

## Automotive-grade N-channel 950 V, 0.280 $\Omega$ typ., 17.5 A MDmesh™ K5 Power MOSFET in a TO-247 package

Datasheet - production data

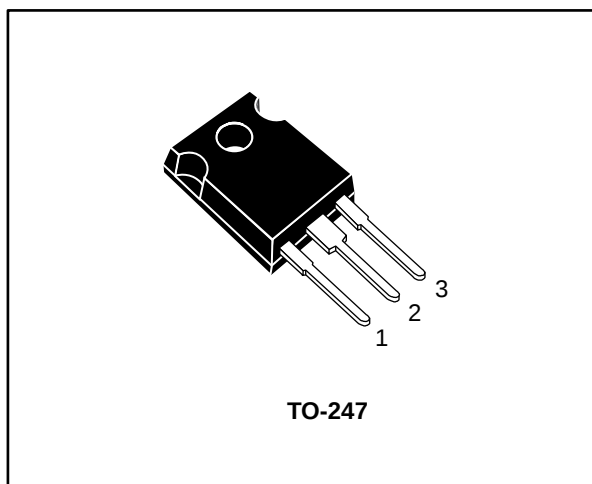
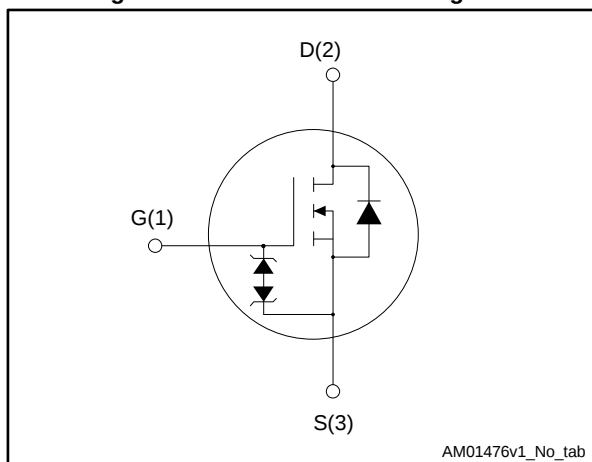


Figure 1: Internal schematic diagram



### Features

| Order code | V <sub>DS</sub> | R <sub>DS(on)</sub> max. | I <sub>D</sub> | P <sub>TOT</sub> |
|------------|-----------------|--------------------------|----------------|------------------|
| STW22N95K5 | 950 V           | 0.330 $\Omega$           | 17.5 A         | 250 W            |

- AEC-Q101 qualified
- Industry's lowest R<sub>DS(on)</sub> x area
- Industry's best FoM (figure of merit)
- Ultra-low gate charge
- 100% avalanche tested
- Zener-protected



### Applications

- Switching applications

### Description

This very high voltage N-channel Power MOSFET is designed using MDmesh™ K5 technology based on an innovative proprietary vertical structure. The result is a dramatic reduction in on-resistance and ultra-low gate charge for applications requiring superior power density and high efficiency.

Table 1: Device summary

| Order code | Marking | Package | Packing |
|------------|---------|---------|---------|
| STW22N95K5 | 22N95K5 | TO-247  | 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                                                             | $\pm 30$   | V                  |
| $I_D$         | Drain current (continuous) at $T_C = 25\text{ }^{\circ}\text{C}$                | 17.5       | A                  |
| $I_D$         | Drain current (continuous) at $T_C = 100\text{ }^{\circ}\text{C}$               | 11         | A                  |
| $I_D^{(1)}$   | Drain current (pulsed)                                                          | 70         | A                  |
| $P_{TOT}$     | Total dissipation at $T_C = 25\text{ }^{\circ}\text{C}$                         | 250        | W                  |
| ESD           | Gate-source human body model ( $R = 1.5\text{ k}\Omega$ , $C = 100\text{ pF}$ ) | 2          | kV                 |
| $dv/dt^{(2)}$ | Peak diode recovery voltage slope                                               | 4.5        | V/ns               |
| $dv/dt^{(3)}$ | MOSFET $dv/dt$ ruggedness                                                       | 50         |                    |
| $T_j$         | Operating junction temperature range                                            | -55 to 150 | $^{\circ}\text{C}$ |
| $T_{stg}$     | Storage temperature range                                                       |            |                    |

**Notes:**

(1) Pulse width limited by safe operating area.

