



STD9NM60N STF9NM60N, STP9NM60N

N-channel 600 V, 0.63 Ω , 6.5 A TO-220, TO-220FP, DPAK
MDmesh™ II Power MOSFET

Features

| Order codes | V _{DSS} (@T _{jmax}) | R _{DS(on)} max. | I _D |
|-------------|---|-----------------------------|----------------|
| STD9NM60N | 650 V | < 0.745 Ω | 6.5 A |
| STF9NM60N | | | |
| STP9NM60N | | | |

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

Application

Switching applications

Description

This series of devices is realized with the second generation of MDmesh™ technology. This revolutionary Power MOSFET associates a new vertical structure to the company's strip layout to yield one of the world's lowest on-resistance and gate charge. It is therefore suitable for the most demanding high efficiency converters.

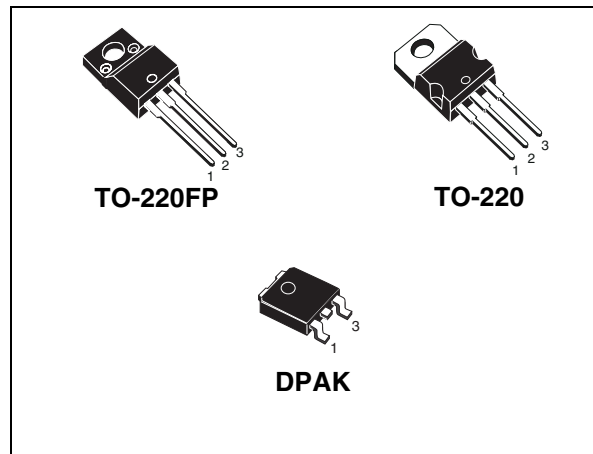


Figure 1. Internal schematic diagram

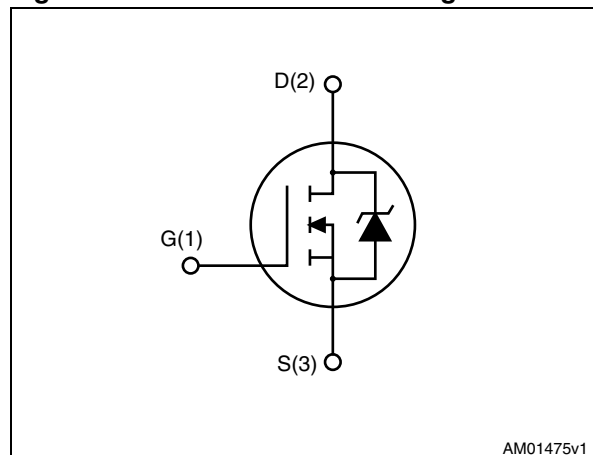


Table 1. Device summary

| Order codes | Marking | Packages | Packaging |
|-------------|---------|----------|---------------|
| STD9NM60N | 9NM60N | DPAK | Tape and reel |
| STF9NM60N | | TO-220FP | Tube |
| STP9NM60N | | TO-220 | |

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 | Package mechanical data | 14 |
| 6 | Revision history | 15 |

1 Electrical ratings

Table 2. Absolute maximum ratings

| Symbol | Parameter | Value | | Unit |
|----------------|--|--------------|--------------------|------------------|
| | | TO-220, DPAK | TO-220FP | |
| V_{DS} | Drain-source voltage ($V_{GS} = 0$) | 600 | | V |
| V_{GS} | Gate- source voltage | ± 25 | | V |
| I_D | Drain current (continuous) at $T_C = 25\text{ }^\circ\text{C}$ | 6.5 | 6.5 ⁽¹⁾ | A |
| I_D | Drain current (continuous) at $T_C = 100\text{ }^\circ\text{C}$ | 4 | 4 ⁽¹⁾ | A |
| $I_{DM}^{(2)}$ | Drain current (pulsed) | 26 | 26 ⁽¹⁾ | A |
| P_{TOT} | Total dissipation at $T_C = 25\text{ }^\circ\text{C}$ | 70 | 25 | W |
| 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 |
| $dv/dt^{(3)}$ | Peak diode recovery voltage slope | 15 | | V/ns |
| T_{stg} | Storage temperature | - 55 to 150 | | $^\circ\text{C}$ |
| T_j | Max. operating junction temperature | 150 | | $^\circ\text{C}$ |

- Limited only by maximum temperature allowed
- Pulse width limited by safe operating area
- $I_{SD} \leq 6.5\text{ A}$, $di/dt \leq 400\text{ A}/\mu\text{s}$, $V_{DD} = 80\% V_{(BR)DSS}$

Table 3. Thermal data

| Symbol | Parameter | Value | | | Unit |
|---------------------|---|-------|--------|----------|---------------------------|
| | | DPAK | TO-220 | TO-220FP | |
| $R_{thj-case}$ | Thermal resistance junction-case max | 1.79 | | 5 | $^\circ\text{C}/\text{W}$ |
| $R_{thj-pcb}^{(1)}$ | Thermal resistance junction-pcb minimum footprint | 50 | | | $^\circ\text{C}/\text{W}$ |
| $R_{thj-amb}$ | Thermal resistance junction-ambient max | | 62.5 | | $^\circ\text{C}/\text{W}$ |
| T_l | Maximum lead temperature for soldering purpose | | 300 | | $^\circ\text{C}$ |

