

## N-channel 600 V, 0.094 $\Omega$ typ., 28 A MDmesh™ DM2 Power MOSFET in a D<sup>2</sup>PAK package

Datasheet - production data

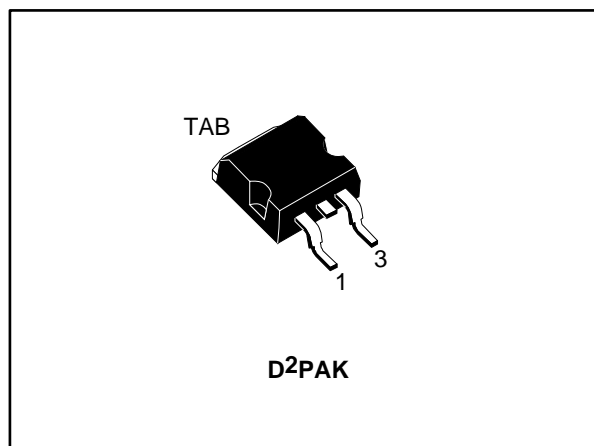
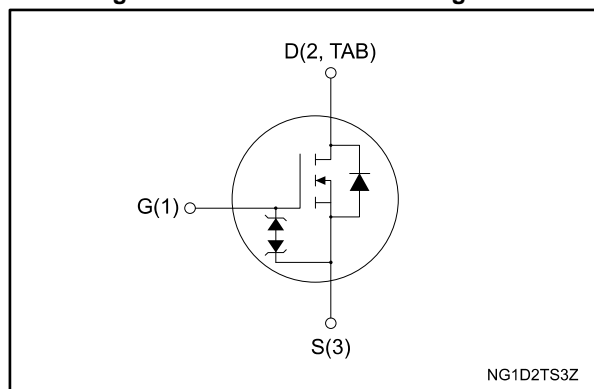


Figure 1: Internal schematic diagram



### Features

| Order code  | V <sub>DS</sub> | R <sub>DS(on)</sub> max. | I <sub>D</sub> | P <sub>TOT</sub> |
|-------------|-----------------|--------------------------|----------------|------------------|
| STB35N60DM2 | 600 V           | 0.110 $\Omega$           | 28 A           | 210 W            |

- Fast-recovery body diode
- Extremely low gate charge and input capacitance
- Low on-resistance
- 100% avalanche tested
- Extremely high dv/dt ruggedness
- Zener-protected

### Applications

- Switching applications

### Description

This high voltage N-channel Power MOSFET is part of the MDmesh™ DM2 fast recovery diode series. It offers very low recovery charge ( $Q_{rr}$ ) and time ( $t_{rr}$ ) combined with low  $R_{DS(on)}$ , rendering it suitable for the most demanding high efficiency converters and ideal for bridge topologies and ZVS phase-shift converters.

Table 1: Device summary

| Order code  | Marking  | Package            | Packing       |
|-------------|----------|--------------------|---------------|
| STB35N60DM2 | 35N60DM2 | D <sup>2</sup> PAK | Tape and reel |

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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  | $\pm 25$   | V                |
| $I_D$          | Drain current (continuous) at $T_{case} = 25\text{ }^\circ\text{C}$  | 28         | A                |
|                | Drain current (continuous) at $T_{case} = 100\text{ }^\circ\text{C}$ | 17         |                  |
| $I_{DM}^{(1)}$ | Drain current (pulsed)   | 112        | A                |
| $P_{TOT}$      | Total dissipation at $T_{case} = 25\text{ }^\circ\text{C}$           | 210        | W                |
| $dv/dt^{(2)}$  | Peak diode recovery voltage slope                                    | 50         | V/ns             |
| $dv/dt^{(3)}$  | MOSFET $dv/dt$ ruggedness  | 50         |                  |
| $T_{stg}$      | Storage temperature  | -55 to 150 | $^\circ\text{C}$ |
| $T_j$          | Operating junction temperature                                       |            |                  |

**Notes:**

<sup>(1)</sup> Pulse width is limited by safe operating area.

<sup>(2)</sup>  $I_{SD} \leq 28\text{ A}$ ,  $di/dt=900\text{ A}/\mu\text{s}$ ;  $V_{DS\text{ peak}} < V_{(BR)DSS}$ ,  $V_{DD} = 400$ .

<sup>(3)</sup>  $V_{DS} \leq 480\text{ V}$ .

**Table 3: Thermal data**

| Symbol              | Parameter                        | Value | Unit                      |
|---------------------|----------------------------------|-------|---------------------------|
| $R_{thj-case}$      | Thermal resistance junction-case | 0.6   | $^\circ\text{C}/\text{W}$ |
| $R_{thj-pcb}^{(1)}$ | Thermal resistance junction-pcb  | 30    |                           |

**Notes:**

<sup>(1)</sup> When mounted on a 1-inch<sup>2</sup> FR-4, 2 Oz copper board.

