

## N-channel 600 V, 6.7 $\Omega$ typ., 1.2 A SuperMESH3™ Power MOSFET in DPAK and IPAK packages

Datasheet – production data

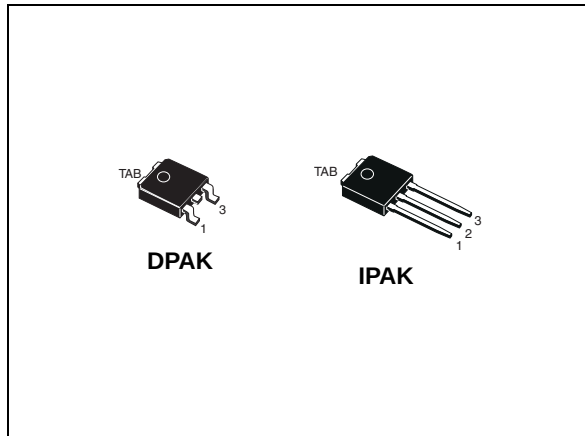
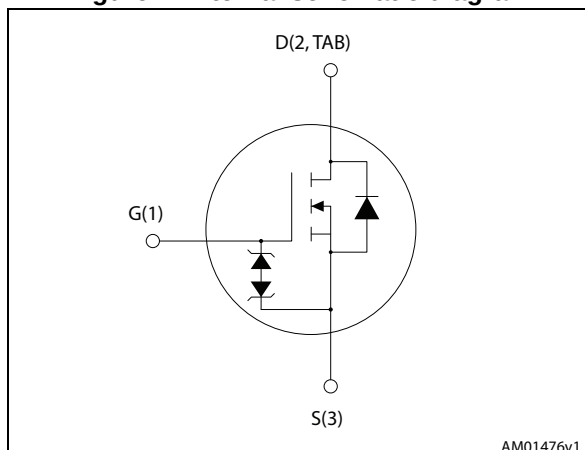


Figure 1. Internal schematic diagram



### Features

| Order codes | $V_{DS}$ | $R_{DS(on)max}$ | $I_D$ | $P_{TOT}$ |
|-------------|----------|-----------------|-------|-----------|
| STD1HN60K3  | 600 V    | 8 $\Omega$      | 1.2 A | 27 W      |
| STU1HN60K3  |          |                 |       |           |

- 100% avalanche tested
- Extremely high dv/dt capability
- Gate charge minimized
- Very low intrinsic capacitance
- Improved diode reverse recovery characteristics
- Zener-protected

### Applications

- Switching applications

### Description

These SuperMESH3™ Power MOSFETs are the result of improvements applied to STMicroelectronics' SuperMESH™ technology, combined with a new optimized vertical structure. These devices boast an extremely low on-resistance, superior dynamic performance and high avalanche capability, rendering them suitable for the most demanding applications.

Table 1. Device summary

| Order codes | Marking | Package | Packaging     |
|-------------|---------|---------|---------------|
| STD1HN60K3  | 1HN60K3 | DPAK    | Tape and reel |
| STU1HN60K3  |         | IPAK    | Tube          |

Contents

1      **Electrical ratings** ..... 3

2      **Electrical characteristics** ..... 4

      2.1    Electrical characteristics (curves) ..... 6

3      **Test circuits** ..... 9

4      **Package mechanical data** ..... 10

5      **Packaging mechanical data** ..... 16

6      **Revision history** ..... 18



# 1 Electrical ratings

Table 2. Absolute maximum ratings

| Symbol         | Parameter                                                                                                              | Value              | Unit               |
|----------------|------------------------------------------------------------------------------------------------------------------------|--------------------|--------------------|
| $V_{DS}$       | Drain- source voltage                                                                                                  | 600                | V                  |
| $V_{GS}$       | Gate- source voltage                                                                                                   | $\pm 30$           | V                  |
| $I_D$          | Drain current (continuous) at $T_C = 25\text{ }^{\circ}\text{C}$                                                       | 1.2 <sup>(1)</sup> | A                  |
| $I_D$          | Drain current (continuous) at $T_C = 100\text{ }^{\circ}\text{C}$                                                      | 0.76               | A                  |
| $I_{DM}^{(1)}$ | Drain current (pulsed)                                                                                                 | 4.8                | A                  |
| $P_{TOT}$      | Total dissipation at $T_C = 25\text{ }^{\circ}\text{C}$                                                                | 27                 | W                  |
| $I_{AR}$       | Avalanche current, repetitive or not-repetitive (pulse width limited by $T_J$ max)                                     | 1.2                | A                  |
| $E_{AS}$       | Single pulse avalanche energy (starting $T_J = 25\text{ }^{\circ}\text{C}$ , $I_D = I_{AR}$ , $V_{DD} = 50\text{ V}$ ) | 60                 | mJ                 |
| $dv/dt^{(2)}$  | Peak diode recovery voltage slope                                                                                      | 5                  | V/ns               |
| $T_J$          | Operating junction temperature                                                                                         | -55 to 150         | $^{\circ}\text{C}$ |
| $T_{stg}$      | Storage temperature                                                                                                    |                    | $^{\circ}\text{C}$ |

1. Pulse width limited by safe operating area

2.  $I_{SD} \leq 1.2\text{ A}$ ,  $di/dt \leq 400\text{ A}/\mu\text{s}$ ,  $V_{DS\text{ peak}} \leq V_{(BR)DSS}$ ,  $V_{DD} = 80\% V_{(BR)DSS}$ .