(2)  $I_{SD} \leq 17.5\text{ A}$ ,  $di/dt \leq 100\text{ A}/\mu\text{s}$ ;  $V_{DS}\text{ peak} \leq V_{(BR)DSS}$ (3)  $V_{DS} \leq 760\text{ V}$ 

Table 3: Thermal data

| Symbol         | Parameter                           | Value | Unit                        |
|----------------|-------------------------------------|-------|-----------------------------|
| $R_{thj-case}$ | Thermal resistance junction-case    | 0.5   | $^{\circ}\text{C}/\text{W}$ |
| $R_{thj-amb}$  | Thermal resistance junction-ambient | 50    | $^{\circ}\text{C}/\text{W}$ |

Table 4: Avalanche characteristics

| Symbol   | Parameter                                                                                                              | Value | Unit |
|----------|------------------------------------------------------------------------------------------------------------------------|-------|------|
| $I_{AR}$ | Avalanche current, repetitive or not repetitive (pulse width limited by $T_{jmax.}$ )                                  | 6     | A    |
| $E_{AS}$ | Single pulse avalanche energy (starting $T_j = 25\text{ }^{\circ}\text{C}$ , $I_D = I_{AR}$ , $V_{DD} = 50\text{ V}$ ) | 182   | mJ   |

## 2 Electrical characteristics

$T_C = 25\text{ }^{\circ}\text{C}$  unless otherwise specified

**Table 5: On/off-state**

| Symbol        | Parameter                         | Test conditions                                                                                       | Min. | Typ.  | Max.     | Unit          |
|---------------|-----------------------------------|-------------------------------------------------------------------------------------------------------|------|-------|----------|---------------|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage    | $V_{GS} = 0\text{ V}$ , $I_D = 1\text{ mA}$                                                           | 950  |       |          | V             |
| $I_{DSS}$     | Zero-gate voltage drain current   | $V_{GS} = 0\text{ V}$ , $V_{DS} = 950\text{ V}$                                                       |      |       | 1        | $\mu\text{A}$ |
|               |                                   | $V_{GS} = 0\text{ V}$ , $V_{DS} = 950\text{ V}$<br>$T_C = 125\text{ }^{\circ}\text{C}$ <sup>(1)</sup> |      |       | 50       | $\mu\text{A}$ |
| $I_{GSS}$     | Gate body leakage current         | $V_{DS} = 0\text{ V}$ , $V_{GS} = \pm 20\text{ V}$                                                    |      |       | $\pm 10$ | $\mu\text{A}$ |
| $V_{GS(th)}$  | Gate threshold voltage            | $V_{DS} = V_{GS}$ , $I_D = 100\text{ }\mu\text{A}$                                                    | 3    | 4     | 5        | V             |
| $R_{DS(on)}$  | Static drain-source on-resistance | $V_{GS} = 10\text{ V}$ , $I_D = 9\text{ A}$                                                           |      | 0.280 | 0.330    | $\Omega$      |

**Notes:**

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

**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>$V_{GS} = 0\text{ V}$                                                                                   | -    | 1550 | -    | pF       |
| $C_{oss}$                  | Output capacitance                    |                                                                                                                                                           | -    | 140  | -    | pF       |
| $C_{rss}$                  | Reverse transfer capacitance          |                                                                                                                                                           | -    | 1    | -    | pF       |
| $C_{o(er)}$ <sup>(1)</sup> | Equivalent capacitance energy related | $V_{GS} = 0\text{ V}$ , $V_{DS} = 0\text{ to }760\text{ V}$                                                                                               | -    | 65   | -    | pF       |
| $C_{o(tr)}$ <sup>(2)</sup> | Equivalent capacitance time related   |                                                                                                                                                           |      | 178  | -    | pF       |
| $R_g$                      | Intrinsic gate resistance             | $f = 1\text{ MHz}$ , $I_D = 0\text{ A}$                                                                                                                   | -    | 3.5  | -    | $\Omega$ |
| $Q_g$                      | Total gate charge                     | $V_{DD} = 760\text{ V}$ ,<br>$I_D = 17.5\text{ A}$<br>$V_{GS} = 10\text{ V}$<br>(see <a href="#">Figure 16: "Test circuit for gate charge behavior"</a> ) | -    | 48   | -    | nC       |
| $Q_{gs}$                   | Gate-source charge                    |                                                                                                                                                           | -    | 9    | -    | nC       |
| $Q_{gd}$                   | Gate-drain charge                     |                                                                                                                                                           | -    | 32.5 | -    | nC       |

**Notes:**

<sup>(1)</sup> $C_{o(er)}$  is a constant capacitance value that gives the same stored energy as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{DSS}$ .