**Table 4: Avalanche characteristics**

| Symbol         | Parameter                                       | Value | Unit |
|----------------|---|-------|------|
| $I_{AR}$       | Avalanche current, repetitive or not repetitive | 6     | A    |
| $E_{AS}^{(1)}$ | Single pulse avalanche energy                   | 650   | mJ   |

**Notes:**

<sup>(1)</sup> starting  $T_j = 25\text{ }^\circ\text{C}$ ,  $I_D = I_{AR}$ ,  $V_{DD} = 50\text{ V}$ .

## 2 Electrical characteristics

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

**Table 5: Static**

| Symbol        | Parameter                         | Test conditions  | Min. | Typ.  | Max.    | Unit          |
|---------------|-----------------------------------|--|------|-------|---------|---------------|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage    | $V_{GS} = 0\text{ V}$ , $I_D = 1\text{ mA}$  | 600  |       |         | V             |
| $I_{DSS}$     | Zero gate voltage drain current   | $V_{GS} = 0\text{ V}$ , $V_{DS} = 600\text{ V}$  |      |       | 10      | $\mu\text{A}$ |
|               |                                   | $V_{GS} = 0\text{ V}$ , $V_{DS} = 600\text{ V}$ ,<br>$T_{\text{case}} = 125\text{ °C}$ |      |       | 100     |               |
| $I_{GSS}$     | Gate-body leakage current         | $V_{DS} = 0\text{ V}$ , $V_{GS} = \pm 25\text{ V}$                                     |      |       | $\pm 5$ | $\mu\text{A}$ |
| $V_{GS(th)}$  | 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 | $V_{GS} = 10\text{ V}$ , $I_D = 14\text{ A}$   |      | 0.094 | 0.11    | $\Omega$      |

**Table 6: Dynamic**

| Symbol                     | Parameter                     | Test conditions  | Min. | Typ. | Max. | Unit          |
|----------------------------|-------------------------------|--|------|------|------|---------------|
| $C_{iss}$                  | Input capacitance             | $V_{DS} = 100\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GS} = 0\text{ V}$   | -    | 2400 | -    | $\mu\text{F}$ |
| $C_{oss}$                  | Output capacitance            |  | -    | 110  | -    |               |
| $C_{rss}$                  | Reverse transfer capacitance  |  | -    | 2.8  | -    |               |
| $C_{oss\text{ eq.}}^{(1)}$ | Equivalent output capacitance | $V_{DS} = 0\text{ to }480\text{ V}$ , $V_{GS} = 0\text{ V}$  | -    | 190  | -    | $\mu\text{F}$ |
| $R_G$                      | Intrinsic gate resistance     | $f = 1\text{ MHz}$ , $I_D = 0\text{ A}$  | -    | 4.3  | -    | $\Omega$      |
| $Q_g$                      | Total gate charge             | $V_{DD} = 480\text{ V}$ , $I_D = 28\text{ A}$ , $V_{GS} = 10\text{ V}$ (see <a href="#">Figure 15: "Test circuit for gate charge behavior"</a> ) | -    | 54   | -    | nC            |
| $Q_{gs}$                   | Gate-source charge            |  | -    | 14.6 | -    |               |
| $Q_{gd}$                   | Gate-drain charge             |  | -    | 24.2 | -    |               |

**Notes:**

<sup>(1)</sup>  $C_{oss\text{ eq.}}$  is defined as a constant equivalent capacitance giving the same charging time as  $C_{oss}$  when  $V_{DS}$  increases from 0 to 80%  $V_{DSS}$ .

Table 7: Switching times

| Symbol       | Parameter           | Test conditions  | Min. | Typ. | Max. | Unit |
|--------------|---------------------|--|------|------|------|------|
| $t_{d(on)}$  | Turn-on delay time  | $V_{DD} = 300\text{ V}$ , $I_D = 14\text{ A}$ $R_G = 4.7\ \Omega$ ,<br>$V_{GS} = 10\text{ V}$ (see <a href="#">Figure 14: "Test circuit for resistive load switching times"</a> and <a href="#">Figure 19: "Switching time waveform"</a> ) | -    | 21.2 | -    | ns   |
| $t_r$        | Rise time           |  | -    | 17   | -    |      |
| $t_{d(off)}$ | Turn-off delay time |  | -    | 68   | -    |      |
| $t_f$        | Fall time           |  | -    | 10.7 | -    |      |

