



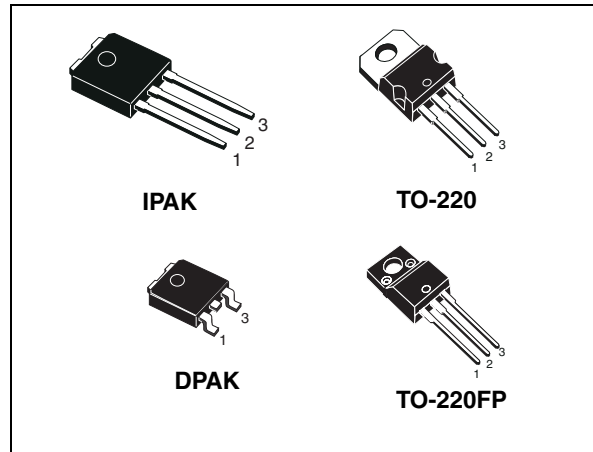
# STD7NM60N, STF7NM60N STP7NM60N, STU7NM60N

N-channel 600 V, 5 A, 0.84  $\Omega$  DPAK, TO-220FP, TO-220, IPAK  
second generation MDmesh™ Power MOSFET

## Features

| Order codes                                      | $V_{DS}$ @<br>$T_{Jmax}$ | $R_{DS(on)}$<br>max. | $I_D$ |
|--------------------------------------------------|--------------------------|----------------------|-------|
| STD7NM60N<br>STF7NM60N<br>STP7NM60N<br>STU7NM60N | 650 V                    | < 0.9 $\Omega$       | 5 A   |

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



## Application

Switching applications

## Description

These devices are N-channel Power MOSFETs realized using the second generation of MDmesh™ technology. It applies the benefits of the multiple drain process to STMicroelectronics' well-known PowerMESH™ horizontal layout structure. The resulting product offers improved on-resistance, low gate charge, high dv/dt capability and excellent avalanche characteristics.

Figure 1. Internal schematic diagram

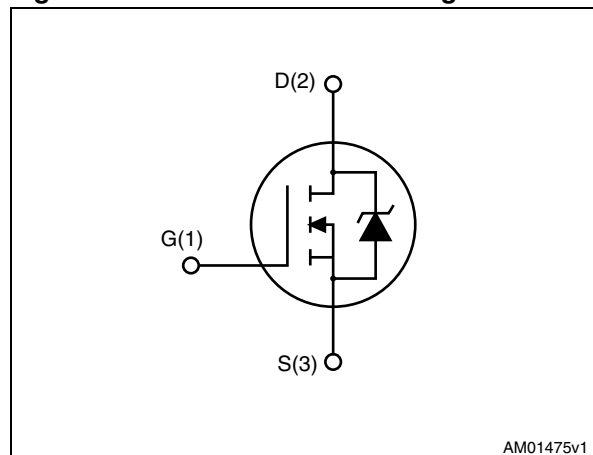


Table 1. Device summary

| Order codes | Marking | Package  | Packaging     |
|-------------|---------|----------|---------------|
| STD7NM60N   | 7NM60N  | DPAK     | Tape and reel |
| STF7NM60N   |         | TO-220FP | Tube          |
| STP7NM60N   |         | TO-220   | Tube          |
| STU7NM60N   |         | 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** ..... 15

6      **Revision history** ..... 16



# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol         | Parameter                                                                                                                               | Value              |                   | Unit               |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------|--------------------|-------------------|--------------------|
|                |                                                                                                                                         | TO-220, IPAK, DPAK | TO-220FP          |                    |
| $V_{DS}$       | Drain-source voltage ( $V_{GS} = 0$ )                                                                                                   | 600                |                   | V                  |
| $V_{GS}$       | Gate-source voltage                                                                                                                     | $\pm 25$           |                   | V                  |
| $I_D$          | Drain current (continuous) at $T_C = 25\text{ }^{\circ}\text{C}$                                                                        | 5                  | 5 <sup>(1)</sup>  | A                  |
| $I_D$          | Drain current (continuous) at $T_C = 100\text{ }^{\circ}\text{C}$                                                                       | 3                  | 3 <sup>(1)</sup>  | A                  |
| $I_{DM}^{(2)}$ | Drain current (pulsed)                                                                                                                  | 20                 | 20 <sup>(1)</sup> | A                  |
| $P_{TOT}$      | Total dissipation at $T_C = 25\text{ }^{\circ}\text{C}$                                                                                 | 45                 | 20                | W                  |
| $dv/dt^{(3)}$  | Peak diode recovery voltage slope                                                                                                       | 15                 |                   | V/ns               |
| $V_{ISO}$      | Insulation withstand voltage (RMS) from all three leads to external heat sink ( $t = 1\text{ s}$ ; $T_C = 25\text{ }^{\circ}\text{C}$ ) |                    | 2500              | V                  |
| $T_{stg}$      | Storage temperature                                                                                                                     | - 55 to 150        |                   | $^{\circ}\text{C}$ |
| $T_j$          | Max. operating junction temperature                                                                                                     | 150                |                   | $^{\circ}\text{C}$ |

1. Limited only by maximum temperature allowed
2. Pulse width limited by safe operating area
3.  $I_{SD} \leq 5\text{ A}$ ,  $di/dt \leq 400\text{ A}/\mu\text{s}$ ,  $V_{Peak} < V_{(BR)DSS}$

**Table 3. Thermal data**

| Symbol                | Parameter                                      | Value |      |        |          | Unit |
|-----------------------|------------------------------------------------|-------|------|--------|----------|------|
|                       |                                                | DPAK  | IPAK | TO-220 | TO-220FP |      |
| R <sub>thj-case</sub> | Thermal resistance junction-case max           | 2.78  |      |        | 6.25     | °C/W |
| R <sub>thj-amb</sub>  | Thermal resistance junction-ambient max        |       | 100  | 62.5   |          | °C/W |
| R <sub>thj-pcb</sub>  | Thermal resistance junction-pcb max            | 50    |      |        |          | °C/W |
| T <sub>l</sub>        | Maximum lead temperature for soldering purpose |       | 300  |        |          | °C   |