- When mounted on 1inch² FR-4 board, 2 oz Cu

Table 4. Avalanche characteristics

| Symbol | Parameter | Value | Unit |
|----------|--|-------|------|
| I_{AR} | Avalanche current, repetitive or not-repetitive (pulse width limited by T_j Max) | 2.5 | A |
| E_{AS} | Single pulse avalanche energy (starting $T_j = 25\text{ }^\circ\text{C}$, $I_D = I_{AR}$, $V_{DD} = 50\text{ V}$) | 115 | mJ |

2 Electrical characteristics

($T_{CASE} = 25\text{ °C}$ 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 ($V_{GS} = 0$) | $V_{DS} = \text{max rating}$ $V_{DS} = \text{max rating}$, @125 °C | | | 1 100 | μA μA |
| 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 | $V_{GS} = 10\text{ V}$, $I_D = 3.25\text{ A}$ | | 0.63 | 0.745 | Ω |

Table 6. Dynamic

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|----------------------------|-------------------------------|--|------|------|------|----------|
| C_{iss} | Input capacitance | $V_{DS} = 50\text{ V}$, $f = 1\text{ MHz}$, $V_{GS} = 0$ | - | 452 | - | pF |
| C_{oss} | Output capacitance | | | 30 | | pF |
| C_{rss} | Reverse transfer capacitance | | | 1.45 | | pF |
| $C_{oss\text{ eq.}}^{(1)}$ | Equivalent output capacitance | $V_{GS} = 0$, $V_{DS} = 0\text{ to }480\text{ V}$ | - | 79 | - | pF |
| Q_g | Total gate charge | $V_{DD} = 480\text{ V}$, $I_D = 6.5\text{ A}$, $V_{GS} = 10\text{ V}$, <i>(see Figure 18)</i> | - | 17.4 | - | nC |
| Q_{gs} | Gate-source charge | | | 3 | | nC |
| Q_{gd} | Gate-drain charge | | | 9.7 | | nC |
| R_g | Gate input resistance | f=1 MHz Gate DC Bias=0 Test signal level=20 mV open drain | - | 4.8 | - | Ω |

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 | $V_{DD} = 480\text{ V}$, $I_D = 6.5\text{ A}$ $R_G = 4.7\ \Omega$, $V_{GS} = 10\text{ V}$ (see Figure 17) | - | 28 | - | ns |
| t_r | Rise time | | | 23 | | ns |
| $t_{d(off)}$ | Turn-off delay time | | | 52.5 | | ns |
| t_f | Fall time | | | 26.7 | | ns |

Table 8. Source drain diode

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|-----------------|-------------------------------|---|------|------|------|---------------|
| I_{SD} | Source-drain current | | - | | 6.5 | A |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) | | | | 26 | A |
| $V_{SD}^{(2)}$ | Forward on voltage | $I_{SD} = 6.5\text{ A}$, $V_{GS} = 0$ | - | | 1.6 | V |
| t_{rr} | Reverse recovery time | $I_{SD} = 6.5\text{ A}$, $di/dt = 100\text{ A}/\mu\text{s}$ $V_{DD} = 60\text{ V}$ (see Figure 22) | - | 264 | | ns |
| Q_{rr} | Reverse recovery charge | | | 1.9 | | μC |
| I_{RRM} | Reverse recovery current | | | 14.6 | | A |
| t_{rr} | Reverse recovery time | $I_{SD} = 6.5\text{ A}$, $di/dt = 100\text{ A}/\mu\text{s}$ $V_{DD} = 60\text{ V}$, $T_j = 150\text{ }^\circ\text{C}$ (see Figure 22) | - | 324 | | ns |
| Q_{rr} | Reverse recovery charge | | | 2.3 | | μC |
| I_{RRM} | Reverse recovery current | | | 14.2 | | A |