Table 8: Source-drain diode

| Symbol          | Parameter                     | Test conditions  | Min. | Typ. | Max. | Unit          |
|-----------------|-------------------------------|--|------|------|------|---------------|
| $I_{SD}$        | Source-drain current          |  | -    |      | 28   | A             |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |  | -    |      | 112  | A             |
| $V_{SD}^{(2)}$  | Forward on voltage            | $V_{GS} = 0\text{ V}$ , $I_{SD} = 28\text{ A}$   | -    |      | 1.6  | V             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 28\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ , $V_{DD} = 60\text{ V}$<br>(see <a href="#">Figure 16: "Test circuit for inductive load switching and diode recovery times"</a> )                                     | -    | 120  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |  | -    | 572  |      | nC            |
| $I_{RRM}$       | Reverse recovery current      |  | -    | 10.2 |      | A             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 28\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ , $V_{DD} = 60\text{ V}$ ,<br>$T_j = 150\text{ }^\circ\text{C}$ (see <a href="#">Figure 16: "Test circuit for inductive load switching and diode recovery times"</a> ) | -    | 215  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |  | -    | 1.89 |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |  | -    | 17.7 |      | A             |

**Notes:**

(1) Pulse width is limited by safe operating area.

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

Table 9: Gate-source Zener diode

| Symbol        | Parameter                     | Test conditions                                      | Min.     | Typ. | Max. | Unit |
|---------------|-------------------------------|--|----------|------|------|------|
| $V_{(BR)GSO}$ | Gate-source breakdown voltage | $I_{GS} = \pm 250\ \mu\text{A}$ , $I_D = 0\text{ A}$ | $\pm 30$ | -    | -    | 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)

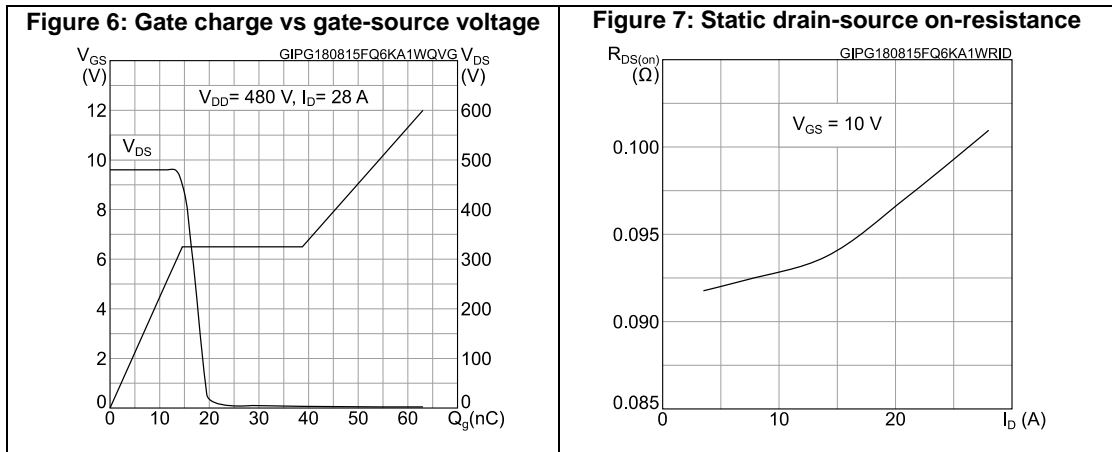
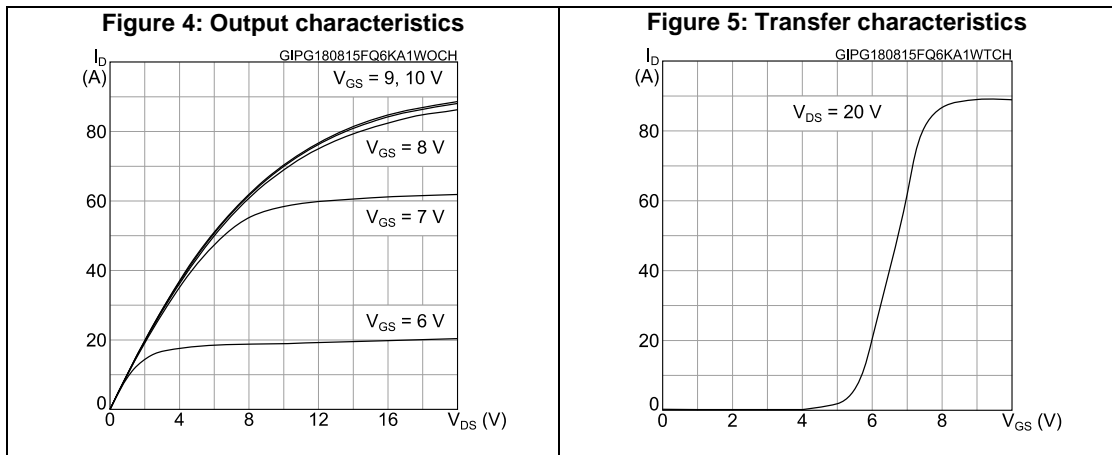
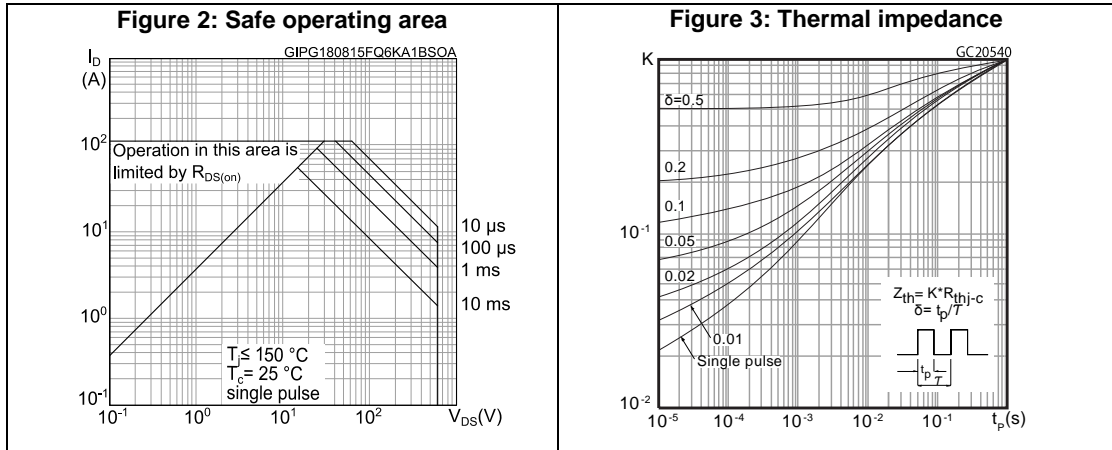