**Table 4. Thermal data**

| Symbol   | Parameter                                                                                                              | Value | Unit |
|----------|------------------------------------------------------------------------------------------------------------------------|-------|------|
| $I_{AR}$ | Avalanche current, repetitive or not-repetitive (pulse width limited by $T_j$ max)                                     | 2     | A    |
| $E_{AS}$ | Single pulse avalanche energy (starting $T_j = 25\text{ }^{\circ}\text{C}$ , $I_D = I_{AR}$ , $V_{DD} = 50\text{ V}$ ) | 119   | mJ   |

## 2 Electrical characteristics

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

**Table 5. On /off states**

| Symbol        | Parameter                                        | Test conditions                                                                      | Min. | Typ. | Max.     | Unit                           |
|---------------|--------------------------------------------------|--------------------------------------------------------------------------------------|------|------|----------|--------------------------------|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage                   | $I_D = 1\text{ mA}$ , $V_{GS} = 0$                                                   | 600  |      |          | V                              |
| $I_{DSS}$     | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max rating}$<br>$V_{DS} = \text{Max rating}$ , $T_C = 125\text{ °C}$ |      |      | 1<br>100 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$     | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20\text{ V}$                                                           |      |      | 100      | nA                             |
| $V_{GS(th)}$  | Gate threshold voltage                           | $V_{DS} = V_{GS}$ , $I_D = 250\text{ }\mu\text{A}$                                   | 2    | 3    | 4        | V                              |
| $R_{DS(on)}$  | Static drain-source on resistance                | $V_{GS} = 10\text{ V}$ , $I_D = 2.5\text{ A}$                                        |      | 0.84 | 0.9      | $\Omega$                       |

**Table 6. Dynamic**

| Symbol                              | Parameter                                                               | Test conditions                                                                                              | Min. | Typ.               | Max. | Unit           |
|-------------------------------------|-------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|------|--------------------|------|----------------|
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 50\text{ V}$ , $f = 1\text{ MHz}$ ,<br>$V_{GS} = 0$                                                | -    | 363<br>24.6<br>1.1 | -    | pF<br>pF<br>pF |
| $C_{oss\text{ eq.}}^{(1)}$          | Output equivalent capacitance                                           | $V_{DS} = 0\text{ to }480\text{ V}$ , $V_{GS} = 0$                                                           | -    | 130                | -    | pF             |
| $R_G$                               | Intrinsic gate resistance                                               | $f = 1\text{ MHz}$ open drain                                                                                | -    | 5.4                | -    | $\Omega$       |
| $Q_g$<br>$Q_{gs}$<br>$Q_{gd}$       | Total gate charge<br>Gate-source charge<br>Gate-drain charge            | $V_{DD} = 480\text{ V}$ , $I_D = 5\text{ A}$ ,<br>$V_{GS} = 10\text{ V}$<br>(see <a href="#">Figure 18</a> ) | -    | 14<br>2.7<br>7.7   | -    | nC<br>nC<br>nC |

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

**Table 7. Switching times**

| Symbol       | Parameter           | Test conditions                                                                                                                      | Min. | Typ. | Max | Unit |
|--------------|---------------------|--------------------------------------------------------------------------------------------------------------------------------------|------|------|-----|------|
| $t_{d(on)}$  | Turn-on delay time  | $V_{DD} = 300\text{ V}$ , $I_D = 2.5\text{ A}$ ,<br>$R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$<br>(see <a href="#">Figure 19</a> ) | -    | 7    | -   | ns   |
| $t_r$        | Rise time           |                                                                                                                                      |      | 10   |     | ns   |
| $t_{d(off)}$ | Turn-off-delay time |                                                                                                                                      |      | 26   |     | ns   |
| $t_f$        | Fall time           |                                                                                                                                      |      | 12   |     | ns   |

**Table 8. Source drain diode**

| Symbol          | Parameter                     | Test conditions                                                                                                                                              | Min. | Typ. | Max. | Unit |
|-----------------|-------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|
| $I_{SD}$        | Source-drain current          |                                                                                                                                                              | -    |      | 5    | A    |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |                                                                                                                                                              |      |      | 20   | A    |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD} = 5\text{ A}$ , $V_{GS} = 0$                                                                                                                         | -    |      | 1.3  | V    |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 5\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$<br>$V_{DD} = 60\text{ V}$ (see <a href="#">Figure 22</a> )                                        | -    | 213  |      | ns   |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                                              |      | 1.5  |      | nC   |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                                              |      | 14   |      | A    |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 5\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$<br>$V_{DD} = 60\text{ V}$ , $T_J = 150\text{ }^\circ\text{C}$<br>(see <a href="#">Figure 22</a> ) | -    | 265  |      | ns   |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                                              |      | 1.8  |      | nC   |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                                              |      | 14   |      | 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 for DPAK, IPAK Figure 3. Thermal impedance for DPAK, IPAK

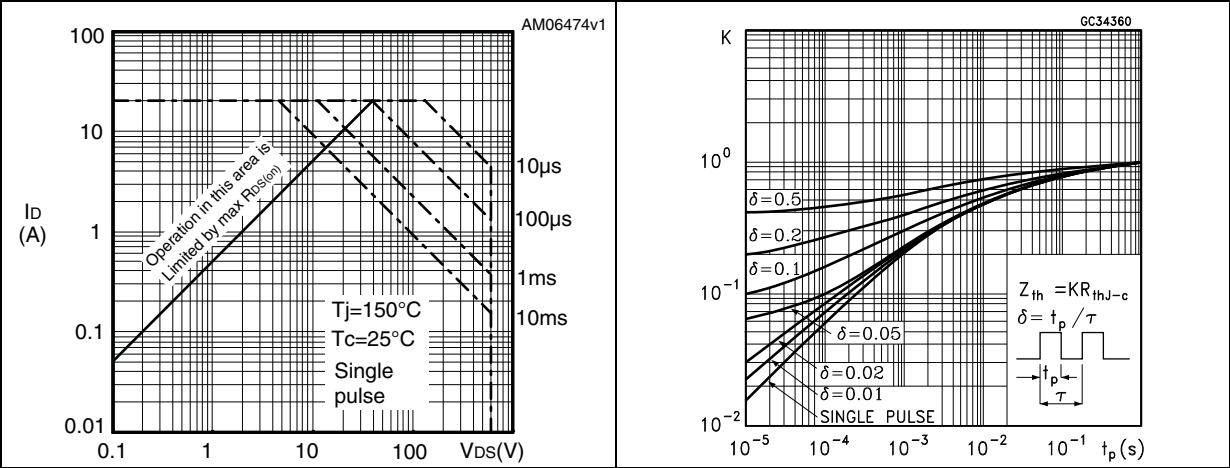


Figure 4. Safe operating area for TO-220FP Figure 5. Thermal impedance for TO-220FP

