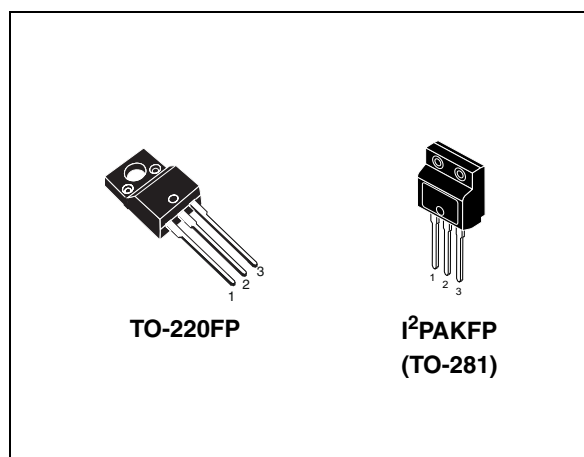


Figure 1. Internal schematic diagram

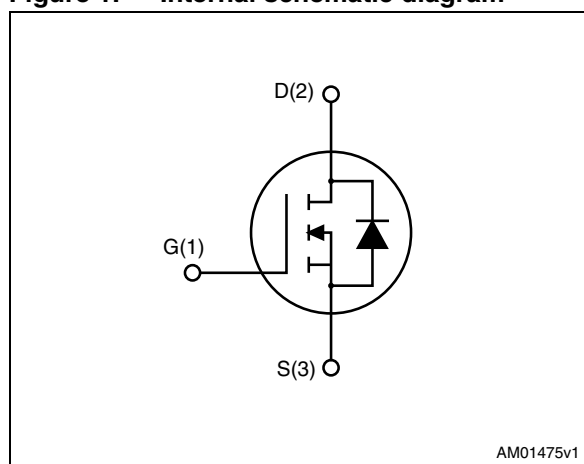


Table 1. Device summary

| Order codes | Marking | Package                       | Packaging |
|-------------|---------|-------------------------------|-----------|
| STF20N65M5  | 20N65M5 | TO-220FP                      | Tube      |
| STFI20N65M5 |         | I <sup>2</sup> PAKFP (TO-281) |           |

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol         | Parameter                                                                                                                               | Value               | Unit               |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------|---------------------|--------------------|
| $V_{GS}$       | Gate-source voltage                                                                                                                     | $\pm 25$            | V                  |
| $I_D$          | Drain current (continuous) at $T_C = 25\text{ }^{\circ}\text{C}$                                                                        | 18 <sup>(1)</sup>   | A                  |
| $I_D$          | Drain current (continuous) at $T_C = 100\text{ }^{\circ}\text{C}$                                                                       | 11.3 <sup>(1)</sup> | A                  |
| $I_{DM}^{(1)}$ | Drain current (pulsed)                                                                                                                  | 72 <sup>(1)</sup>   | A                  |
| $P_{TOT}$      | Total dissipation at $T_C = 25\text{ }^{\circ}\text{C}$                                                                                 | 30                  | W                  |
| $dv/dt^{(2)}$  | Peak diode recovery voltage slope                                                                                                       | 15                  | V/ns               |
| $V_{ISO}$      | 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                                                                                                                     | - 55 to 150         | $^{\circ}\text{C}$ |
| $T_j$          | Max. operating junction temperature                                                                                                     | 150                 | $^{\circ}\text{C}$ |

1. Limited by maximum junction temperature

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

**Table 3. Thermal data**

| Symbol         | Parameter                               | Value | Unit                        |
|----------------|-----------------------------------------|-------|-----------------------------|
| $R_{thj-case}$ | Thermal resistance junction-case max    | 4.17  | $^{\circ}\text{C}/\text{W}$ |
| $R_{thj-amb}$  | Thermal resistance junction-ambient max | 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 $T_{jmax}$ )                     | 4     | A    |
| $E_{AS}$ | Single pulse avalanche energy (starting $t_j=25^{\circ}\text{C}$ , $I_d=I_{AR}$ ; $V_{dd}=50\text{ V}$ ) | 270   | mJ   |

