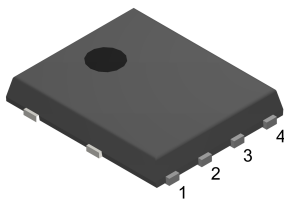
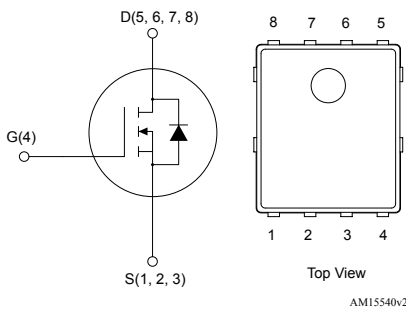


# N-channel 100 V, 14.5 mΩ typ., 12 A, STripFET F7 DeepGATE Power MOSFET in a PowerFLAT 5x6 package


**PowerFLAT 5x6**


## Features

| Order code | $V_{DS}$ | $R_{DS(on)}$ max. | $I_D$ | $P_{TOT}$ |
|------------|----------|-------------------|-------|-----------|
| STL60N10F7 | 100 V    | 18 mΩ             | 12 A  | 5 W       |

- Among the lowest  $R_{DS(on)}$  on the market
- Excellent FoM (figure of merit)
- Low  $C_{rss}/C_{iss}$  ratio for EMI immunity
- High avalanche ruggedness

## Applications

- Switching applications

## Description

This N-channel Power MOSFET utilizes STripFET F7 technology with an enhanced trench gate structure that results in very low on-state resistance, while also reducing internal capacitance and gate charge for faster and more efficient switching.



### Product status link

[STL60N10F7](#)

### Product summary

|            |               |
|------------|---------------|
| Order code | STL60N10F7    |
| Marking    | 60N10F7       |
| Package    | PowerFLAT 5x6 |
| Packing    | Tape and reel |

# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

| Symbol            | Parameter                                                             | Value       | Unit               |
|-------------------|-----------------------------------------------------------------------|-------------|--------------------|
| $V_{DS}$          | Drain-source voltage                                                  | 100         | V                  |
| $V_{GS}$          | Gate-source voltage                                                   | 20          | V                  |
| $I_D^{(1)}$       | Drain current (continuous) at $T_C = 25\text{ }^{\circ}\text{C}$      | 46          | A                  |
|                   | Drain current (continuous) at $T_C = 100\text{ }^{\circ}\text{C}$     | 33          | A                  |
| $I_D^{(2)}$       | Drain current (continuous) at $T_{pcb} = 25\text{ }^{\circ}\text{C}$  | 12          | A                  |
|                   | Drain current (continuous) at $T_{pcb} = 100\text{ }^{\circ}\text{C}$ | 9           | A                  |
| $I_{DM}^{(2)(3)}$ | Drain current (pulsed)                                                | 48          | A                  |
| $P_{TOT}^{(1)}$   | Total power dissipation at $T_C = 25\text{ }^{\circ}\text{C}$         | 72          | W                  |
| $P_{TOT}^{(2)}$   | Total power dissipation at $T_{pcb} = 25\text{ }^{\circ}\text{C}$     | 5           | W                  |
| $T_{stg}$         | Storage temperature range                                             | - 55 to 175 | $^{\circ}\text{C}$ |
| $T_J$             | Operating junction temperature range                                  |             | $^{\circ}\text{C}$ |

1. This value is rated according to  $R_{thj-c}$ .
2. This value is rated according to  $R_{thj-pcb}$ .
3. Pulse width is limited by safe operating area.

**Table 2. Thermal data**

| Symbol              | Parameter                        | Value | Unit                 |
|---------------------|----------------------------------|-------|----------------------|
| $R_{thj-case}$      | Thermal resistance junction-case | 2.08  | $^{\circ}\text{C/W}$ |
| $R_{thj-pcb}^{(1)}$ | Thermal resistance junction-pcb  | 31    |                      |

1. When mounted on a 1-inch<sup>2</sup> FR-4 board, 2oz Cu,  $t < 10\text{ s}$ .

## 2 Electrical characteristics

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

**Table 3. On/off states**

| Symbol        | Parameter                         | Test conditions                                                                       | Min. | Typ. | Max. | Unit          |
|---------------|-----------------------------------|---------------------------------------------------------------------------------------|------|------|------|---------------|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage    | $V_{GS} = 0\text{ V}$ , $I_D = 1\text{ mA}$                                           | 100  |      |      | V             |
| $I_{DSS}$     | Zero gate voltage drain current   | $V_{GS} = 0\text{ V}$ , $V_{DS} = 100\text{ V}$                                       |      |      | 1    | $\mu\text{A}$ |
|               |                                   | $V_{GS} = 0\text{ V}$ , $V_{DS} = 100\text{ V}$ , $T_C = 125\text{ }^{\circ}\text{C}$ |      |      | 100  | $\mu\text{A}$ |
| $I_{GSS}$     | Gate-body leakage current         | $V_{DS} = 0\text{ V}$ , $V_{GS} = 20\text{ V}$                                        |      |      | 100  | nA            |
| $V_{GS(th)}$  | Gate threshold voltage            | $V_{DS} = V_{GS}$ , $I_D = 250\text{ }\mu\text{A}$                                    | 2.5  |      | 4.5  | V             |
| $R_{DS(on)}$  | Static drain-source on-resistance | $V_{GS} = 10\text{ V}$ , $I_D = 6\text{ A}$                                           |      | 14.5 | 18   | m $\Omega$    |

