



# STL21N65M5

N-channel 650 V, 0.175  $\Omega$ , 17 A ultra low gate charge MDmesh™ V Power MOSFET in PowerFLAT™ 8x8 HV package

Datasheet — production data

## Features

| Order code | V <sub>DSS</sub> @<br>T <sub>Jmax</sub> | R <sub>DS(on)</sub><br>max | I <sub>D</sub>      |
|------------|---|----------------------------|---------------------|
| STL21N65M5 | 710 V                                   | < 0.190 $\Omega$           | 17 A <sup>(1)</sup> |

1. The value is rated according to R<sub>thj-case</sub>

- 100% avalanche tested
- Low input capacitance and gate charge
- Low gate input resistance

## 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.

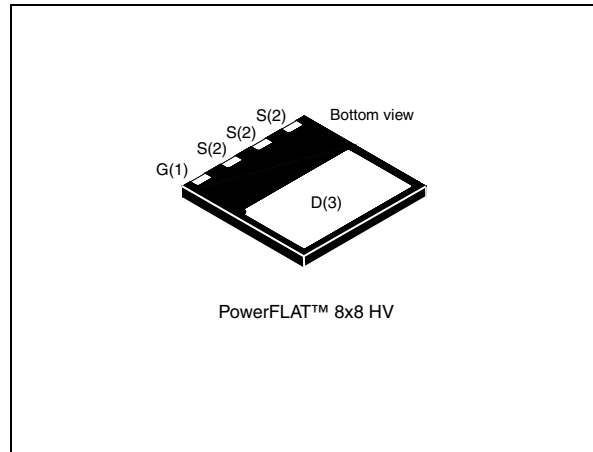


Figure 1. Internal schematic diagram

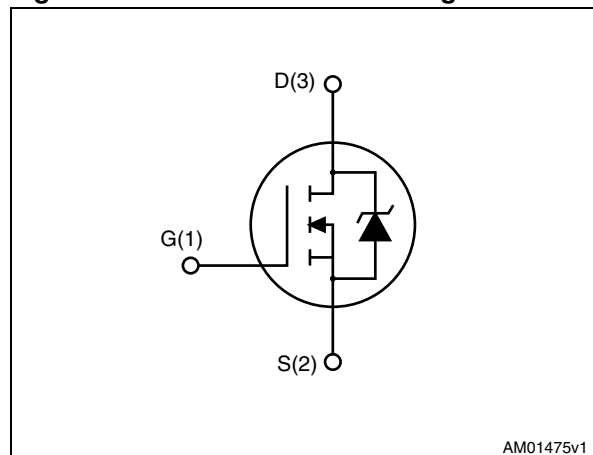


Table 1. Device summary

| Order code | Marking | Package           | Packaging     |
|------------|---------|-------------------|---------------|
| STL21N65M5 | 21N65M5 | PowerFLAT™ 8x8 HV | Tape and reel |

## Contents

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol             | Parameter  | Value       | Unit             |
|--------------------|--|-------------|------------------|
| $V_{DS}$           | Drain-source voltage   | 650         | V                |
| $V_{GS}$           | Gate-source voltage  | $\pm 25$    | V                |
| $I_D^{(1)}$        | Drain current (continuous) at $T_C = 25\text{ }^\circ\text{C}$   | 17          | A                |
| $I_D^{(1)}$        | Drain current (continuous) at $T_C = 100\text{ }^\circ\text{C}$  | 11          | A                |
| $I_{DM}^{(1),(2)}$ | Drain current (pulsed)   | 68          | A                |
| $I_D^{(3)}$        | Drain current (continuous) at $T_{amb} = 25\text{ }^\circ\text{C}$   | 2.7         | A                |
| $I_D^{(3)}$        | Drain current (continuous) at $T_{amb} = 100\text{ }^\circ\text{C}$  | 1.7         | A                |
| $I_{DM}^{(2),(3)}$ | Drain current (pulsed)   | 10.8        | A                |
| $P_{TOT}^{(3)}$    | Total dissipation at $T_{amb} = 25\text{ }^\circ\text{C}$  | 3           | W                |
| $P_{TOT}^{(1)}$    | Total dissipation at $T_C = 25\text{ }^\circ\text{C}$  | 125         | W                |
| $I_{AR}$           | Avalanche current, repetitive or not-repetitive (pulse width limited by $T_j$ max)                                   | 5           | A                |
| $E_{AS}$           | Single pulse avalanche energy (starting $T_j = 25\text{ }^\circ\text{C}$ , $I_D = I_{AR}$ , $V_{DD} = 50\text{ V}$ ) | 400         | mJ               |
| $dv/dt^{(4)}$      | Peak diode recovery voltage slope  | 15          | V/ns             |
| $T_{stg}$          | Storage temperature  | - 55 to 150 | $^\circ\text{C}$ |
| $T_j$              | Max. operating junction temperature  | 150         | $^\circ\text{C}$ |

1. The value is rated according to  $R_{thj-case}$ .
2. Pulse width limited by safe operating area.
3. When mounted on FR-4 board of  $1\text{ inch}^2$ , 2oz Cu.
4.  $I_{SD} \leq 17\text{ A}$ ,  $di/dt \leq 400\text{ A}/\mu\text{s}$ ,  $V_{Peak} < V_{(BR)DSS}$ ,  $V_{DD} = 400\text{ V}$ .