Table 3. Thermal data

| Symbol         | Parameter                               | Value |      | Unit                        |
|----------------|-----------------------------------------|-------|------|-----------------------------|
|                |                                         | DPAK  | IPAK |                             |
| $R_{thj-case}$ | Thermal resistance junction-case max.   | 4.63  |      | $^{\circ}\text{C}/\text{W}$ |
| $R_{thj-amb}$  | Thermal resistance junction-ambient max |       | 100  | $^{\circ}\text{C}/\text{W}$ |
| $R_{thj-pcb}$  | Thermal resistance junction-pcb max.    | 50    |      | $^{\circ}\text{C}/\text{W}$ |

## 2 Electrical characteristics

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

**Table 4. On /off states**

| Symbol                      | Parameter                                               | Test conditions                                                                          | Min. | Typ. | Max.     | Unit                           |
|-----------------------------|---------------------------------------------------------|------------------------------------------------------------------------------------------|------|------|----------|--------------------------------|
| $V_{(\text{BR})\text{DSS}}$ | Drain-source breakdown voltage                          | $I_D = 1\text{ mA}$ , $V_{\text{GS}} = 0$                                                | 600  |      |          | V                              |
| $I_{\text{DSS}}$            | Zero gate voltage drain current ( $V_{\text{GS}} = 0$ ) | $V_{\text{DS}} = 600\text{ V}$<br>$V_{\text{DS}} = 600\text{ V}$ , $T_C = 125\text{ °C}$ |      |      | 1<br>50  | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{\text{GSS}}$            | Gate-body leakage current ( $V_{\text{DS}} = 0$ )       | $V_{\text{GS}} = \pm 20\text{ V}$                                                        |      |      | $\pm 10$ | $\mu\text{A}$                  |
| $V_{\text{GS(th)}}$         | Gate threshold voltage                                  | $V_{\text{DS}} = V_{\text{GS}}$ , $I_D = 50\text{ }\mu\text{A}$                          | 2    | 3.75 | 4.5      | V                              |
| $R_{\text{DS(on)}}$         | Static drain-source on-resistance                       | $V_{\text{GS}} = 10\text{ V}$ , $I_D = 0.6\text{ A}$                                     |      | 6.7  | 8        | $\Omega$                       |

**Table 5. Dynamic**

| Symbol                   | Parameter                             | Test conditions                                                                                             | Min. | Typ. | Max. | Unit     |
|--------------------------|---------------------------------------|-------------------------------------------------------------------------------------------------------------|------|------|------|----------|
| $C_{\text{iss}}$         | Input capacitance                     | $V_{\text{DS}} = 50\text{ V}$ , $f = 1\text{ MHz}$ ,<br>$V_{\text{GS}} = 0$                                 | -    | 140  | -    | pF       |
| $C_{\text{oss}}$         | Output capacitance                    |                                                                                                             | -    | 13   | -    | pF       |
| $C_{\text{rss}}$         | Reverse transfer capacitance          |                                                                                                             | -    | 2    | -    | pF       |
| $C_{\text{o(tr)}}^{(1)}$ | Equivalent capacitance time related   | $V_{\text{DS}} = 0\text{ to }480\text{ V}$ , $V_{\text{GS}} = 0$                                            | -    | 9    | -    | pF       |
| $C_{\text{o(tr)}}^{(2)}$ | Equivalent capacitance energy related |                                                                                                             | -    | 6    | -    | pF       |
| $R_g$                    | Gate input resistance                 | $f = 1\text{ MHz}$ open drain                                                                               | -    | 10   | -    | $\Omega$ |
| $Q_g$                    | Total gate charge                     | $V_{\text{DD}} = 480\text{ V}$ , $I_D = 1.2\text{ A}$ ,<br>$V_{\text{GS}} = 10\text{ V}$<br>(see Figure 16) | -    | 9.5  | -    | nC       |
| $Q_{\text{gs}}$          | Gate-source charge                    |                                                                                                             | -    | 1.5  | -    | nC       |
| $Q_{\text{gd}}$          | Gate-drain charge                     |                                                                                                             | -    | 6.5  | -    | nC       |

1.  $C_{\text{o(tr)}}^{(1)}$  is defined as a constant equivalent capacitance giving the same charging time as  $C_{\text{oss}}$  when  $V_{\text{DS}}$  increases from 0 to 80%  $V_{\text{DS}}$
2.  $C_{\text{o(tr)}}^{(2)}$  is defined as a constant equivalent capacitance giving the same charging time as  $C_{\text{oss}}$  when  $V_{\text{DS}}$  increases from 0 to 80%  $V_{\text{DS}}$

Table 6. Switching times

| Symbol       | Parameter           | Test conditions                                                                                                     | Min. | Typ. | Max | Unit |
|--------------|---------------------|---------------------------------------------------------------------------------------------------------------------|------|------|-----|------|
| $t_{d(on)}$  | Turn-on delay time  | $V_{DD} = 300\text{ V}$ , $I_D = 0.6\text{ A}$ ,<br>$R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$<br>(see Figure 10) | -    | 7    | -   | ns   |
| $t_r$        | Rise time           |                                                                                                                     | -    | 10   | -   | ns   |
| $t_{d(off)}$ | Turn-off-delay time |                                                                                                                     | -    | 23   | -   | ns   |
| $t_f$        | Fall time           |                                                                                                                     | -    | 31   | -   | ns   |

Table 7. Source drain diode

| Symbol          | Parameter                     | Test conditions                                                                                                                               | Min. | Typ. | Max | Unit |
|-----------------|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|------|------|-----|------|
| $I_{SD}$        | Source-drain current          |                                                                                                                                               | -    |      | 1.2 | A    |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |                                                                                                                                               | -    |      | 4.8 | A    |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD} = 1.2\text{ A}$ , $V_{GS} = 0$                                                                                                        | -    |      | 1.6 | V    |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 1.2\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$<br>$V_{DD} = 60\text{ V}$<br>(see Figure 11)                                     | -    | 180  |     | ns   |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                               | -    | 500  |     | nC   |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                               | -    | 5.6  |     | A    |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 1.2\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$<br>$V_{DD} = 60\text{ V}$ , $T_J = 150\text{ }^\circ\text{C}$<br>(see Figure 11) | -    | 200  |     | ns   |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                               | -    | 570  |     | nC   |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                               | -    | 6    |     | A    |

1. Pulse width limited by safe operating area
2. Pulsed: pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%

Table 8. Gate-source Zener diode

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

The built-in back-to-back Zener diodes have been specifically designed to enhance not only the device's ESD capability, but also to make them capable of safely absorbing any voltage transients that may occasionally be applied from gate to source. In this respect, the Zener voltage is appropriate to achieve efficient and cost-effective protection of device integrity. The integrated Zener diodes thus eliminate the need for external components.