**Table 4. Dynamic**

| Symbol    | Parameter                    | Test conditions                                                                                                                 | Min. | Typ. | Max. | Unit |
|-----------|------------------------------|---------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|
| $C_{iss}$ | Input capacitance            | $V_{DS} = 50\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GS} = 0\text{ V}$                                                             | -    | 1640 | -    | pF   |
| $C_{oss}$ | Output capacitance           |                                                                                                                                 | -    | 360  | -    | pF   |
| $C_{rss}$ | Reverse transfer capacitance |                                                                                                                                 | -    | 25   | -    | pF   |
| $Q_g$     | Total gate charge            | $V_{DD} = 50\text{ V}$ , $I_D = 12\text{ A}$ , $V_{GS} = 10\text{ V}$<br>(see Figure 13. Test circuit for gate charge behavior) | -    | 25   | -    | nC   |
| $Q_{gs}$  | Gate-source charge           |                                                                                                                                 | -    | 12   | -    | nC   |
| $Q_{gd}$  | Gate-drain charge            |                                                                                                                                 | -    | 5    | -    | nC   |
| $Q_{oss}$ | Output charge                | $V_{DD} = 40\text{ V}$ , $V_{GS} = 0\text{ V}$                                                                                  | -    | 28   | -    | nC   |

**Table 5. Switching times**

| Symbol       | Parameter           | Test conditions                                                                                         | Min. | Typ. | Max. | Unit |
|--------------|---------------------|---------------------------------------------------------------------------------------------------------|------|------|------|------|
| $t_{d(on)}$  | Turn-on delay time  | $V_{DD} = 50\text{ V}$ , $I_D = 6\text{ A}$ ,<br>$R_G = 4.7\text{ }\Omega$ , $V_{GS} = 10\text{ V}$     | -    | 15   | -    | ns   |
| $t_r$        | Rise time           |                                                                                                         | -    | 17   | -    | ns   |
| $t_{d(off)}$ | Turn-off-delay time | (see Figure 12. Test circuit for resistive load switching times and Figure 17. Switching time waveform) | -    | 24   | -    | ns   |
| $t_f$        | Fall time           |                                                                                                         | -    | 8    | -    | ns   |

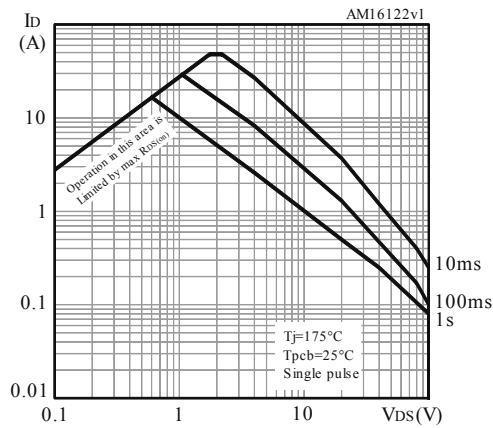
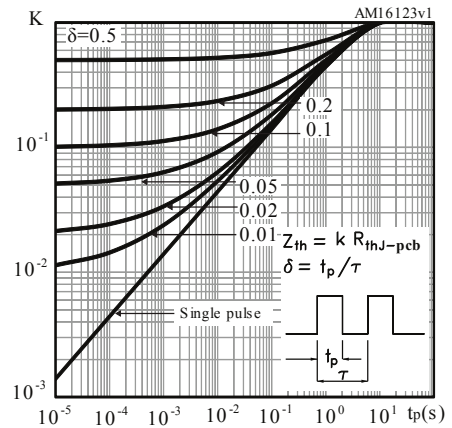
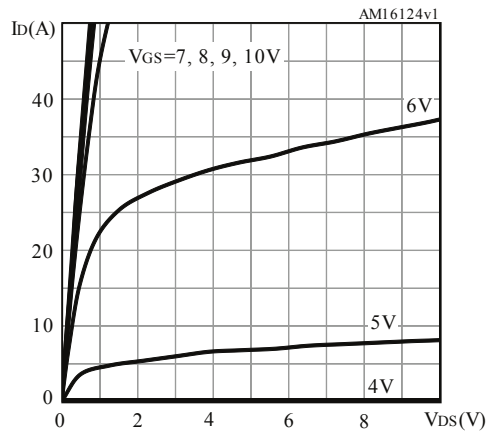
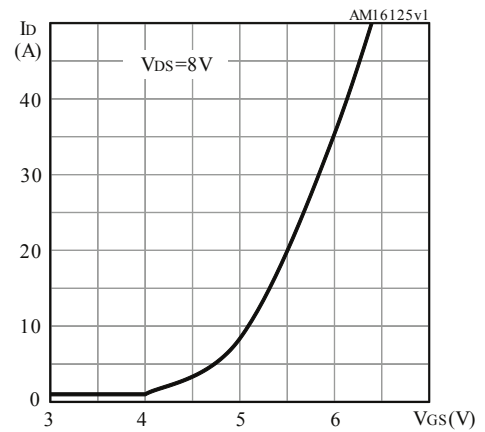
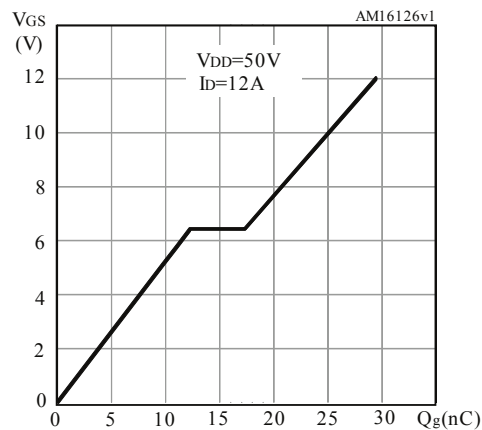
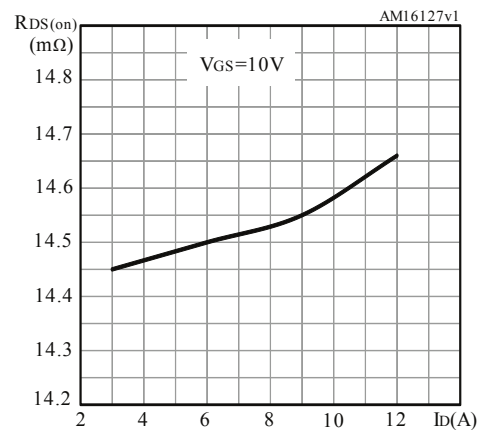
**Table 6. Source-drain diode**