**Table 3. Thermal data**

| Symbol              | Parameter                            | Value | Unit                      |
|---------------------|--------------------------------------|-------|---------------------------|
| $R_{thj-case}$      | Thermal resistance junction-case max | 1     | $^\circ\text{C}/\text{W}$ |
| $R_{thj-amb}^{(1)}$ | Thermal resistance junction-amb max  | 45    | $^\circ\text{C}/\text{W}$ |

1. When mounted on  $1\text{ inch}^2$  FR-4 board, 2 oz Cu.

## 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 ( $V_{GS} = 0$ ) | $V_{DS} = 650\text{ V}$<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                | $V_{GS} = 10\text{ V}$ , $I_D = 8.5\text{ A}$                              |      | 0.175 | 0.190     | $\Omega$                       |

**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>$V_{GS} = 0$   | -    | 1950 | -    | pF       |
| $C_{oss}$         | Output capacitance                    |  |      | 46   |      | pF       |
| $C_{rss}$         | Reverse transfer capacitance          |  |      | 3    |      | pF       |
| $C_{o(tr)}^{(1)}$ | Equivalent capacitance time related   | $V_{DS} = 0\text{ to }520\text{ V}$ , $V_{GS} = 0$   | -    | 133  | -    | pF       |
| $C_{o(er)}^{(2)}$ | Equivalent capacitance energy related |  |      | 44   |      | pF       |
| $R_G$             | Intrinsic gate resistance             | $f = 1\text{ MHz}$ open drain  | -    | 2.5  | -    | $\Omega$ |
| $Q_g$             | Total gate charge                     | $V_{DD} = 520\text{ V}$ , $I_D = 8.5\text{ A}$ ,<br>$V_{GS} = 10\text{ V}$<br>(see <a href="#">Figure 16</a> ) | -    | 44   | -    | nC       |
| $Q_{gs}$          | Gate-source charge                    |  |      | 12   |      | nC       |
| $Q_{gd}$          | Gate-drain charge                     |  |      | 17   |      | nC       |

1.  $C_{oss\text{ eq}}$  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.  $C_{oss\text{ eq}}$  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 6. Switching times**

| Symbol       | Parameter           | Test conditions                                 | Min. | Typ. | Max | Unit |
|--------------|---------------------|---|------|------|-----|------|
| $t_{d(off)}$ | Turn-off delay time | $V_{DD} = 400\text{ V}$ , $I_D = 11\text{ A}$ , |      | 37   |     | ns   |
| $t_r$        | Rise time           | $R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$    | -    | 10   | -   | ns   |
| $t_c$        | Cross time          | (see <a href="#">Figure 17</a> ),               |      | 24   |     | ns   |
| $t_f$        | Fall time           | (see <a href="#">Figure 20</a> )                |      | 12   |     | ns   |

**Table 7. Source drain diode**

| Symbol          | Parameter                     | Test conditions   | Min. | Typ. | Max. | Unit          |
|-----------------|-------------------------------|---|------|------|------|---------------|
| $I_{SD}$        | Source-drain current          |   | -    |      | 17   | A             |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |   | -    |      | 68   | A             |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD} = 17\text{ A}$ , $V_{GS} = 0$                       | -    |      | 1.5  | V             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 17\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ | -    | 294  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       | $V_{DD} = 100\text{ V}$ (see <a href="#">Figure 17</a> )    |      | 4    |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |   |      | 28   |      | A             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 17\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ | -    | 340  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       | $V_{DD} = 100\text{ V}$ , $T_j = 150\text{ }^\circ\text{C}$ |      | 5    |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      | (see <a href="#">Figure 17</a> )                            |      | 29   |      | 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