## 2 Electrical characteristics

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

**Table 5. On /off states**

| Symbol        | Parameter                                        | Test conditions                                                            | Min. | Typ.  | Max.      | Unit                           |
|---------------|--------------------------------------------------|----------------------------------------------------------------------------|------|-------|-----------|--------------------------------|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage                   | $I_D = 1\text{ mA}$ , $V_{GS} = 0$                                         | 650  |       |           | V                              |
| $I_{DSS}$     | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = 650\text{ V}$<br>$V_{DS} = 650\text{ V}$ , $T_C = 125\text{ °C}$ |      |       | 1<br>100  | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$     | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 25\text{ V}$                                                 |      |       | $\pm 100$ | nA                             |
| $V_{GS(th)}$  | Gate threshold voltage                           | $V_{DS} = V_{GS}$ , $I_D = 250\text{ }\mu\text{A}$                         | 3    | 4     | 5         | V                              |
| $R_{DS(on)}$  | Static drain-source on-resistance                | $V_{GS} = 10\text{ V}$ , $I_D = 9\text{ A}$                                |      | 0.160 | 0.19      | $\Omega$                       |

**Table 6. Dynamic**

| Symbol                              | Parameter                                                               | Test conditions                                                                                              | Min. | Typ.              | Max. | Unit           |
|-------------------------------------|-------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|------|-------------------|------|----------------|
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 100\text{ V}$ , $f = 1\text{ MHz}$ ,<br>$V_{GS} = 0$                                               | -    | 1434<br>38<br>3.7 | -    | pF<br>pF<br>pF |
| $C_{o(tr)}^{(1)}$                   | Equivalent capacitance time related                                     | $V_{DS} = 0\text{ to }520\text{ V}$ , $V_{GS} = 0$                                                           | -    | 118               | -    | pF             |
| $C_{o(er)}^{(2)}$                   | Equivalent capacitance energy related                                   |                                                                                                              | -    | 35                | -    | pF             |
| $R_G$                               | Intrinsic gate resistance                                               | $f = 1\text{ MHz}$ open drain                                                                                | -    | 3.5               | -    | $\Omega$       |
| $Q_g$<br>$Q_{gs}$<br>$Q_{gd}$       | Total gate charge<br>Gate-source charge<br>Gate-drain charge            | $V_{DD} = 520\text{ V}$ , $I_D = 9\text{ A}$ ,<br>$V_{GS} = 10\text{ V}$<br>(see <a href="#">Figure 16</a> ) | -    | 36<br>7.5<br>18   | -    | nC<br>nC<br>nC |

1. Time related is defined as a constant equivalent capacitance giving the same charging time as  $C_{oss}$  when  $V_{DS}$  increases from 0 to 80%  $V_{DSS}$
2. Energy related is defined as a constant equivalent capacitance giving the same stored energy as  $C_{oss}$  when  $V_{DS}$  increases from 0 to 80%  $V_{DSS}$

**Table 7. Switching times**

| Symbol       | Parameter          | Test conditions                                                                                                                                                      | Min. | Typ. | Max | Unit |
|--------------|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|-----|------|
| $t_{d(v)}$   | Voltage delay time | $V_{DD} = 400\text{ V}$ , $I_D = 12\text{ A}$ ,<br>$R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$<br>(see <a href="#">Figure 17</a> and<br><a href="#">Figure 20</a> ) | -    | 43   | -   | ns   |
| $t_{r(v)}$   | Voltage rise time  |                                                                                                                                                                      |      | 7.5  |     | ns   |
| $t_{f(i)}$   | Current fall time  |                                                                                                                                                                      |      | 7.5  |     | ns   |
| $t_{c(off)}$ | Crossing time      |                                                                                                                                                                      |      | 11.5 |     | 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            | $I_{SD} = 18\text{ A}$ , $V_{GS} = 0$                                                                                                                          | -    |      | 1.5  | V             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 18\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$<br>$V_{DD} = 100\text{ V}$ (see <a href="#">Figure 20</a> )                                        | -    | 288  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                                                |      | 4    |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                                                |      | 27   |      | A             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 18\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$<br>$V_{DD} = 100\text{ V}$ , $T_J = 150\text{ }^\circ\text{C}$<br>(see <a href="#">Figure 20</a> ) | -    | 342  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                                                |      | 4.7  |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                                                |      | 28   |      | 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