## 2.1 Electrical characteristics (curves)

Figure 2. Safe operating area

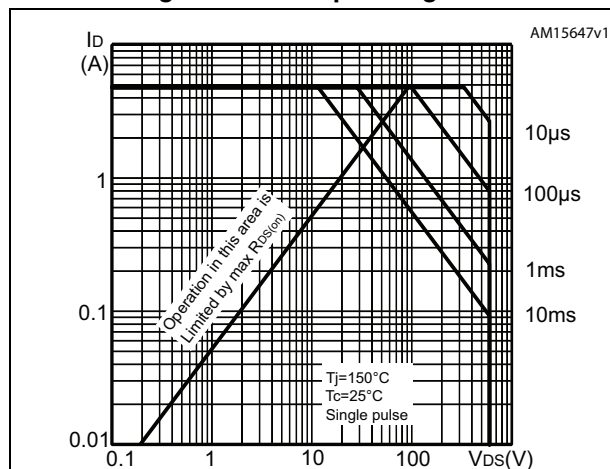


Figure 3. Thermal impedance

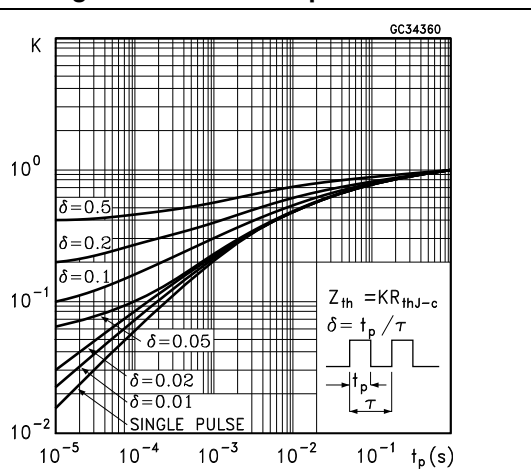


Figure 4. Output characteristics

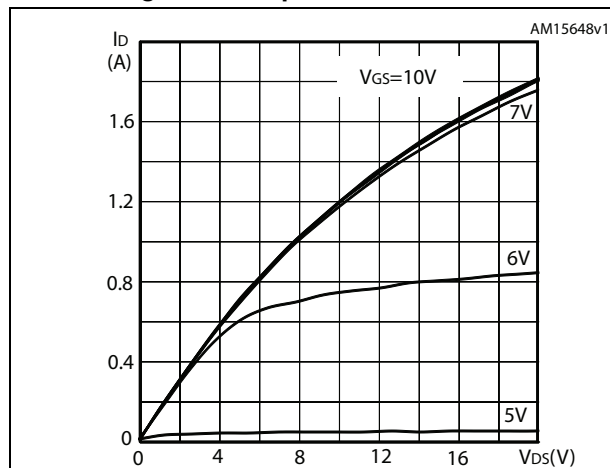


Figure 5. Transfer characteristics

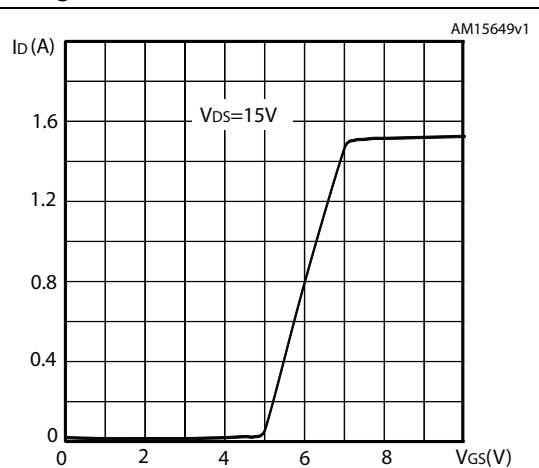
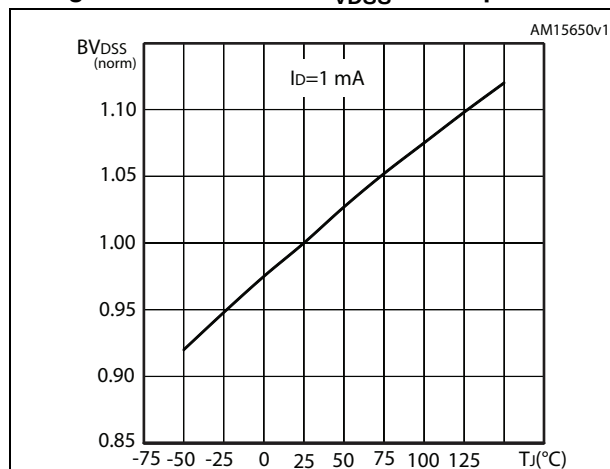
Figure 6. Normalized  $B_{VDS}$  vs temperature

