



# STD12N65M5, STF12N65M5, STI12N65M5 STP12N65M5, STU12N65M5

N-channel 650 V, 0.39  $\Omega$ , 8.5 A MDmesh™ V Power MOSFET  
DPAK, I<sup>2</sup>PAK, TO-220FP, TO-220, IPAK

## Features

| Type       | V <sub>DSS</sub> @<br>T <sub>Jmax</sub> | R <sub>DS(on)</sub><br>max | I <sub>D</sub>       | P <sub>TOT</sub> |
|------------|---|----------------------------|----------------------|------------------|
| STD12N65M5 | 710 V                                   | < 0.43 $\Omega$            | 8.5 A                | 70 W             |
| STF12N65M5 |   |                            | 8.5 A <sup>(1)</sup> | 25 W             |
| STI12N65M5 |   |                            | 8.5 A                | 70 W             |
| STP12N65M5 |   |                            | 8.5 A                | 70 W             |
| STU12N65M5 |   |                            | 8.5 A                | 70 W             |

1. Limited only by maximum temperature allowed

- Worldwide best R<sub>DS(on)</sub> \* area
- Higher V<sub>DSS</sub> rating and high dv/dt capability
- Excellent switching performance
- Easy to drive
- 100% avalanche tested

## Application

Switching applications

## Description

The devices are 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.

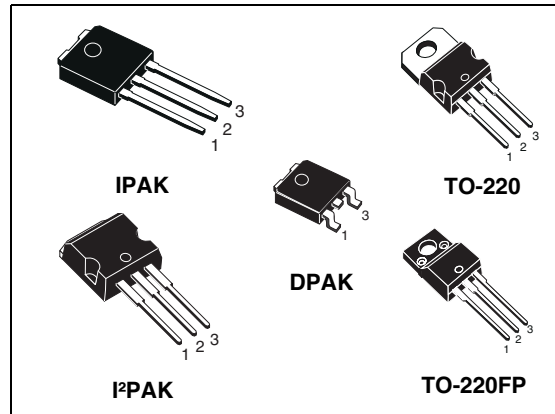
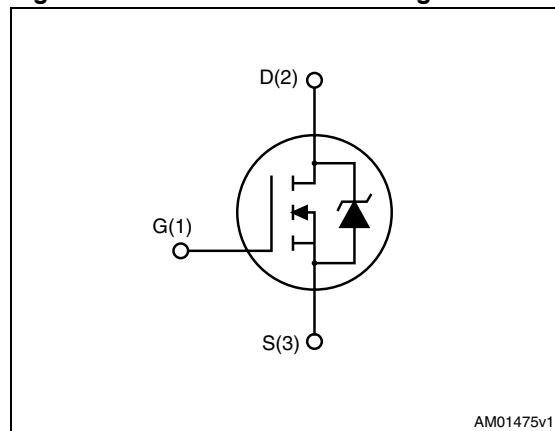


Figure 1. Internal schematic diagram



AM01475v1

Table 1. Device summary

| Order codes | Marking | Packages           | Packaging     |
|-------------|---------|--------------------|---------------|
| STD12N65M5  | 12N65M5 | DPAK               | Tape and reel |
| STF12N65M5  |         | TO-220FP           | Tube          |
| STI12N65M5  |         | I <sup>2</sup> PAK | Tube          |
| STP12N65M5  |         | TO-220             | Tube          |
| STU12N65M5  |         | IPAK               | Tube          |

## Contents

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# 1 Electrical ratings (a)

**Table 2. Absolute maximum ratings**

| Symbol                         | Parameter  | Value                                  |                    | Unit |
|--------------------------------|--|--|--------------------|------|
|                                |  | TO-220, IPAK, DPAK, I <sup>2</sup> PAK | TO-220FP           |      |
| V <sub>DS</sub>                | Drain-source voltage (V <sub>GS</sub> = 0)   | 650                                    |                    | V    |
| V <sub>GS</sub>                | Gate-source voltage  | 25                                     |                    | V    |
| I <sub>D</sub>                 | Drain current (continuous) at T <sub>C</sub> = 25 °C   | 8.5                                    | 8.5 <sup>(1)</sup> | A    |
| I <sub>D</sub>                 | Drain current (continuous) at T <sub>C</sub> = 100 °C  | 5.4                                    | 5.4 <sup>(1)</sup> | A    |
| I <sub>DM</sub> <sup>(2)</sup> | Drain current (pulsed)   | 34                                     | 34 <sup>(1)</sup>  | A    |
| P <sub>TOT</sub>               | Total dissipation at T <sub>C</sub> = 25 °C  | 70                                     | 25                 | W    |
| I <sub>AR</sub>                | Avalanche current, repetitive or not-repetitive (pulse width limited by T <sub>j</sub> max)                                | 2.5                                    |                    | A    |
| E <sub>AS</sub>                | Single pulse avalanche energy (starting T <sub>j</sub> = 25 °C, I <sub>D</sub> = I <sub>AR</sub> , V <sub>DD</sub> = 50 V) | 150                                    |                    | mJ   |
| dv/dt <sup>(3)</sup>           | Peak diode recovery voltage slope  | 15                                     |                    | V/ns |
| V <sub>ISO</sub>               | Insulation withstand voltage (RMS) from all three leads to external heat sink (t = 1 s; T <sub>C</sub> = 25 °C)            |  | 2500               | V    |
| T <sub>stg</sub>               | Storage temperature  | - 55 to 150                            |                    | °C   |
| T <sub>j</sub>                 | Max. operating junction temperature  | 150                                    |                    | °C   |

- Limited only by maximum temperature allowed
- Pulse width limited by safe operating area
- I<sub>SD</sub> ≤ 8.5 A, di/dt ≤ 400 A/μs; V<sub>Peak</sub> < V<sub>(BR)DSS</sub>

