



# STW60N65M5 STFW60N65M5

N-channel 650 V, 0.049  $\Omega$ , 46 A MDmesh™ V Power MOSFET  
in TO-247, TO-3PF

## Features

| Order codes               | V <sub>DSS</sub> @<br>T <sub>Jmax</sub> | R <sub>DS(on)</sub><br>max | I <sub>D</sub> |
|---------------------------|---|----------------------------|----------------|
| STFW60N65M5<br>STW60N65M5 | 710 V                                   | < 0.059 $\Omega$           | 46 A           |

- Worldwide best R<sub>DS(on)</sub> \* area amongst the silicon based devices
- Higher V<sub>DSS</sub> rating
- High dv/dt capability
- Excellent switching performance
- Easy to drive
- 100% avalanche tested

## Application

Switching applications

## Description

The devices are N-channel MDmesh™ V Power MOSFET 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.

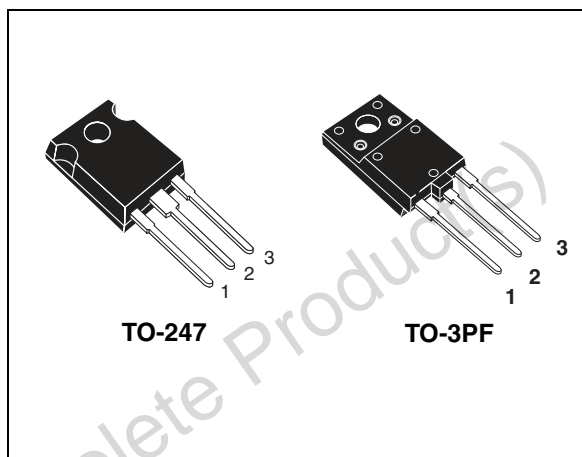


Figure 1. Internal schematic diagram

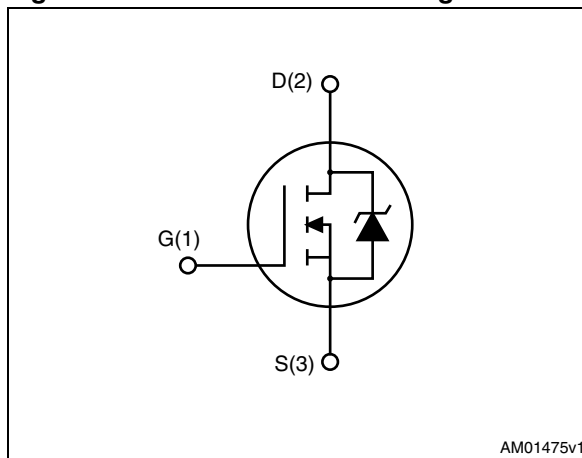


Table 1. Device summary

| Order codes               | Marking | Package          | Packaging |
|---------------------------|---------|------------------|-----------|
| STFW60N65M5<br>STW60N65M5 | 60N65M5 | TO-3PF<br>TO-247 | Tube      |

# Contents

|          |   |           |
|----------|---|-----------|
| <b>1</b> | <b>Electrical ratings</b> .....           | <b>3</b>  |
| <b>2</b> | <b>Electrical characteristics</b> .....   | <b>4</b>  |
| 2.1      | Electrical characteristics (curves) ..... | 6         |
| <b>3</b> | <b>Test circuits</b> .....                | <b>9</b>  |
| <b>4</b> | <b>Package mechanical data</b> .....      | <b>10</b> |
| <b>5</b> | <b>Revision history</b> .....             | <b>15</b> |

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol         | Parameter   | Value       |        | Unit |
|----------------|---|-------------|--------|------|
|                |   | TO-247      | TO-3PF |      |
| $V_{GS}$       | Gate-source voltage   | ± 25        |        | V    |
| $I_D$          | Drain current (continuous) at $T_C = 25\text{ °C}$  | 46          |        | A    |
| $I_D$          | Drain current (continuous) at $T_C = 100\text{ °C}$   | 29          |        | A    |
| $I_{DM}^{(1)}$ | Drain current (pulsed)  | 184         |        | A    |
| $P_{TOT}$      | Total dissipation at $T_C = 25\text{ °C}$   | 255         | 79     | W    |
| $I_{AR}$       | Avalanche current, repetitive or not-repetitive (pulse width limited by $T_j$ max)                            | 12          |        | A    |
| $E_{AS}$       | Single pulse avalanche energy (starting $T_j = 25\text{ °C}$ , $I_D = I_{AR}$ , $V_{DD} = 50\text{ V}$ )      | 1400        |        | mJ   |
| $dv/dt^{(2)}$  | Peak diode recovery voltage slope   | 15          |        | V/ns |
| $V_{ISO}$      | Insulation withstand voltage (RMS) from all three leads to external heat sink ( $t=1s$ ; $T_c=25\text{ °C}$ ) | 3500        |        | V    |
| $T_{stg}$      | Storage temperature   | - 55 to 150 |        | °C   |
| $T_j$          | Max. operating junction temperature   | 150         |        | °C   |