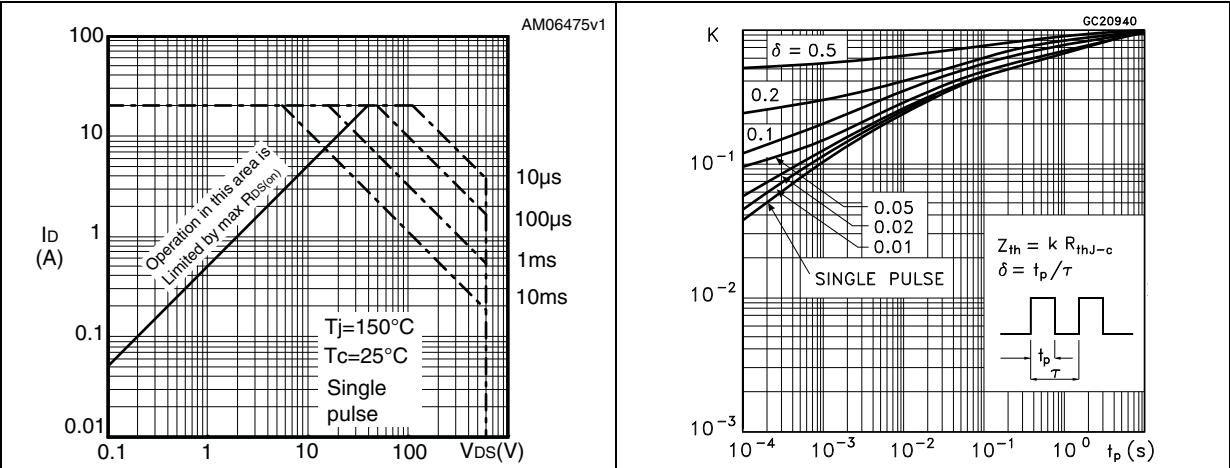


Figure 6. Safe operating area for TO-220 Figure 7. Thermal impedance for TO-220

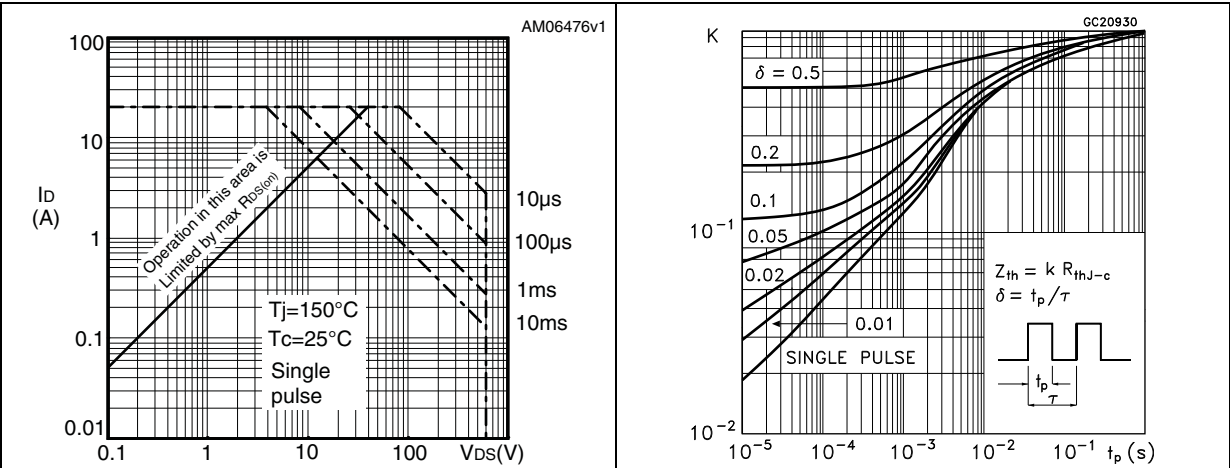


Figure 8. Output characteristics

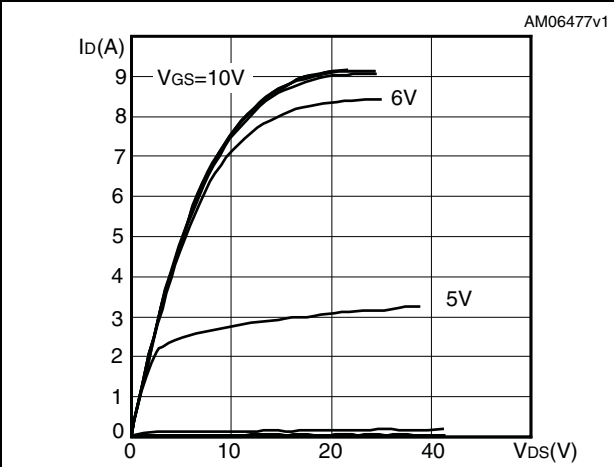


Figure 9. Transfer characteristics

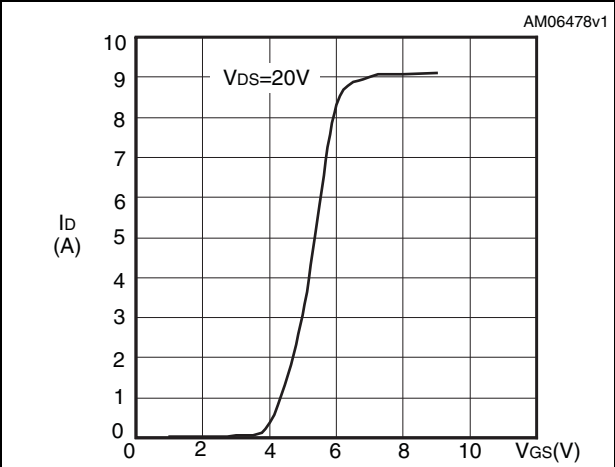


Figure 10. Gate charge vs gate-source voltage

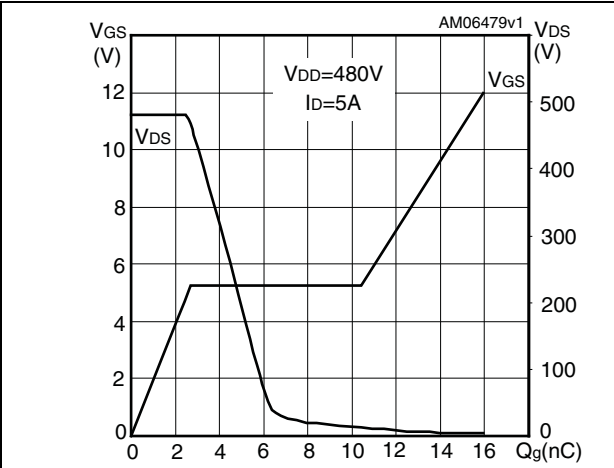


Figure 11. Static drain-source on resistance