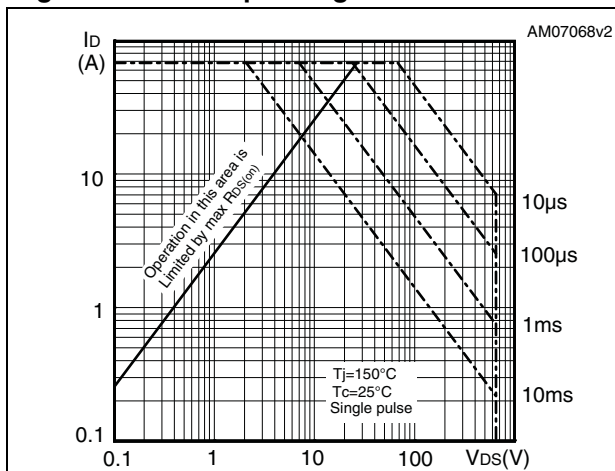


Figure 3. Thermal impedance

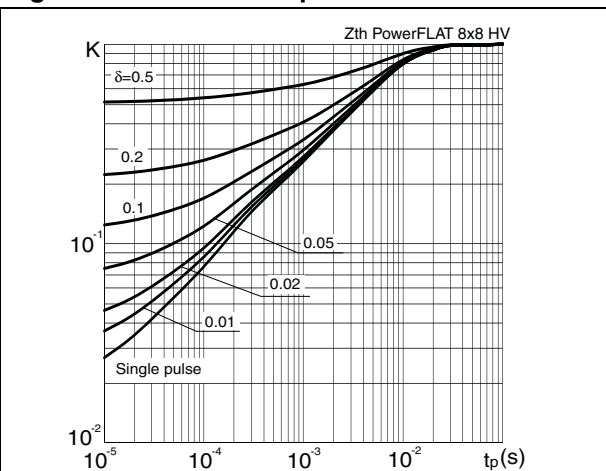


Figure 4. Output characteristics

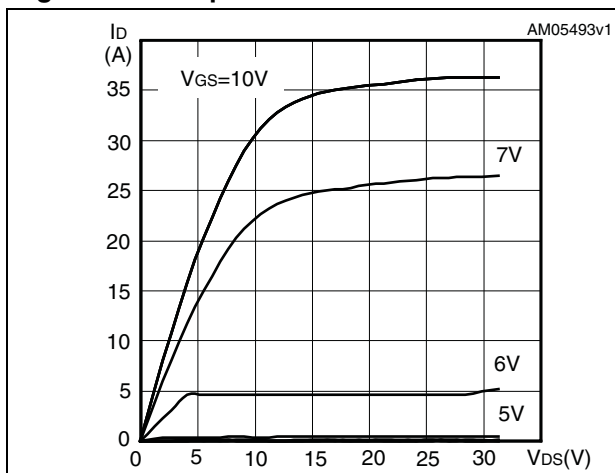


Figure 5. Transfer characteristics

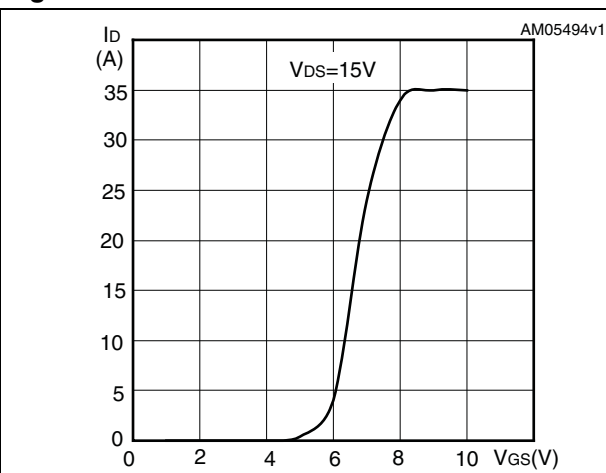


Figure 6. Gate charge vs gate-source voltage

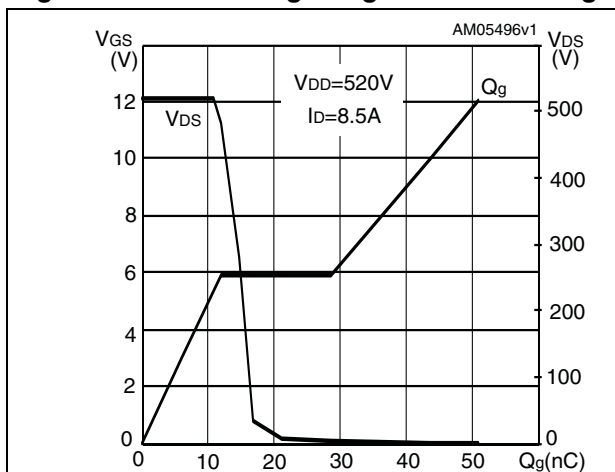


Figure 7. Static drain-source on-resistance

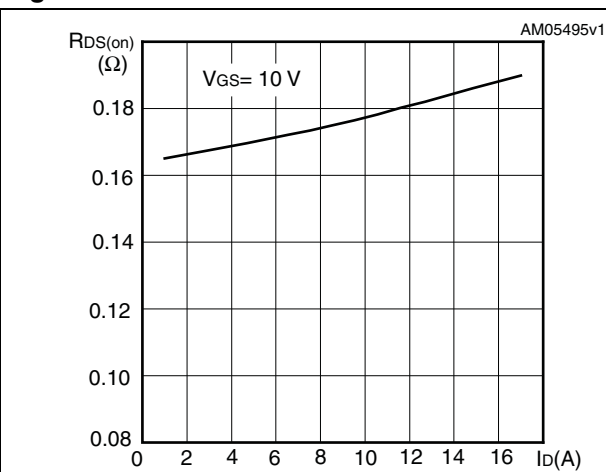


Figure 8. Output capacitance stored energy