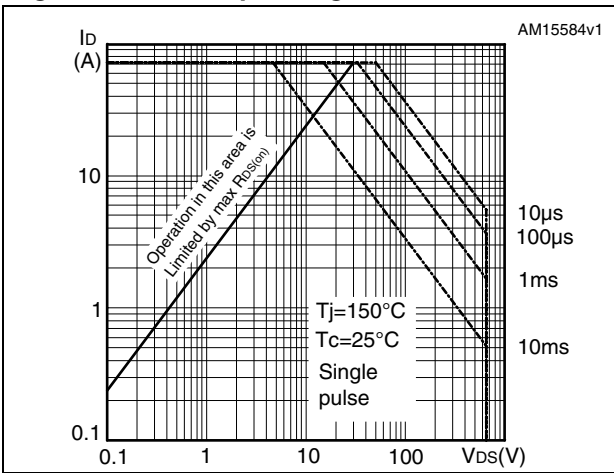


Figure 3. Thermal impedance

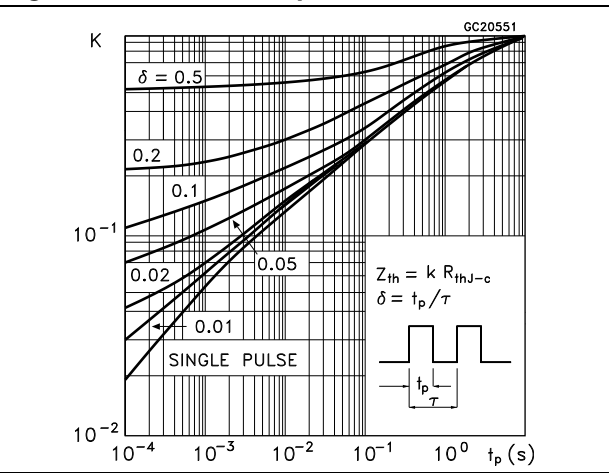


Figure 4. Output characteristics

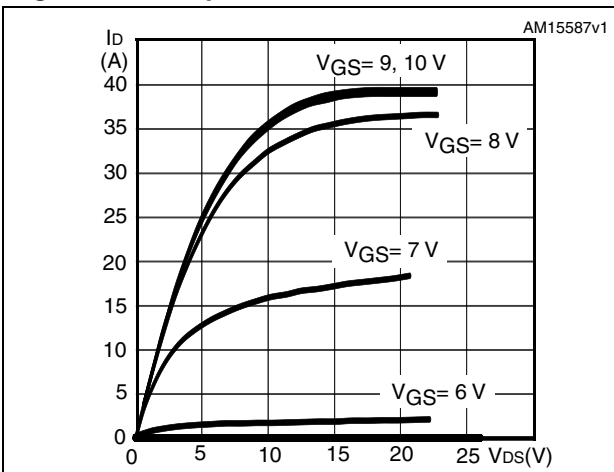


Figure 5. Transfer characteristics

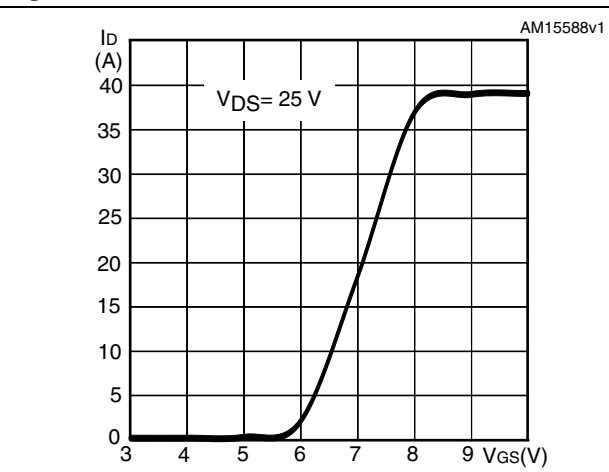


Figure 6. Gate charge vs gate-source voltage

