

## Automotive-grade N-channel 650 V, 0.024 $\Omega$ typ., 69 A, MDmesh™ V Power MOSFET in a TO-247 package

Datasheet - production data

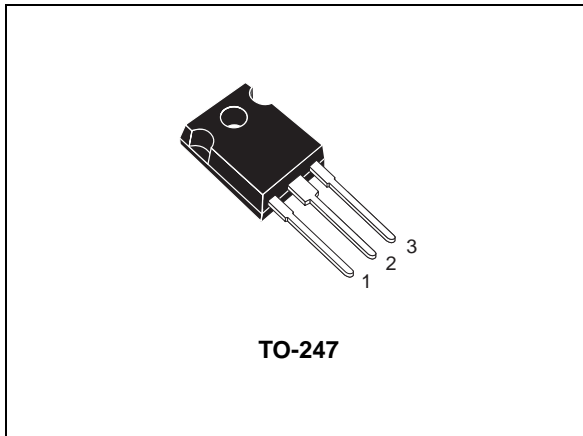
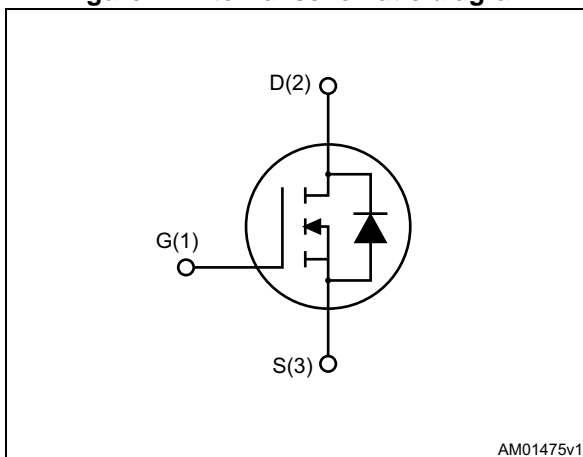


Figure 1. Internal schematic diagram



### Features

| Order code | $V_{DS} @ T_{jmax.}$ | $R_{DS(on) max.}$ | $I_D$ |
|------------|----------------------|-------------------|-------|
| STW78N65M5 | 710 V                | 0.032 $\Omega$    | 69 A  |

- Designed for automotive applications and AEC-Q101 qualified
- Higher  $V_{DSS}$  rating
- Higher dv/dt capability
- Excellent switching performance
- Easy to drive
- 100% avalanche tested

### Applications

- Switching applications

### Description

This device is an 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.

Table 1. Device summary

| Order code | Marking | Package | Packaging |
|------------|---------|---------|-----------|
| STW78N65M5 | 78N65M5 | TO-247  | Tube      |

# 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                |
| $I_D$          | Drain current (continuous) at $T_C = 25\text{ }^\circ\text{C}$  | 69          | A                |
| $I_D$          | Drain current (continuous) at $T_C = 100\text{ }^\circ\text{C}$ | 41.5        | A                |
| $I_{DM}^{(1)}$ | Drain current (pulsed)  | 276         | A                |
| $P_{TOT}$      | Total dissipation at $T_C = 25\text{ }^\circ\text{C}$           | 450         | W                |
| $dv/dt^{(2)}$  | Peak diode recovery voltage slope                               | 15          | V/ns             |
| $dv/dt^{(3)}$  | MOSFET $dv/dt$ ruggedness                                       | 50          | V/ns             |
| $T_{stg}$      | Storage temperature   | - 55 to 150 | $^\circ\text{C}$ |
| $T_j$          | Max. operating junction temperature                             | 150         | $^\circ\text{C}$ |

1. Pulse width limited by safe operating area

2.  $I_{SD} \leq 69\text{ A}$ ,  $di/dt = 400\text{ A}/\mu\text{s}$ ,  $V_{DS\text{ peak}} < V_{(BR)DSS}$ ,  $V_{DD} = 400\text{ V}$

3.  $V_{DS} \leq 520\text{ V}$

**Table 3. Thermal data**

| Symbol                | Parameter                               | Value | Unit                      |
|-----------------------|---|-------|---------------------------|
| $R_{thj\text{-case}}$ | Thermal resistance junction-case max    | 0.28  | $^\circ\text{C}/\text{W}$ |
| $R_{thj\text{-amb}}$  | Thermal resistance junction-ambient max | 50    | $^\circ\text{C}/\text{W}$ |