<sup>(2)</sup> $C_{o(tr)}$  is a constant capacitance value that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{DSS}$ .

Table 7: Switching times

| Symbol       | Parameter           | Test conditions                                                                                                                                                                                                                              | Min. | Typ. | Max. | Unit |
|--------------|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|
| $t_{d(on)}$  | Turn-on delay time  | $V_{DD} = 475\text{ V}$ , $I_D = 9\text{ A}$ , $R_G = 4.7\ \Omega$<br>$V_{GS} = 10\text{ V}$<br>(see <a href="#">Figure 15: "Test circuit for resistive load switching times"</a> and <a href="#">Figure 20: "Switching time waveform"</a> ) | -    | 18   | -    | ns   |
| $t_r$        | Rise time           |                                                                                                                                                                                                                                              | -    | 9    | -    | ns   |
| $t_{d(off)}$ | Turn-off delay time |                                                                                                                                                                                                                                              | -    | 65   | -    | ns   |
| $t_f$        | Fall time           |                                                                                                                                                                                                                                              | -    | 18   | -    | ns   |

Table 8: Source-drain diode

| Symbol          | Parameter                     | Test conditions                                                                                                                                                                                                                       | Min. | Typ. | Max. | Unit          |
|-----------------|-------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|---------------|
| $I_{SD}$        | Source-drain current          |                                                                                                                                                                                                                                       | -    |      | 17.5 | A             |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |                                                                                                                                                                                                                                       | -    |      | 70   | A             |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD} = 17.5\text{ A}$ , $V_{GS} = 0\text{ V}$                                                                                                                                                                                      | -    |      | 1.5  | V             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 17.5\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ ,<br>$V_{DD} = 60\text{ V}$<br>(see <a href="#">Figure 17: "Test circuit for inductive load switching and diode recovery times"</a> )                                   | -    | 513  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                                                                                                                       | -    | 12   |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                                                                                                                       | -    | 46   |      | A             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 17.5\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$<br>$V_{DD} = 60\text{ V}$ , $T_j = 150\text{ }^\circ\text{C}$<br>(see <a href="#">Figure 17: "Test circuit for inductive load switching and diode recovery times"</a> ) | -    | 670  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                                                                                                                       | -    | 15   |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                                                                                                                       | -    | 44   |      | 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%.

Table 9: Gate-source Zener diode

| Symbol                | Parameter                     | Test conditions                                 | Min. | Typ. | Max. | Unit |
|-----------------------|-------------------------------|-------------------------------------------------|------|------|------|------|
| $V_{(BR)\text{ GSO}}$ | Gate-source breakdown voltage | $I_{GS} = \pm 1\text{ mA}$ , $I_D = 0\text{ A}$ | 30   | -    | -    | V    |

The built-in back-to-back Zener diodes are specifically designed to enhance the ESD performance of the device. The Zener voltage facilitates efficient and cost-effective device integrity protection, thus eliminating the need for additional external componentry.