1. Pulse width limited by safe operating area

2.  $I_{SD} \leq 46\text{ A}$ ,  $di/dt \leq 400\text{ A}/\mu\text{s}$ ,  $V_{DD} = 400\text{ V}$ ,  $V_{Peak} < V_{(BR)DSS}$

**Table 3. Thermal data**

| Symbol         | Parameter                                      | Value  |        | Unit |
|----------------|--|--------|--------|------|
|                |  | TO-247 | TO-3PF |      |
| $R_{thj-case}$ | Thermal resistance junction-case max           | 0.49   | 1.58   | °C/W |
| $R_{thj-amb}$  | Thermal resistance junction-ambient max        | 50     |        | °C/W |
| $T_l$          | Maximum lead temperature for soldering purpose | 300    |        | °C   |

## 2 Electrical characteristics

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

**Table 4. 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 ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max rating}$<br>$V_{DS} = \text{Max rating}$ , $T_C = 125\text{ °C}$ |      |       | 1<br>100 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$     | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 25\text{ V}$   |      |       | 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                | $V_{GS} = 10\text{ V}$ , $I_D = 23\text{ A}$   |      | 0.049 | 0.059    | $\Omega$                       |

**Table 5. Dynamic**

| Symbol            | Parameter                             | Test conditions   | Min. | Typ. | Max. | Unit     |
|-------------------|---------------------------------------|---|------|------|------|----------|
| $C_{iss}$         | Input capacitance                     | $V_{DS} = 100\text{ V}$ , $f = 1\text{ MHz}$ ,<br>$V_{GS} = 0$  | -    | 6810 | -    | pF       |
| $C_{oss}$         | Output capacitance                    |   |      | 141  |      | pF       |
| $C_{rss}$         | Reverse transfer capacitance          |   |      | 6.2  |      | pF       |
| $C_{o(tr)}^{(1)}$ | Equivalent capacitance time related   | $V_{DS} = 0\text{ to }520\text{ V}$ , $V_{GS} = 0$  | -    | 480  | -    | pF       |
| $C_{o(er)}^{(2)}$ | Equivalent capacitance energy related |   |      | 140  |      | pF       |
| $R_G$             | Intrinsic gate resistance             | $f = 1\text{ MHz}$ open drain   | -    | 1    | -    | $\Omega$ |
| $Q_g$             | Total gate charge                     | $V_{DD} = 520\text{ V}$ , $I_D = 23\text{ A}$ ,<br>$V_{GS} = 10\text{ V}$<br>(see <a href="#">Figure 17</a> ) | -    | 139  | -    | nC       |
| $Q_{gs}$          | Gate-source charge                    |   |      | 34   |      | nC       |
| $Q_{gd}$          | Gate-drain charge                     |   |      | 52   |      | nC       |

- $C_{o(tr)}$  is a constant capacitance value that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{DSS}$ .
- $C_{o(er)}$  is a constant capacitance value that gives the same stored energy as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{DSS}$ .

**Table 6. Switching times**

| Symbol      | Parameter          | Test conditions                                 | Min. | Typ. | Max | Unit |
|-------------|--------------------|---|------|------|-----|------|
| $t_d$ (v)   | Voltage delay time | $V_{DD} = 400\text{ V}$ , $I_D = 30\text{ A}$ , |      | 90   |     | ns   |
| $t_r$ (v)   | Voltage rise time  | $R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$    |      | 11   |     | ns   |
| $t_f$ (i)   | Current fall time  | (see <a href="#">Figure 18</a> )                | -    | 13   | -   | ns   |
| $t_c$ (off) | Crossing time      | (see <a href="#">Figure 21</a> )                |      | 16   |     | ns   |

**Table 7. Source drain diode**

| Symbol          | Parameter                     | Test conditions   | Min. | Typ. | Max. | Unit          |
|-----------------|-------------------------------|---|------|------|------|---------------|
| $I_{SD}$        | Source-drain current          |   |      |      | 46   | A             |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |   | -    |      | 184  | A             |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD} = 46\text{ A}$ , $V_{GS} = 0$                       | -    |      | 1.5  | V             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 46\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ |      | 448  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       | $V_{DD} = 100\text{ V}$ (see <a href="#">Figure 21</a> )    | -    | 10   |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |   |      | 45   |      | A             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 46\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ |      | 534  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       | $V_{DD} = 100\text{ V}$ , $T_j = 150\text{ }^\circ\text{C}$ | -    | 14   |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      | (see <a href="#">Figure 21</a> )                            |      | 52   |      | 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-3FP