**Table 4. Avalanche characteristics**

| Symbol   | Parameter  | Value | Unit |
|----------|--|-------|------|
| $I_{AR}$ | Max current during repetitive or single pulse avalanche (pulse width limited by $T_{JMAX}$ )                         | 15    | A    |
| $E_{AS}$ | Single pulse avalanche energy (starting $T_j = 25\text{ }^\circ\text{C}$ , $I_D = I_{AR}$ , $V_{DD} = 50\text{ V}$ ) | 2000  | 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 ( $V_{GS} = 0$ )  | $I_D = 1\text{ mA}$   | 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                | $V_{GS} = 10\text{ V}, I_D = 34.5\text{ A}$                             |      | 0.024 | 0.032     | $\Omega$                       |

**Table 6. Dynamic**

| Symbol            | Parameter                             | Test conditions   | Min. | Typ. | Max. | Unit     |
|-------------------|---------------------------------------|---|------|------|------|----------|
| $C_{iss}$         | Input capacitance                     | $V_{DS} = 100\text{ V}, f = 1\text{ MHz},$<br>$V_{GS} = 0$  | -    | 9000 | -    | pF       |
| $C_{oss}$         | Output capacitance                    |   | -    | 210  | -    | pF       |
| $C_{rss}$         | Reverse transfer capacitance          |   | -    | 9    | -    | pF       |
| $C_{o(tr)}^{(1)}$ | Equivalent capacitance time related   | $V_{GS} = 0, V_{DS} = 0\text{ to }520\text{ V}$   | -    | 768  | -    | pF       |
| $C_{o(er)}^{(2)}$ | Equivalent capacitance energy related | $V_{GS} = 0, V_{DS} = 0\text{ to }520\text{ V}$   | -    | 205  | -    | pF       |
| $R_G$             | Intrinsic gate resistance             | $f = 1\text{ MHz open drain}$   | -    | 1.5  | -    | $\Omega$ |
| $Q_g$             | Total gate charge                     | $V_{DD} = 520\text{ V}, I_D = 34.5\text{ A},$<br>$V_{GS} = 10\text{ V}$<br>(see <a href="#">Figure 16</a> ) | -    | 203  | -    | nC       |
| $Q_{gs}$          | Gate-source charge                    |   | -    | 50   | -    | nC       |
| $Q_{gd}$          | Gate-drain charge                     |   | -    | 84   | -    | 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 7. Switching times

| Symbol       | Parameter          | Test conditions   | Min. | Typ. | Max. | Unit |
|--------------|--------------------|---|------|------|------|------|
| $t_{d(V)}$   | Voltage delay time | $V_{DD} = 400\text{ V}$ , $I_D = 40\text{ A}$ ,<br>$R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$<br>(see <a href="#">Figure 17</a> )<br>(see <a href="#">Figure 20</a> ) | -    | 163  | -    | ns   |
| $t_{r(V)}$   | Voltage rise time  |   | -    | 14   | -    | ns   |
| $t_{f(i)}$   | Current fall time  |   | -    | 14   | -    | ns   |
| $t_{c(off)}$ | Crossing time      |   | -    | 26   | -    | ns   |

Table 8. Source drain diode

| Symbol          | Parameter                     | Test conditions   | Min. | Typ. | Max. | Unit          |
|-----------------|-------------------------------|---|------|------|------|---------------|
| $I_{SD}$        | Source-drain current          |   | -    |      | 69   | A             |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |   | -    |      | 276  | A             |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD} = 69\text{ A}$ , $V_{GS} = 0$   | -    |      | 1.5  | V             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 69\text{ A}$ ,<br>$di/dt = 100\text{ A}/\mu\text{s}$  | -    | 504  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |   | -    | 13   |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      | $V_{DD} = 100\text{ V}$ (see <a href="#">Figure 17</a> )  | -    | 49   |      | A             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 69\text{ A}$ ,<br>$di/dt = 100\text{ A}/\mu\text{s}$<br>$V_{DD} = 100\text{ V}$ , $T_j = 150\text{ }^\circ\text{C}$<br>(see <a href="#">Figure 17</a> ) | -    | 635  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |   | -    | 19   |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |   | -    | 59   |      | 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