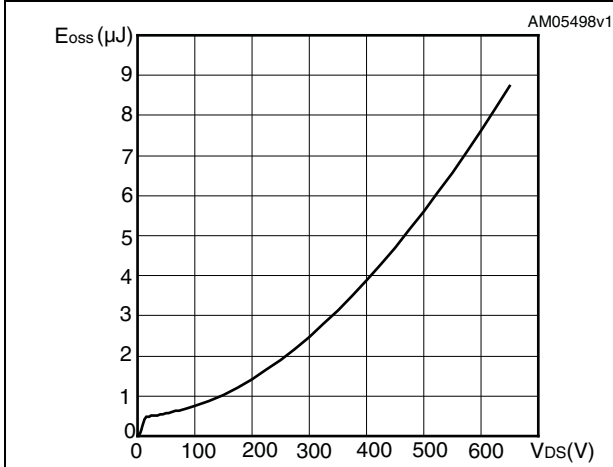


Figure 9. Capacitance variations

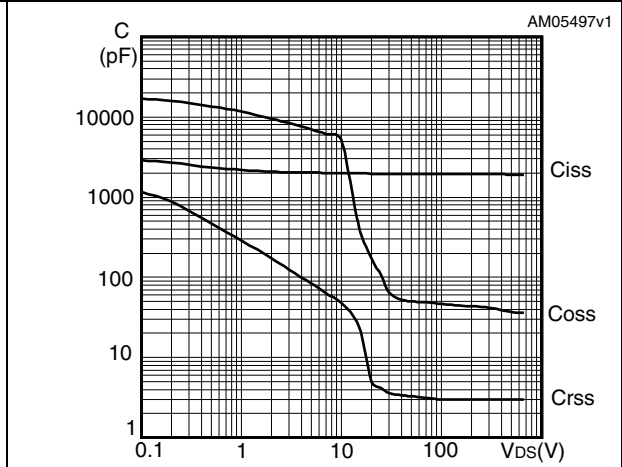


Figure 10. Normalized gate threshold voltage vs temperature

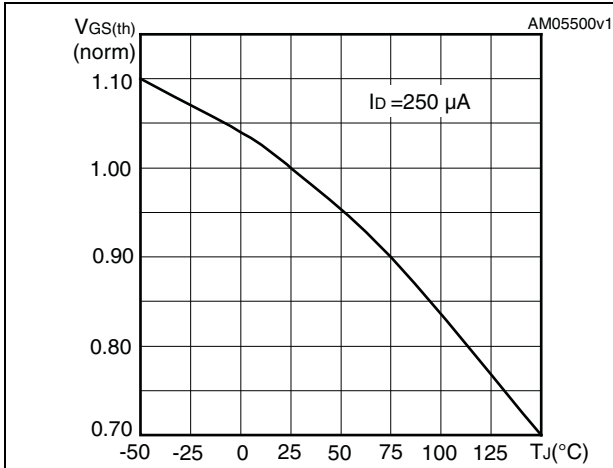


Figure 11. Normalized on-resistance vs temperature

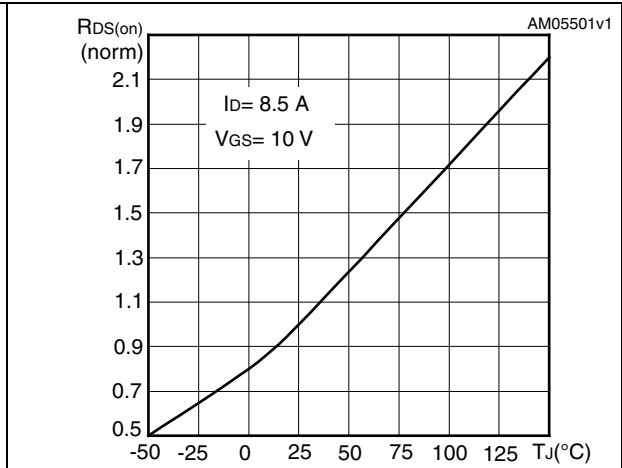


Figure 12. Source-drain diode forward characteristics

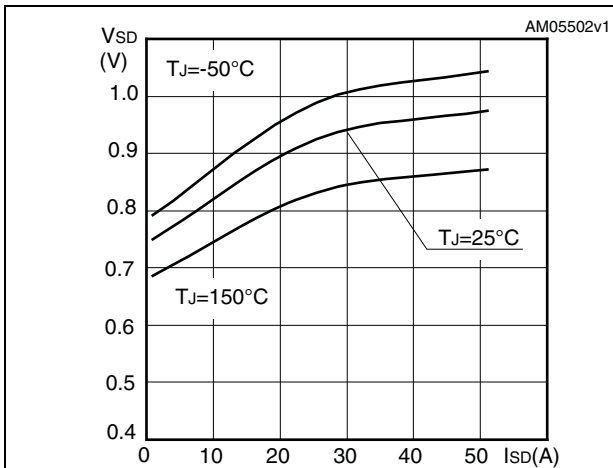


Figure 13. Normalized VDS vs temperature