**Table 3. Thermal data**

| Symbol                              | Parameter                                      | Value |      |                    |        |          | Unit |
|-------------------------------------|--|-------|------|--------------------|--------|----------|------|
|                                     |  | DPAK  | IPAK | I <sup>2</sup> PAK | TO-220 | TO-220FP |      |
| R <sub>thj-case</sub>               | Thermal resistance junction-case max           | 1.79  |      |                    | 5      | °C/W     |      |
| R <sub>thj-amb</sub>                | Thermal resistance junction-ambient max        |       | 100  | 62.5               |        | °C/W     |      |
| R <sub>thj-pcb</sub> <sup>(1)</sup> | Thermal resistance junction-pcb max            | 50    |      |                    |        | °C/W     |      |
| T <sub>l</sub>                      | Maximum lead temperature for soldering purpose | 300   |      |                    |        | °C       |      |

- When mounted on 1inch<sup>2</sup> FR-4 board, 2 oz Cu

a. All data which refers solely to the TO-220FP package is preliminary



## 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 ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max rating}$<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 ( $V_{DS} = 0$ )       | $V_{GS} = \pm 25\text{ V}$   |      |      | 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                | $V_{GS} = 10\text{ V}$ , $I_D = 4.3\text{ A}$  |      | 0.39 | 0.43     | $\Omega$                       |

**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>$V_{GS} = 0$   | -    | 900  | -    | pF       |
| $C_{oss}$         | Output capacitance                    |  |      | 22   |      | pF       |
| $C_{rss}$         | Reverse transfer capacitance          |  |      | 2    |      | pF       |
| $C_{o(tr)}^{(1)}$ | Equivalent capacitance time related   | $V_{DS} = 0\text{ to }520\text{ V}$ , $V_{GS} = 0$   | -    | 64   | -    | pF       |
| $C_{o(er)}^{(2)}$ | Equivalent capacitance energy related |  |      | 21   |      | pF       |
| $R_G$             | Intrinsic gate resistance             | $f = 1\text{ MHz}$ open drain  | -    | 2.5  | -    | $\Omega$ |
| $Q_g$             | Total gate charge                     | $V_{DD} = 520\text{ V}$ , $I_D = 4.3\text{ A}$ ,<br>$V_{GS} = 10\text{ V}$<br>(see <a href="#">Figure 20</a> ) | -    | 22   | -    | nC       |
| $Q_{gs}$          | Gate-source charge                    |  |      | 9    |      | nC       |
| $Q_{gd}$          | Gate-drain charge                     |  |      | 7    |      | nC       |

1. 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. 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 |
|-------------|--------------------|--|------|------|------|------|
| $t_d$ (V)   | Voltage delay time | $V_{DD} = 400$ V, $I_D = 5$ A,         |      | 28   |      | ns   |
| $t_r$ (V)   | Voltage rise time  | $R_G = 4.7$ $\Omega$ , $V_{GS} = 10$ V | -    | 9.5  | -    | ns   |
| $t_f$ (i)   | Current fall time  | (see <a href="#">Figure 21</a> )       |      | 24   |      | ns   |
| $t_c$ (off) | Crossing time      | (see <a href="#">Figure 24</a> )       |      | 34   |      | ns   |

**Table 7. Source drain diode**

| Symbol          | Parameter                     | Test conditions                                   | Min. | Typ. | Max. | Unit    |
|-----------------|-------------------------------|---|------|------|------|---------|
| $I_{SD}$        | Source-drain current          |   |      |      | 8.5  | A       |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |   |      |      | 34   | A       |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD} = 8.5$ A, $V_{GS} = 0$                    |      |      | 1.5  | V       |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 8.5$ A, $di/dt = 100$ A/ $\mu$ s        |      | 230  |      | ns      |
| $Q_{rr}$        | Reverse recovery charge       | $V_{DD} = 100$ V (see <a href="#">Figure 24</a> ) |      | 2.2  |      | $\mu$ C |
| $I_{RRM}$       | Reverse recovery current      |   |      | 19   |      | A       |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 8.5$ A, $di/dt = 100$ A/ $\mu$ s        |      | 280  |      | ns      |
| $Q_{rr}$        | Reverse recovery charge       | $V_{DD} = 100$ V, $T_j = 150$ °C                  |      | 2.7  |      | $\mu$ C |
| $I_{RRM}$       | Reverse recovery current      | (see <a href="#">Figure 24</a> )                  |      | 19   |      | A       |

1. Pulse width limited by safe operating area

2. Pulsed: pulse duration = 300  $\mu$ s, duty cycle 1.5%

## 2.1 Electrical characteristics (curves)

Figure 2. Safe operating area for TO-220 and Figure 3. Thermal impedance for TO-220 and I<sup>2</sup>PAK

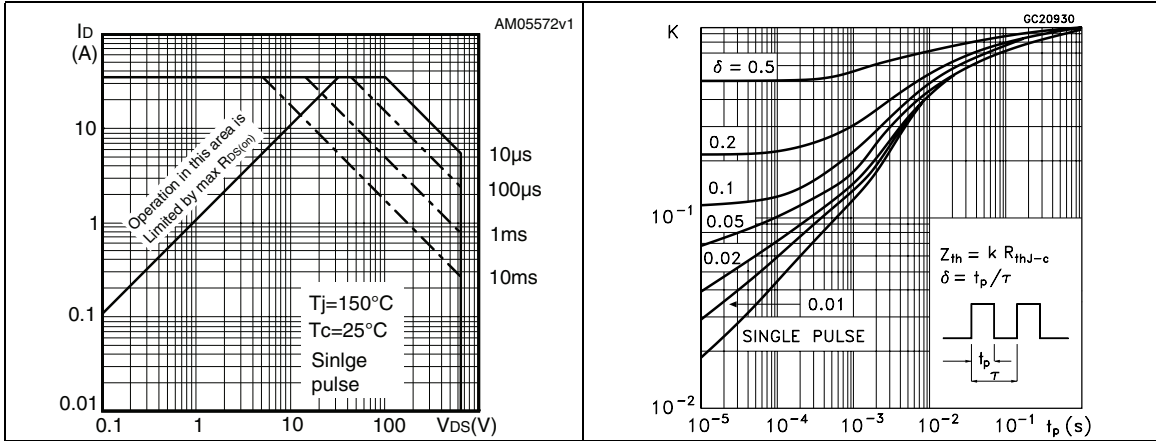


Figure 4. Safe operating area for TO-220FP Figure 5. Thermal impedance for TO-220FP