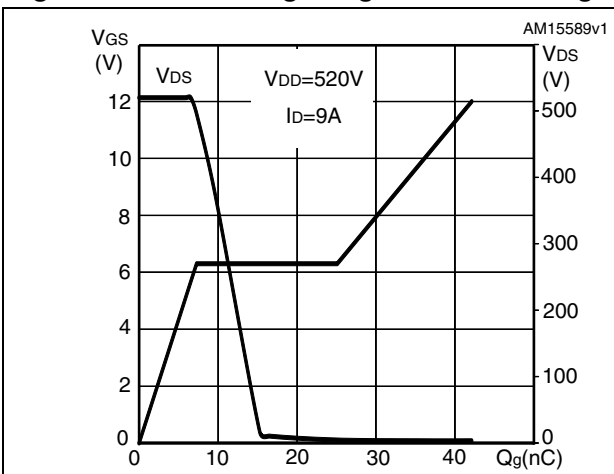


Figure 7. Static drain-source on-resistance

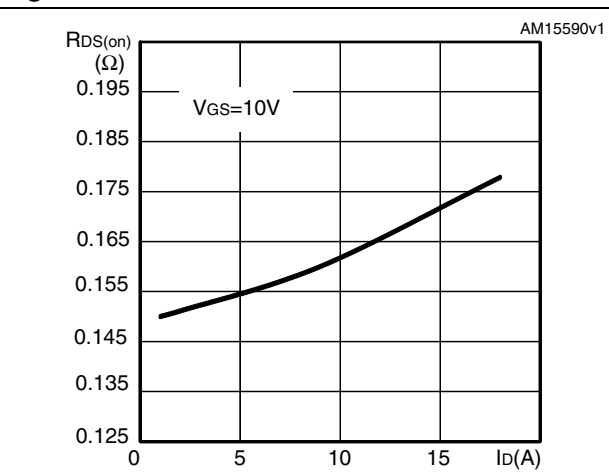


Figure 8. Capacitance variations

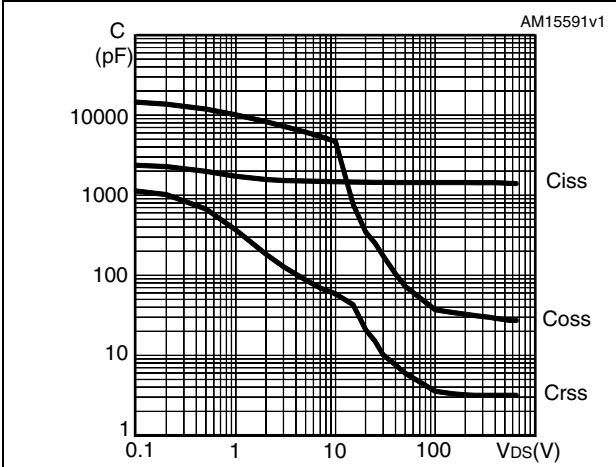


Figure 9. Output capacitance stored energy

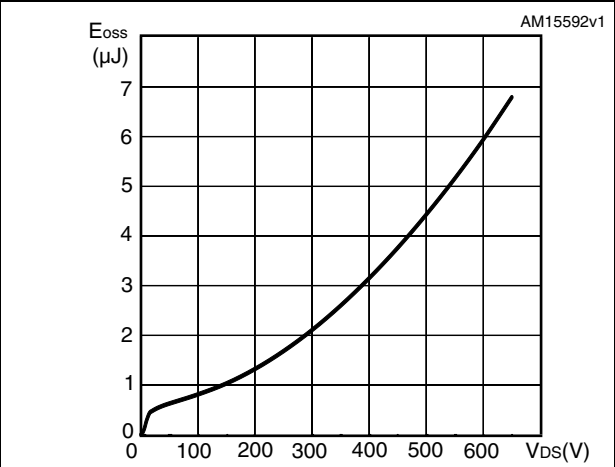


Figure 10. Normalized gate threshold voltage vs temperature