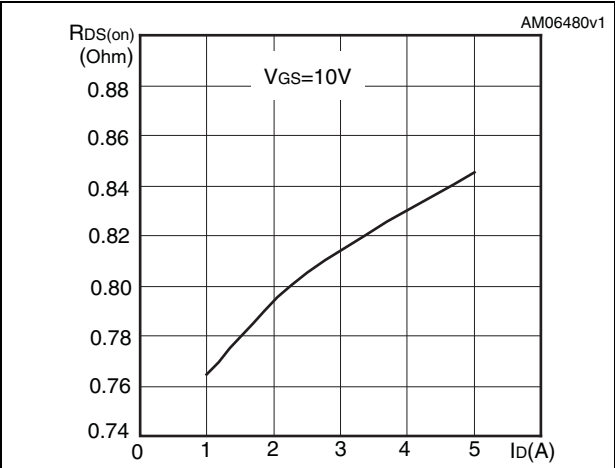


Figure 12. Capacitance variations

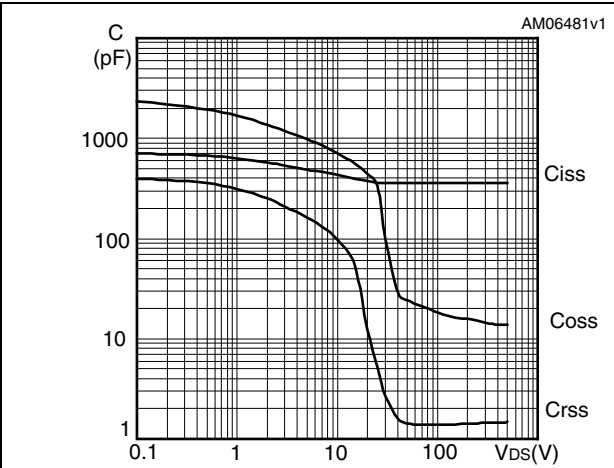


Figure 13. Output capacitance stored energy

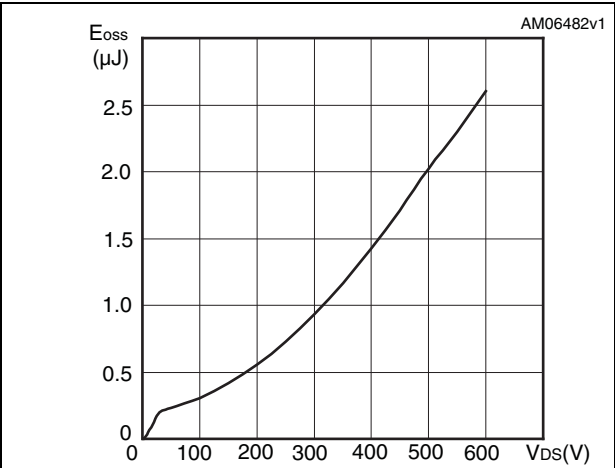


Figure 14. Normalized gate threshold voltage vs temperature

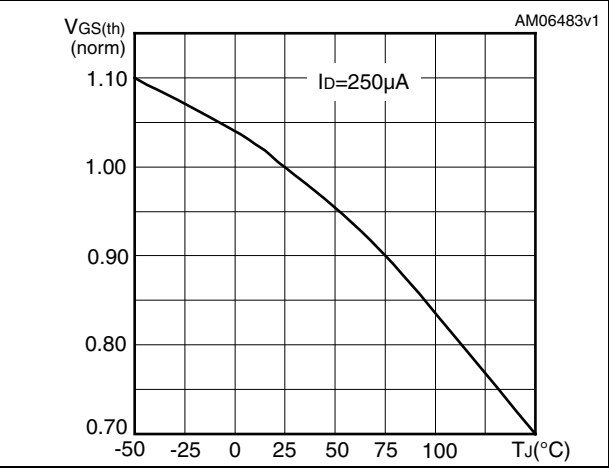


Figure 15. Normalized on resistance vs temperature

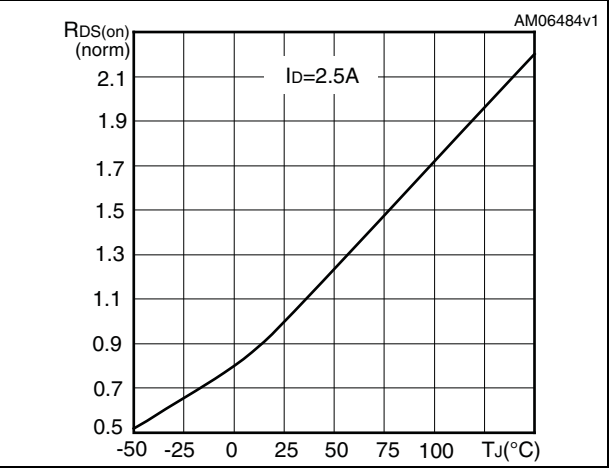
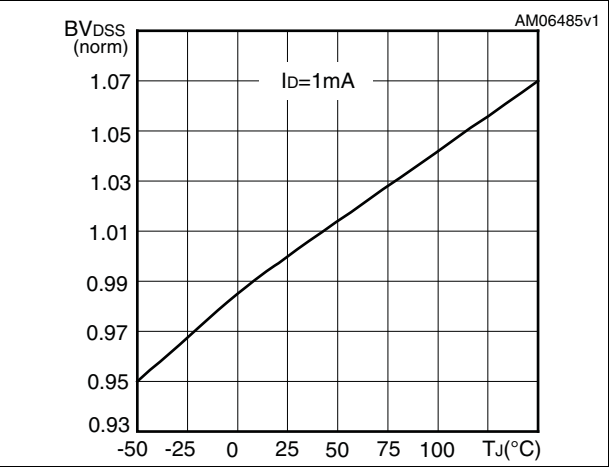