Figure 7. Static drain-source on-resistance

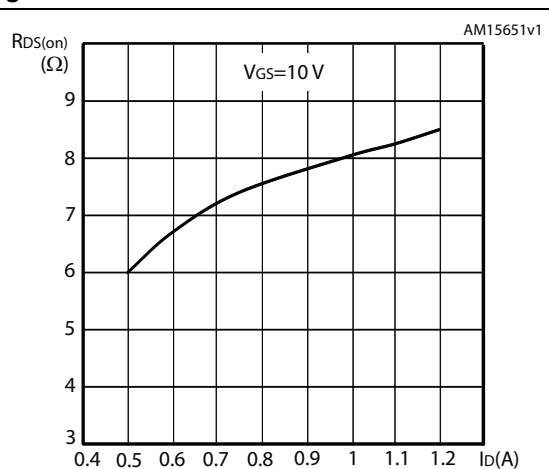


Figure 8. Gate charge vs gate-source voltage

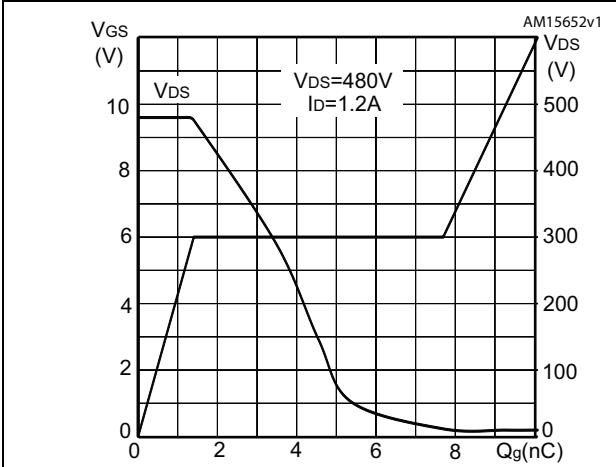


Figure 9. Capacitance variations

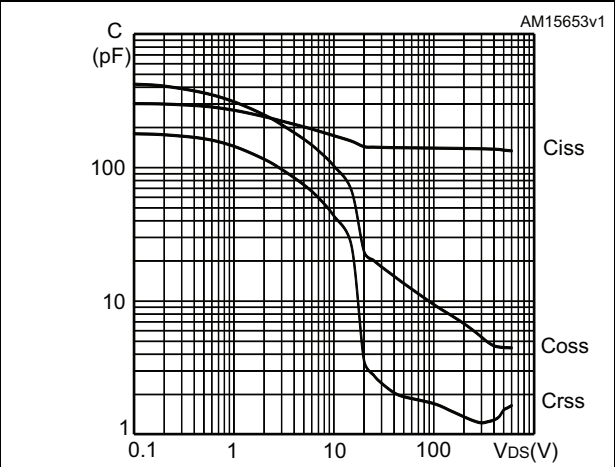


Figure 10. Normalized gate threshold voltage vs temperature

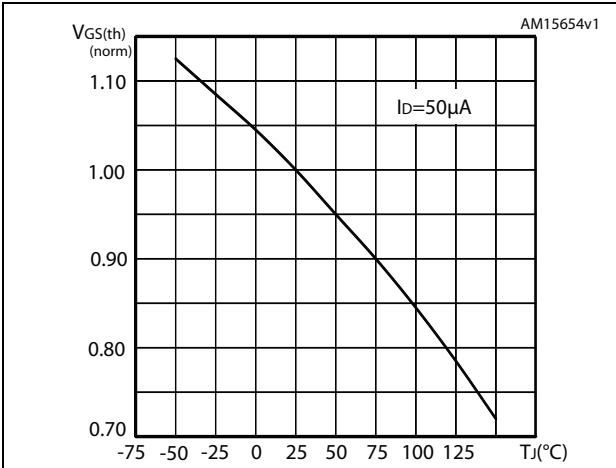


Figure 11. Normalized on-resistance vs temperature

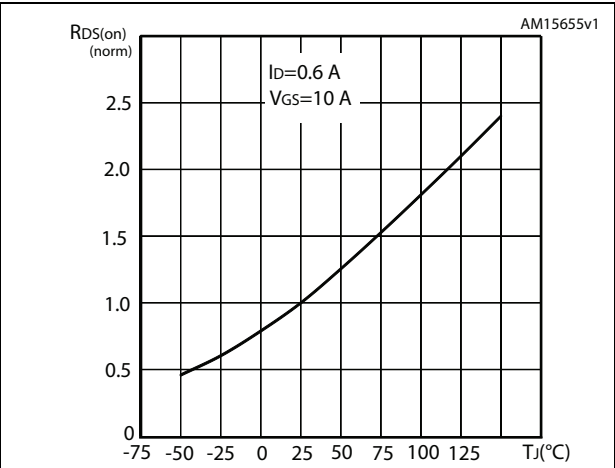


Figure 12. Source-drain diode forward characteristics

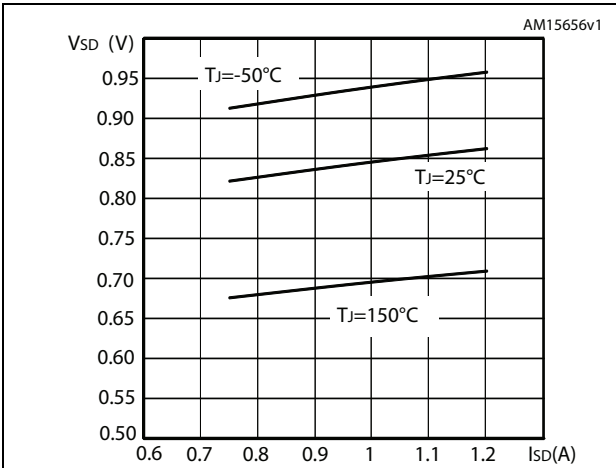
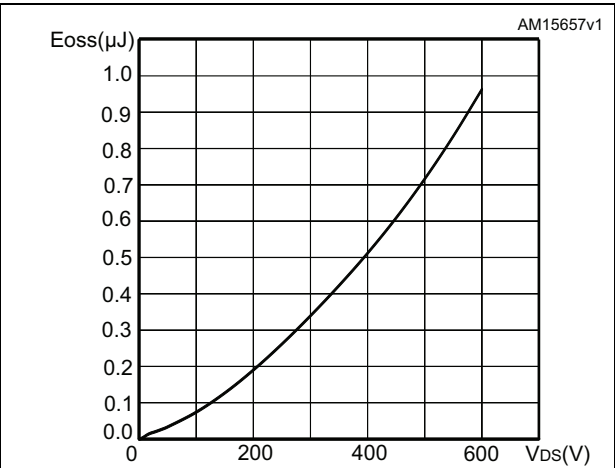
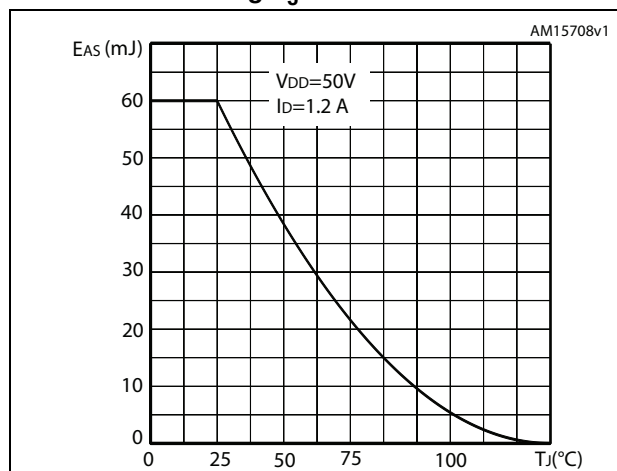