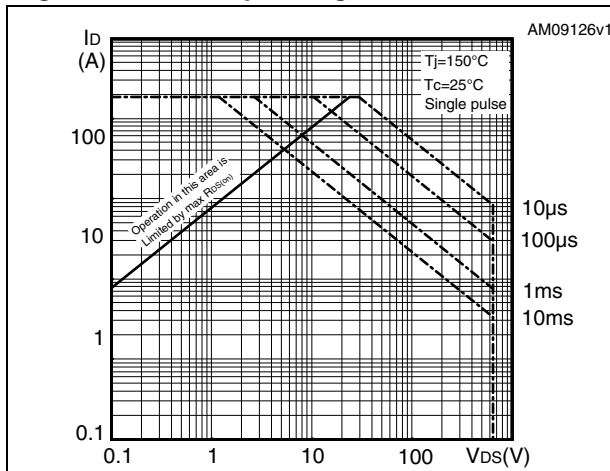


Figure 3. Thermal impedance for TO-3FP

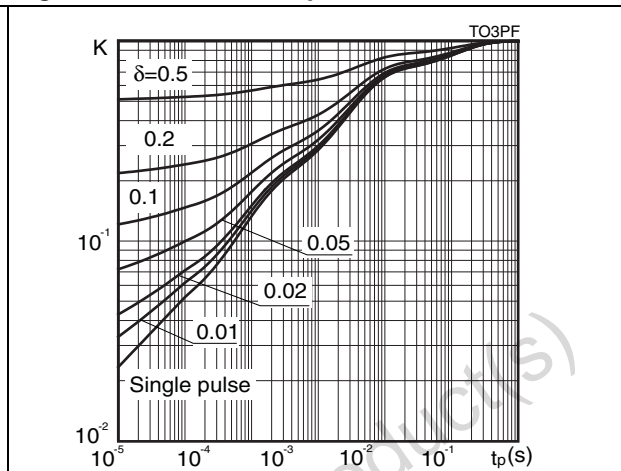


Figure 4. Safe operating area for TO-247

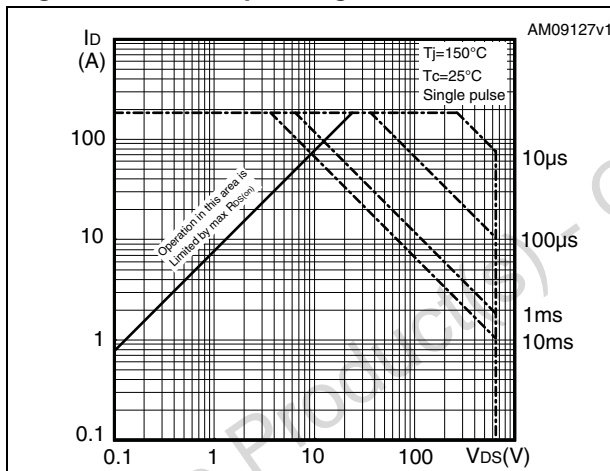


Figure 5. Thermal impedance for TO-247

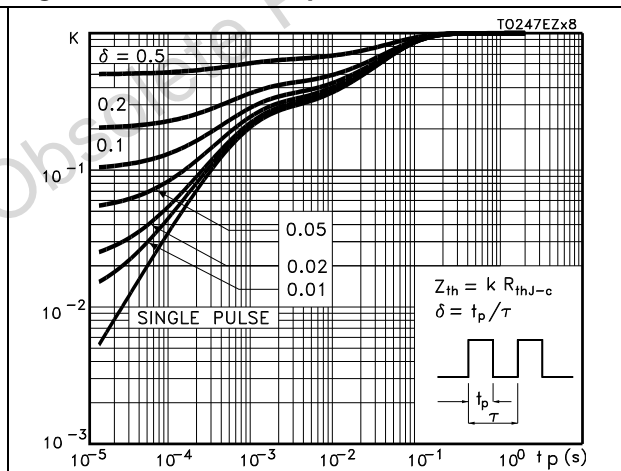


Figure 6. Output characteristics

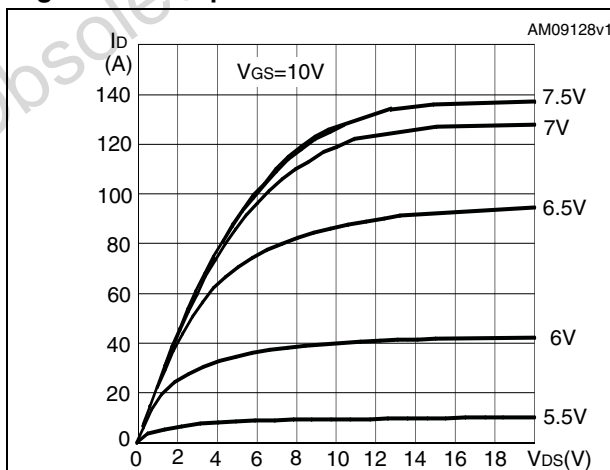


Figure 7. Transfer characteristics