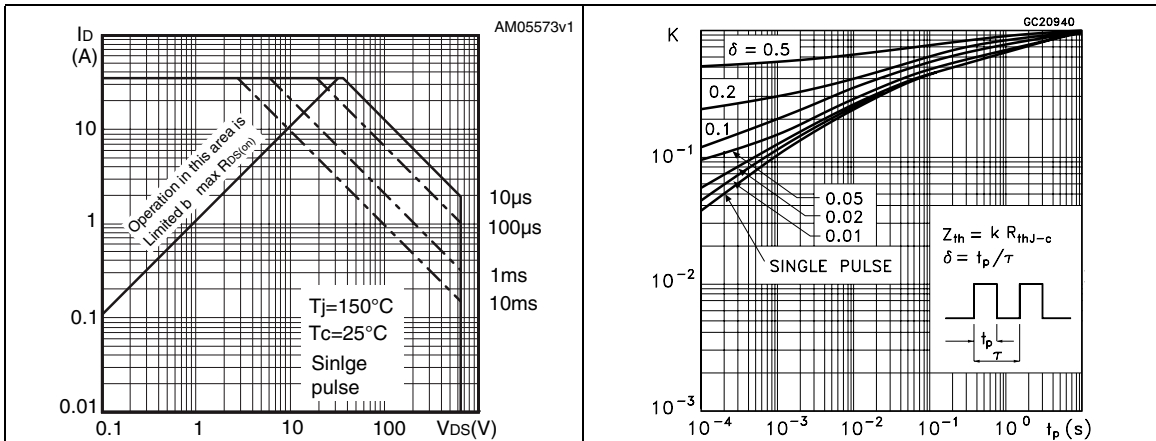


Figure 6. Safe operating area for DPAK, IPAK Figure 7. Thermal impedance for DPAK, IPAK

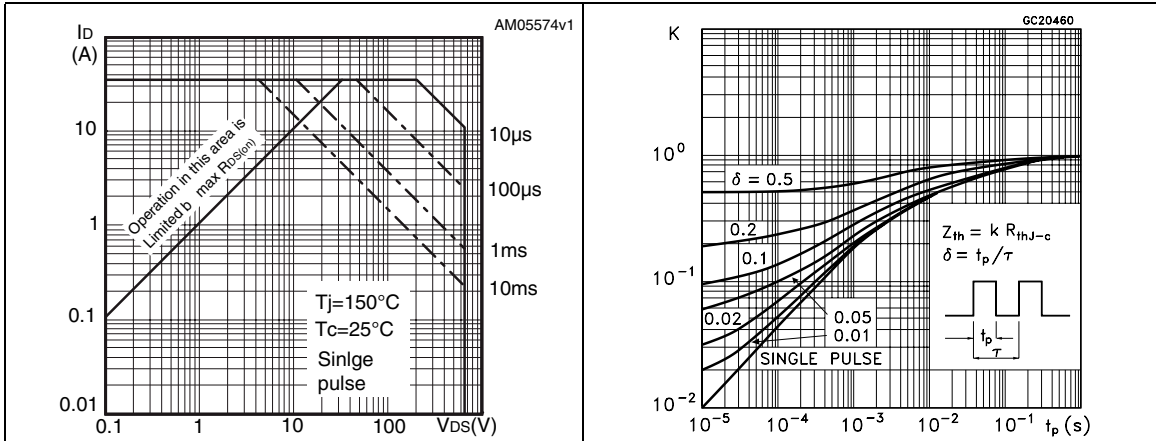


Figure 8. Output characteristics

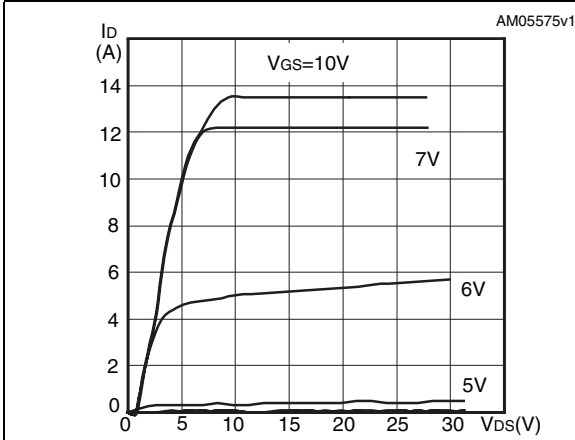


Figure 9. Transfer characteristics

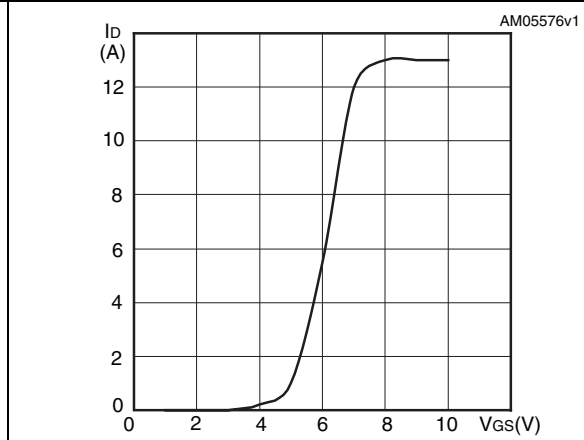


Figure 10. Gate charge vs gate-source voltage Figure 11. Static drain-source on resistance