## 2.1 Electrical characteristics (curves)

Figure 2: Safe operating area

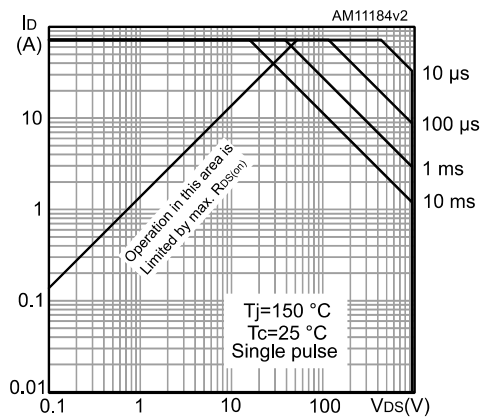


Figure 3: Thermal impedance

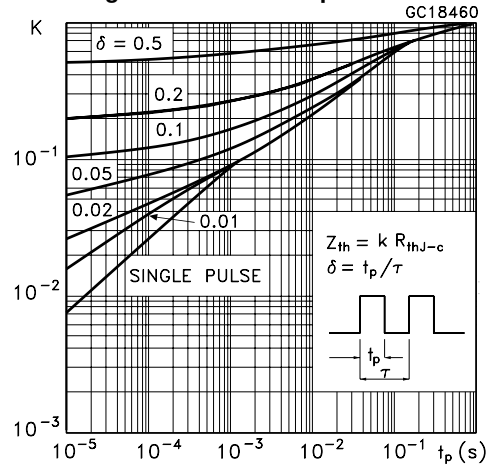


Figure 4: Output characteristics

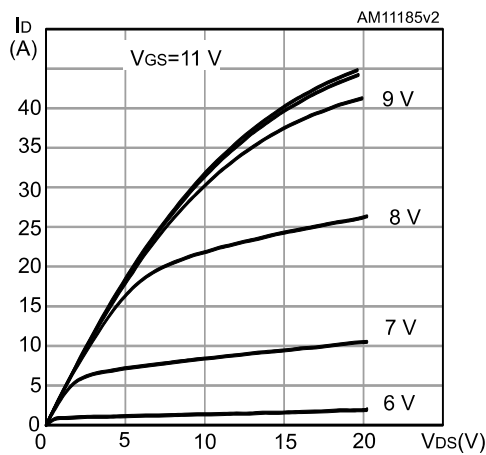


Figure 5: Transfer characteristics

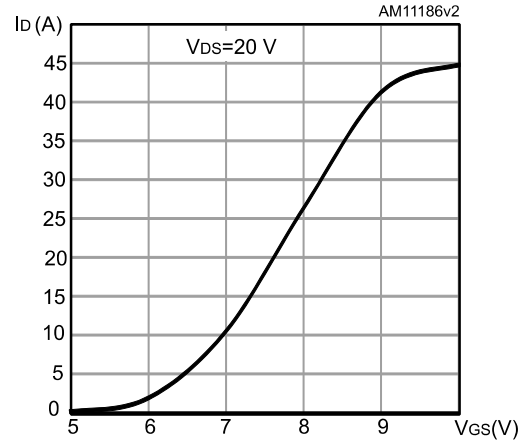


Figure 6: Gate charge vs gate-source voltage

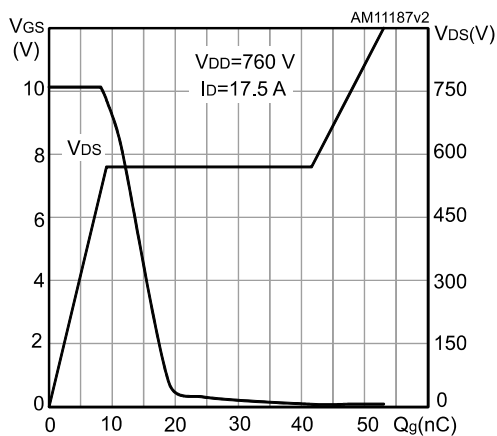


Figure 7: Static drain-source on-resistance

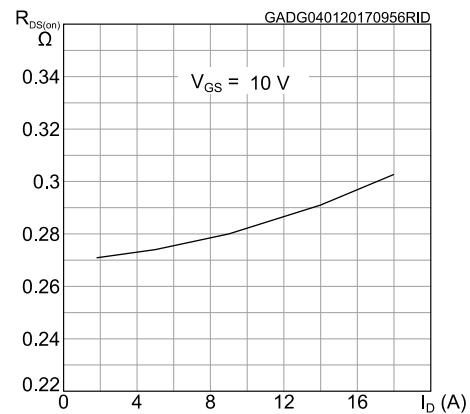


Figure 8: Capacitance variation

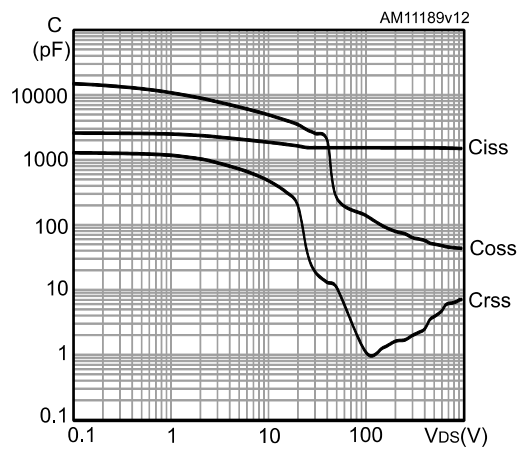