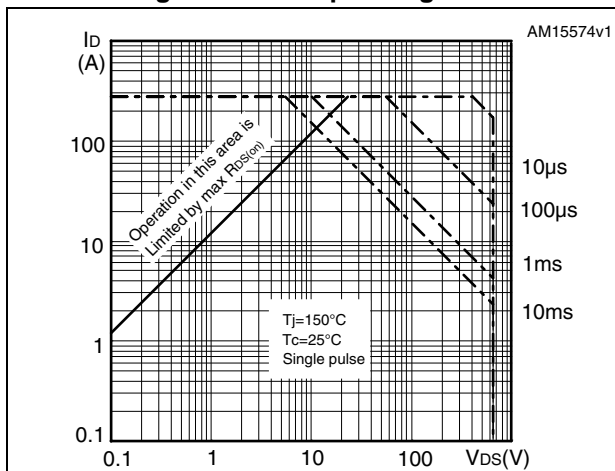


Figure 3. Thermal impedance

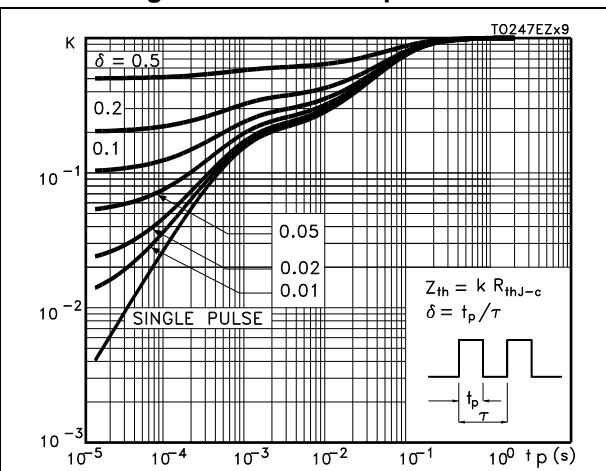


Figure 4. Output characteristics

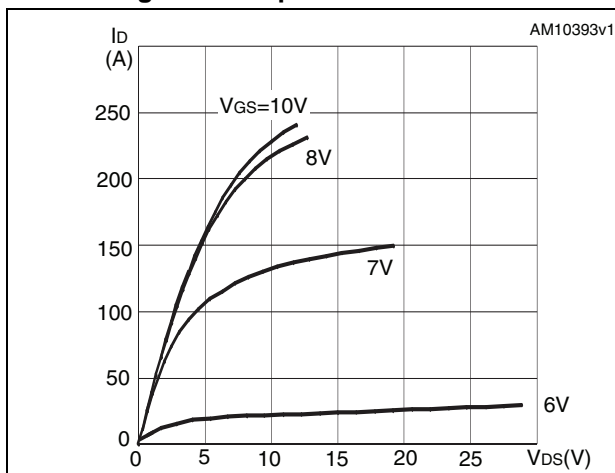


Figure 5. Transfer characteristics

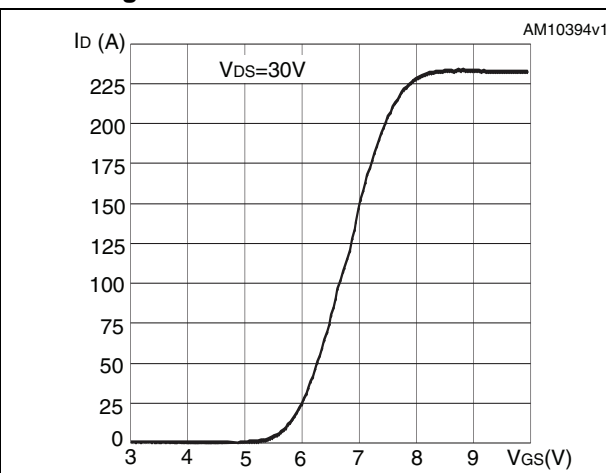


Figure 6. Gate charge vs gate-source voltage

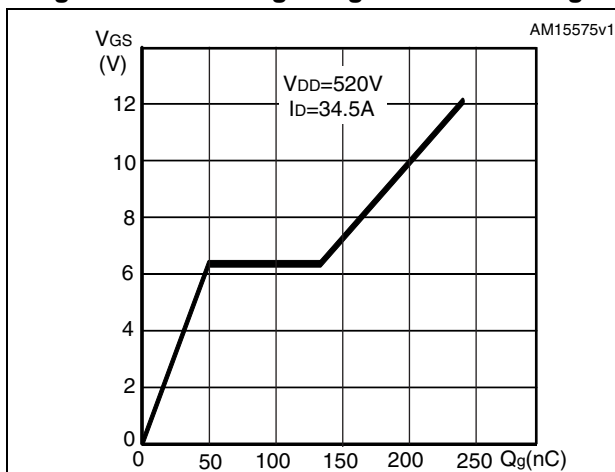