Figure 8: Capacitance variations

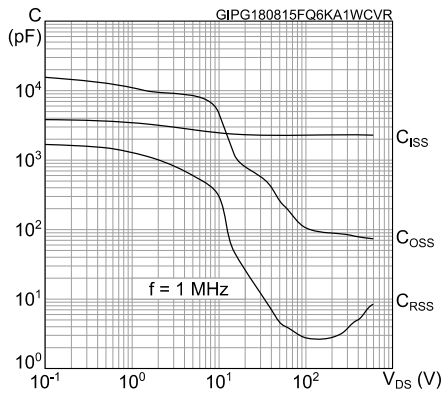


Figure 9: Normalized gate threshold voltage vs temperature

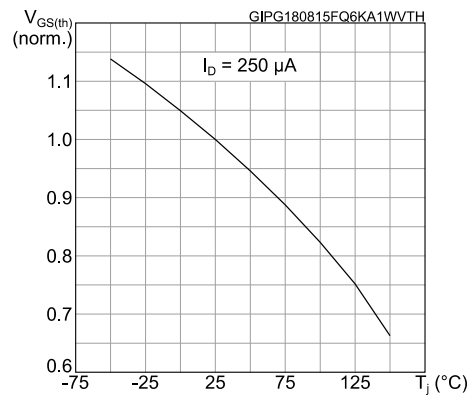


Figure 10: Normalized on-resistance vs temperature

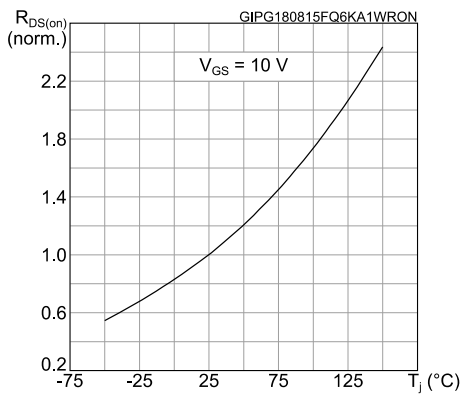


Figure 11: Normalized V(BR)DSS vs temperature

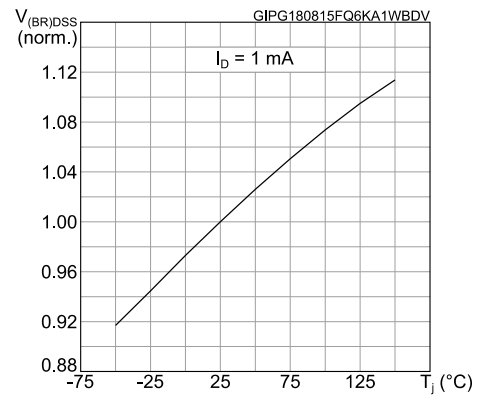


Figure 12: Output capacitance stored energy

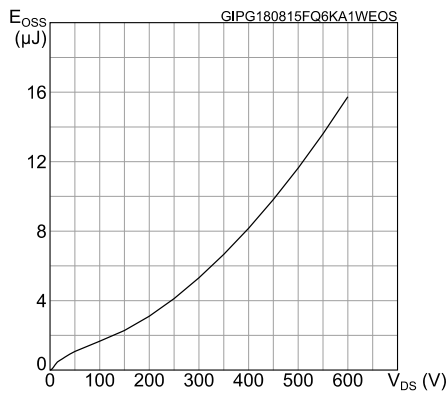
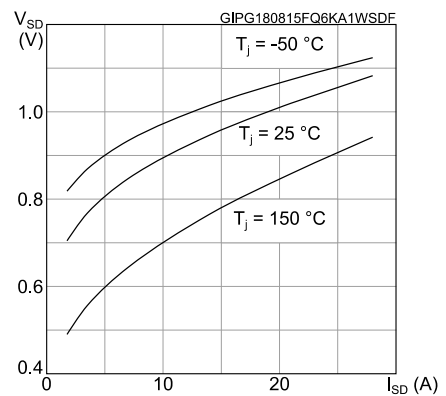
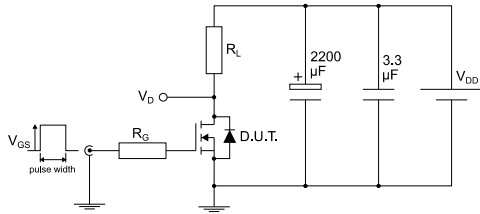


Figure 13: Source-drain diode forward characteristics



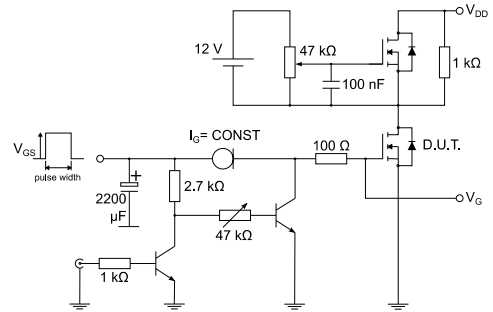
### 3 Test circuits

**Figure 14: Test circuit for resistive load switching times**



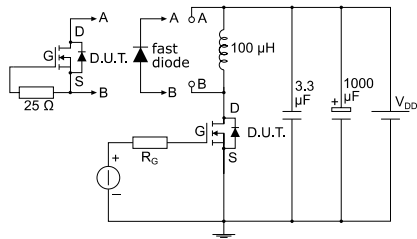
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**Figure 15: Test circuit for gate charge behavior**



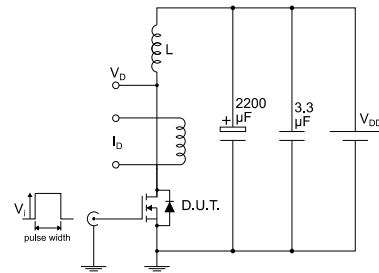
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**Figure 16: Test circuit for inductive load switching and diode recovery times**



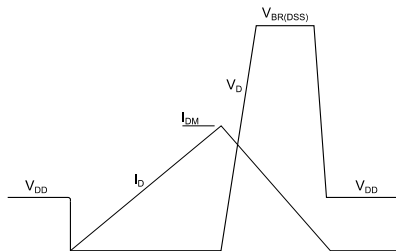
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**Figure 17: Unclamped inductive load test circuit**



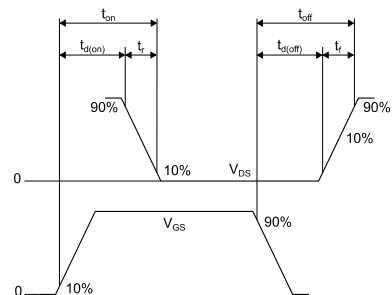
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**Figure 18: Unclamped inductive waveform**