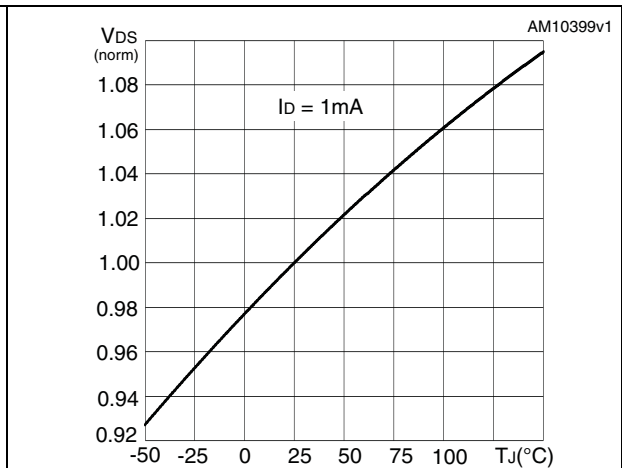
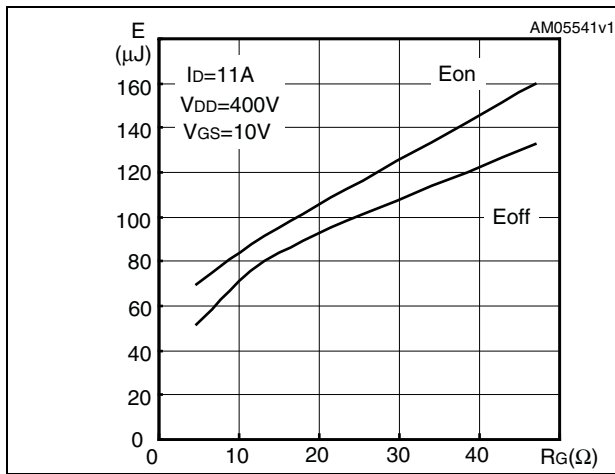


Figure 14. Switching losses vs gate resistance (1)



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



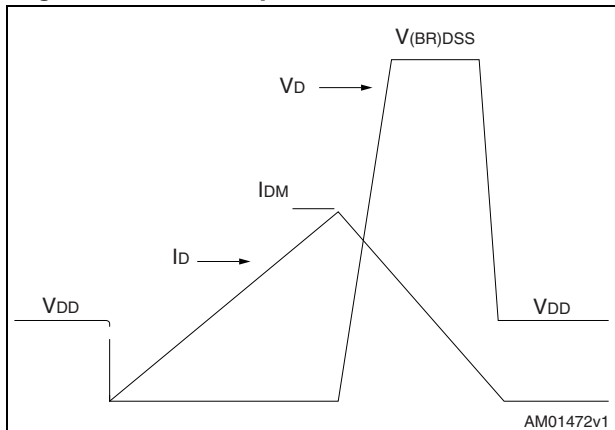
AM01470v1

Figure 18. Unclamped inductive load test circuit



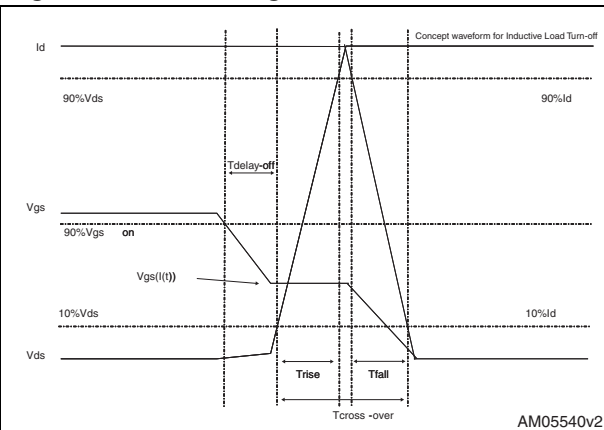
AM01471v1

Figure 19. Unclamped inductive waveform



AM01472v1

Figure 20. Switching time waveform



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.