Figure 7. Static drain-source on-resistance

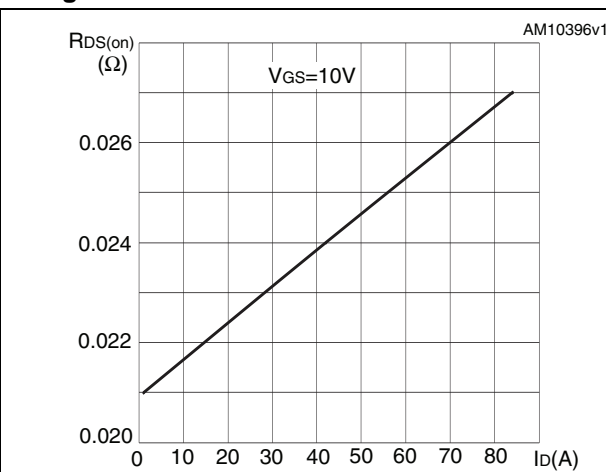


Figure 8. Capacitance variations

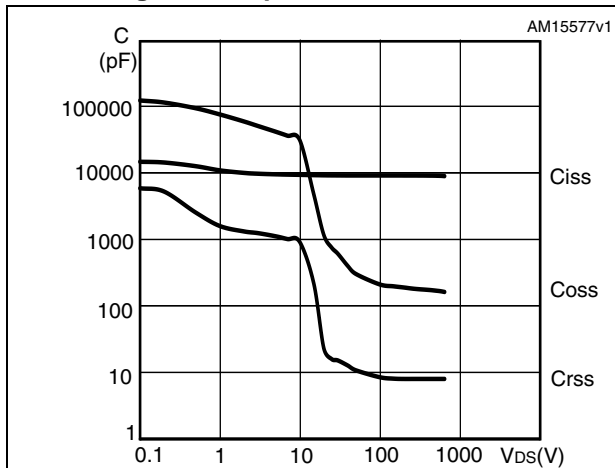


Figure 9. Output capacitance stored energy

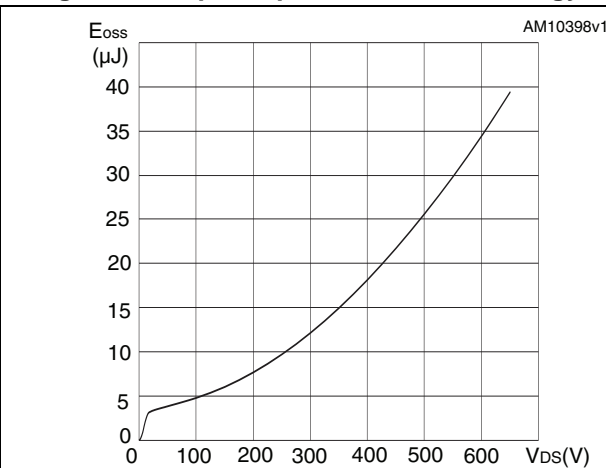


Figure 10. Normalized gate threshold voltage vs temperature

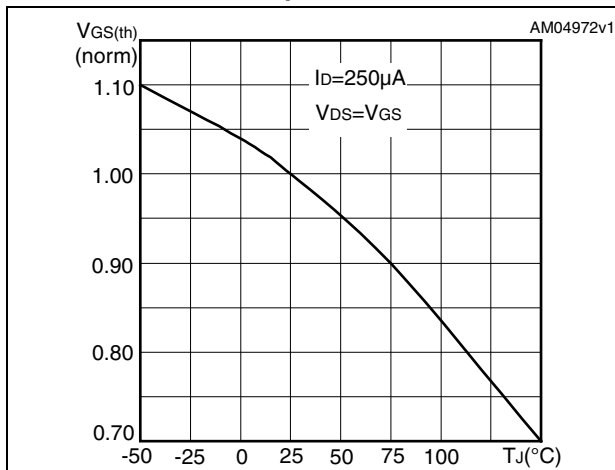