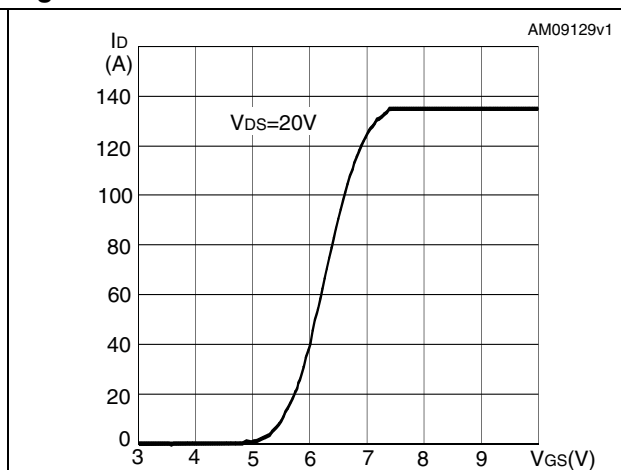


Figure 8. Gate charge vs gate-source voltage Figure 9. Static drain-source on resistance

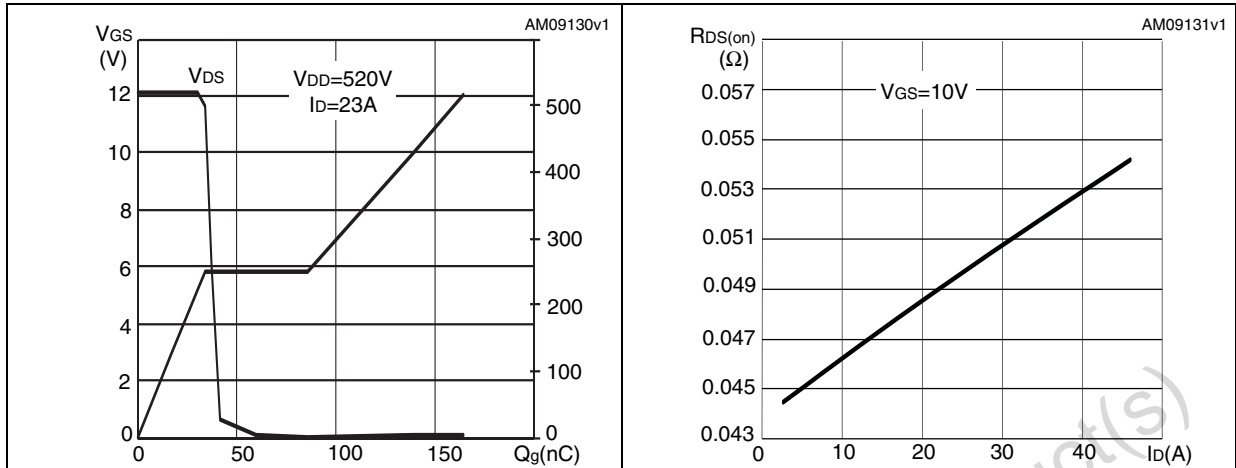


Figure 10. Capacitance variations Figure 11. Output capacitance stored energy

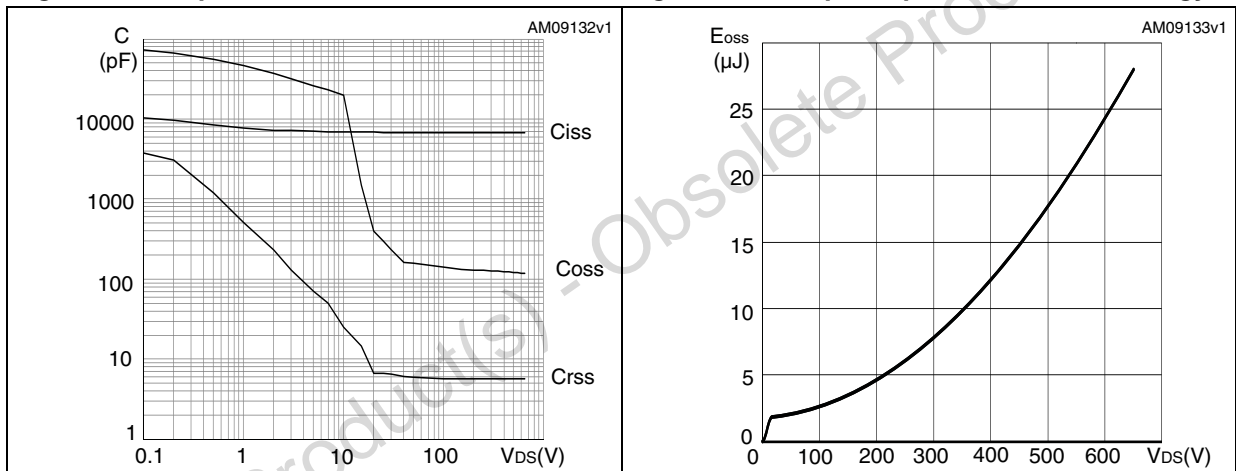


Figure 12. Normalized gate threshold voltage vs temperature Figure 13. Normalized on resistance vs temperature