1. Pulse width limited by safe operating area

2. Pulsed: Pulse duration = 300 μs , duty cycle 1.5%

2.1 Electrical characteristics (curves)

Figure 2. Safe operating area for TO-220

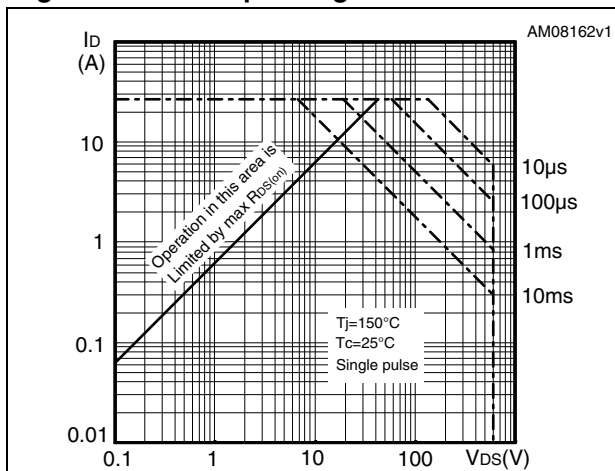


Figure 3. Thermal impedance for TO-220

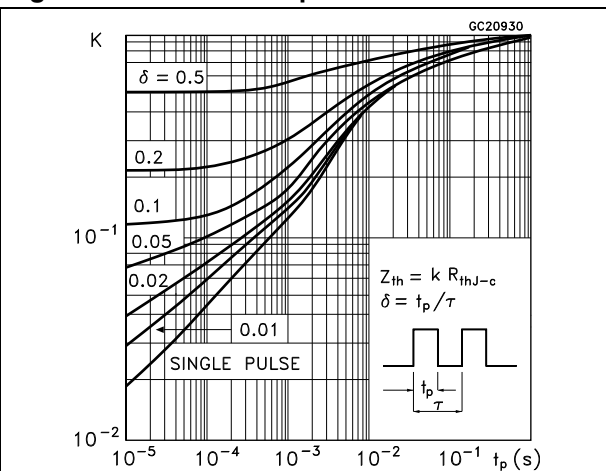


Figure 4. Safe operating area for DPAK

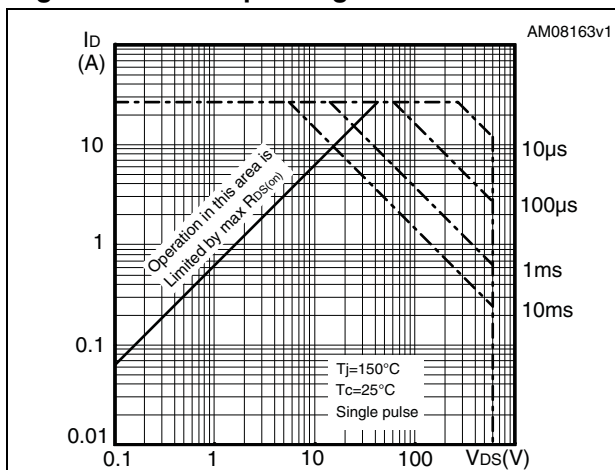


Figure 5. Thermal impedance for DPAK

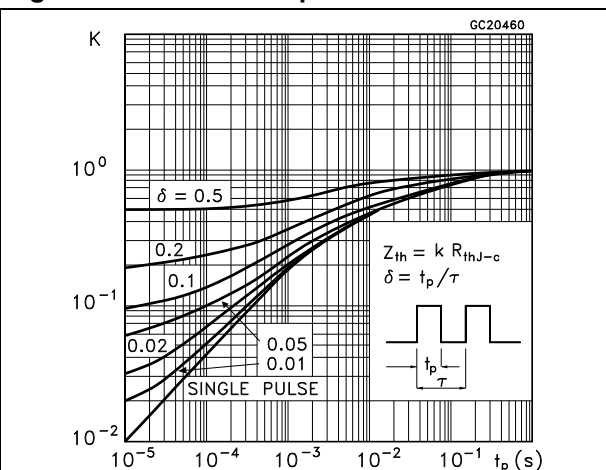