Figure 11. Normalized on-resistance vs temperature

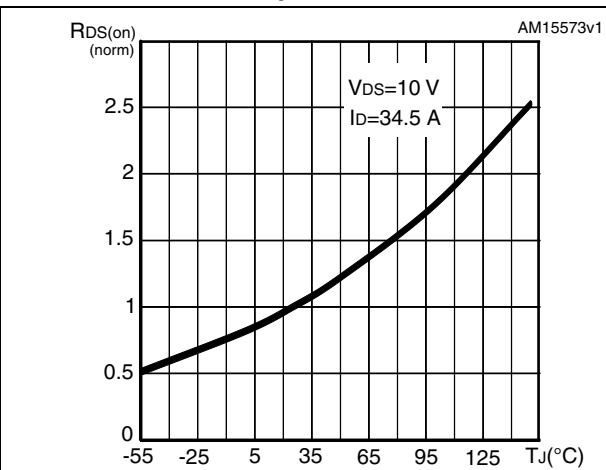


Figure 12. Source-drain diode forward characteristics

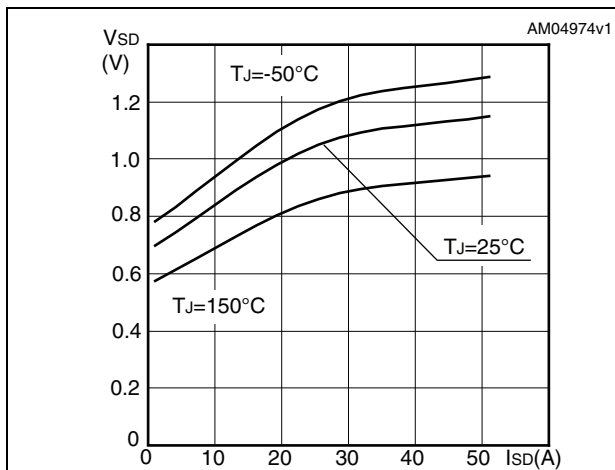


Figure 13. Normalized VDS vs temperature

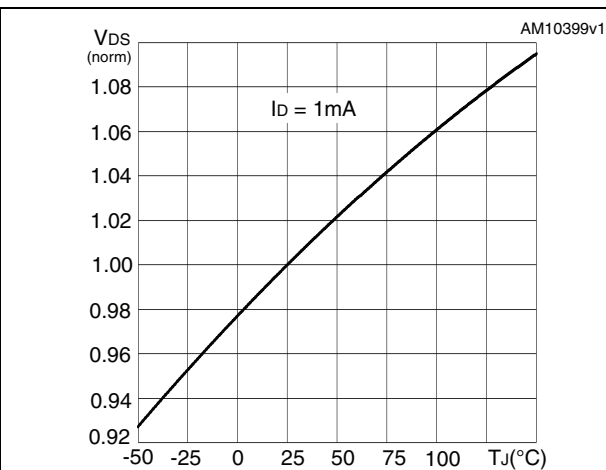
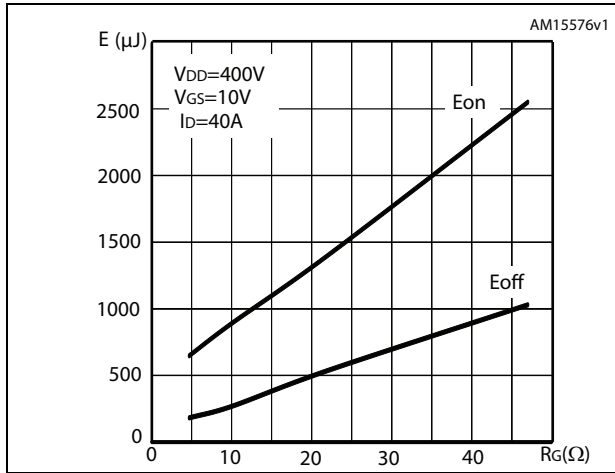


Figure 14. Switching losses vs gate resistance (1)