| Symbol          | Parameter                     | Test conditions                                                                                                                                                                                                                     | Min. | Typ. | Max. | Unit |
|-----------------|-------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|
| $I_{SD}$        | Source-drain current          |                                                                                                                                                                                                                                     | -    |      | 12   | A    |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |                                                                                                                                                                                                                                     | -    |      | 48   | A    |
| $V_{SD}^{(2)}$  | Forward on voltage            | $V_{GS} = 0\text{ V}$ , $I_{SD} = 16\text{ A}$                                                                                                                                                                                      | -    |      | 1.1  | V    |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 12\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ ,<br>$V_{DD} = 50\text{ V}$ , $T_J = 150\text{ }^\circ\text{C}$<br>(see <a href="#">Figure 14. Test circuit for inductive load switching and diode recovery times</a> ) | -    | 53   |      | ns   |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                                                                                                                     | -    | 67   |      | nC   |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                                                                                                                     | -    | 2.5  |      | A    |

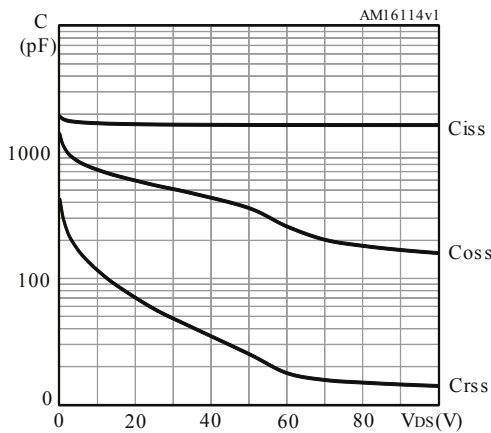
1. Pulse width limited by safe operating area.

2. Pulse test: pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%.

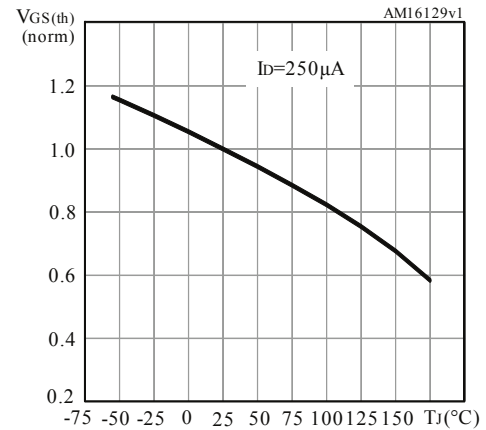
## 2.1 Electrical characteristics (curves)

**Figure 1. Safe operating area**

**Figure 2. Thermal impedance**

**Figure 3. Output characteristics**

**Figure 4. Transfer characteristics**

**Figure 5. Gate charge vs gate-source voltage**

**Figure 6. Static drain-source on-resistance**


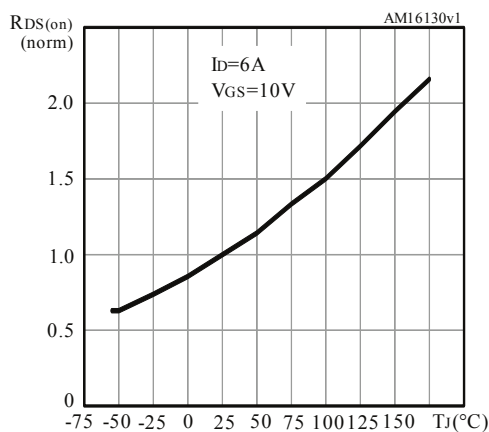
**Figure 7. Capacitance variations**



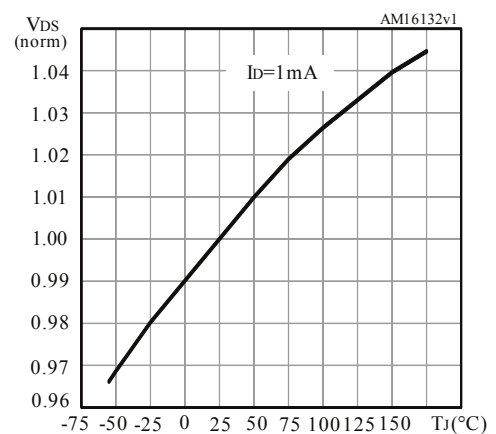
**Figure 8. Normalized gate threshold voltage vs temperature**