Figure 6. Safe operating area for TO-220FP

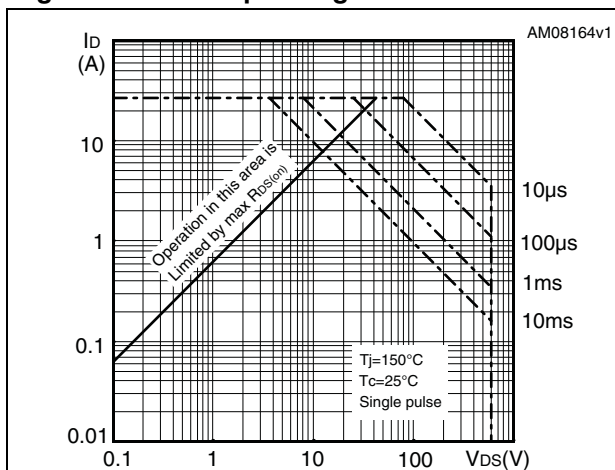


Figure 7. Thermal impedance for TO-220FP

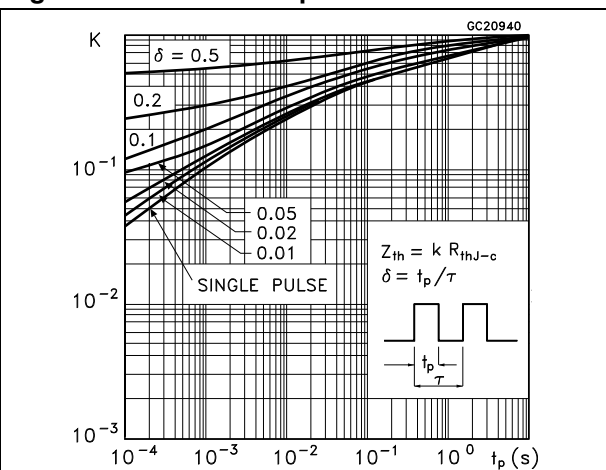


Figure 8. Output characteristics

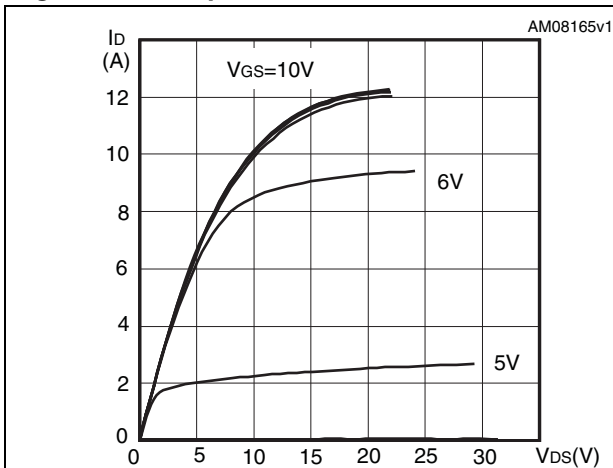


Figure 9. Transfer characteristics

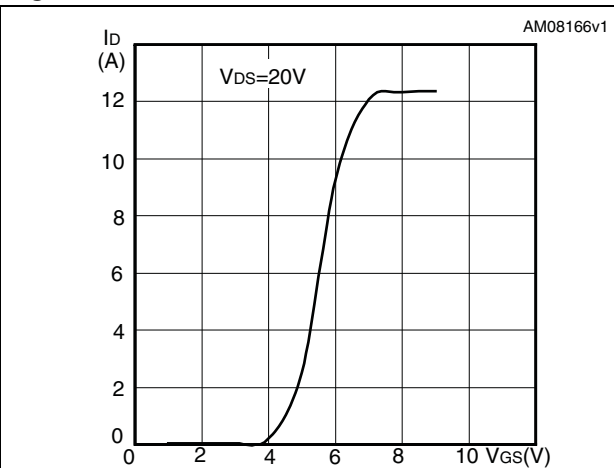


Figure 10. Gate charge vs gate-source voltage

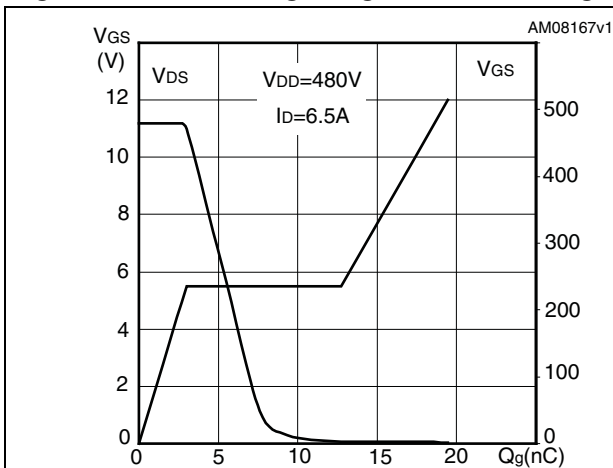


Figure 11. Static drain-source on resistance