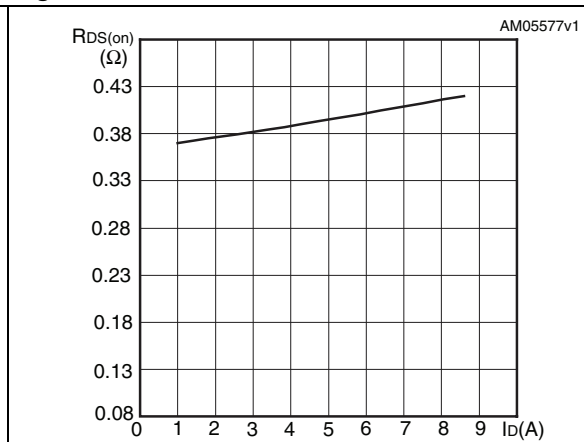
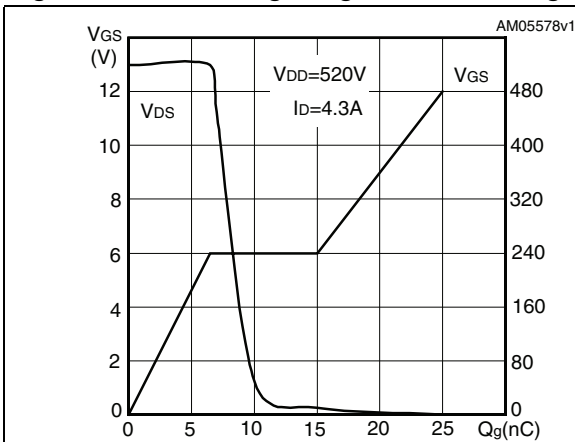