Figure 9: Output capacitance stored energy

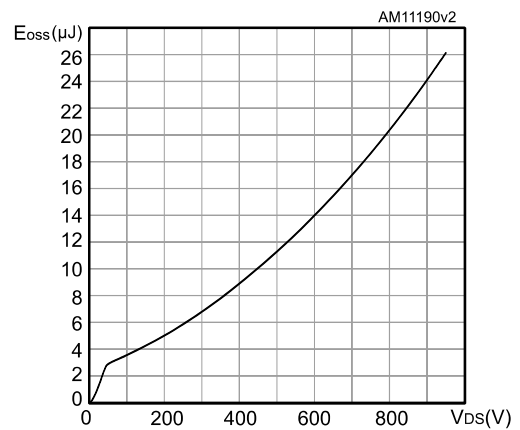


Figure 10: Normalized gate threshold voltage vs temperature

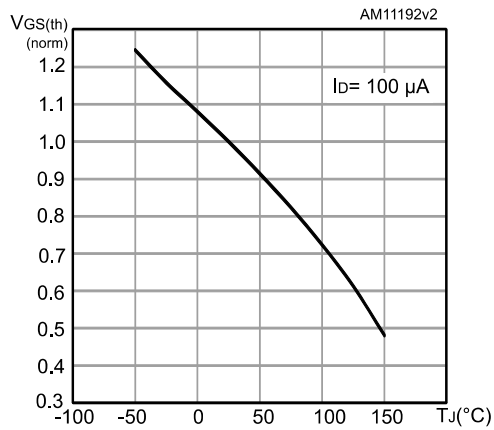


Figure 11: Normalized on-resistance vs temperature

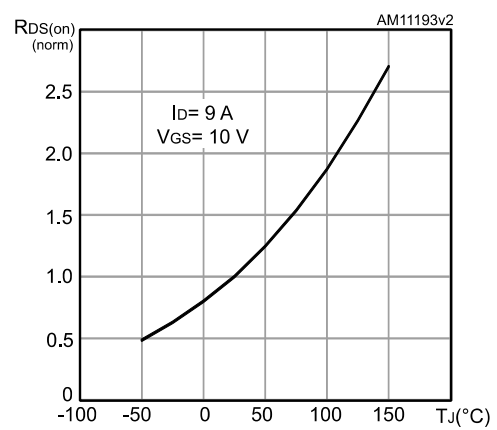
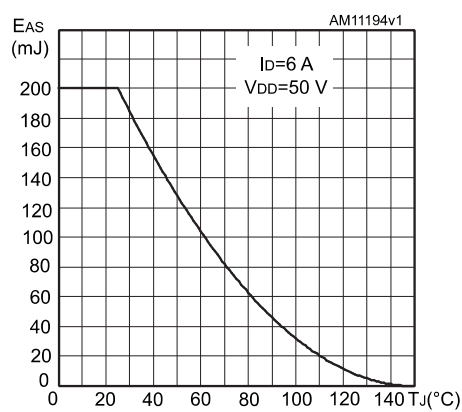
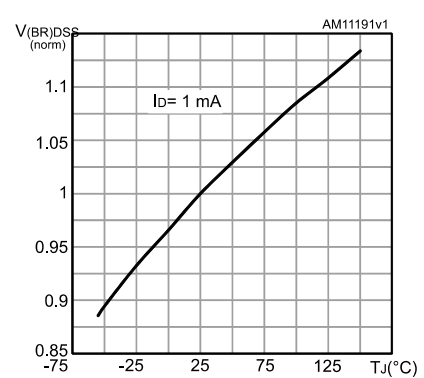
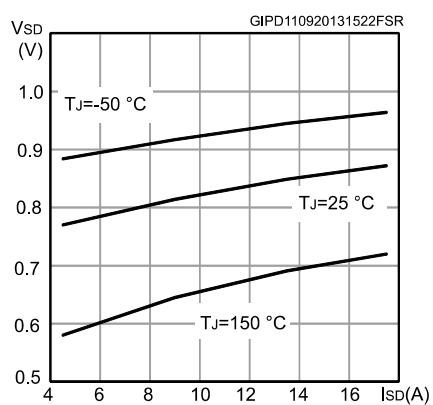
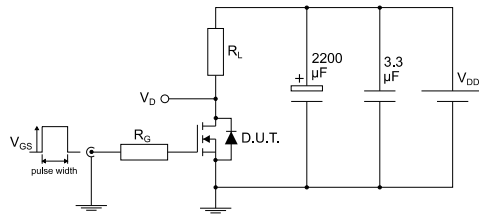
Figure 12: Maximum avalanche energy vs starting  $T_J$ Figure 13: Normalized  $V_{(BR)DSS}$  vs temperature