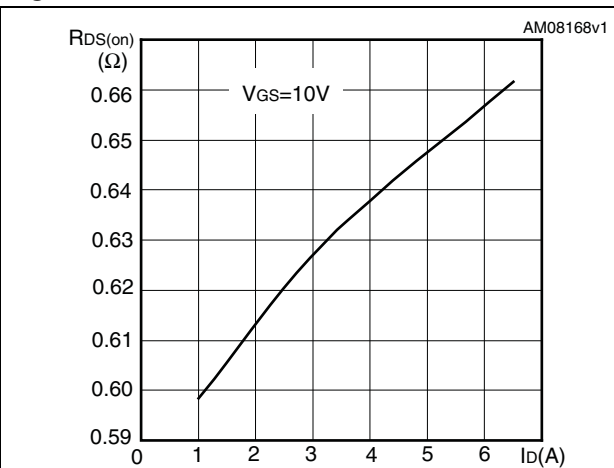


Figure 12. Capacitance variations

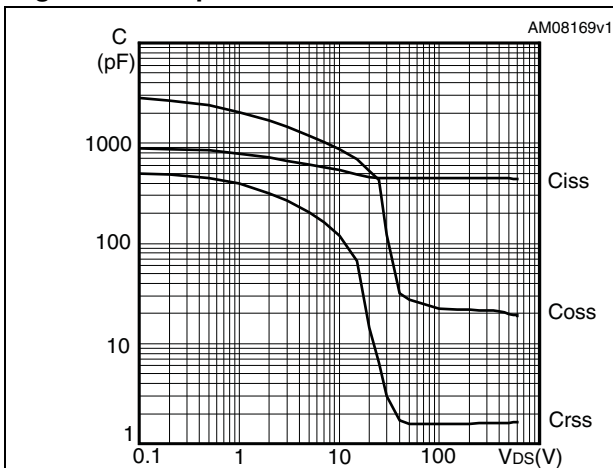


Figure 13. Output capacitance stored energy

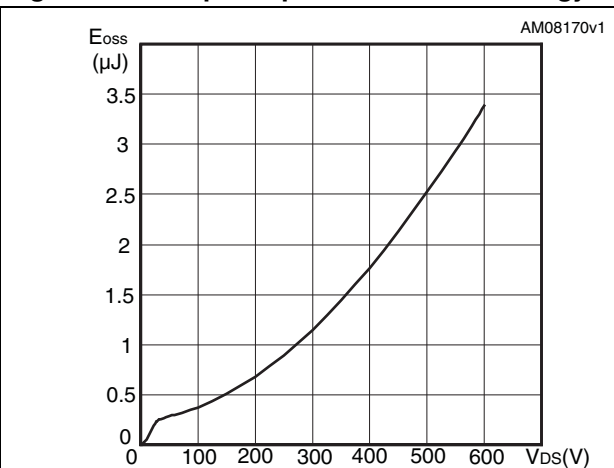


Figure 14. Normalized gate threshold voltage vs temperature

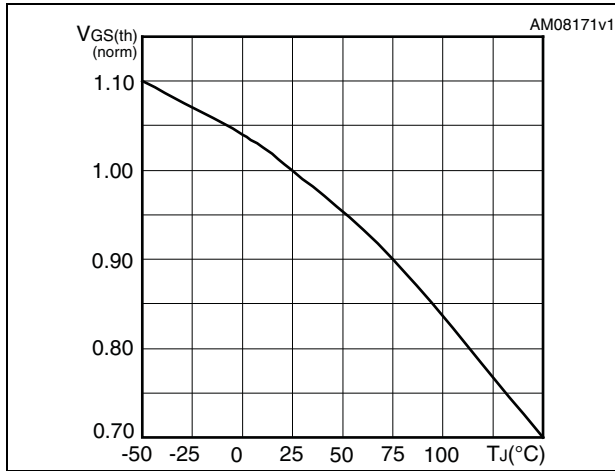


Figure 15. Normalized on resistance vs temperature

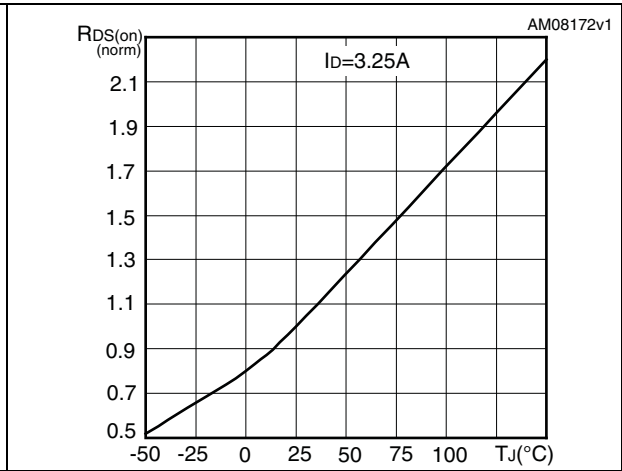
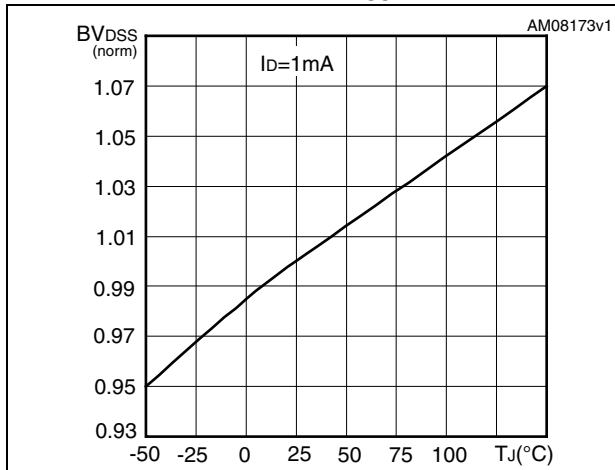