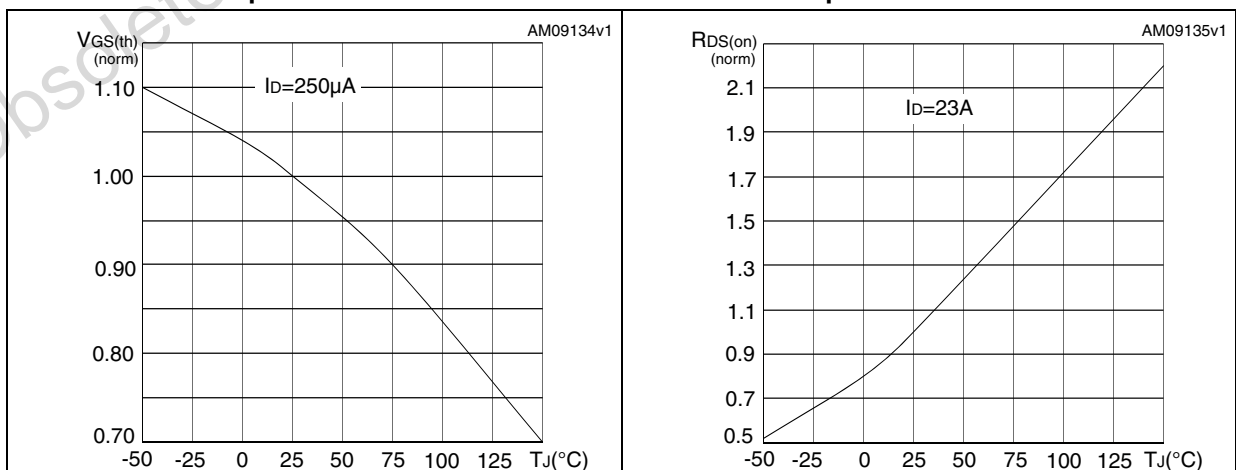
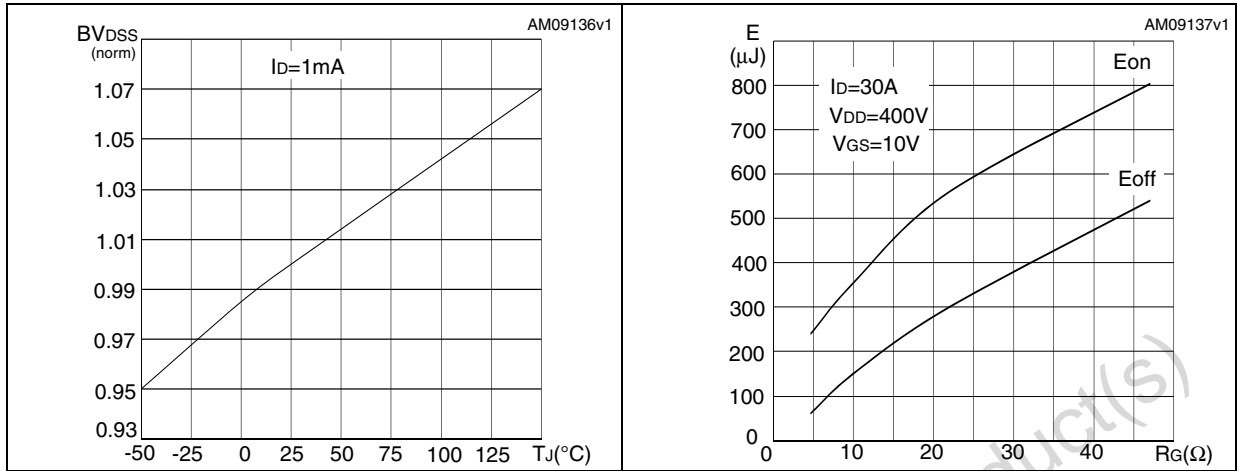


Figure 14. Normalized  $B_{VDSS}$  vs temperature

Figure 15. Switching losses vs gate resistance (1)