Figure 14: Source-drain diode forward characteristics



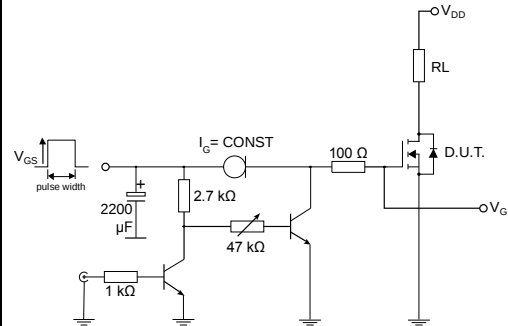
### 3 Test circuits

**Figure 15: Test circuit for resistive load switching times**



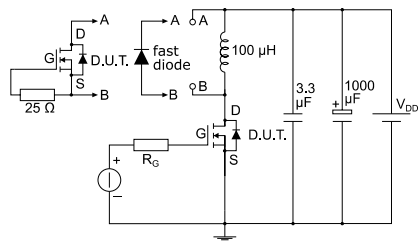
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**Figure 16: Test circuit for gate charge behavior**



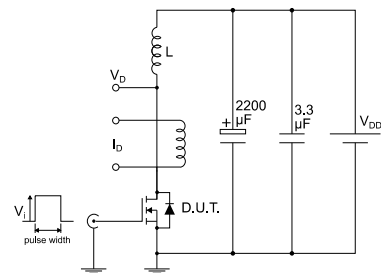
AM01469v10

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



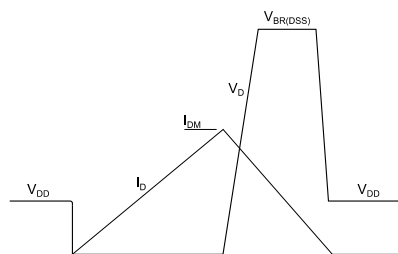
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**Figure 18: Unclamped inductive load test circuit**



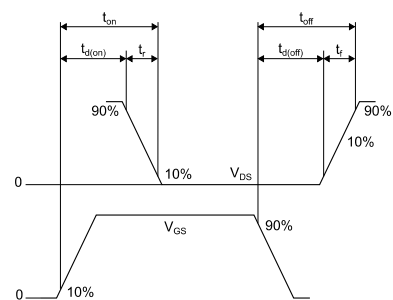
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**Figure 19: Unclamped inductive waveform**