Figure 12. Capacitance variations

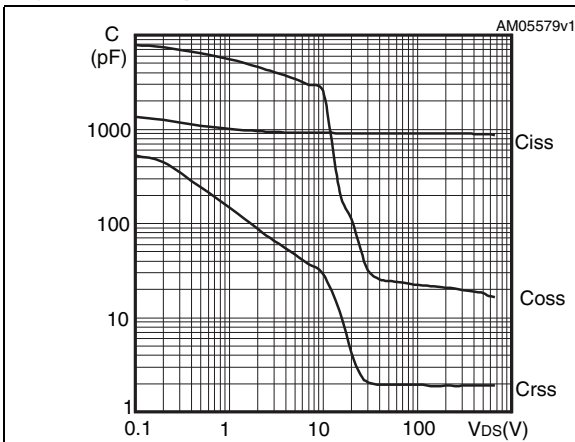


Figure 13. Output capacitance stored energy

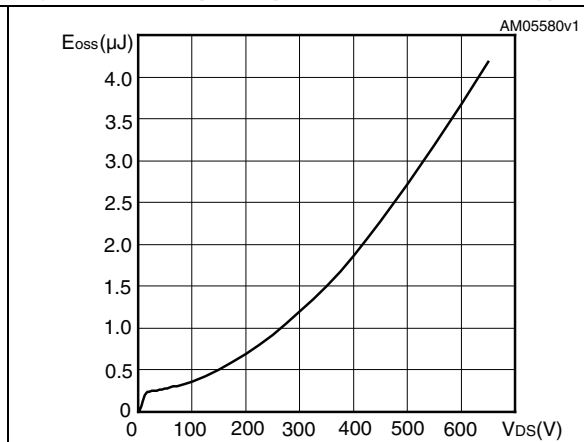


Figure 14. Normalized gate threshold voltage vs temperature

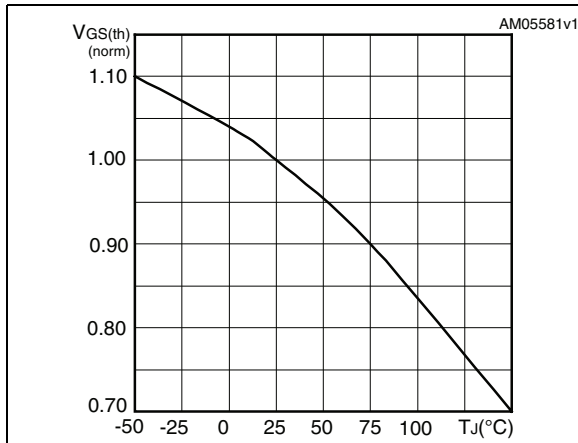


Figure 15. Normalized on resistance vs temperature

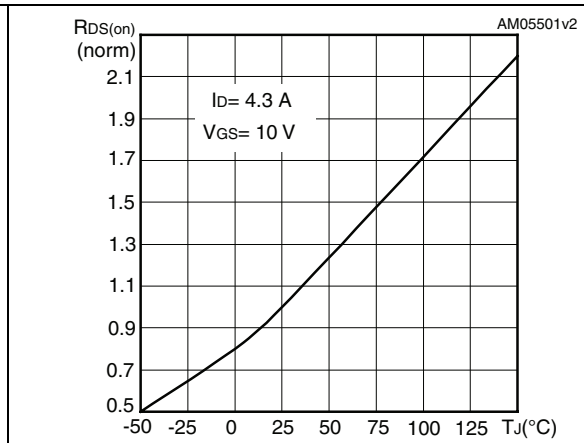


Figure 16. Source-drain diode forward characteristics

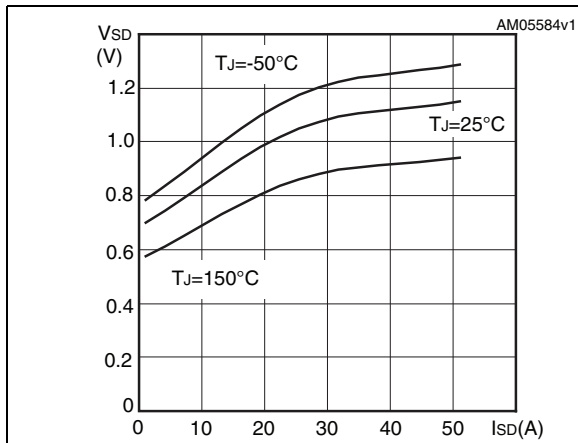


Figure 17. Normalized B<sub>VDSS</sub> vs temperature

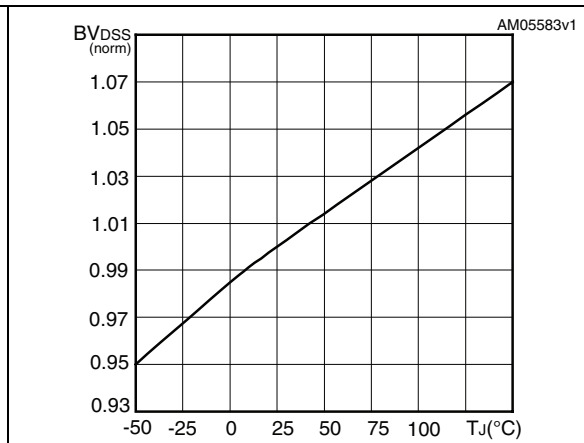
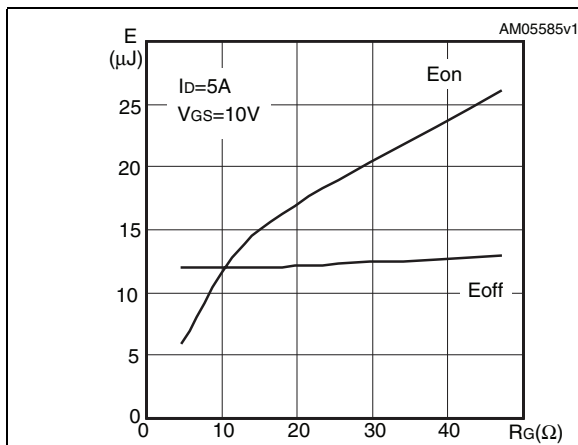


Figure 18. Switching losses vs gate resistance (1)