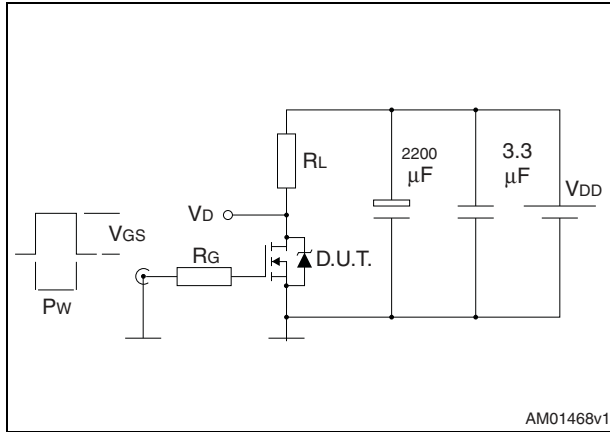
1.  $E_{on}$  including reverse recovery of a SiC diode

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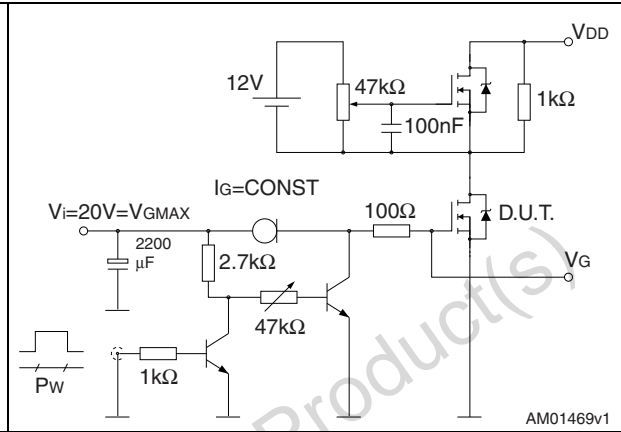
### 3 Test circuits