Figure 13. Output capacitance stored energy



**Figure 14. Maximum avalanche energy vs. starting  $T_J$**



### 3 Test circuits

Figure 15. Switching times test circuit for resistive load



Figure 16. Gate charge test circuit

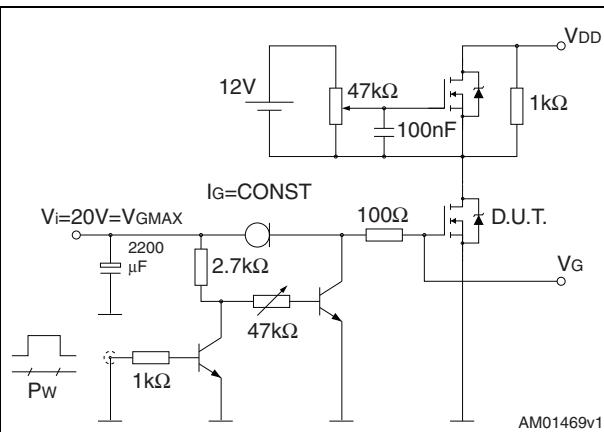


Figure 17. Test circuit for inductive load switching and diode recovery times

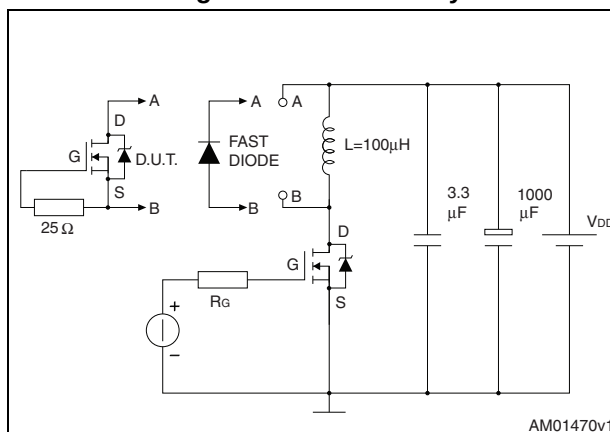


Figure 18. Unclamped inductive load test circuit

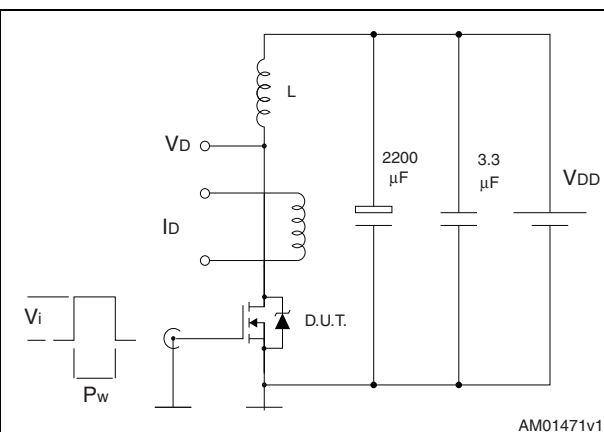


Figure 19. Unclamped inductive waveform

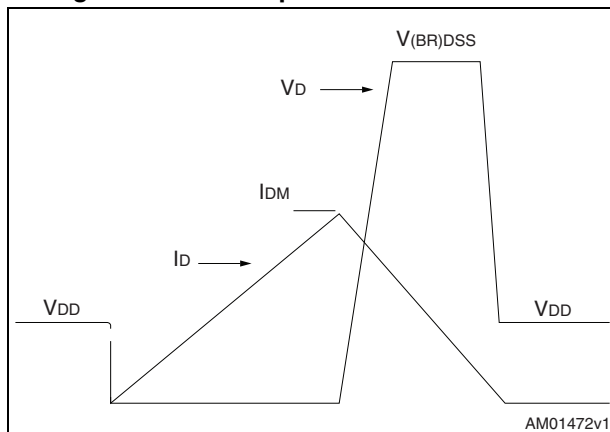


Figure 20. Switching time waveform



## 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<sup>®</sup> is an ST trademark.

Table 9. DPAK (TO-252) mechanical data

| Dim. | mm   |      |       |
|------|------|------|-------|
|      | Min. | Typ. | Max.  |
| A    | 2.20 |      | 2.40  |
| A1   | 0.90 |      | 1.10  |
| A2   | 0.03 |      | 0.23  |
| b    | 0.64 |      | 0.90  |
| b4   | 5.20 |      | 5.40  |
| c    | 0.45 |      | 0.60  |
| c2   | 0.48 |      | 0.60  |
| D    | 6.00 |      | 6.20  |
| D1   |      | 5.10 |       |
| E    | 6.40 |      | 6.60  |
| E1   |      | 4.70 |       |
| e    |      | 2.28 |       |
| e1   | 4.40 |      | 4.60  |
| H    | 9.35 |      | 10.10 |
| L    | 1.00 |      | 1.50  |
| (L1) |      | 2.80 |       |
| L2   |      | 0.80 |       |
| L4   | 0.60 |      | 1.00  |
| R    |      | 0.20 |       |
| V2   | 0°   |      | 8°    |