**Table 8. PowerFLAT™ 8x8 HV mechanical data**

| Dim. | mm   |      |      |
|------|------|------|------|
|      | Min. | Typ. | Max. |
| A    | 0.80 | 0.90 | 1.00 |
| A1   | 0.00 | 0.02 | 0.05 |
| b    | 0.95 | 1.00 | 1.05 |
| D    |      | 8.00 |      |
| E    |      | 8.00 |      |
| D2   | 7.05 | 7.20 | 7.30 |
| E2   | 4.15 | 4.30 | 4.40 |
| e    |      | 2.00 |      |
| L    | 0.40 | 0.50 | 0.60 |
| aaa  |      | 0.10 |      |
| bbb  |      | 0.10 |      |
| ccc  |      | 0.10 |      |

Figure 21. PowerFLAT™ 8x8 HV drawing mechanical data

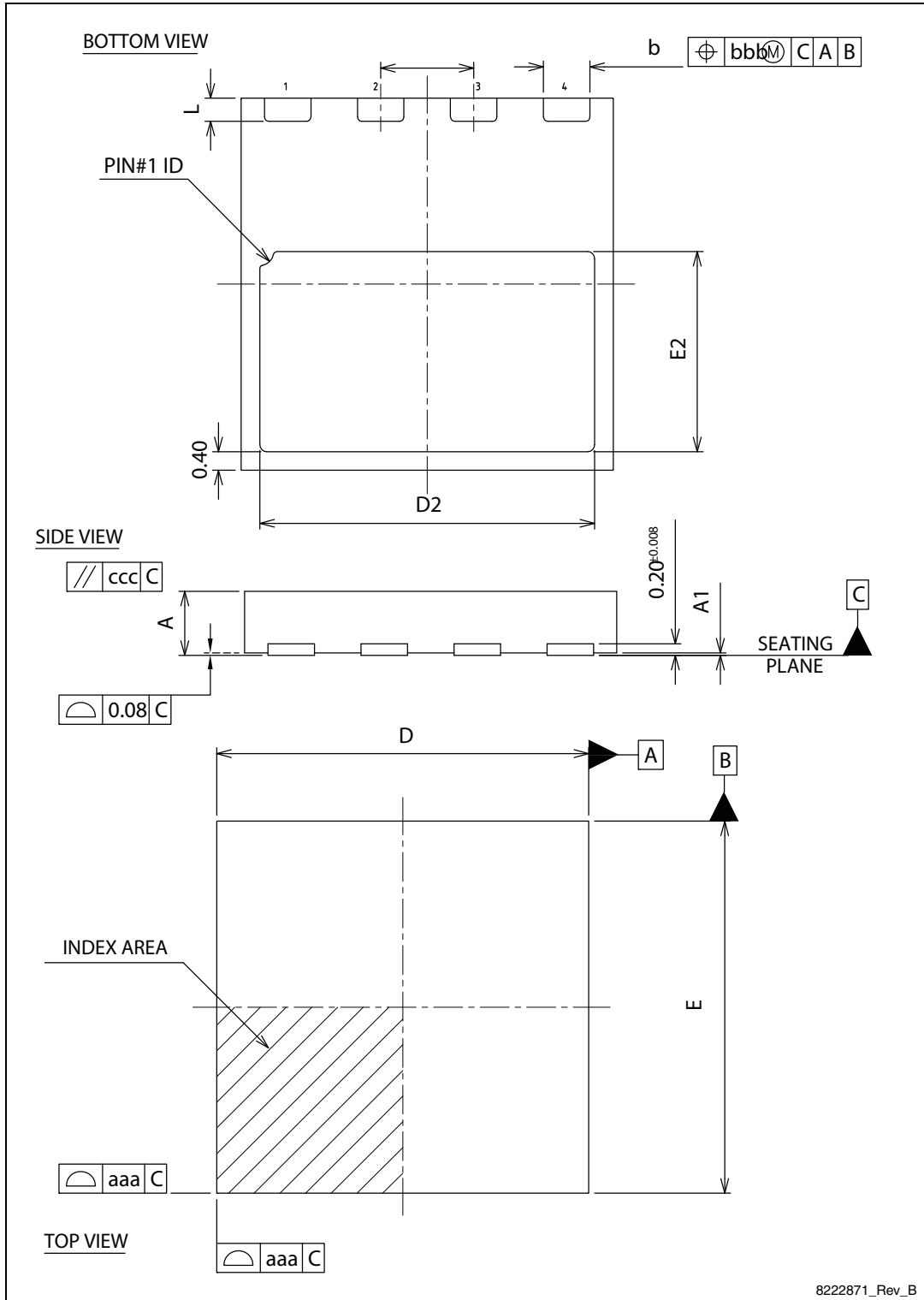
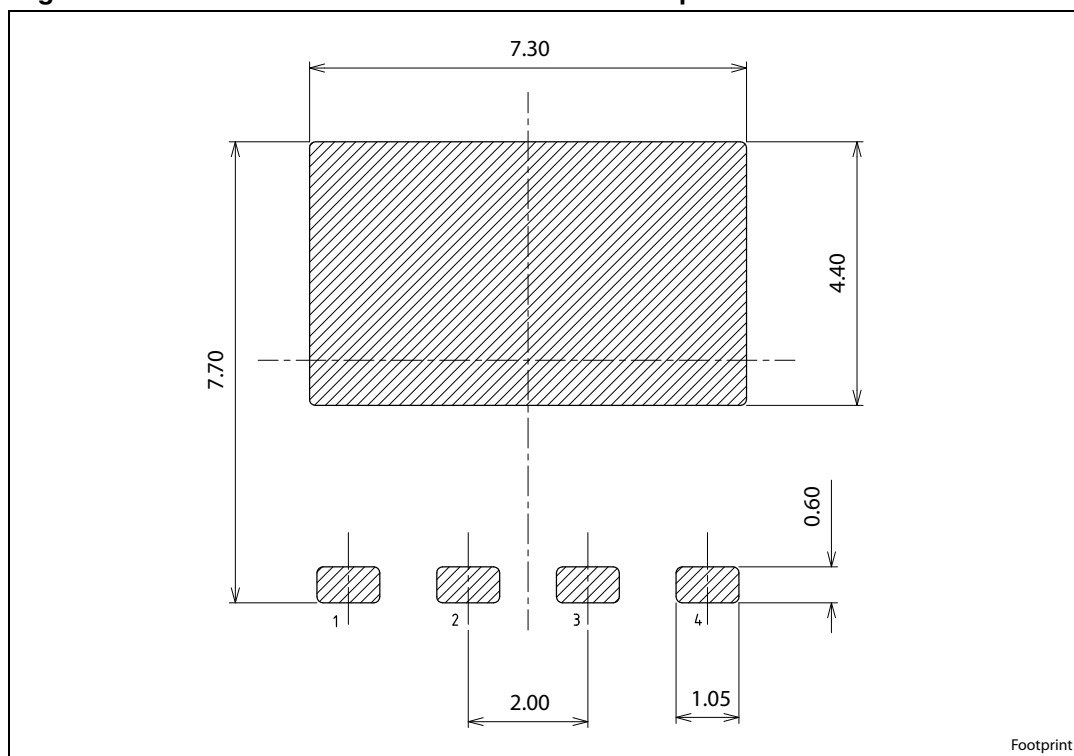