Figure 16. Normalized B_{VDSS} vs temperature



3 Test circuits

Figure 17. Switching times test circuit for resistive load

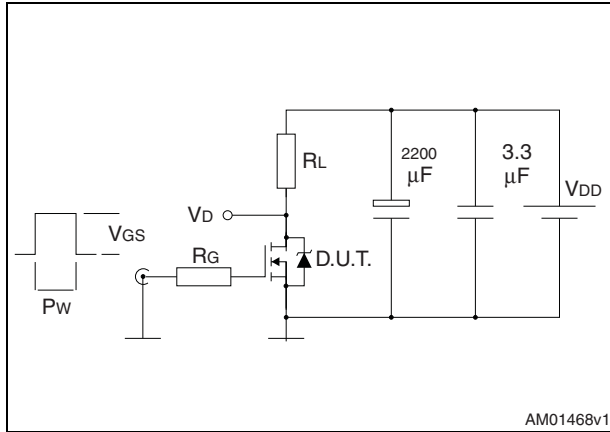


Figure 18. Gate charge test circuit

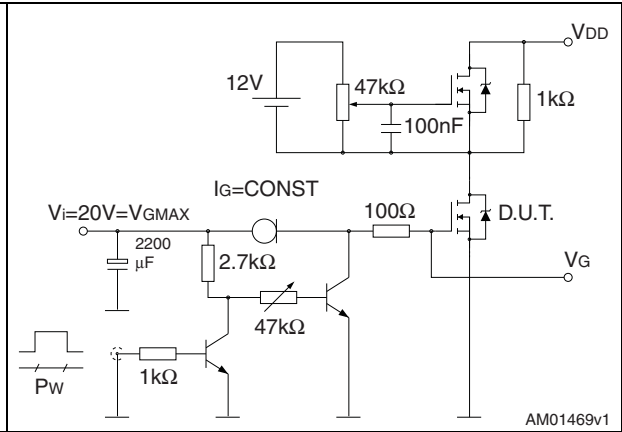


Figure 19. Test circuit for inductive load switching and diode recovery times

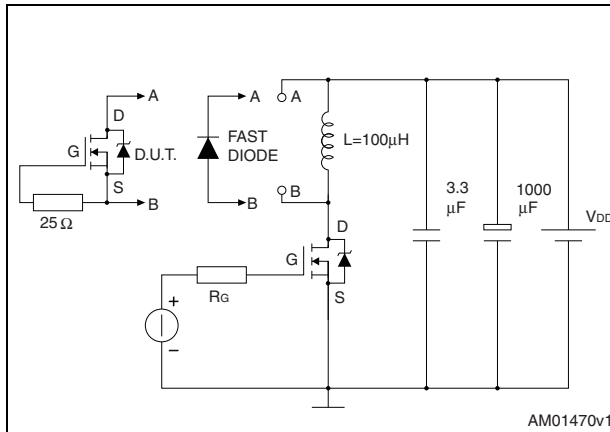


Figure 20. Unclamped inductive load test circuit

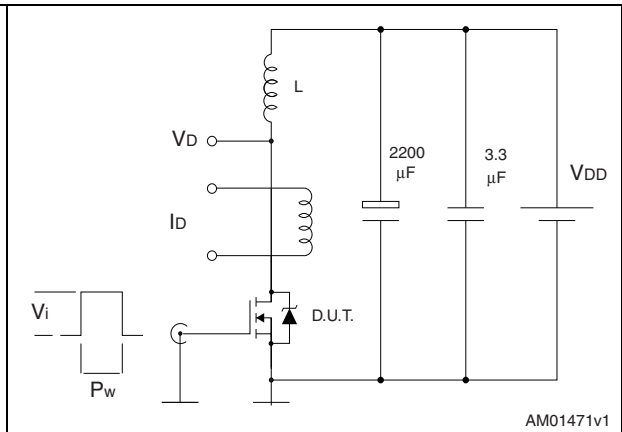


Figure 21. Unclamped inductive waveform

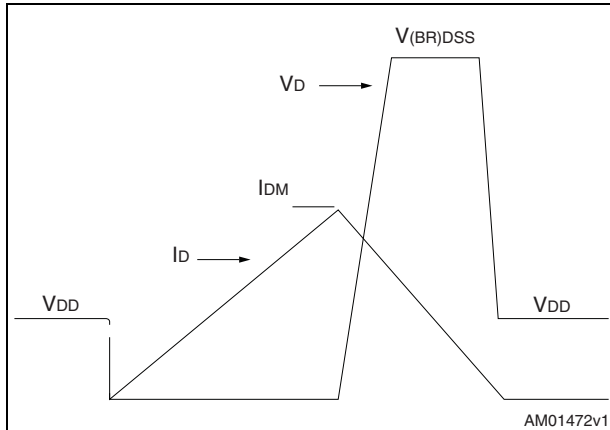
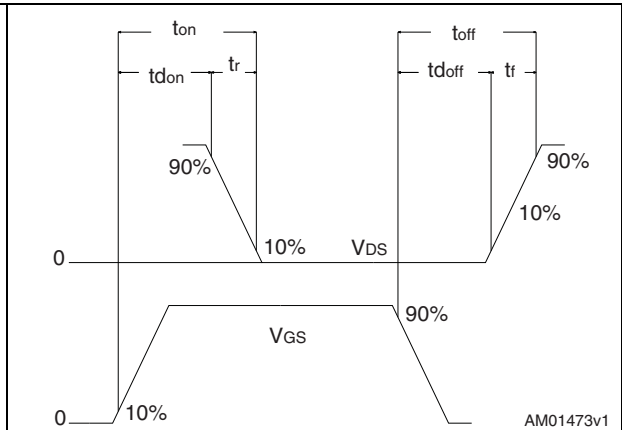