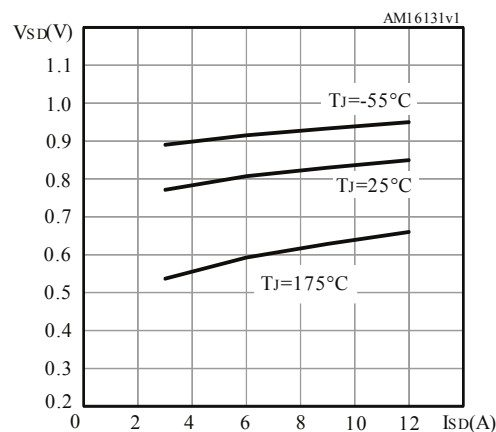
**Figure 9. Normalized on-resistance vs temperature**



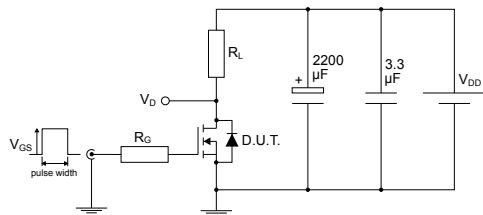
**Figure 10. Normalized  $V_{(BR)DSS}$  vs temperature**



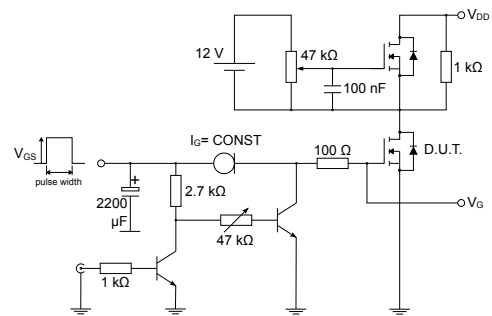
**Figure 11. Source-drain diode forward characteristics**