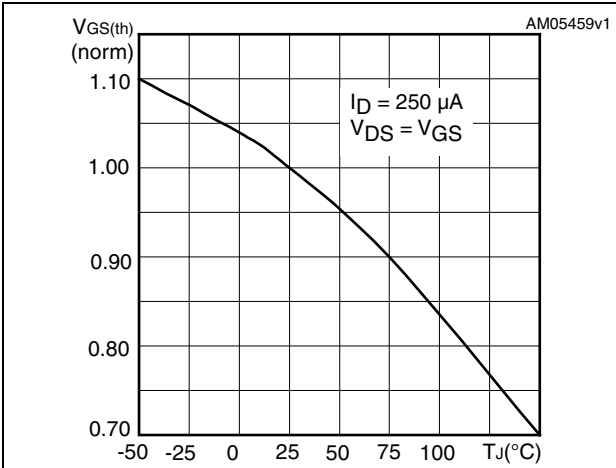


Figure 11. Normalized on-resistance vs temperature

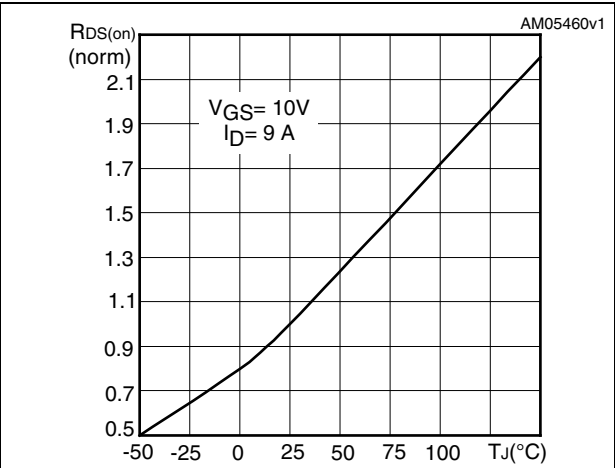


Figure 12. Normalized  $B_{V_{DS}}$  vs temperature

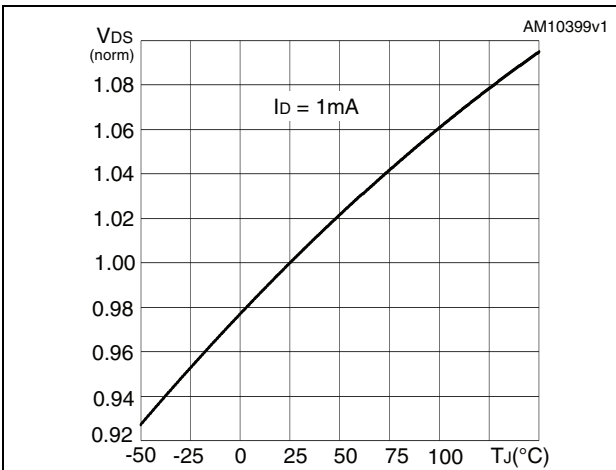
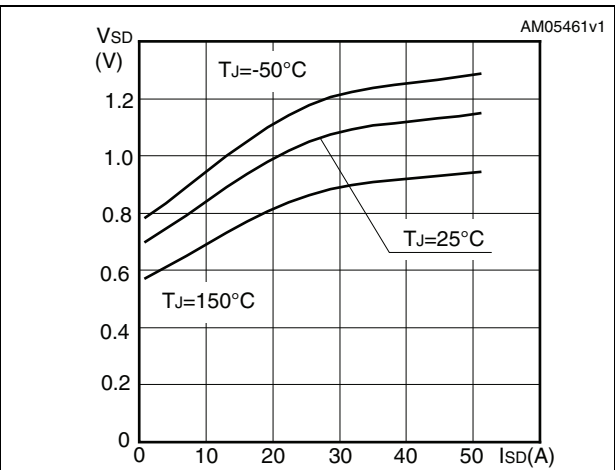
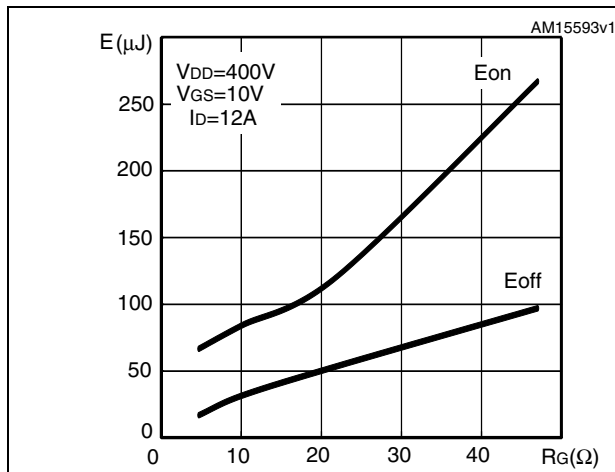