Figure 16. Switching times test circuit for resistive load



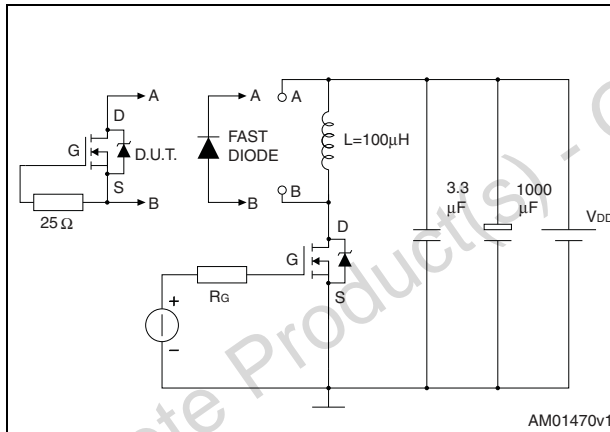
AM01468v1

Figure 17. Gate charge test circuit



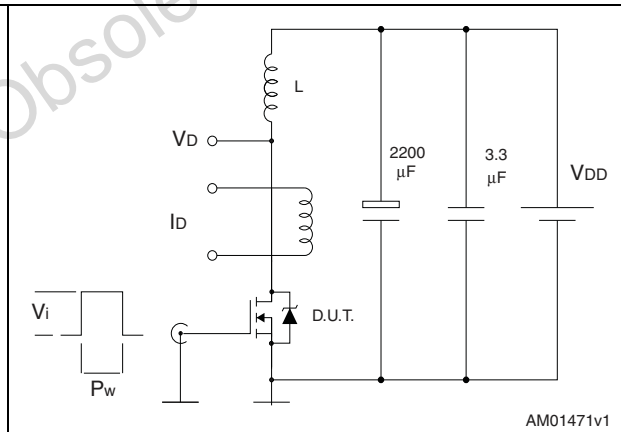
AM01469v1

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



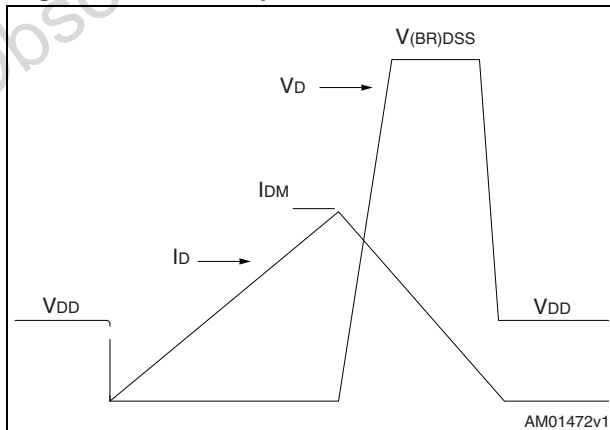
AM01470v1

Figure 19. Unclamped inductive load test circuit



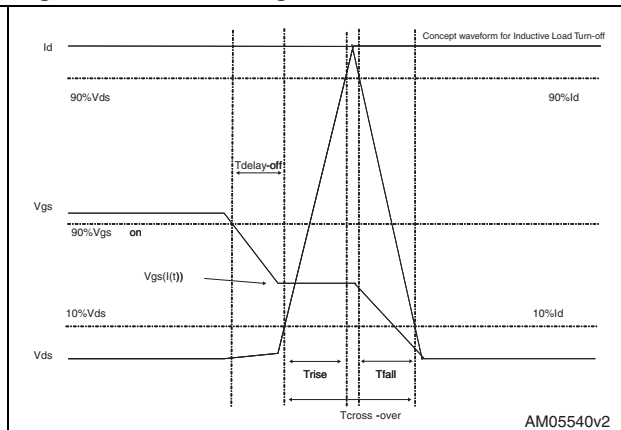
AM01471v1

Figure 20. Unclamped inductive waveform



AM01472v1

Figure 21. Switching time waveform



AM05540v2

## 4 Package mechanical data

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.

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Table 8. TO-3PF mechanical data

| Dim. | mm    |      |       |
|------|-------|------|-------|
|      | Min.  | Typ. | Max.  |
| A    | 5.30  |      | 5.70  |
| C    | 2.80  |      | 3.20  |
| D    | 3.10  |      | 3.50  |
| D1   | 1.80  |      | 2.20  |
| E    | 0.80  |      | 1.10  |
| F    | 0.65  |      | 0.95  |
| F2   | 1.80  |      | 2.20  |
| G    | 10.30 |      | 11.50 |
| G1   |       | 5.45 |       |
| H    | 15.30 |      | 15.70 |
| L    | 9.80  | 10   | 10.20 |
| L2   | 22.80 |      | 23.20 |
| L3   | 26.30 |      | 26.70 |
| L4   | 43.20 |      | 44.40 |
| L5   | 4.30  |      | 4.70  |
| L6   | 24.30 |      | 24.70 |
| L7   | 14.60 |      | 15    |
| N    | 1.80  |      | 2.20  |
| R    | 3.80  |      | 4.20  |
| Dia  | 3.40  |      | 3.80  |