1. Eon including reverse recovery of a SiC diode



### 3 Test circuits

Figure 19. Switching times test circuit for resistive load

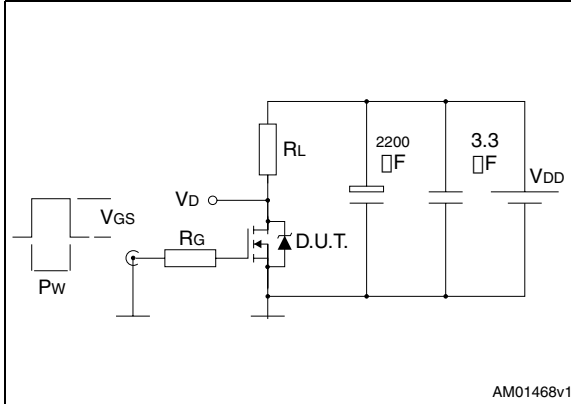


Figure 20. Gate charge test circuit

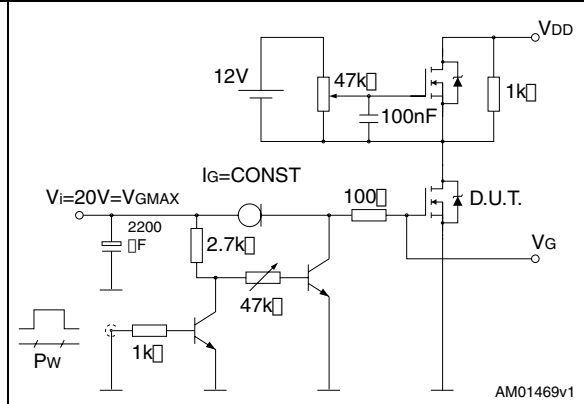


Figure 21. Test circuit for inductive load switching and diode recovery times

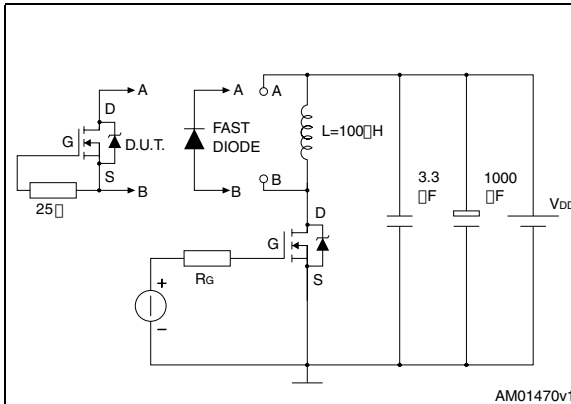


Figure 22. Unclamped inductive load test circuit

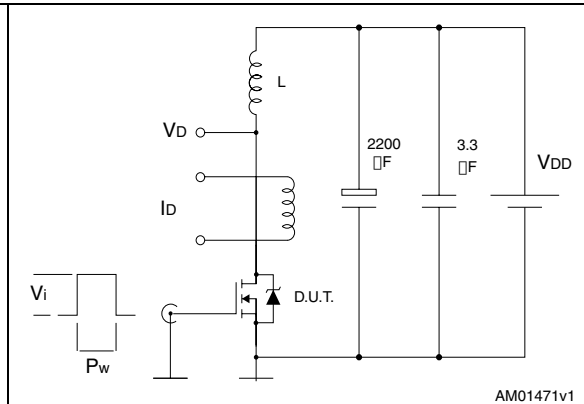


Figure 23. Unclamped inductive waveform

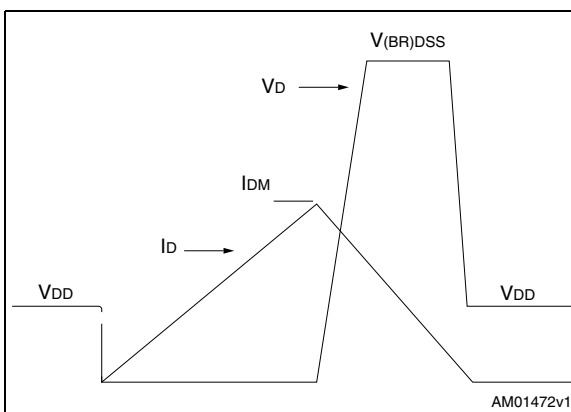
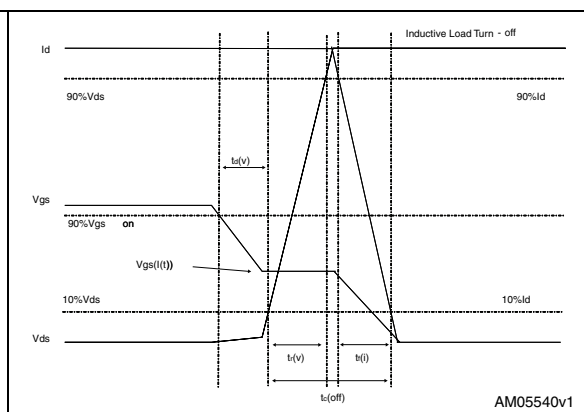


Figure 24. Switching time waveform



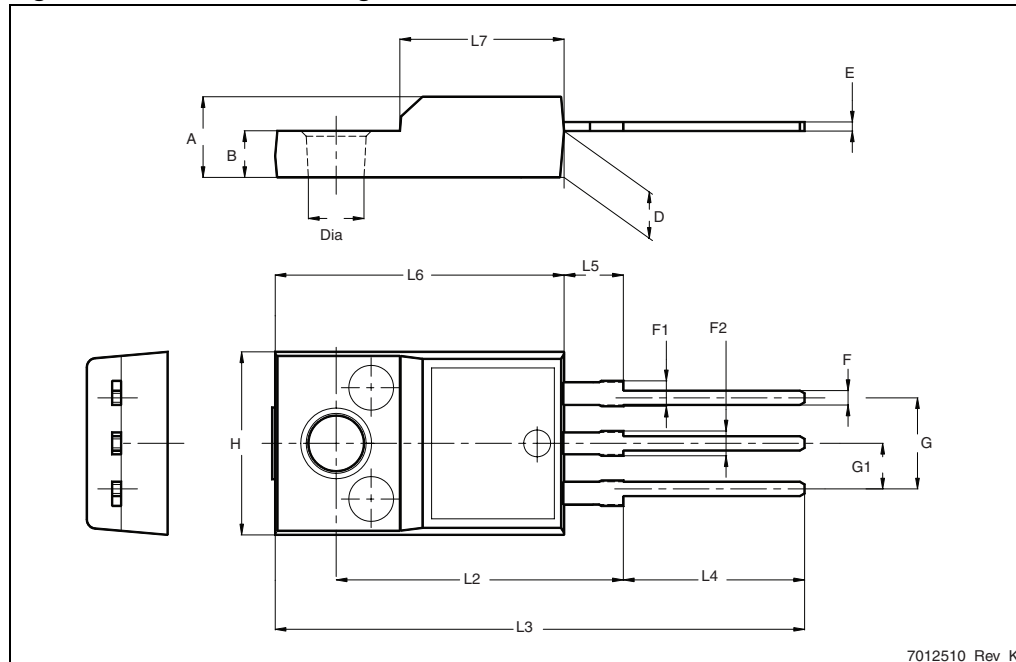
## 4 Package mechanical data

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 is an ST trademark.

Table 8. TO-220FP mechanical data

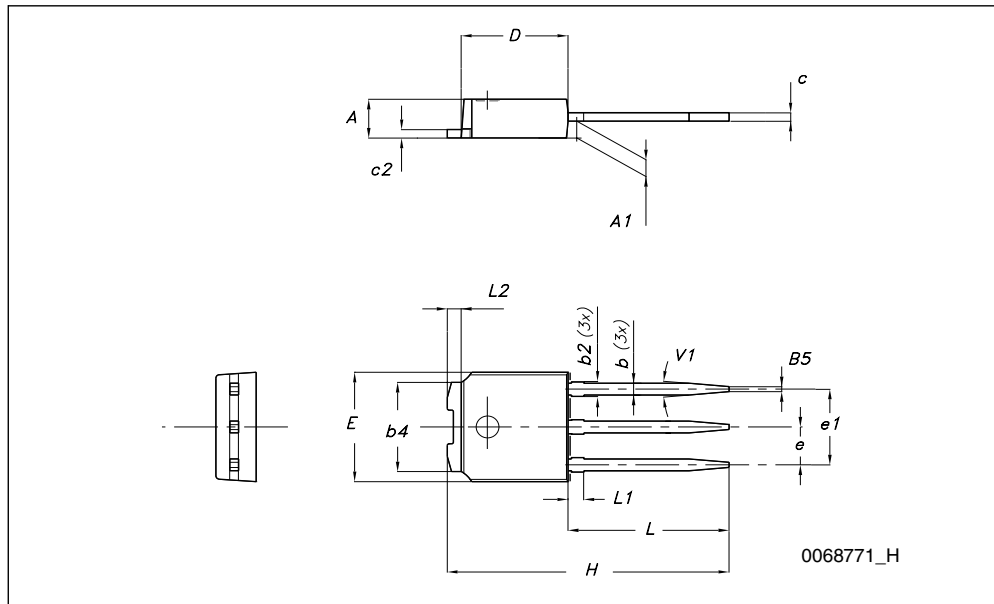
| Dim. | mm   |      |      |
|------|------|------|------|
|      | Min. | Typ. | Max. |
| A    | 4.4  |      | 4.6  |
| B    | 2.5  |      | 2.7  |
| D    | 2.5  |      | 2.75 |
| E    | 0.45 |      | 0.7  |
| F    | 0.75 |      | 1    |
| F1   | 1.15 |      | 1.70 |
| F2   | 1.15 |      | 1.70 |
| 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 25. TO-220FP drawing