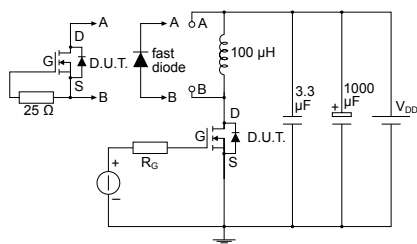
### 3 Test circuits

**Figure 12. Test circuit for resistive load switching times**


AM01468v1

**Figure 13. Test circuit for gate charge behavior**


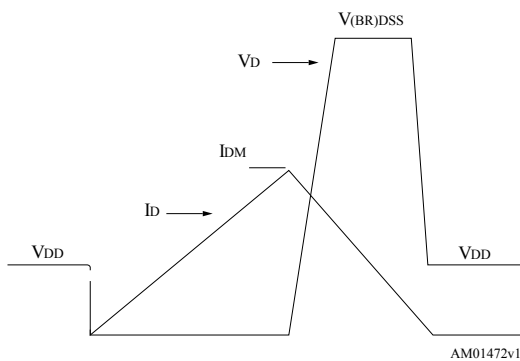
AM01469v1

**Figure 14. Test circuit for inductive load switching and diode recovery times**


AM01470v1

**Figure 15. Unclamped inductive load test circuit**


AM01471v1

**Figure 16. Unclamped inductive waveform**


AM01472v1

**Figure 17. Switching time waveform**

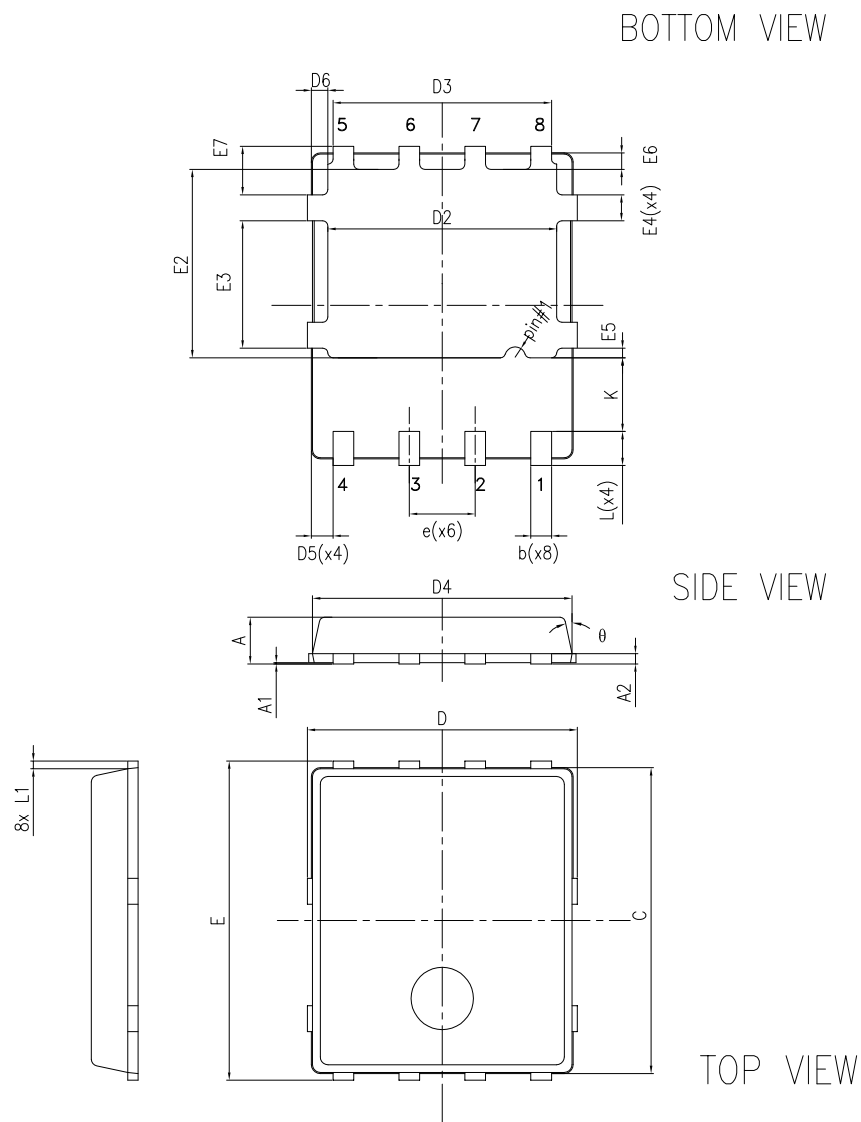

AM01473v1

## 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 PowerFLAT 5x6 type R package information

**Figure 18. PowerFLAT 5x6 type R package outline**



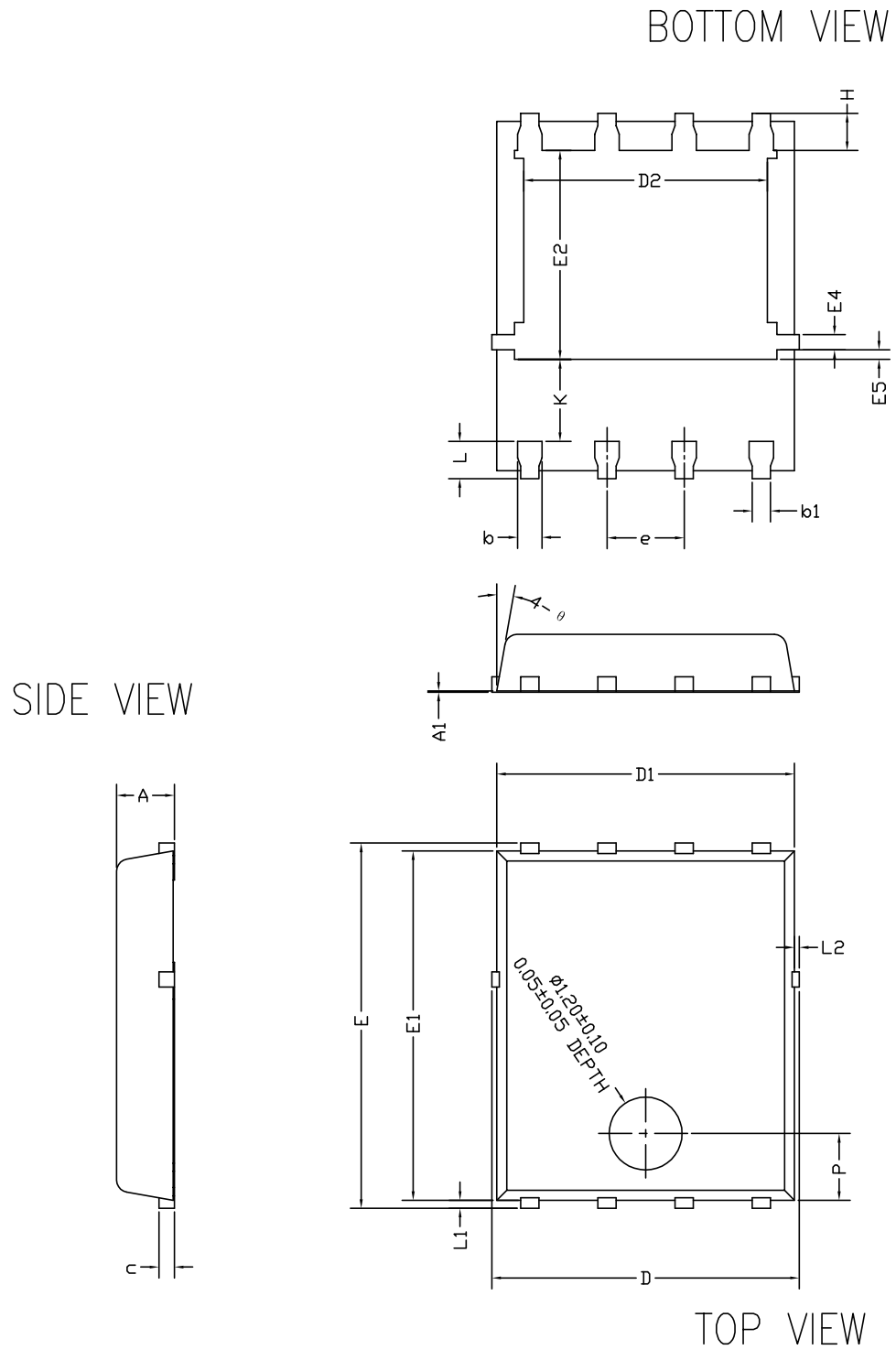
A0ER\_8231817\_Rev20

**Table 7. PowerFLAT 5x6 type R mechanical data**

| Dim. | mm    |       |       |
|------|-------|-------|-------|
|      | Min.  | Typ.  | Max.  |
| A    | 0.80  |       | 1.00  |
| A1   | 0.02  |       | 0.05  |
| A2   |       | 0.25  |       |
| b    | 0.30  |       | 0.50  |
| C    | 5.80  | 6.00  | 6.20  |
| D    | 5.00  | 5.20  | 5.40  |
| D2   | 4.15  |       | 4.45  |
| D3   | 4.05  | 4.20  | 4.35  |
| D4   | 4.80  | 5.00  | 5.20  |
| D5   | 0.25  | 0.40  | 0.55  |
| D6   | 0.15  | 0.30  | 0.45  |
| e    |       | 1.27  |       |