Figure 22. TO-3PF drawing

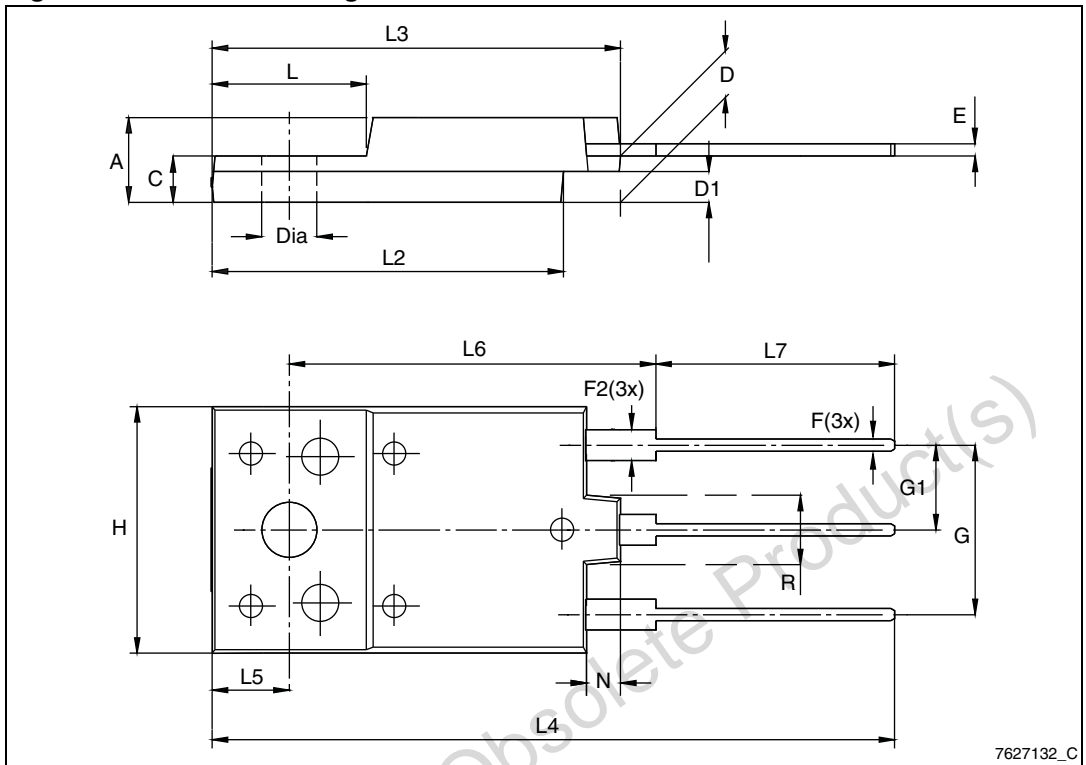
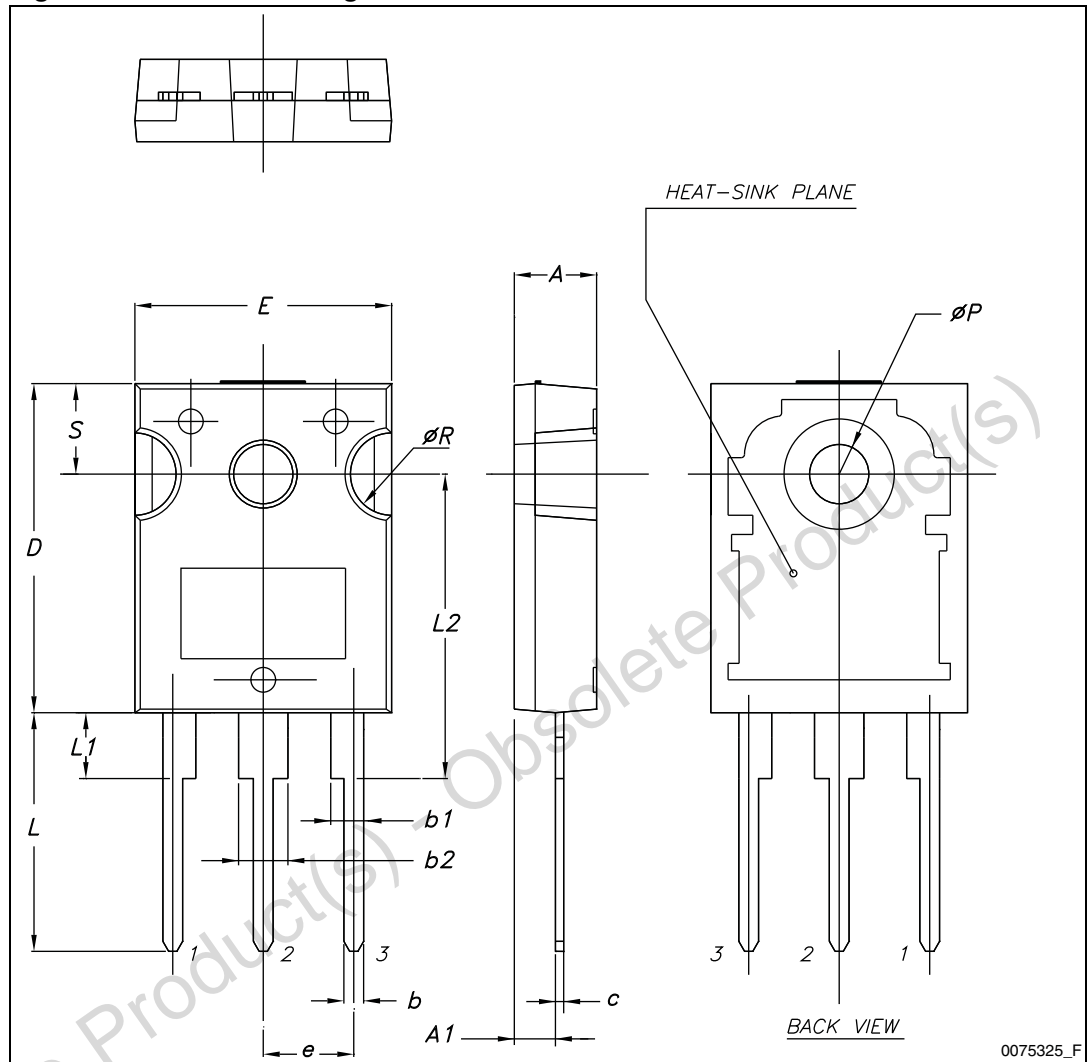


Table 9. TO-247 mechanical data

| Dim. | mm    |       |       |
|------|-------|-------|-------|
|      | Min.  | Typ.  | Max.  |
| A    | 4.85  |       | 5.15  |
| A1   | 2.20  |       | 2.60  |
| b    | 1.0   |       | 1.40  |
| b1   | 2.0   |       | 2.40  |
| b2   | 3.0   |       | 3.40  |
| c    | 0.40  |       | 0.80  |
| D    | 19.85 |       | 20.15 |
| E    | 15.45 |       | 15.75 |
| e    |       | 5.45  |       |
| L    | 14.20 |       | 14.80 |
| L1   | 3.70  |       | 4.30  |
| L2   |       | 18.50 |       |
| ØP   | 3.55  |       | 3.65  |
| ØR   | 4.50  |       | 5.50  |
| S    |       | 5.50  |       |

Figure 23. TO-247 drawing



0075325\_F

## 5 Revision history

Table 10. Document revision history

| Date        | Revision | Changes  |
|-------------|----------|--|
| 15-Nov-2010 | 1        | First release.   |
| 05-May-2011 | 2        | Document status promoted from preliminary data to datasheet. |

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