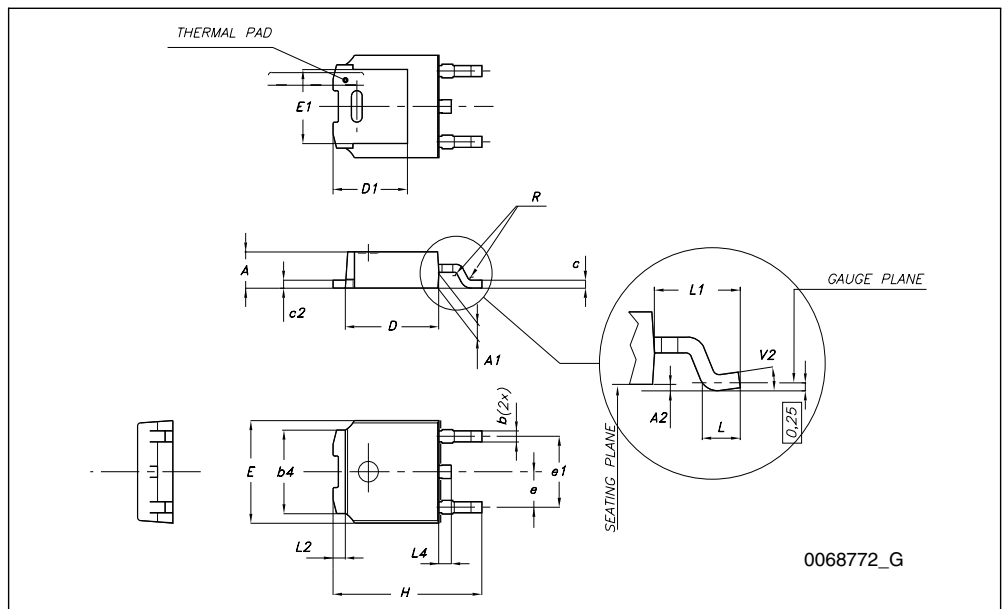
**TO-251 (IPAK) mechanical data**

| 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°   |      |



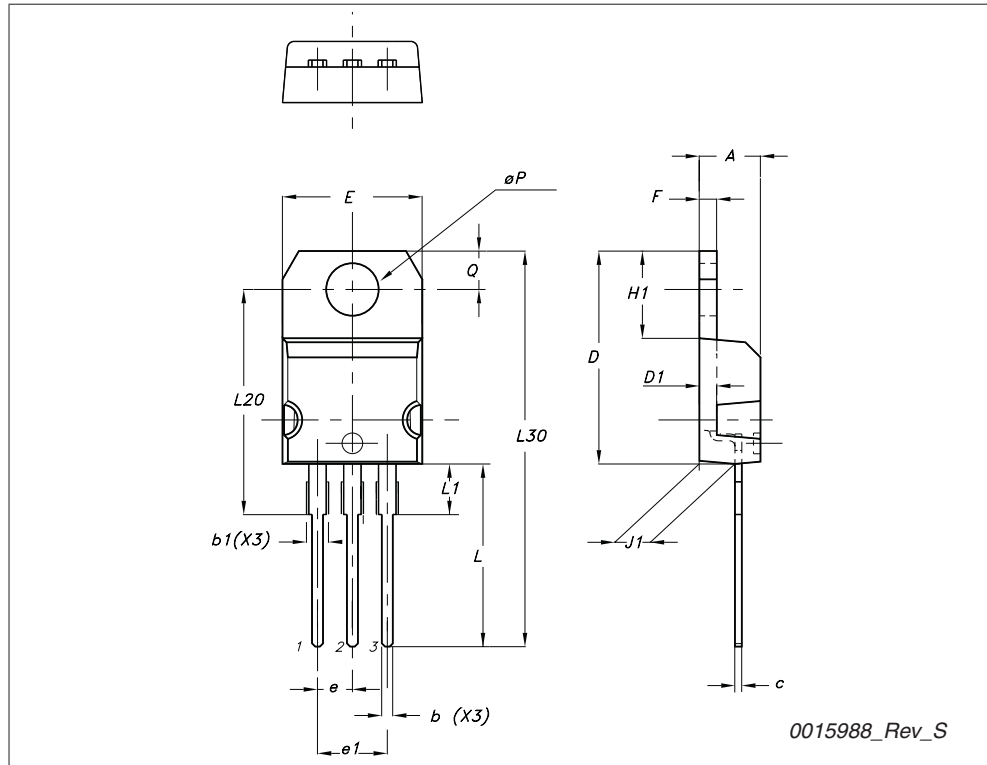
**TO-252 (DPAK) mechanical data**

| 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°    |



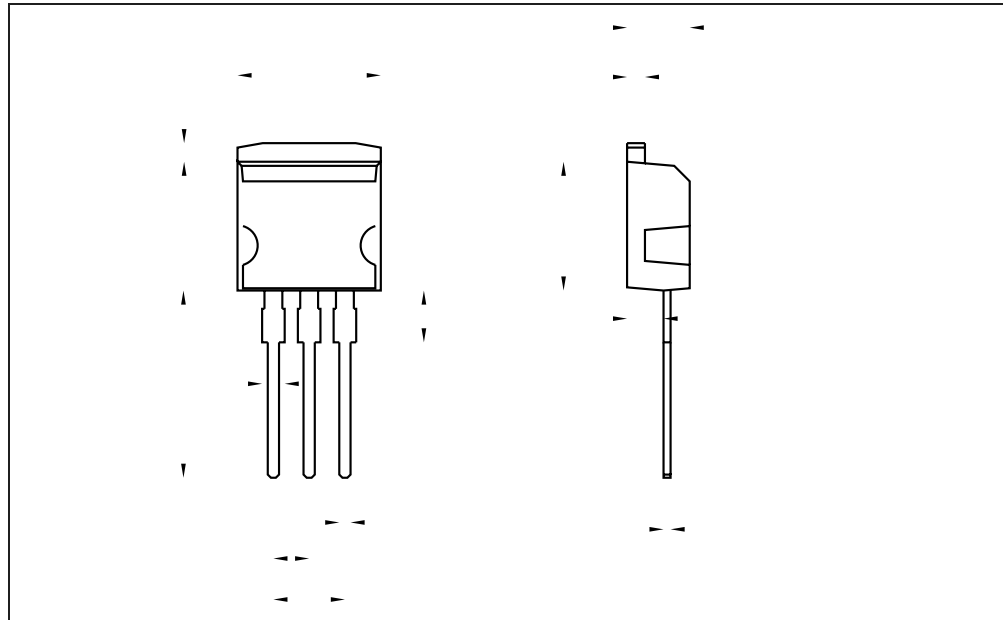
TO-220 type A mechanical data

| 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 |       |
| ∅P  | 3.75  |       | 3.85  |
| Q   | 2.65  |       | 2.95  |



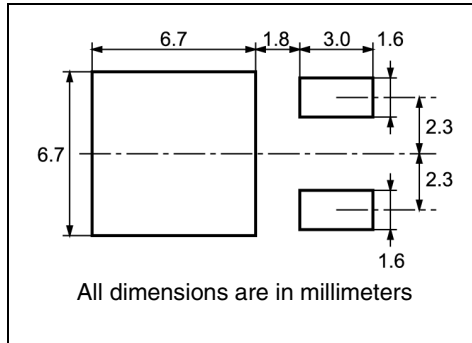
I<sup>2</sup>PAK (TO-262) mechanical data

| Dim | mm   |     |       | inch  |     |       |
|-----|------|-----|-------|-------|-----|-------|
|     | Min  | Typ | Max   | Min   | Typ | Max   |
| A   | 4.40 |     | 4.60  | 0.173 |     | 0.181 |
| A1  | 2.40 |     | 2.72  | 0.094 |     | 0.107 |
| b   | 0.61 |     | 0.88  | 0.024 |     | 0.034 |
| b1  | 1.14 |     | 1.70  | 0.044 |     | 0.066 |
| c   | 0.49 |     | 0.70  | 0.019 |     | 0.027 |
| c2  | 1.23 |     | 1.32  | 0.048 |     | 0.052 |
| D   | 8.95 |     | 9.35  | 0.352 |     | 0.368 |
| e   | 2.40 |     | 2.70  | 0.094 |     | 0.106 |
| e1  | 4.95 |     | 5.15  | 0.194 |     | 0.202 |
| E   | 10   |     | 10.40 | 0.393 |     | 0.410 |
| L   | 13   |     | 14    | 0.511 |     | 0.551 |
| L1  | 3.50 |     | 3.93  | 0.137 |     | 0.154 |
| L2  | 1.27 |     | 1.40  | 0.050 |     | 0.055 |



## 5 Packaging mechanical data

### DPAK FOOTPRINT



### TAPE AND REEL SHIPMENT

40 mm min. Access hole at slot location

Full radius

Tape slot in core for tape start 2.5mm min. width

G measured at hub

User Direction of Feed

FEED DIRECTION

Bending radius

#### REEL MECHANICAL DATA

| DIM. | mm   |      | inch  |        |