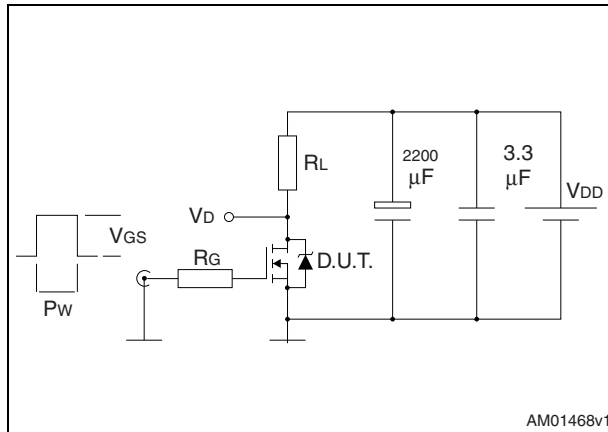
Figure 16. Normalized  $B_{VDSS}$  vs temperature



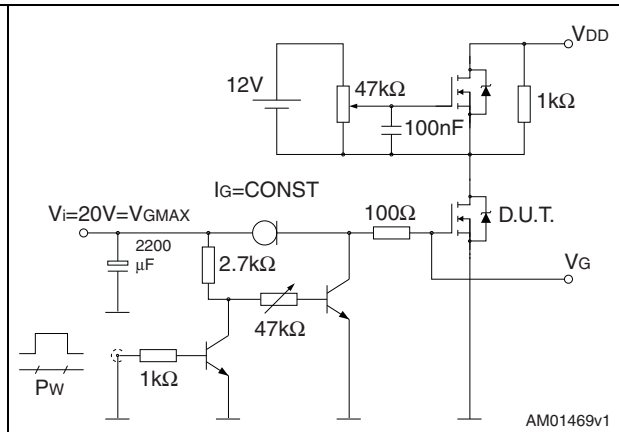


### 3 Test circuits

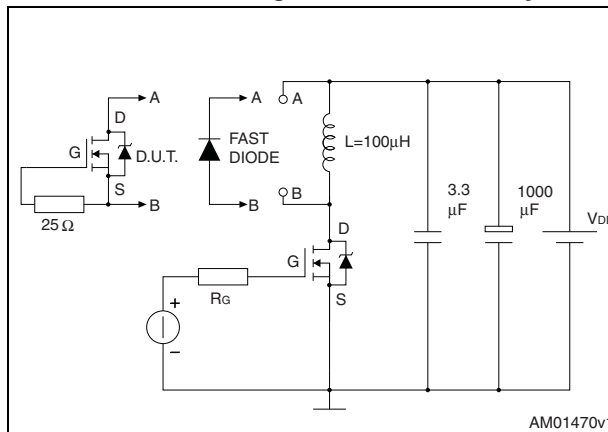
**Figure 17. Switching times test circuit for resistive load**



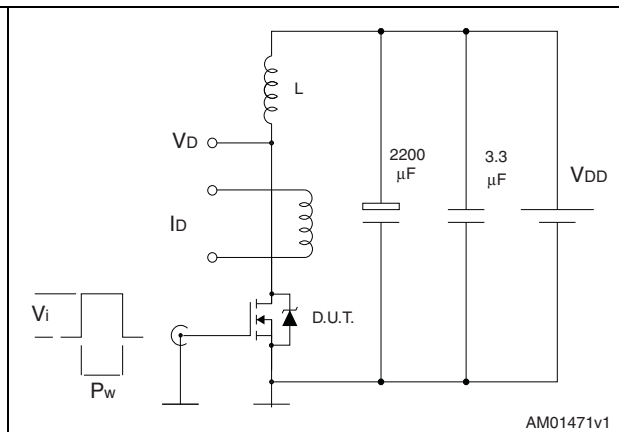
**Figure 18. Gate charge test circuit**



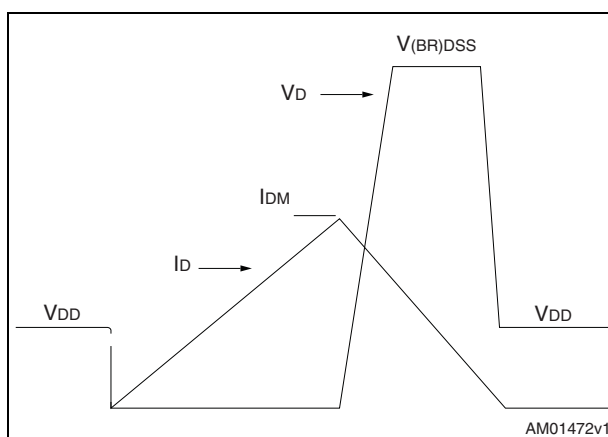
**Figure 19. Test circuit for inductive load switching and diode recovery times**