| E    | 5.95  | 6.15  | 6.35  |
| E2   | 3.50  |       | 3.70  |
| E3   | 2.35  |       | 2.55  |
| E4   | 0.40  |       | 0.60  |
| E5   | 0.08  |       | 0.28  |
| E6   | 0.20  | 0.325 | 0.45  |
| E7   | 0.75  | 0.90  | 1.05  |
| K    | 1.275 |       | 1.575 |
| L    | 0.60  |       | 0.80  |
| L1   | 0.05  | 0.15  | 0.25  |
| θ    | 0°    |       | 12°   |

## 4.2 PowerFLAT 5x6 type R SUBCON package information

Figure 19. PowerFLAT 5x6 type R SUBCON package outline

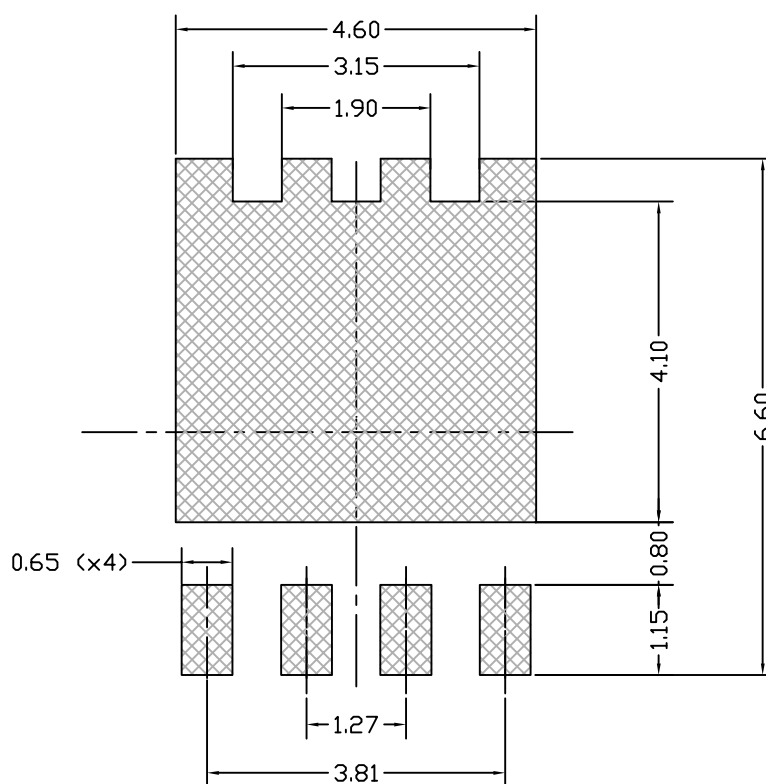


8472137\_SUBCON\_998G\_Type\_R\_REV4

**Table 8. PowerFLAT 5x6 type R SUBCON package mechanical data**

| Dim. | mm   |      |      |
|------|------|------|------|
|      | Min. | Typ. | Max. |
| A    | 0.90 | 0.95 | 1.00 |
| A1   |      | 0.02 |      |
| b    | 0.35 | 0.40 | 0.45 |
| b1   |      | 0.30 |      |
| c    | 0.21 | 0.25 | 0.34 |
| D    |      |      | 5.10 |
| D1   | 4.80 | 4.90 | 5.00 |
| D2   | 3.91 | 4.01 | 4.11 |
| e    | 1.17 | 1.27 | 1.37 |
| E    | 5.90 | 6.00 | 6.10 |
| E1   | 5.70 | 5.75 | 5.80 |
| E2   | 3.34 | 3.44 | 3.54 |
| E4   | 0.15 | 0.25 | 0.35 |
| E5   | 0.06 | 0.16 | 0.26 |
| H    | 0.51 | 0.61 | 0.71 |
| K    | 1.10 |      |      |
| L    | 0.51 | 0.61 | 0.71 |
| L1   | 0.06 | 0.13 | 0.20 |
| L2   |      |      | 0.10 |
| P    | 1.00 | 1.10 | 1.20 |
| θ    | 8°   | 10°  | 12°  |