AM01472v1

**Figure 19: 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 D<sup>2</sup>PAK (TO-263) type A package information

Figure 20: D<sup>2</sup>PAK (TO-263) type A package outline

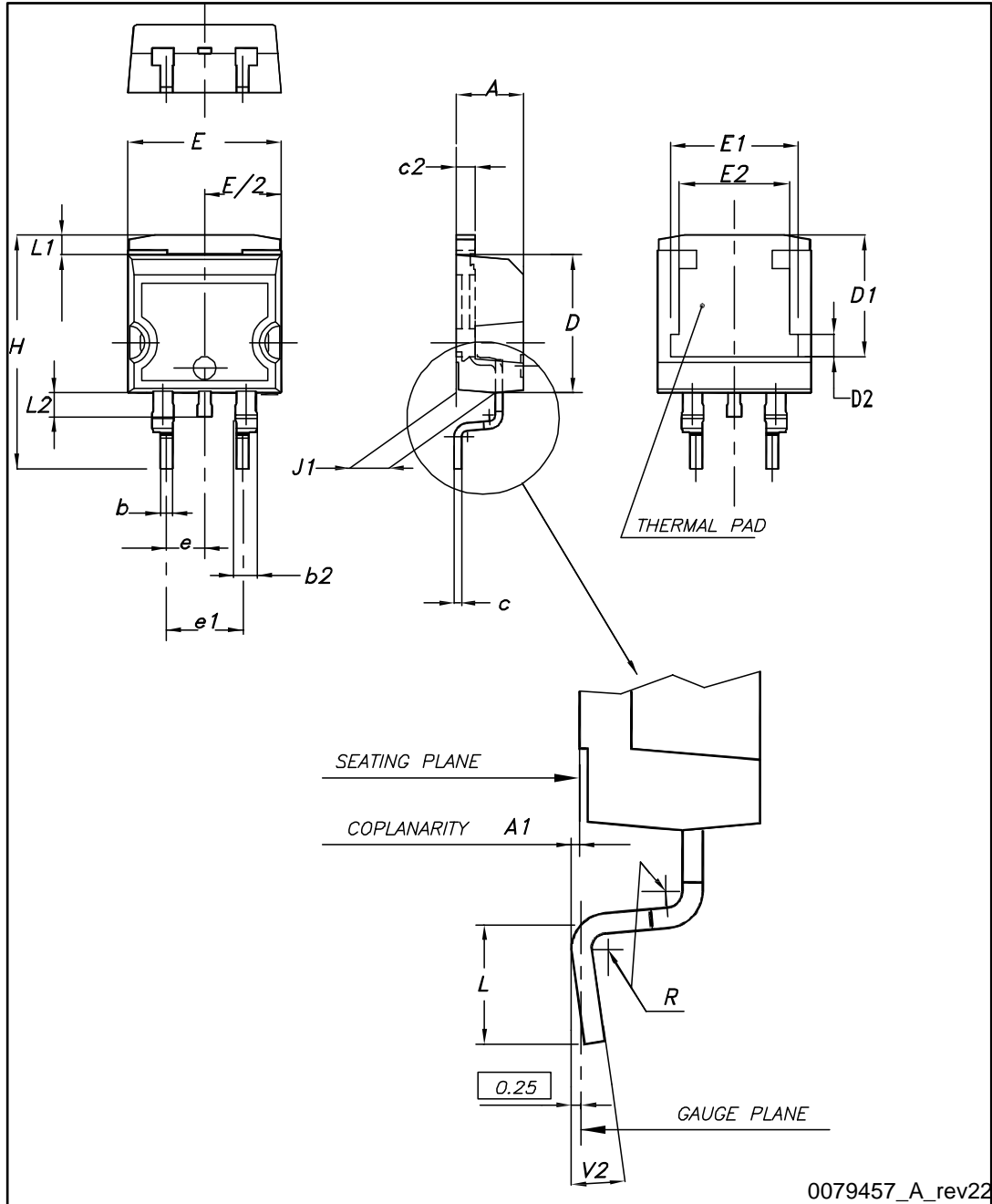
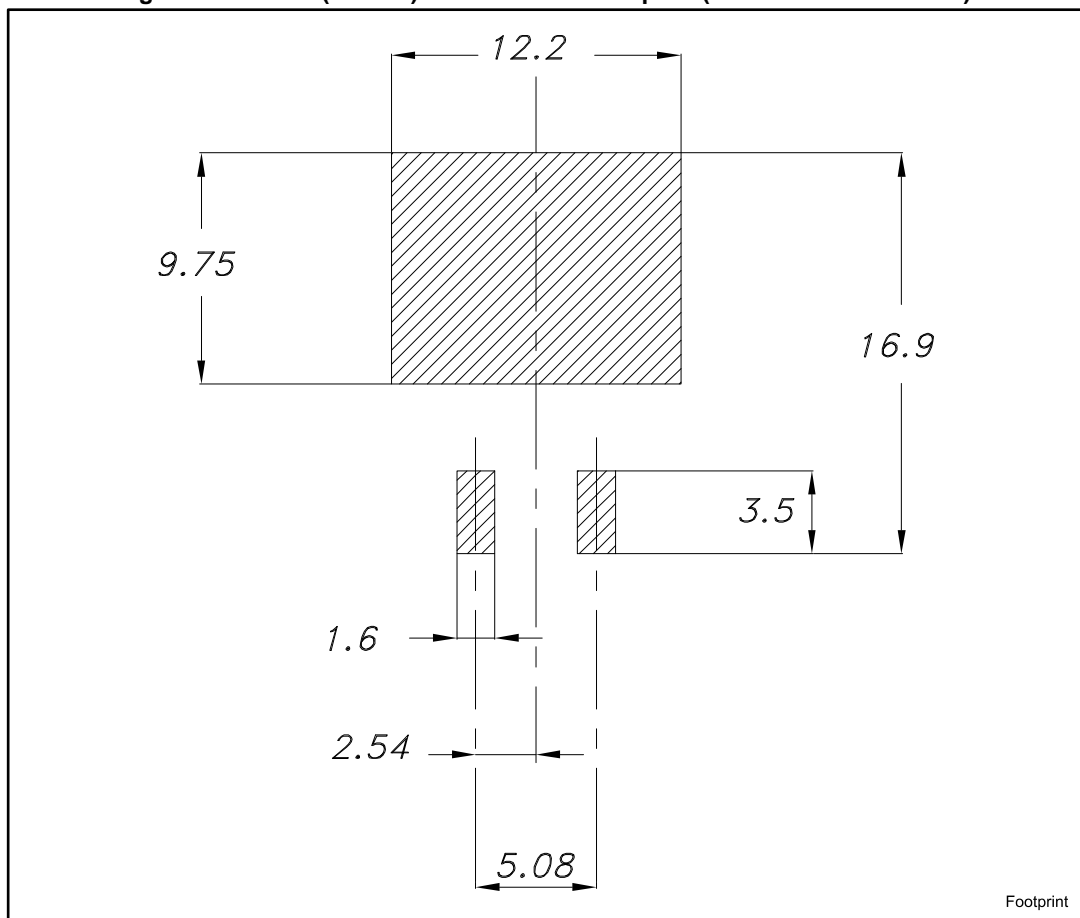