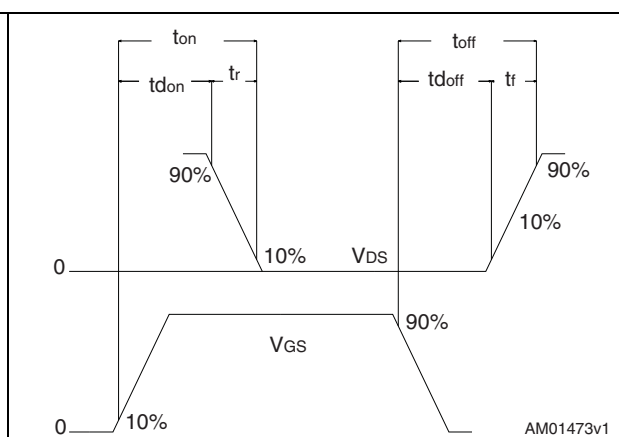
**Figure 20. Unclamped inductive load test circuit**



**Figure 21. Unclamped inductive waveform**



**Figure 22. Switching time waveform**



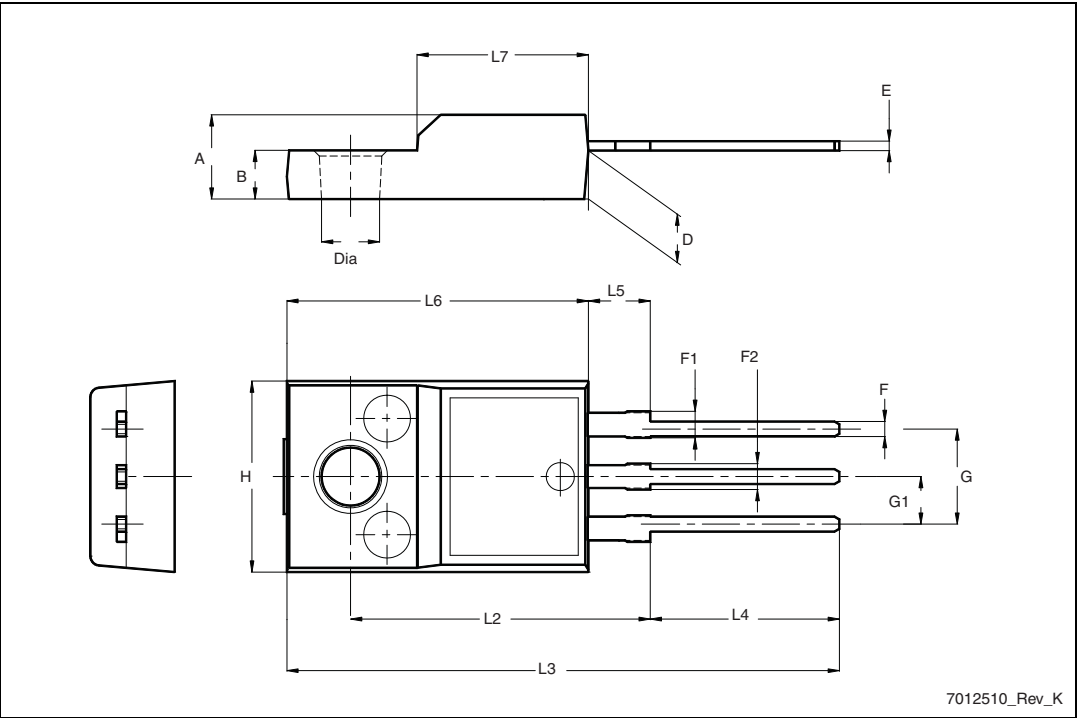
## 4 Package mechanical data

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 9. TO-220FP mechanical data

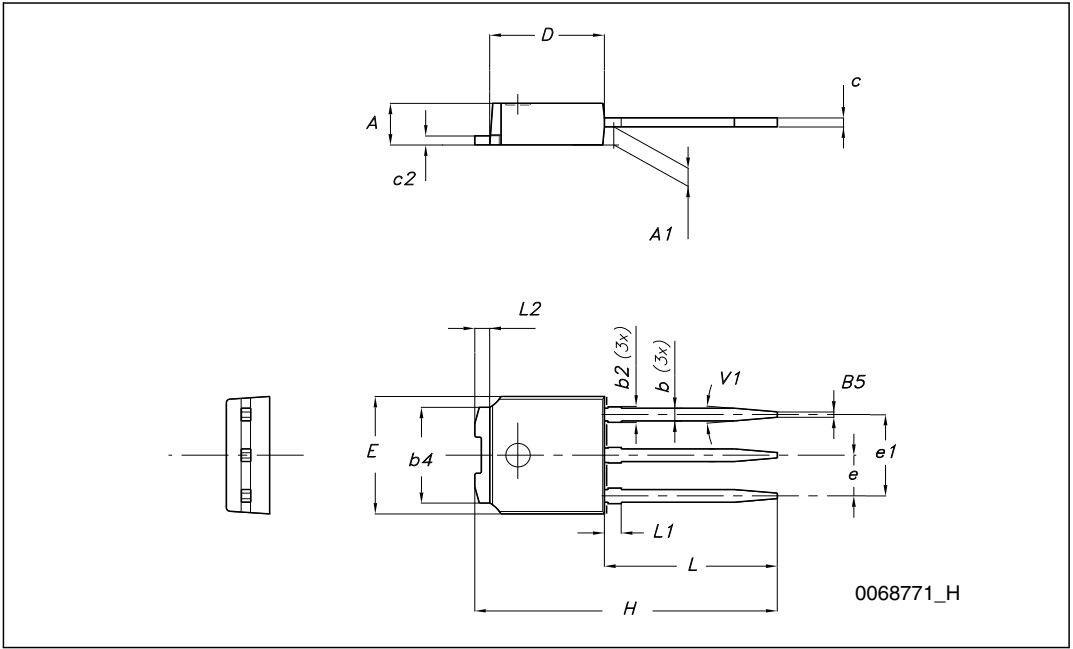
| Dim. | mm   |      |      |
|------|------|------|------|
|      | Min. | Typ. | Max. |
| A    | 4.4  |      | 4.6  |
| B    | 2.5  |      | 2.7  |
| D    | 2.5  |      | 2.75 |
| E    | 0.45 |      | 0.7  |
| F    | 0.75 |      | 1    |
| F1   | 1.15 |      | 1.70 |
| F2   | 1.15 |      | 1.70 |
| G    | 4.95 |      | 5.2  |
| G1   | 2.4  |      | 2.7  |
| H    | 10   |      | 10.4 |
| L2   |      | 16   |      |
| L3   | 28.6 |      | 30.6 |
| L4   | 9.8  |      | 10.6 |
| L5   | 2.9  |      | 3.6  |
| L6   | 15.9 |      | 16.4 |
| L7   | 9    |      | 9.3  |
| Dia  | 3    |      | 3.2  |