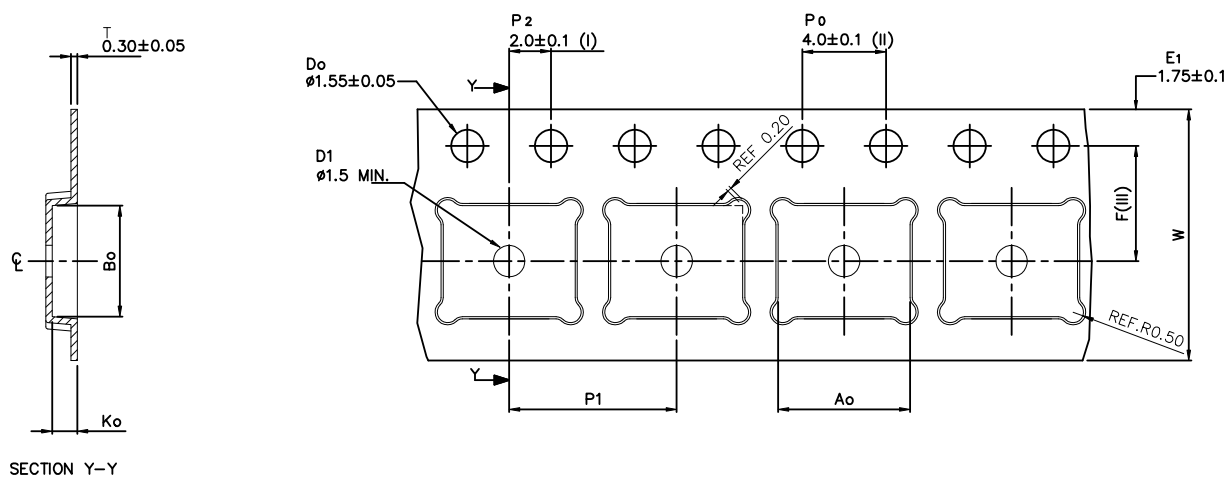
**Figure 20. PowerFLAT 5x6 recommended footprint (dimensions are in mm)**



8231817\_FOOTPRINT\_simp\_Rev\_20

### 4.3 PowerFLAT 5x6 packing information

Figure 21. PowerFLAT 5x6 tape (dimensions are in mm)



|    |               |
|----|---------------|
| Ao | 6.30 +/– 0.1  |
| Bo | 5.30 +/– 0.1  |
| Ko | 1.20 +/– 0.1  |
| F  | 5.50 +/– 0.1  |
| P1 | 8.00 +/– 0.1  |
| W  | 12.00 +/– 0.3 |

(I) Measured from centreline of sprocket hole to centreline of pocket.

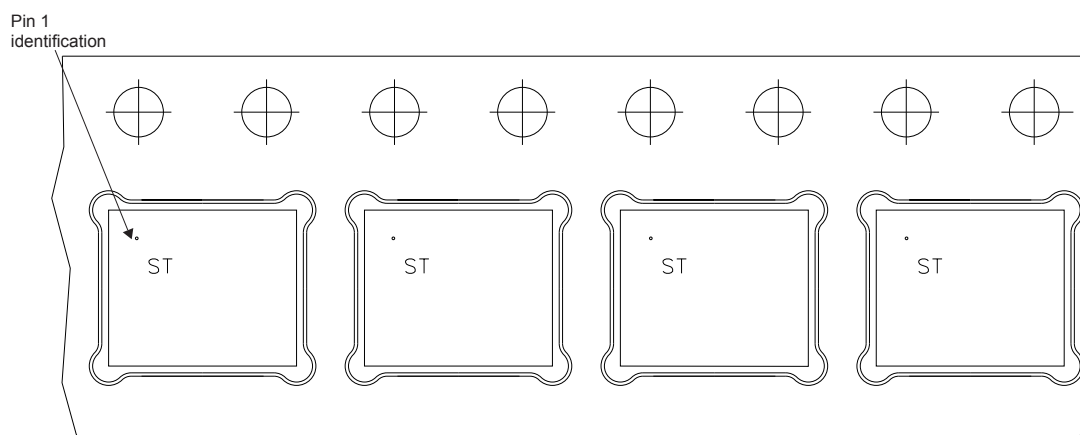
(II) Cumulative tolerance of 10 sprocket holes is  $\pm 0.20$ .