Figure 22. PowerFLAT™ 8x8 HV recommended footprint



# 5 Packaging mechanical data

Figure 23. PowerFLAT™ 8x8 HV tape

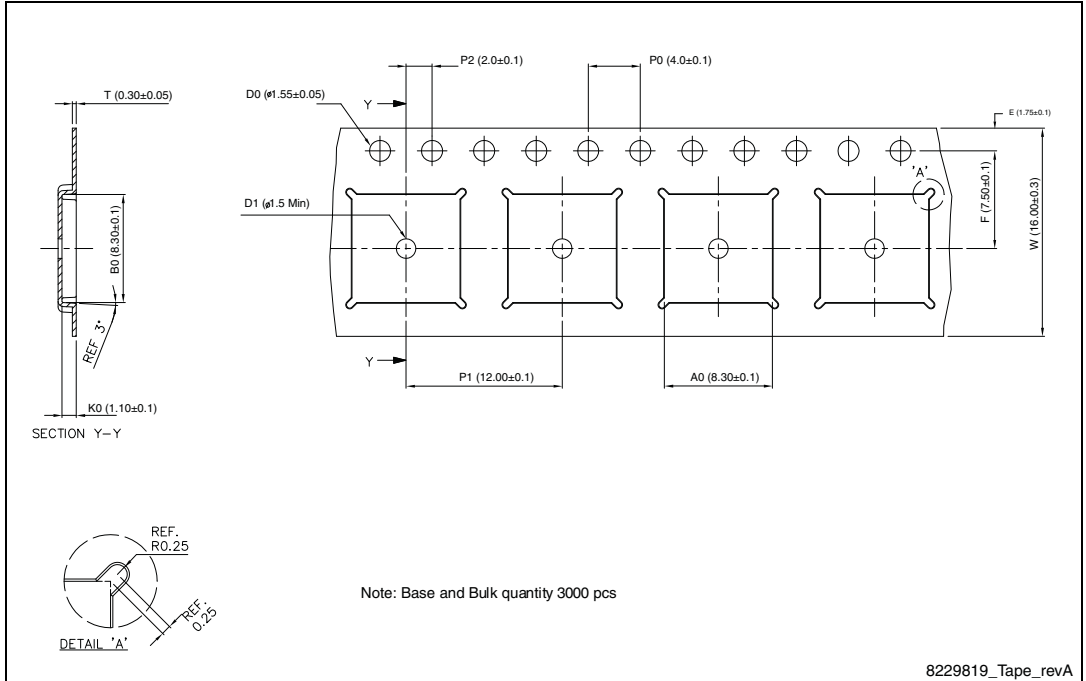


Figure 24. PowerFLAT™ 8x8 HV package orientation in carrier tape

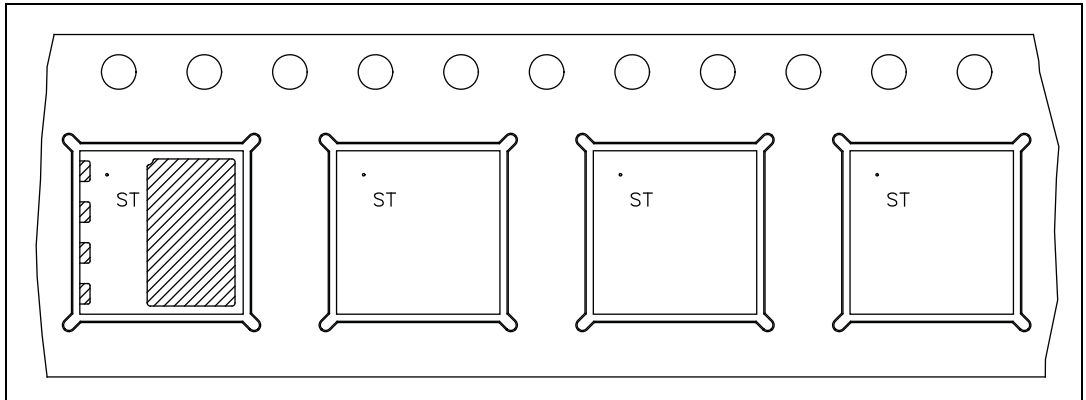
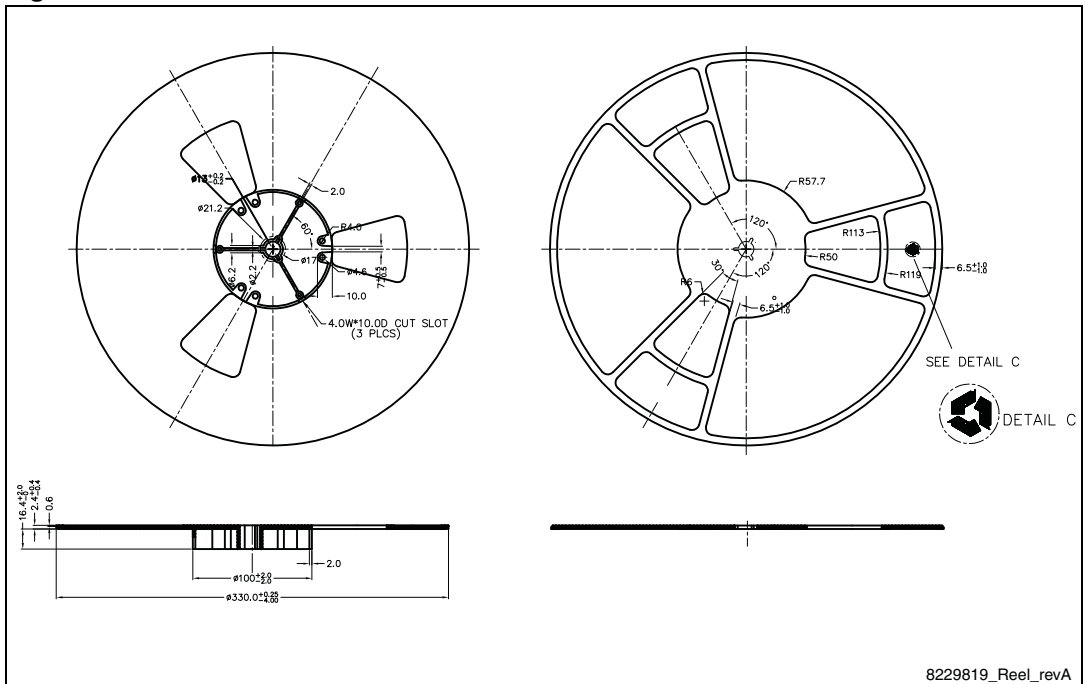


Figure 25. PowerFLAT™ 8x8 HV reel



8229819\_Reel\_revA

## 6 Revision history

**Table 9. Document revision history**

| Date        | Revision | Changes  |
|-------------|----------|--|
| 28-Apr-2010 | 1        | First release.   |
| 14-Jun-2010 | 2        | $R_{DS(on)}$ typical value has been corrected.   |
| 14-Mar-2011 | 3        | <i>Figure 2: Safe operating area</i> , <i>Figure 3: Thermal impedance</i> and <i>Figure 7: Static drain-source on-resistance</i> have been updated.    |
| 18-May-2011 | 4        | $R_{DS(on)}$ limits in <i>Table 4</i> have been updated.   |
| 29-May-2011 | 5        | <i>Section 4: Package mechanical data</i> has been updated.<br>Added new section: <i>Section 5: Packaging mechanical data</i> .<br>Minor text changes. |

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