Figure 22. Switching time waveform



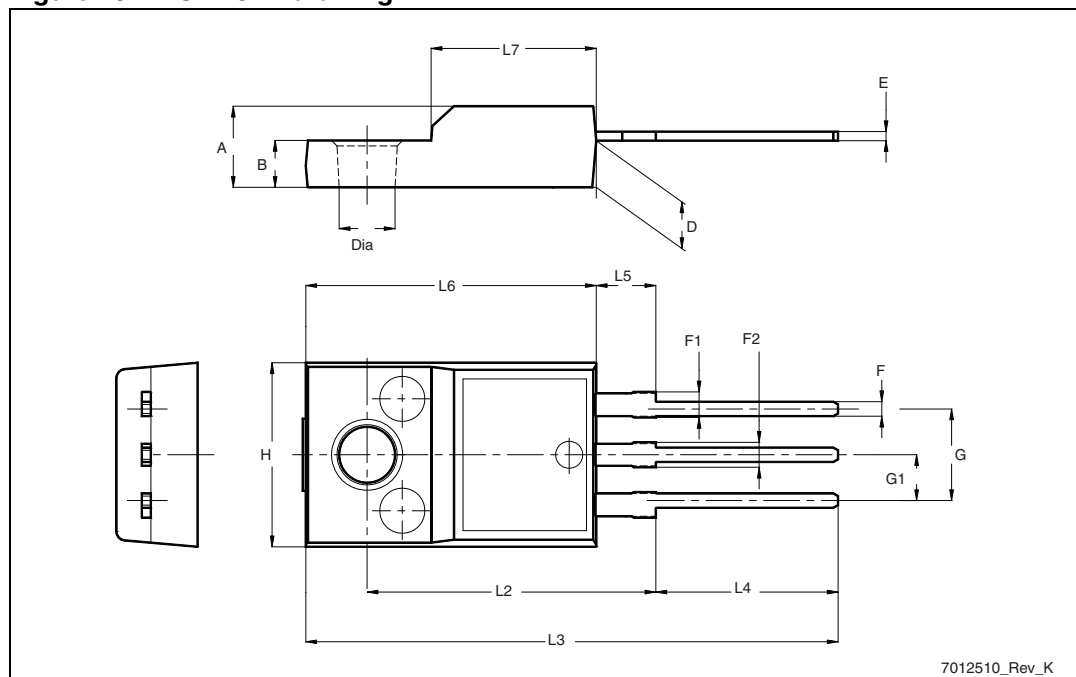
4 Package mechanical data

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. ECOPACK is an ST trademark.

Table 9. TO-220FP mechanical data

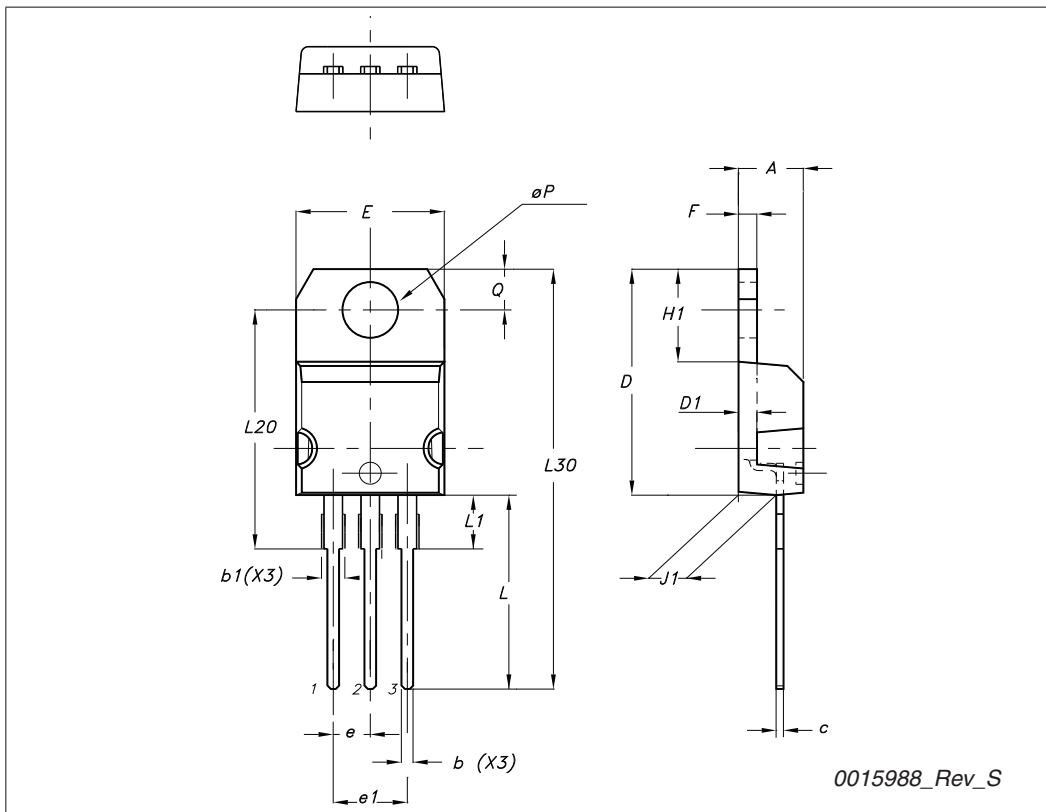
| Dim. | mm | | |
|------|------|------|------|
| | Min. | Typ. | Max. |
| A | 4.4 | | 4.6 |
| B | 2.5 | | 2.7 |
| D | 2.5 | | 2.75 |
| E | 0.45 | | 0.7 |
| F | 0.75 | | 1 |
| F1 | 1.15 | | 1.70 |
| F2 | 1.15 | | 1.70 |
| G | 4.95 | | 5.2 |
| G1 | 2.4 | | 2.7 |
| H | 10 | | 10.4 |
| L2 | | 16 | |
| L3 | 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