AM01472v1

**Figure 20: Switching time waveform**



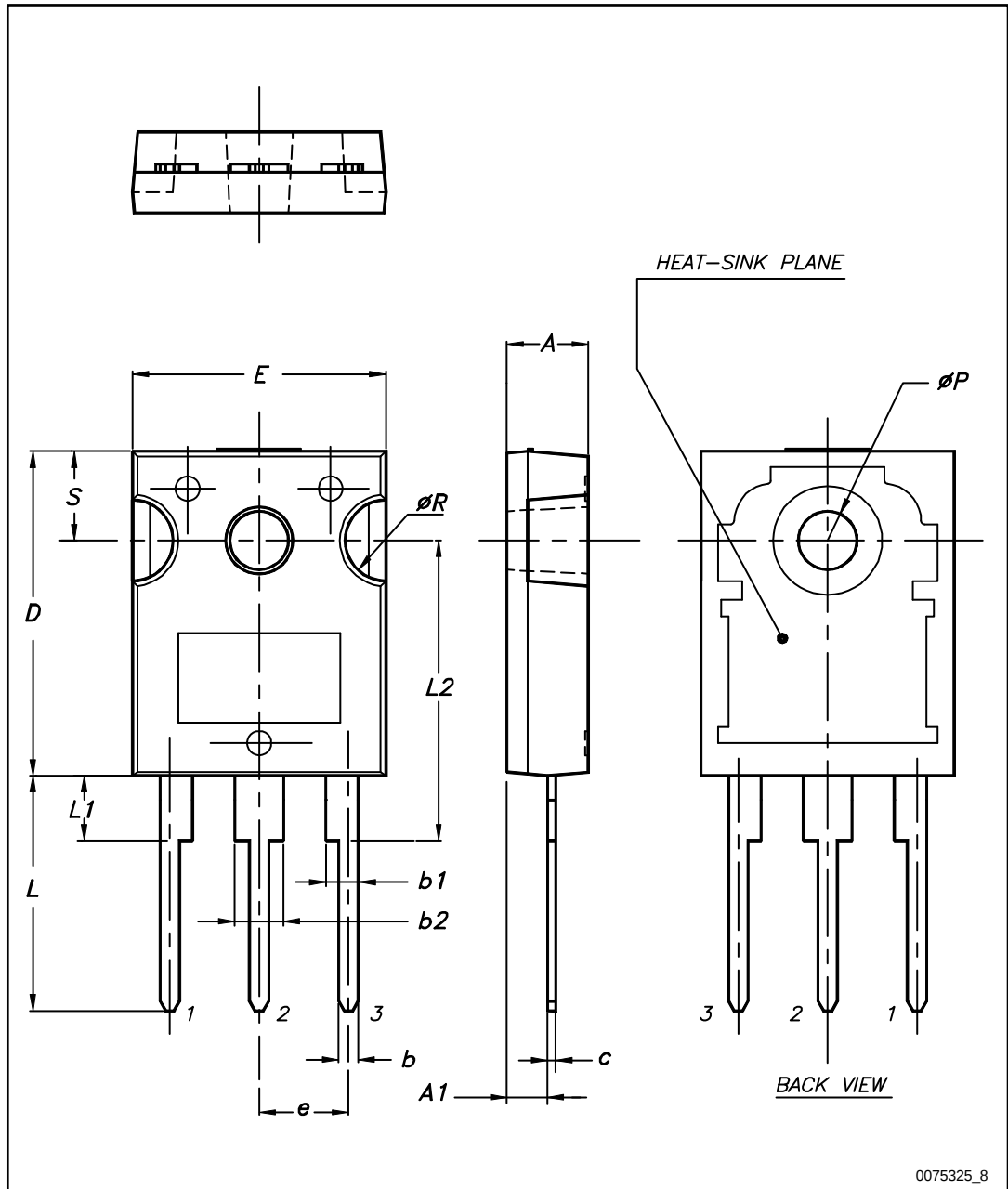
AM01473v1

## 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-247 package information

Figure 21: TO-247 package outline



0075325\_8

Table 10: TO-247 package 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  |

## 5 Revision history

**Table 11: Document revision history**

| Date        | Revision | Changes                                                                                                                                                                                                                                                                  |
|-------------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 17-Oct-2013 | 1        | First release.                                                                                                                                                                                                                                                           |
| 19-Dec-2013 | 2        | Datasheet promoted from preliminary to production data<br>Modified: title and <i>Features</i><br>Minor text changes                                                                                                                                                      |
| 20-Mar-2014 | 3        | – Modified: note 3 in Table 2<br>– Modified: $Q_{gs}$ and $Q_{gd}$ typical values in Table 5<br>– Modified: typical values in Table 6 and 7<br>– Updated: Figure 6<br>– Minor text changes                                                                               |
| 11-Jan-2017 | 4        | Updated title, features and description in cover page.<br>Minor text changes in <a href="#">Section 1: "Electrical ratings"</a> and <a href="#">Section 2: "Electrical characteristics"</a> .<br>Changed <a href="#">Figure 7: "Static drain-source on-resistance"</a> . |

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