Figure 21. DPAK (TO-252) drawing

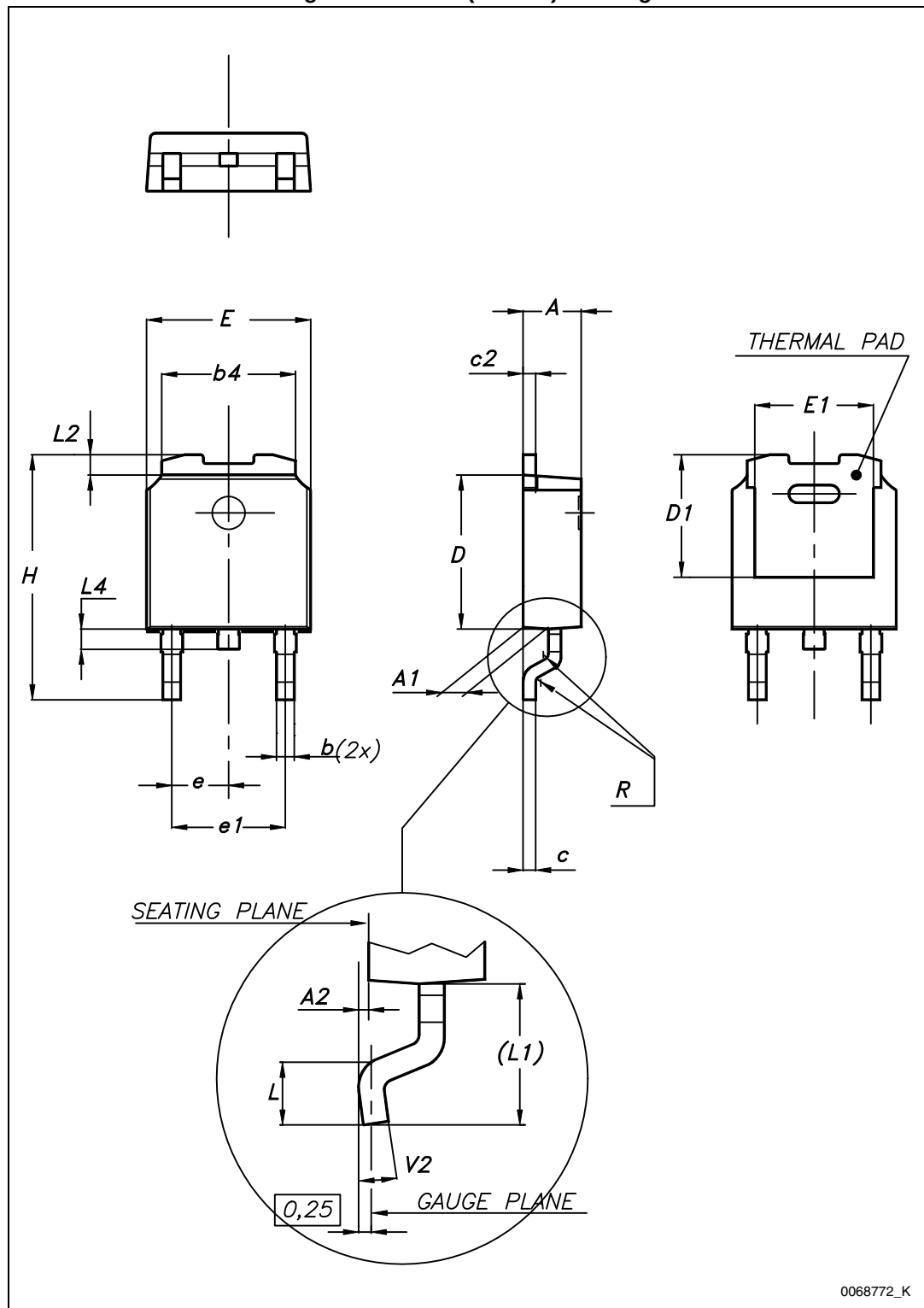
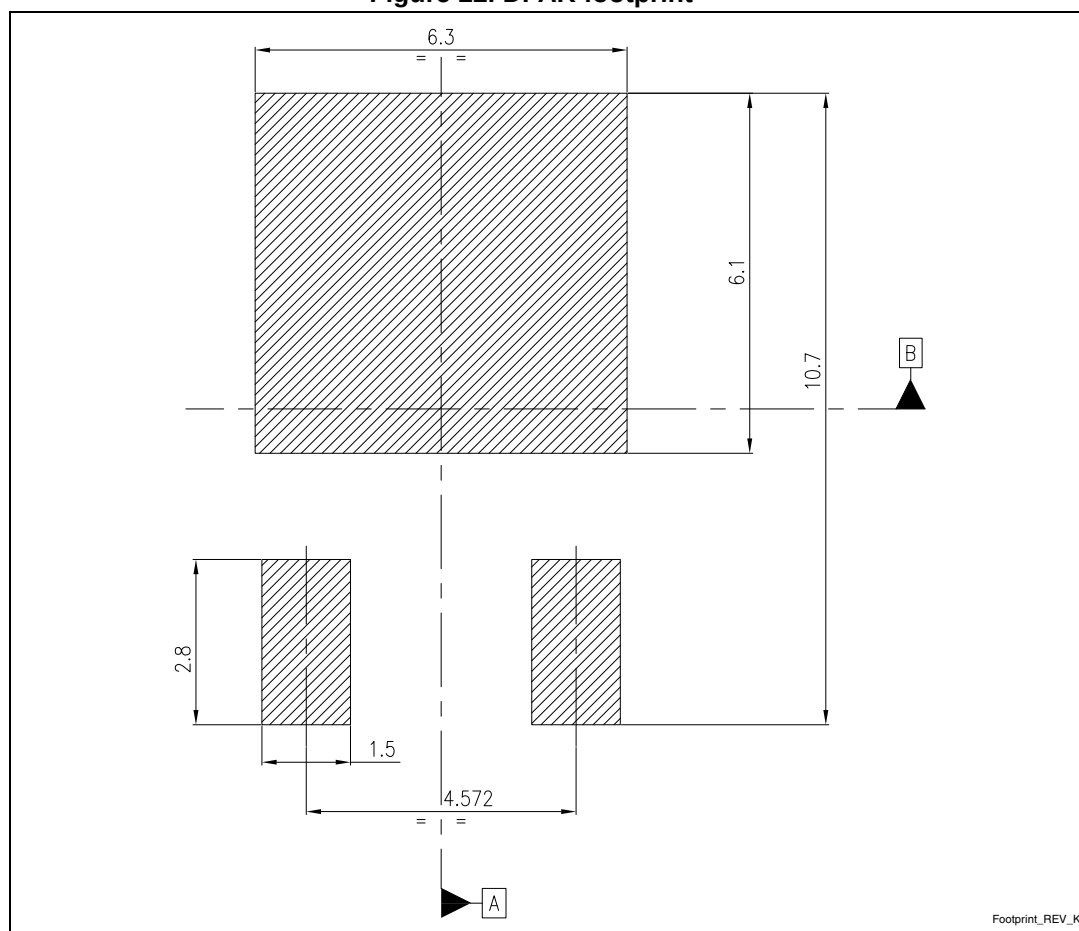