Figure 13. Drain-source diode forward characteristics



**Figure 14. Switching losses vs gate resistance**  
(1)

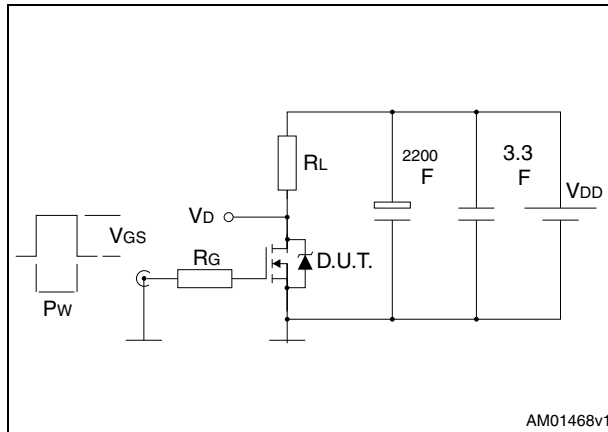


1.  $E_{on}$  including reverse recovery of a SiC diode

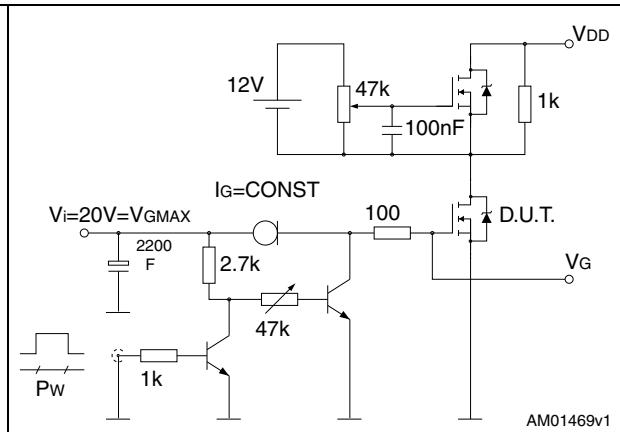


### 3 Test circuits

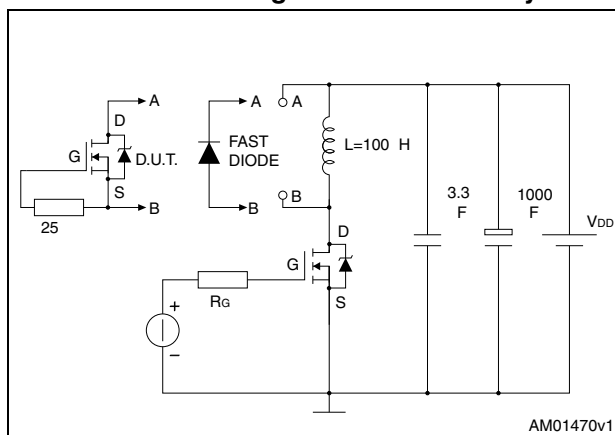
**Figure 15. Switching times test circuit for resistive load**



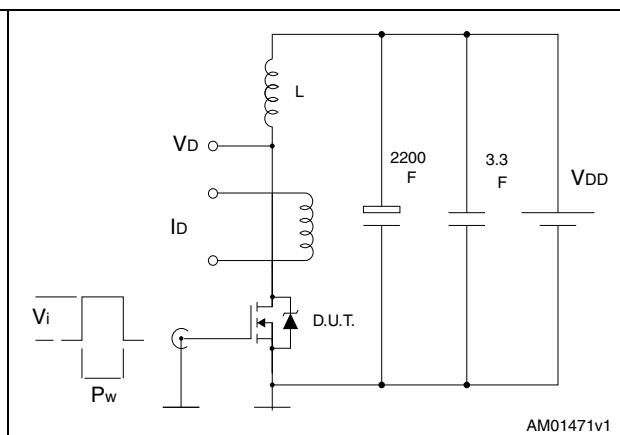
**Figure 16. Gate charge test circuit**



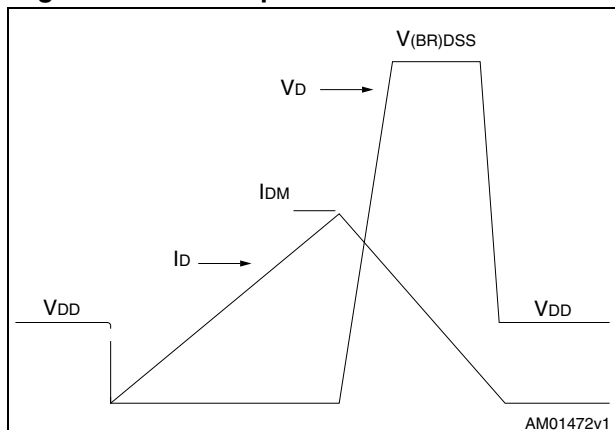
**Figure 17. Test circuit for inductive load switching and diode recovery times**