Figure 23. TO-220FP drawing mechanical data



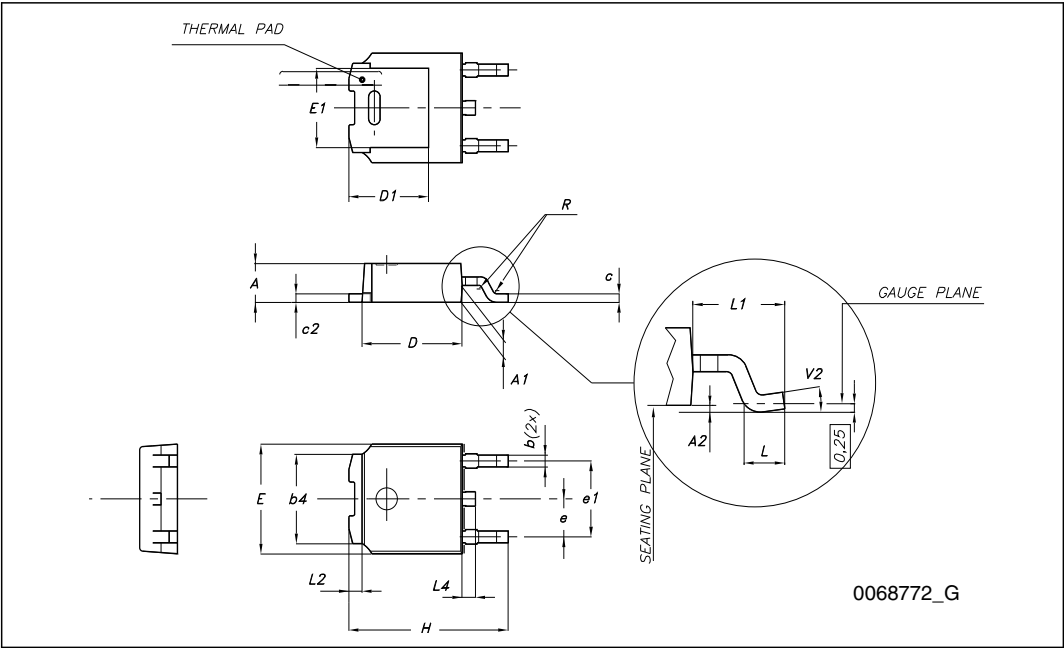
TO-251 (IPAK) mechanical data

| 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 |
| 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  |      |
| V1   |      | 10 °  |      |



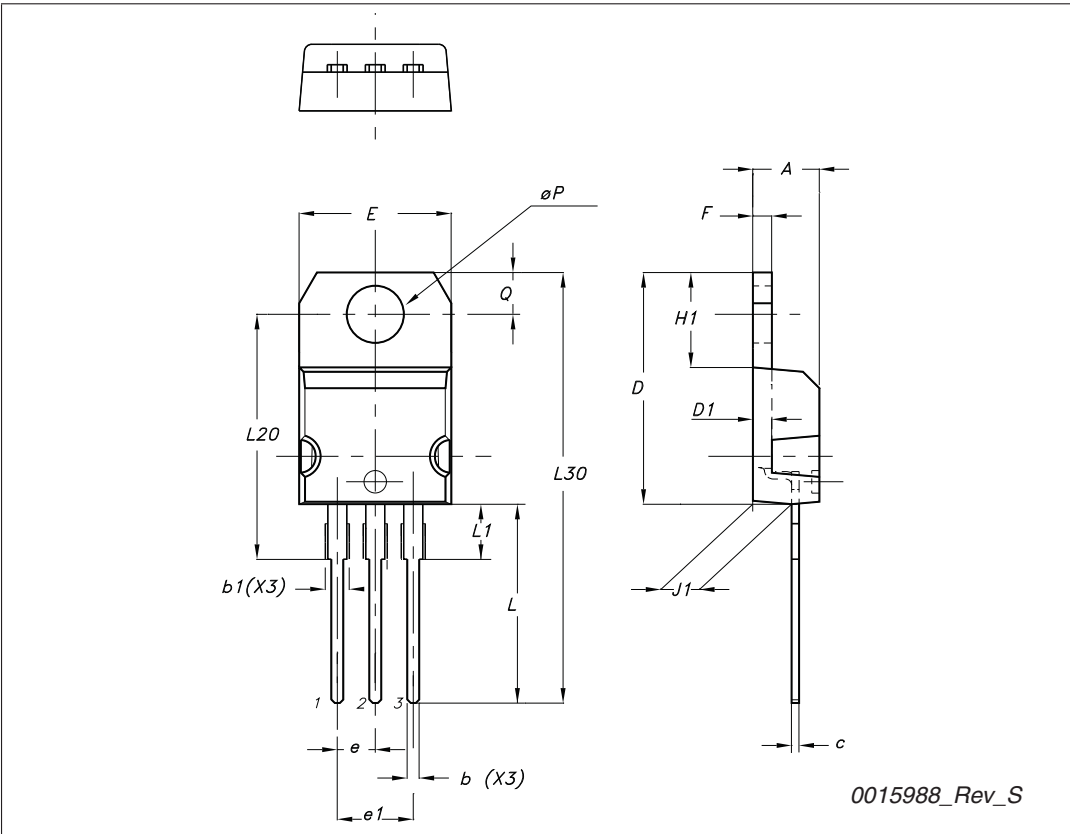
TO-252 (DPAK) mechanical data

| 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    |      |       |
| L1   |      | 2.80 |       |
| L2   |      | 0.80 |       |
| L4   | 0.60 |      | 1     |
| R    |      | 0.20 |       |
| V2   | 0°   |      | 8°    |