Figure 22. DPAK footprint (a)

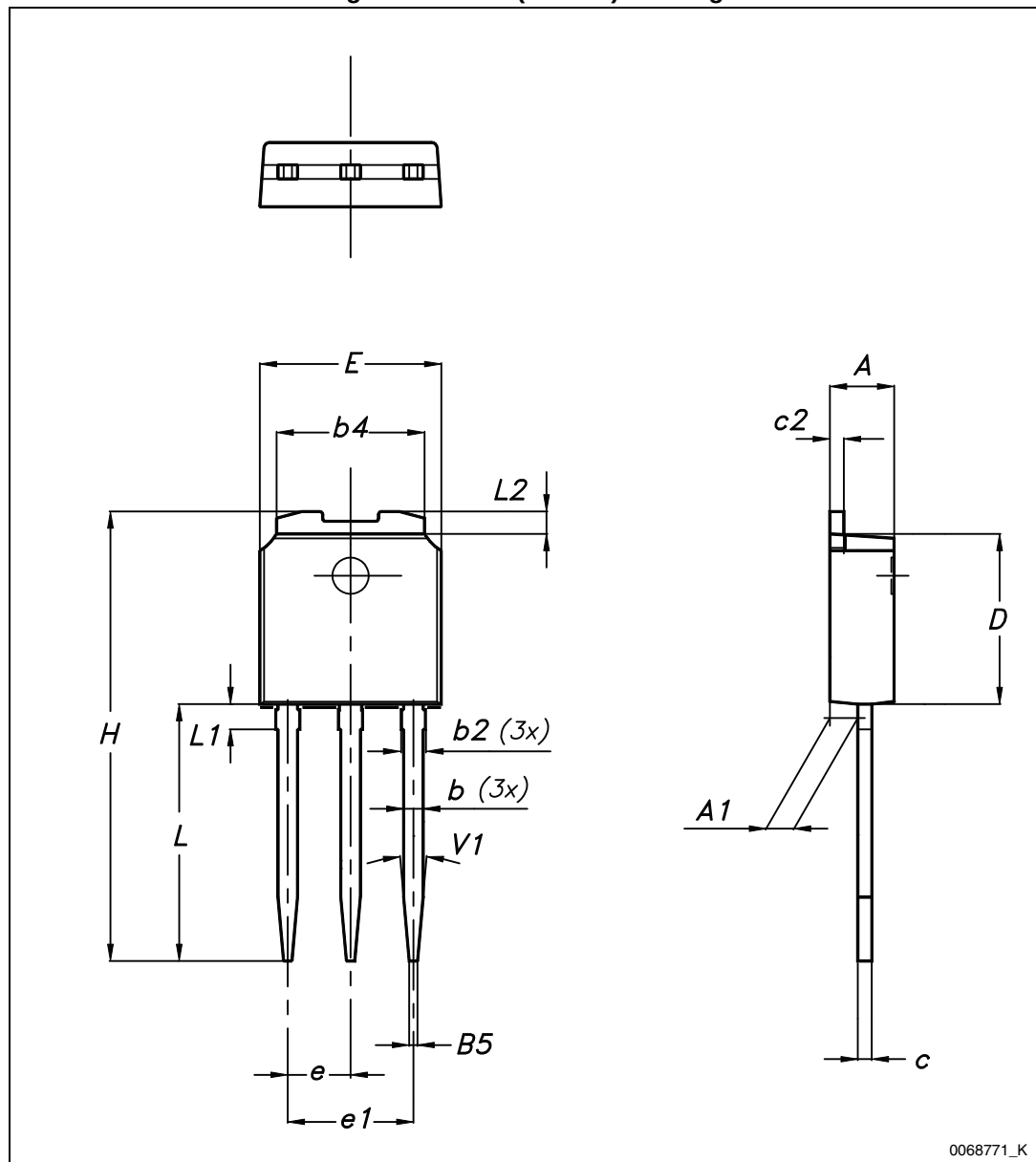


a. All dimensions are in millimeters

Table 10. IPAK (TO-251) mechanical data

| DIM | mm.  |       |      |
|-----|------|-------|------|
|     | min. | typ.  | max. |
| A   | 2.20 |       | 2.40 |
| A1  | 0.90 |       | 1.10 |
| b   | 0.64 |       | 0.90 |
| b2  |      |       | 0.95 |
| b4  | 5.20 |       | 5.40 |
| B5  |      | 0.30  |      |
| c   | 0.45 |       | 0.60 |
| c2  | 0.48 |       | 0.60 |
| D   | 6.00 |       | 6.20 |
| E   | 6.40 |       | 6.60 |
| e   |      | 2.28  |      |
| e1  | 4.40 |       | 4.60 |
| H   |      | 16.10 |      |
| L   | 9.00 |       | 9.40 |
| L1  | 0.80 |       | 1.20 |
| L2  |      | 0.80  | 1.00 |
| V1  |      | 10°   |      |

Figure 23. IPAK (TO-251) drawing



## 5 Packaging mechanical data

Table 11. DPAK (TO-252) tape and reel mechanical data

| Tape |      |      | Reel      |      |      |
|------|------|------|-----------|------|------|
| Dim. | mm   |      | Dim.      | mm   |      |
|      | Min. | Max. |           | Min. | Max. |
| A0   | 6.8  | 7    | A         |      | 330  |
| B0   | 10.4 | 10.6 | B         | 1.5  |      |
| B1   |      | 12.1 | C         | 12.8 | 13.2 |
| D    | 1.5  | 1.6  | D         | 20.2 |      |
| D1   | 1.5  |      | G         | 16.4 | 18.4 |
| E    | 1.65 | 1.85 | N         | 50   |      |
| F    | 7.4  | 7.6  | T         |      | 22.4 |
| K0   | 2.55 | 2.75 |           |      |      |
| P0   | 3.9  | 4.1  | Base qty. |      | 2500 |
| P1   | 7.9  | 8.1  | Bulk qty. |      | 2500 |
| P2   | 1.9  | 2.1  |           |      |      |
| R    | 40   |      |           |      |      |
| T    | 0.25 | 0.35 |           |      |      |
| W    | 15.7 | 16.3 |           |      |      |