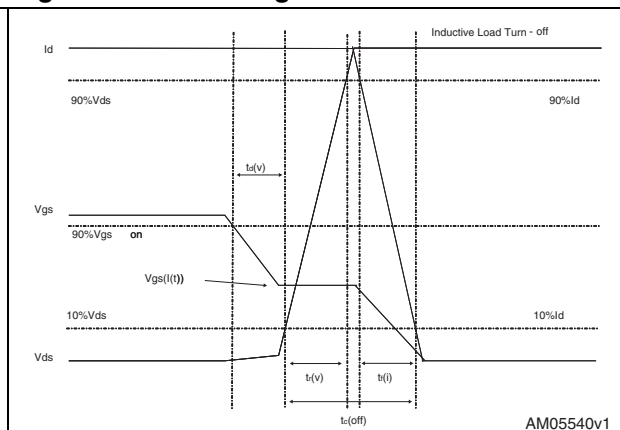
**Figure 18. Unclamped inductive load test circuit**



**Figure 19. Unclamped inductive waveform**



**Figure 20. Switching time waveform**



## 4 Package mechanical data

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

Table 9. 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  |

Figure 21. TO-220FP drawing

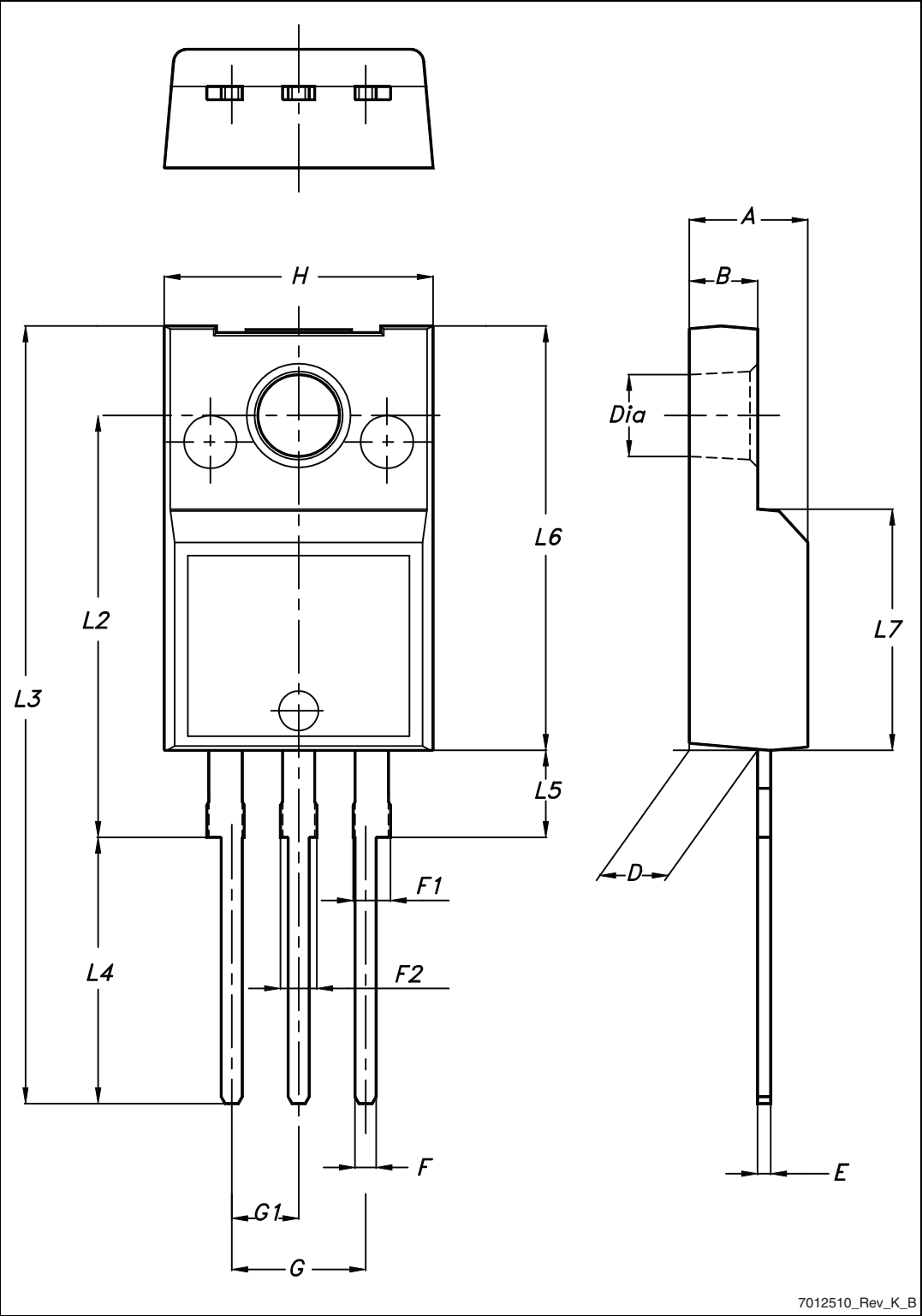
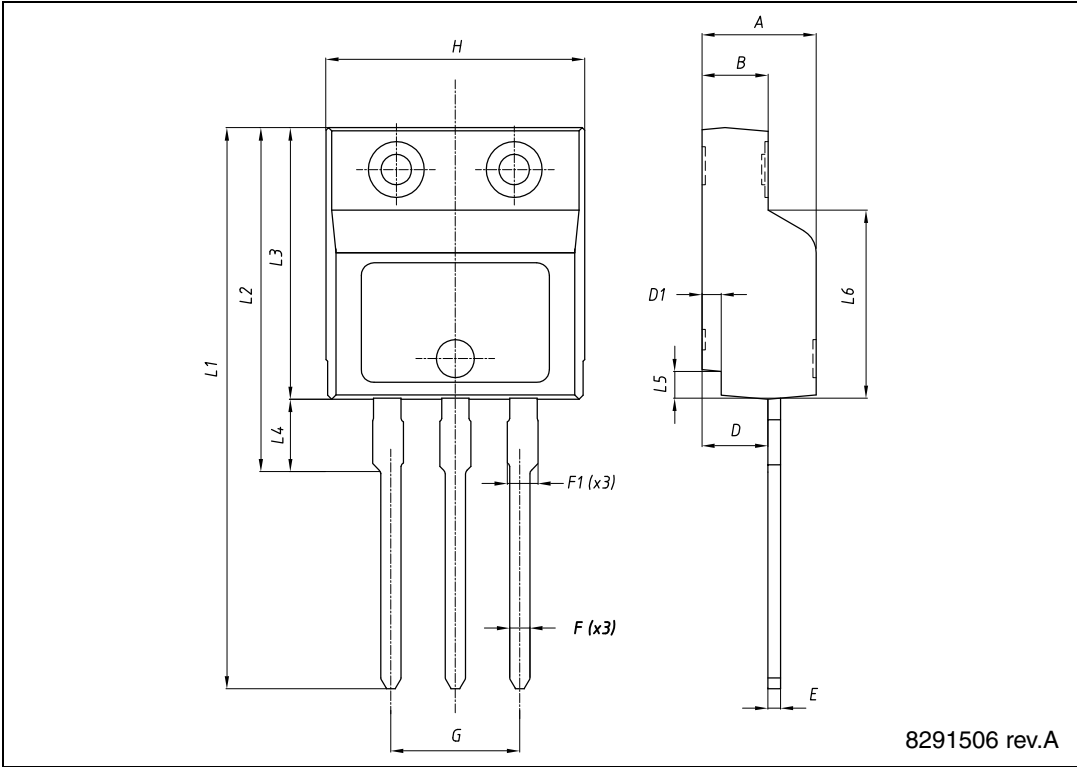


Table 10. I<sup>2</sup>PAKFP (TO-281) mechanical data

| Dim. | mm    |      |       |
|------|-------|------|-------|
|      | Min.  | Typ. | Max.  |
| A    | 4.40  | -    | 4.60  |
| B    | 2.50  |      | 2.70  |
| D    | 2.50  |      | 2.75  |
| D1   | 0.65  |      | 0.85  |
| E    | 0.45  |      | 0.70  |
| F    | 0.75  |      | 1.00  |
| F1   |       |      | 1.20  |
| G    | 4.95  |      | 5.20  |
| H    | 10.00 |      | 10.40 |
| L1   | 21.00 |      | 23.00 |
| L2   | 13.20 |      | 14.10 |
| L3   | 10.55 |      | 10.85 |
| L4   | 2.70  |      | 3.20  |
| L5   | 0.85  |      | 1.25  |
| L6   | 7.30  |      | 7.50  |

Figure 22. I<sup>2</sup>PAKFP (TO-281) drawing



## 5 Revision history

**Table 11. Document revision history**

| Date        | Revision | Changes                                                                 |
|-------------|----------|-------------------------------------------------------------------------|
| 01-Feb-2013 | 1        | First release. Part numbers previously included in datasheet DM00049308 |

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