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



### 3 Test circuits

Figure 15. Switching times test circuit for resistive load



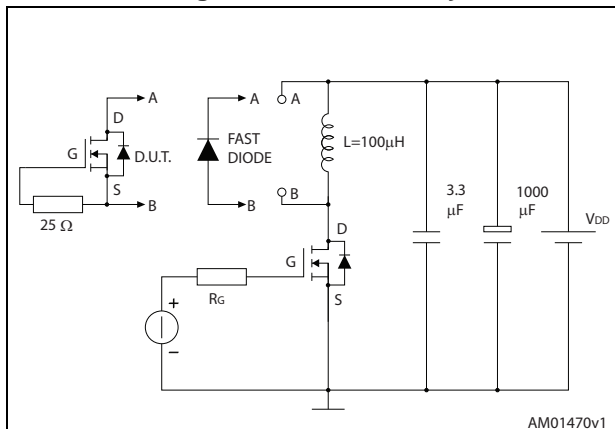
AM01468v1

Figure 16. Gate charge test circuit



AM01469v1

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



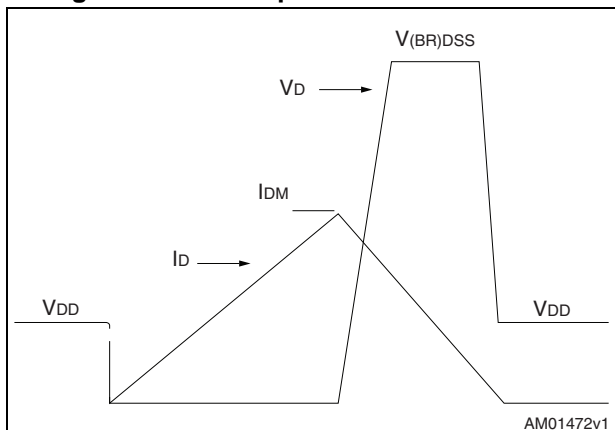
AM01470v1

Figure 18. Unclamped inductive load test circuit



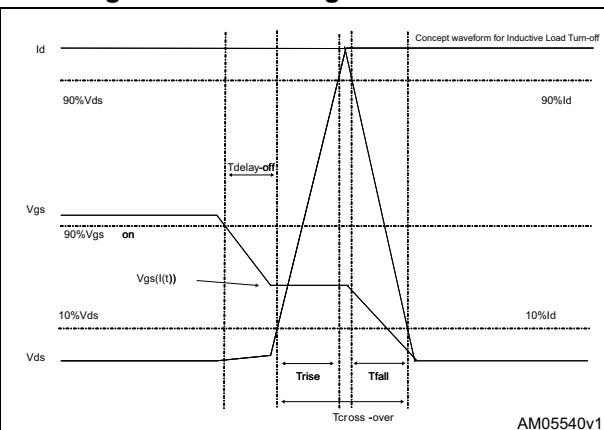
AM01471v1

Figure 19. Unclamped inductive waveform



AM01472v1

Figure 20. Switching time waveform



AM05540v1

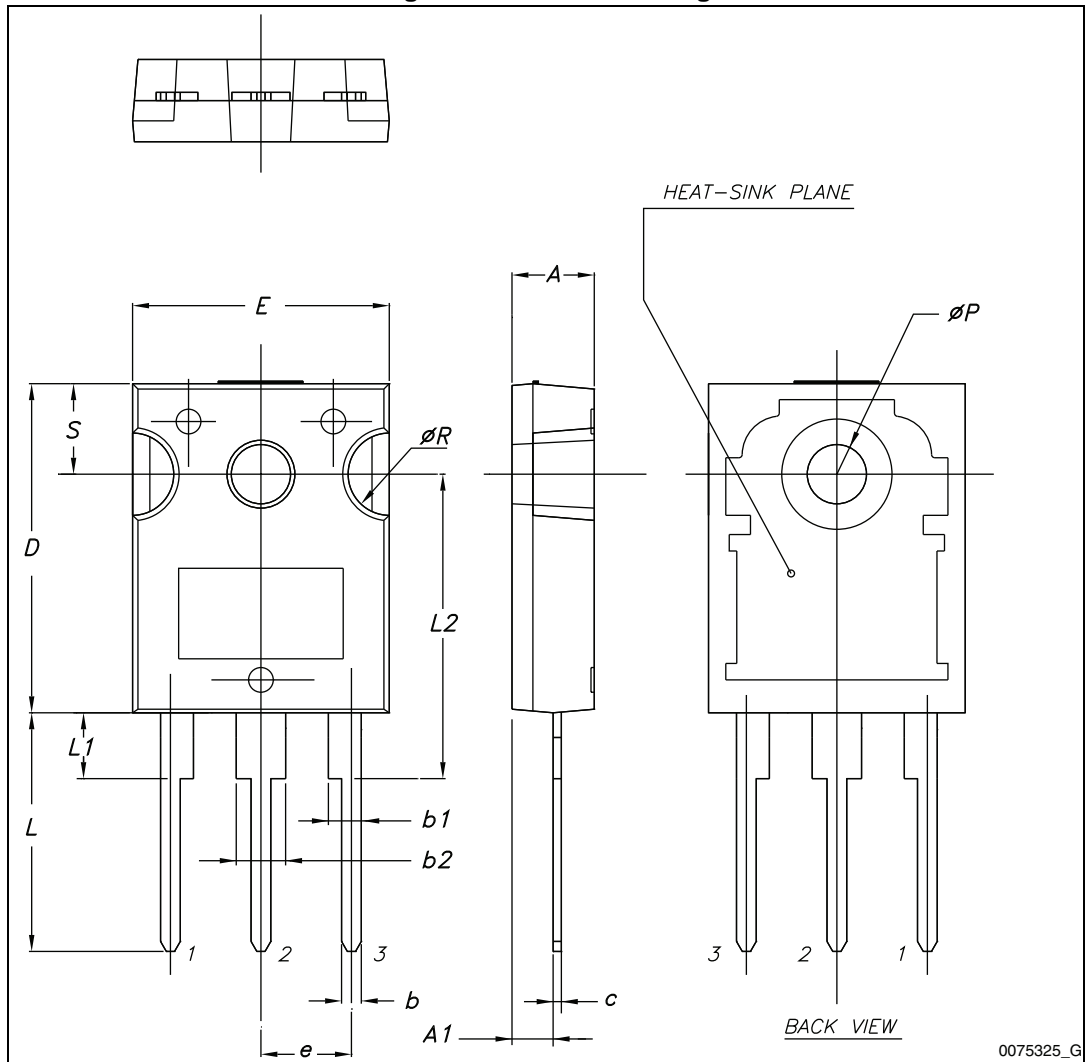
## 4 Package mechanical data

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 is an ST trademark.

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    | 5.30  | 5.45  | 5.60  |
| L    | 14.20 |       | 14.80 |
| L1   | 3.70  |       | 4.30  |
| L2   |       | 18.50 |       |
| ØP   | 3.55  |       | 3.65  |
| ØR   | 4.50  |       | 5.50  |
| S    | 5.30  | 5.50  | 5.70  |

Figure 21. TO-247 drawing



0075325\_G

## 5 Revision history

Table 10. Document revision history

| Date        | Revision | Changes  |