(III) Measured from centreline of sprocket hole to centreline of pocket

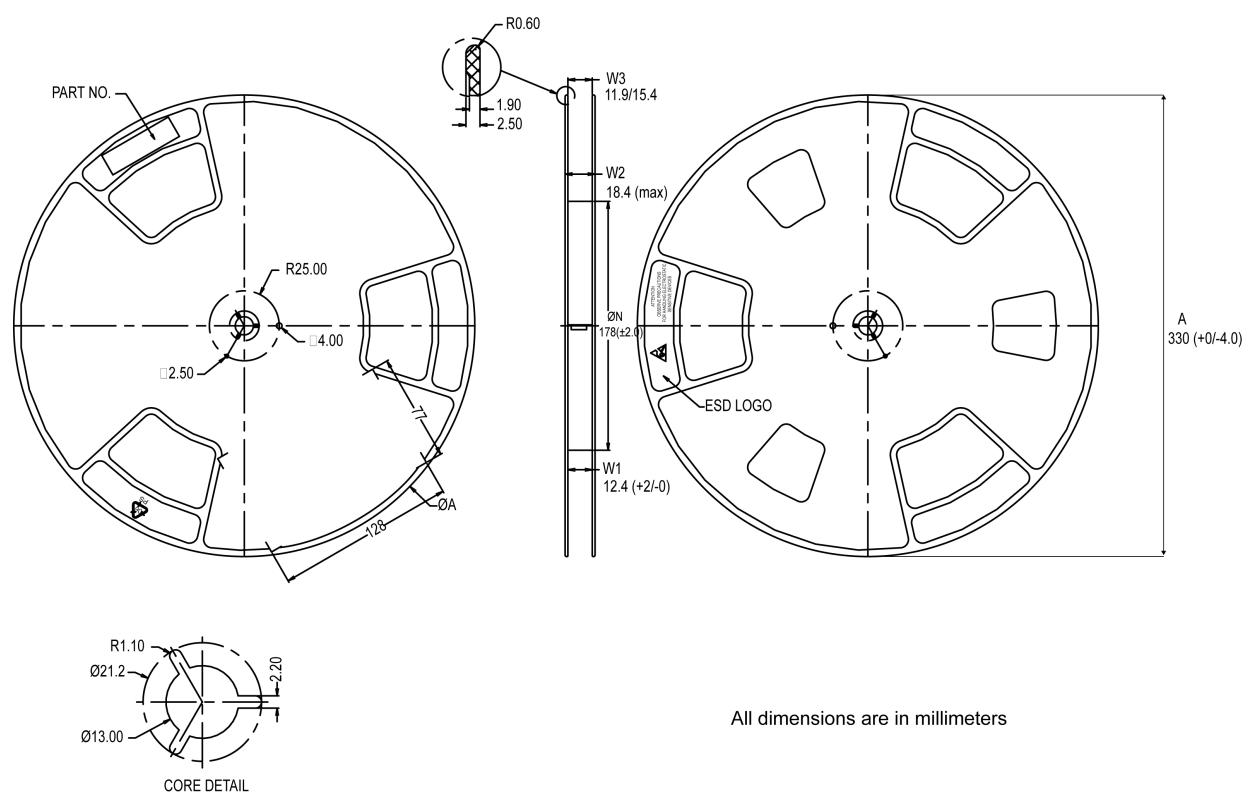
Base and bulk quantity 3000 pcs  
 All dimensions are in millimeters

8234350\_Tape\_rev\_C

Figure 22. PowerFLAT 5x6 package orientation in carrier tape



**Figure 23. PowerFLAT 5x6 reel**



8234350\_Reel\_rev\_C

## Revision history

**Table 9. Document revision history**

| Date        | Revision | Changes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|-------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 29-Mar-2013 | 1        | First release.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| 23-May-2013 | 2        | <ul style="list-style-type: none"> <li>– Document status promoted from target data to production data</li> <li>– Modified: <math>V_{GS(th)}</math> values in <i>Table 4</i></li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 28-Oct-2013 | 3        | <ul style="list-style-type: none"> <li>– Modified: title, <math>R_{DS(on)}</math> in cover page</li> <li>– Modified: <math>R_{DS(on)}</math> typical and max values in <i>Table 4</i>, <math>C_{iss}</math> typical value in table 5</li> <li>– Added: <math>Q_{SS}</math> in <i>Table 5</i></li> <li>– Modified: <math>t_{d(on)}</math> and <math>T_r</math> typical values</li> <li>– Modified: <math>T_{rr}</math>, <math>Q_{rr}</math> and <math>I_{RRM}</math> typical values in <i>Table 7</i></li> <li>– Added: <i>Section 2.1: Electrical characteristics (curves)</i></li> <li>– Updated: <i>Section 4: Package mechanical data</i></li> <li>– Minor text changes</li> </ul> |
| 13-Feb-2020 | 4        | <p>Updated <a href="#">Section 4 Package information</a>.</p> <p>Minor text changes.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |

## Contents

|          |                                                      |           |
|----------|------------------------------------------------------|-----------|
| <b>1</b> | <b>Electrical ratings .....</b>                      | <b>2</b>  |
| <b>2</b> | <b>Electrical characteristics.....</b>               | <b>3</b>  |
| 2.1      | Electrical characteristics (curves) .....            | 5         |
| <b>3</b> | <b>Test circuits .....</b>                           | <b>7</b>  |
| <b>4</b> | <b>Package information.....</b>                      | <b>8</b>  |
| 4.1      | PowerFLAT 5x6 type R package information.....        | 8         |
| 4.2      | PowerFLAT 5x6 type R SUBCON package information..... | 9         |
| 4.3      | PowerFLAT 5x6 packing information .....              | 12        |
|          | <b>Revision history .....</b>                        | <b>15</b> |

**IMPORTANT NOTICE – PLEASE READ CAREFULLY**

STMicroelectronics NV and its subsidiaries ("ST") reserve the right to make changes, corrections, enhancements, modifications, and improvements to ST products and/or to this document at any time without notice. Purchasers should obtain the latest relevant information on ST products before placing orders. ST products are sold pursuant to ST's terms and conditions of sale in place at the time of order acknowledgement.

Purchasers are solely responsible for the choice, selection, and use of ST products and ST assumes no liability for application assistance or the design of Purchasers' products.

No license, express or implied, to any intellectual property right is granted by ST herein.

Resale of ST products with provisions different from the information set forth herein shall void any warranty granted by ST for such product.

ST and the ST logo are trademarks of ST. For additional information about ST trademarks, please refer to [www.st.com/trademarks](http://www.st.com/trademarks). All other product or service names are the property of their respective owners.

Information in this document supersedes and replaces information previously supplied in any prior versions of this document.

© 2020 STMicroelectronics – All rights reserved