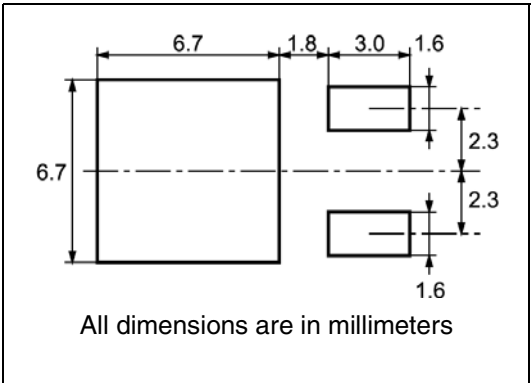
TO-220 type A mechanical data

| Dim | mm    |       |       |
|-----|-------|-------|-------|
|     | Min   | Typ   | Max   |
| A   | 4.40  |       | 4.60  |
| b   | 0.61  |       | 0.88  |
| b1  | 1.14  |       | 1.70  |
| c   | 0.48  |       | 0.70  |
| D   | 15.25 |       | 15.75 |
| D1  |       | 1.27  |       |
| E   | 10    |       | 10.40 |
| e   | 2.40  |       | 2.70  |
| e1  | 4.95  |       | 5.15  |
| F   | 1.23  |       | 1.32  |
| H1  | 6.20  |       | 6.60  |
| J1  | 2.40  |       | 2.72  |
| L   | 13    |       | 14    |
| L1  | 3.50  |       | 3.93  |
| L20 |       | 16.40 |       |
| L30 |       | 28.90 |       |
| ØP  | 3.75  |       | 3.85  |
| Q   | 2.65  |       | 2.95  |

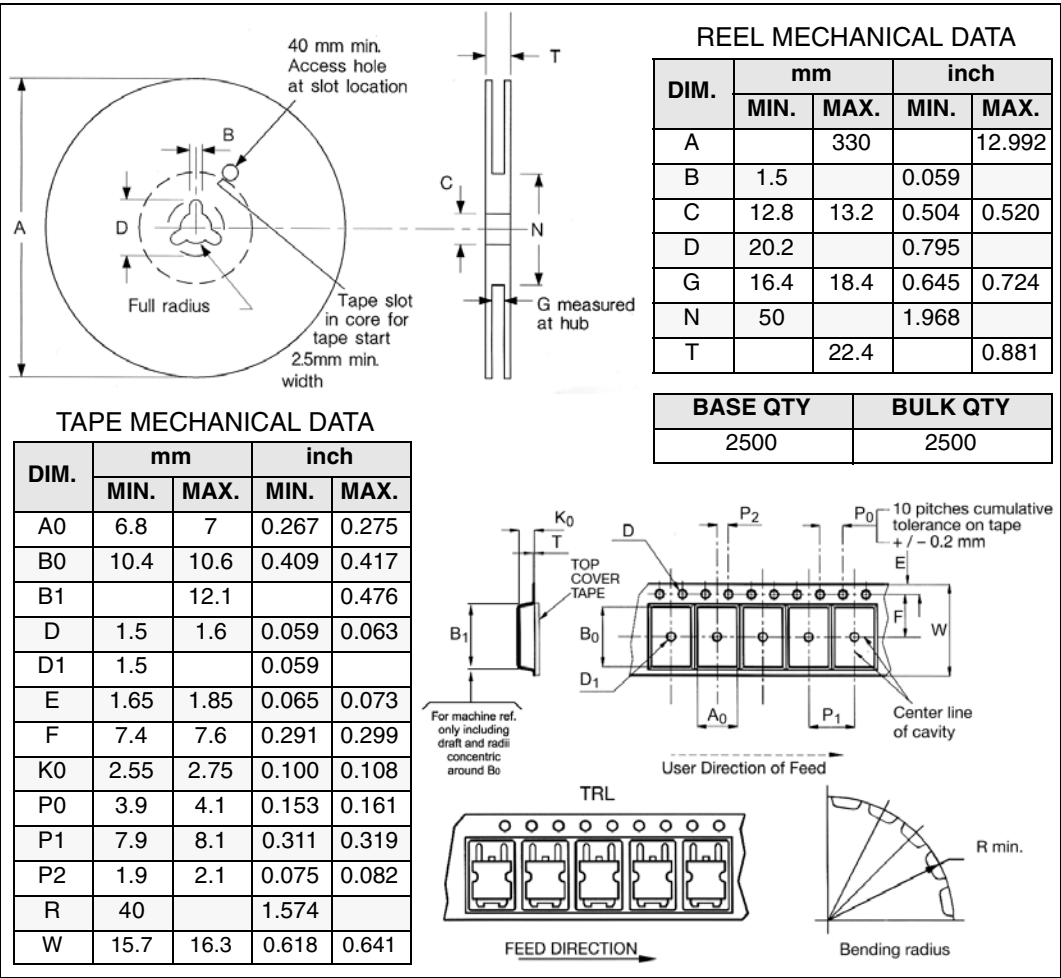


# 5 Packaging mechanical data

## DPAK FOOTPRINT



## TAPE AND REEL SHIPMENT



## 6 Revision history

**Table 10. Document revision history**

| Date        | Revision | Changes                                                     |
|-------------|----------|-------------------------------------------------------------|
| 29-Oct-2009 | 1        | First release.                                              |
| 19-Jul-2010 | 2        | Corrected values in <a href="#">Table 3: Thermal data</a> . |
| 11-Oct-2010 | 3        | Inserted new value in <a href="#">Table 6: Dynamic</a>      |
| 04-Nov-2010 | 4        | Changed $R_{DS(on)}$ typical value.                         |



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