|-------------|----------|--|
| 16-Jul-2012 | 1        | First release.   |
| 22-Jan-2013 | 2        | Modified: $R_{DS(on)}$ on first page, $I_D$ , $I_{DM}$ on <a href="#">Table 2</a> , note 2 on <a href="#">Table 2</a> , typical values on <a href="#">Table 6</a> , <a href="#">7</a> , max and typical values on <a href="#">Table 8</a> , <a href="#">Figure 2</a> , <a href="#">6</a> , <a href="#">8</a> , <a href="#">9</a> , <a href="#">11</a> and <a href="#">14</a>                       |
| 07-Aug-2013 | 3        | <ul style="list-style-type: none"><li>– Minor text changes</li><li>– Modified: <a href="#">Applications</a> in first page</li><li>– Added: MOSFET dv/dt ruggedness parameter in <a href="#">Table 2</a></li><li>– Added: <a href="#">Table 4: Avalanche characteristics</a></li><li>– Modified: <a href="#">Figure 15</a>, <a href="#">16</a>, <a href="#">17</a> and <a href="#">18</a></li></ul> |
| 08-Aug-2013 | 4        | <ul style="list-style-type: none"><li>– Minor text changes</li><li>– Modified: <a href="#">Figure 14</a></li></ul>   |

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