Table 10: D<sup>2</sup>PAK (TO-263) type A package mechanical data

| Dim. | mm   |      |       |
|------|------|------|-------|
|      | Min. | Typ. | Max.  |
| A    | 4.40 |      | 4.60  |
| A1   | 0.03 |      | 0.23  |
| b    | 0.70 |      | 0.93  |
| b2   | 1.14 |      | 1.70  |
| c    | 0.45 |      | 0.60  |
| c2   | 1.23 |      | 1.36  |
| D    | 8.95 |      | 9.35  |
| D1   | 7.50 | 7.75 | 8.00  |
| D2   | 1.10 | 1.30 | 1.50  |
| E    | 10   |      | 10.40 |
| E1   | 8.50 | 8.70 | 8.90  |
| E2   | 6.85 | 7.05 | 7.25  |
| e    |      | 2.54 |       |
| e1   | 4.88 |      | 5.28  |
| H    | 15   |      | 15.85 |
| J1   | 2.49 |      | 2.69  |
| L    | 2.29 |      | 2.79  |
| L1   | 1.27 |      | 1.40  |
| L2   | 1.30 |      | 1.75  |
| R    |      | 0.4  |       |
| V2   | 0°   |      | 8°    |

Figure 21: D<sup>2</sup>PAK (TO-263) recommended footprint (dimensions are in mm)