Figure 24. Tape for DPAK (TO-252)

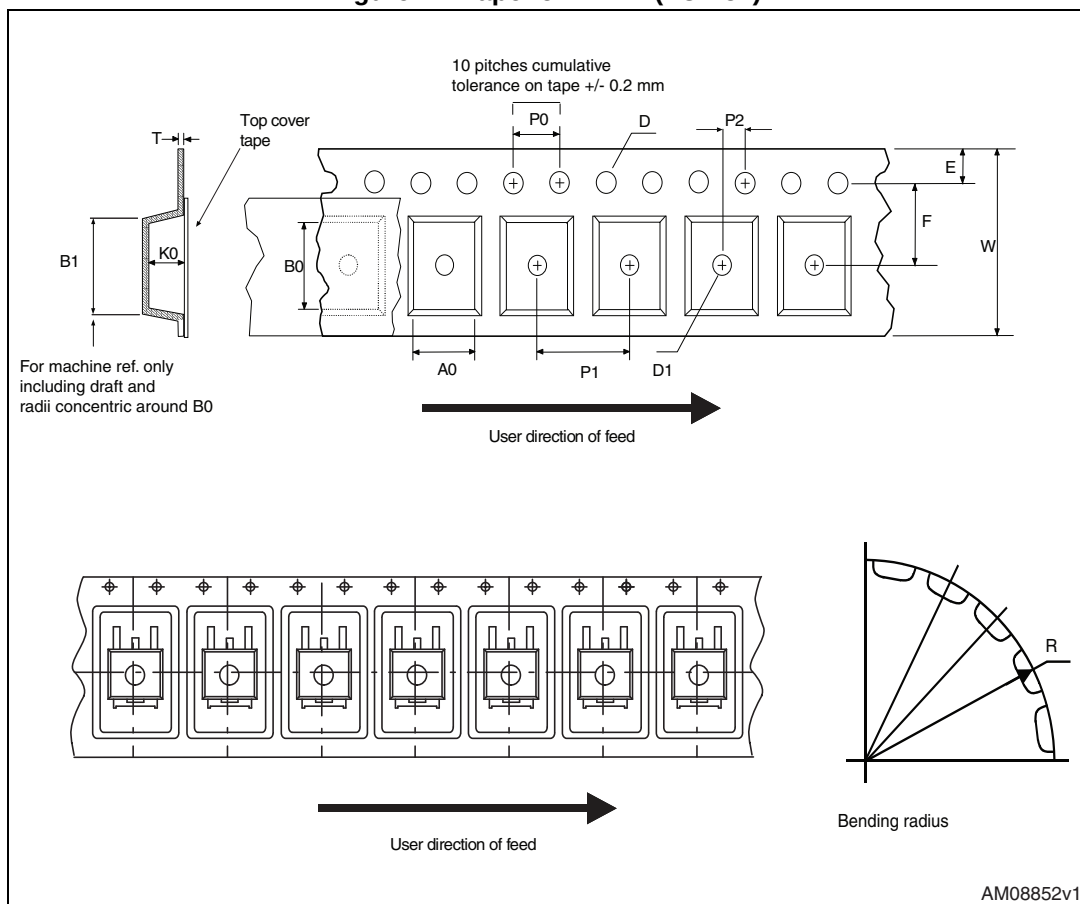
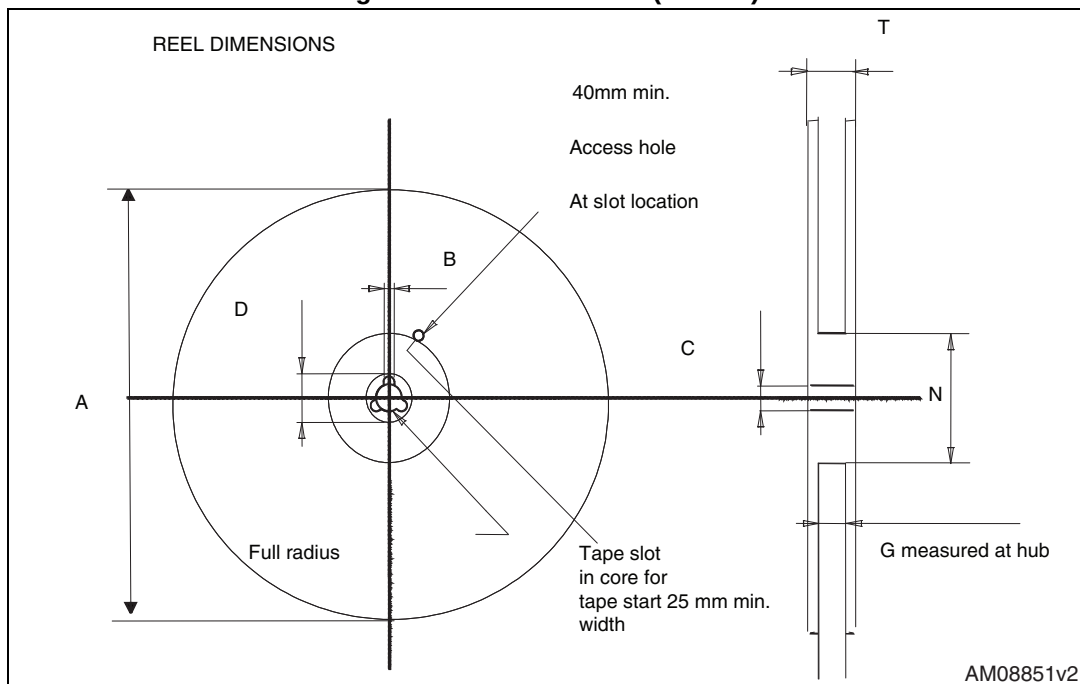


Figure 25. Reel for DPAK (TO-252)



## 6 Revision history

**Table 12. Document revision history**

| Date        | Revision | Changes        |
|-------------|----------|----------------|
| 09-Apr-2013 | 1        | First release. |

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