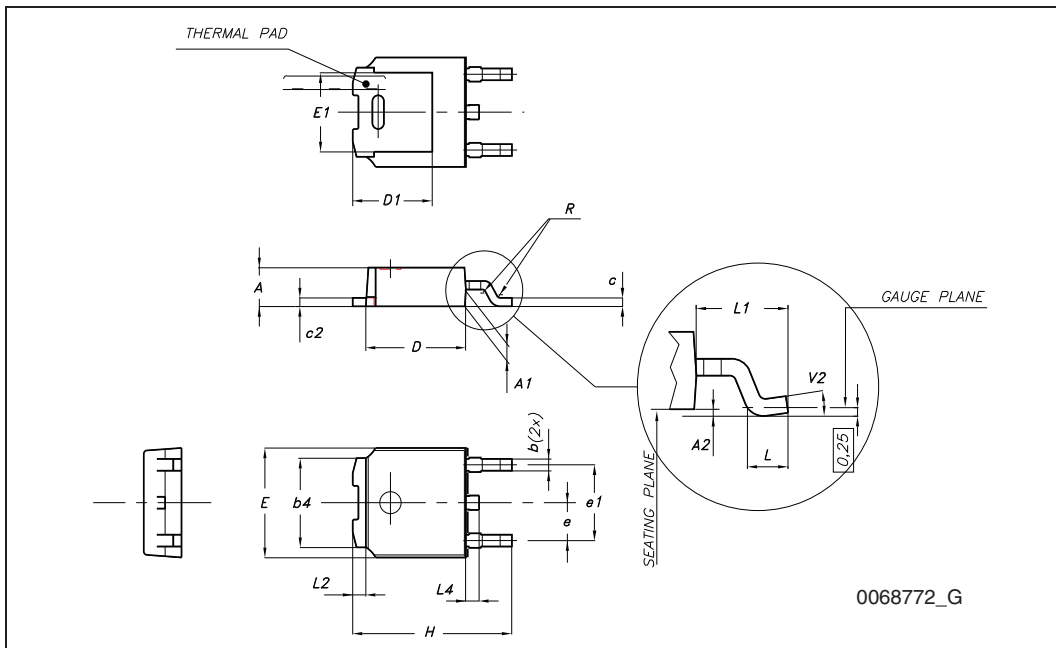
TO-220 type A mechanical data

| 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 |



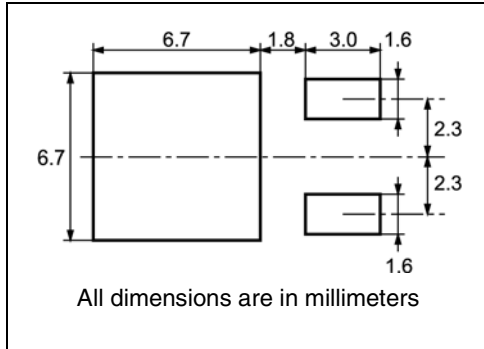
TO-252 (DPAK) mechanical data

| 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° |



5 Package 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

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 |

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 |

10 pitches cumulative tolerance on tape ± 0.2 mm

User Direction of Feed

Center line of cavity

For machine ref. only including draft and radii concentric around B0

FEED DIRECTION

Bending radius R min.

6 Revision history

Table 10. Document revision history

| Date | Revision | Changes |
|-------------|----------|----------------|
| 20-Oct-2010 | 1 | First release. |

Please Read Carefully:

Information in this document is provided solely in connection with ST products. STMicroelectronics NV and its subsidiaries ("ST") reserve the right to make changes, corrections, modifications or improvements, to this document, and the products and services described herein at any time, without notice.

All ST products are sold pursuant to ST's terms and conditions of sale.

Purchasers are solely responsible for the choice, selection and use of the ST products and services described herein, and ST assumes no liability whatsoever relating to the choice, selection or use of the ST products and services described herein.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted under this document. If any part of this document refers to any third party products or services it shall not be deemed a license grant by ST for the use of such third party products or services, or any intellectual property contained therein or considered as a warranty covering the use in any manner whatsoever of such third party products or services or any intellectual property contained therein.

UNLESS OTHERWISE SET FORTH IN ST'S TERMS AND CONDITIONS OF SALE ST DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY WITH RESPECT TO THE USE AND/OR SALE OF ST PRODUCTS INCLUDING WITHOUT LIMITATION IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION), OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.

UNLESS EXPRESSLY APPROVED IN WRITING BY AN AUTHORIZED ST REPRESENTATIVE, ST PRODUCTS ARE NOT RECOMMENDED, AUTHORIZED OR WARRANTED FOR USE IN MILITARY, AIR CRAFT, SPACE, LIFE SAVING, OR LIFE SUSTAINING APPLICATIONS, NOR IN PRODUCTS OR SYSTEMS WHERE FAILURE OR MALFUNCTION MAY RESULT IN PERSONAL INJURY, DEATH, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE. ST PRODUCTS WHICH ARE NOT SPECIFIED AS "AUTOMOTIVE GRADE" MAY ONLY BE USED IN AUTOMOTIVE APPLICATIONS AT USER'S OWN RISK.

Resale of ST products with provisions different from the statements and/or technical features set forth in this document shall immediately void any warranty granted by ST for the ST product or service described herein and shall not create or extend in any manner whatsoever, any liability of ST.

ST and the ST logo are trademarks or registered trademarks of ST in various countries.

Information in this document supersedes and replaces all information previously supplied.

The ST logo is a registered trademark of STMicroelectronics. All other names are the property of their respective owners.

© 2010 STMicroelectronics - All rights reserved

STMicroelectronics group of companies

Australia - Belgium - Brazil - Canada - China - Czech Republic - Finland - France - Germany - Hong Kong - India - Israel - Italy - Japan - Malaysia - Malta - Morocco - Philippines - Singapore - Spain - Sweden - Switzerland - United Kingdom - United States of America

www.st.com