### 4.2 D<sup>2</sup>PAK packing information

Figure 22: Tape

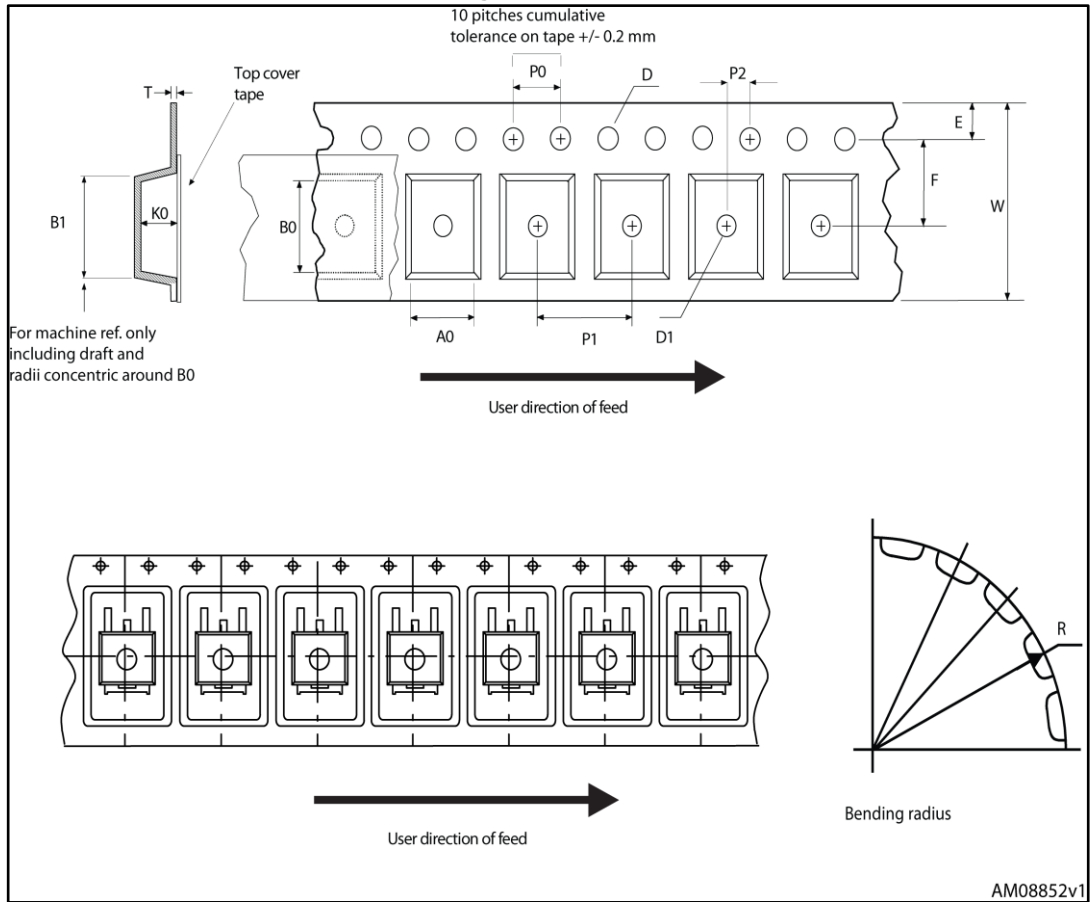
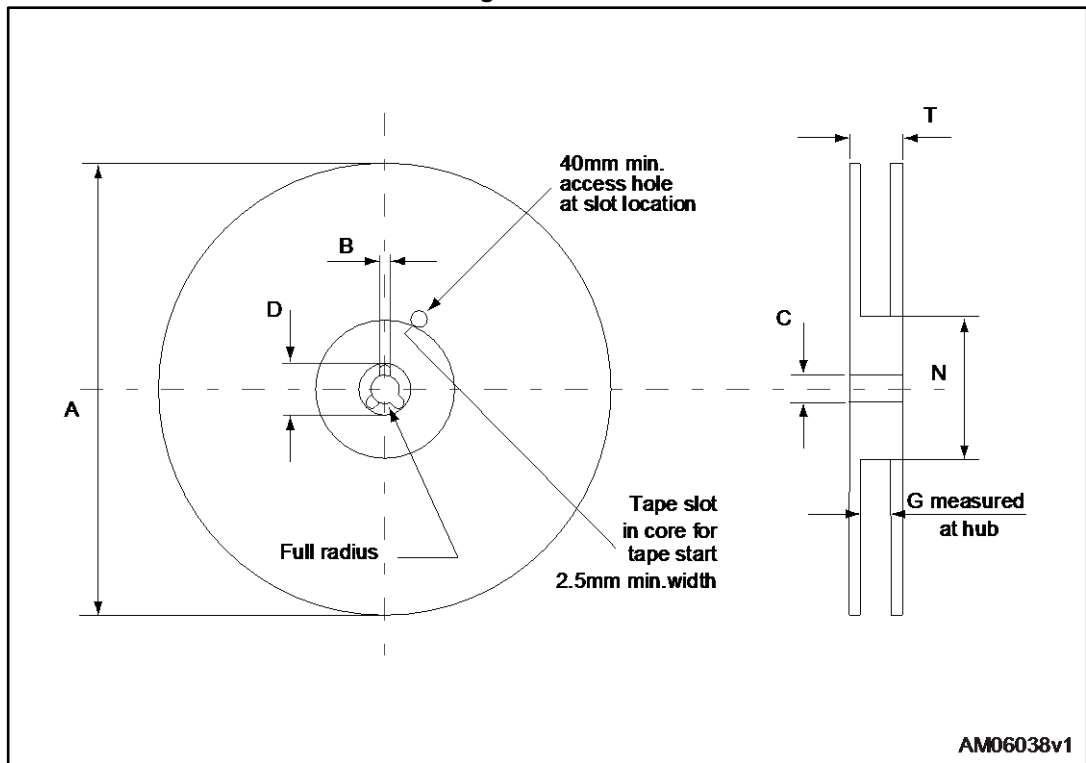


Figure 23: Reel



AM06038v1

Table 11: D<sup>2</sup>PAK tape and reel mechanical data

| Tape |      |      | Reel     |      |      |
|------|------|------|----------|------|------|
| Dim. | mm   |      | Dim.     | mm   |      |
|      | Min. | Max. |          | Min. | Max. |
| A0   | 10.5 | 10.7 | A        |      | 330  |
| B0   | 15.7 | 15.9 | B        | 1.5  |      |
| D    | 1.5  | 1.6  | C        | 12.8 | 13.2 |
| D1   | 1.59 | 1.61 | D        | 20.2 |      |
| E    | 1.65 | 1.85 | G        | 24.4 | 26.4 |
| F    | 11.4 | 11.6 | N        | 100  |      |
| K0   | 4.8  | 5.0  | T        |      | 30.4 |
| P0   | 3.9  | 4.1  |          |      |      |
| P1   | 11.9 | 12.1 | Base qty |      | 1000 |
| P2   | 1.9  | 2.1  | Bulk qty |      | 1000 |
| R    | 50   |      |          |      |      |
| T    | 0.25 | 0.35 |          |      |      |
| W    | 23.7 | 24.3 |          |      |      |

## 5 Revision history

Table 12: Document revision history

| Date        | Revision | Changes         |
|-------------|----------|-----------------|
| 08-Sep-2015 | 1        | Initial version |

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