|------|------|------|-------|--------|
|      | MIN. | MAX. | MIN.  | MAX.   |
| A    |      | 330  |       | 12.992 |
| B    | 1.5  |      | 0.059 |        |
| C    | 12.8 | 13.2 | 0.504 | 0.520  |
| D    | 20.2 |      | 0.795 |        |
| G    | 16.4 | 18.4 | 0.645 | 0.724  |
| N    | 50   |      | 1.968 |        |
| T    |      | 22.4 |       | 0.881  |

| BASE QTY | BULK QTY |
|----------|----------|
| 2500     | 2500     |

#### TAPE MECHANICAL DATA

| DIM. | mm   |      | inch  |       |
|------|------|------|-------|-------|
|      | MIN. | MAX. | MIN.  | MAX.  |
| A0   | 6.8  | 7    | 0.267 | 0.275 |
| B0   | 10.4 | 10.6 | 0.409 | 0.417 |
| B1   |      | 12.1 |       | 0.476 |
| D    | 1.5  | 1.6  | 0.059 | 0.063 |
| D1   | 1.5  |      | 0.059 |       |
| E    | 1.65 | 1.85 | 0.065 | 0.073 |
| F    | 7.4  | 7.6  | 0.291 | 0.299 |
| K0   | 2.55 | 2.75 | 0.100 | 0.108 |
| P0   | 3.9  | 4.1  | 0.153 | 0.161 |
| P1   | 7.9  | 8.1  | 0.311 | 0.319 |
| P2   | 1.9  | 2.1  | 0.075 | 0.082 |
| R    | 40   |      | 1.574 |       |
| W    | 15.7 | 16.3 | 0.618 | 0.641 |



## 6 Revision history

Table 9. Document revision history

| Date        | Revision | Changes  |
|-------------|----------|--|
| 24-Feb-2009 | 1        | First release  |
| 27-Feb-2009 | 2        | Corrected package information on first page  |
| 21-Jan-2010 | 3        | Document status promoted from preliminary data to datasheet  |
| 29-Jun-2010 | 4        | <ul style="list-style-type: none"><li>– <a href="#">Figure 15: Normalized on resistance vs temperature</a> has been updated</li><li>– <math>V_{GS}</math> vale in <a href="#">Table 4</a> has been corrected</li></ul> |

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