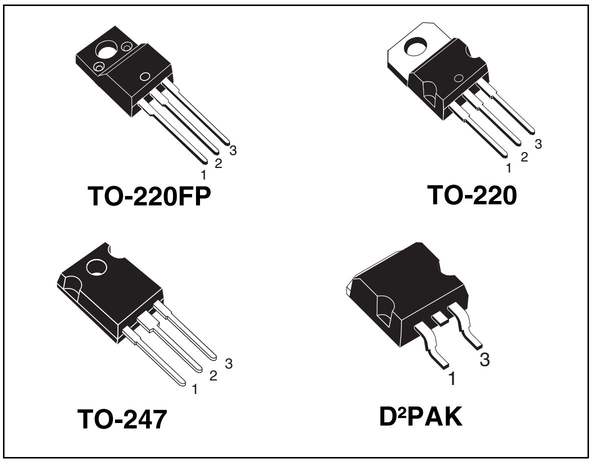
# STB23NM50N, STF23NM50N
# STP23NM50N, STW23NM50N

N-channel 500 V, 0.162 Ω, 17 A TO-220, TO-220FP, TO-247, $D^2PAK$
MDmesh™ II Power MOSFET

## Features

| Type | $V_{DSS}$ (@Tjmax) | $R_{DS(on)}$ max | $I_D$ |
|---|---|---|---|
| STB23NM50N | 550 V | < 0.19Ω | 17 A |
| STF23NM50N | | | |
| STP23NM50N | | | |
| STW23NM50N | | | |

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




## Application

Switching applications

## Description

These devices are made using 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**

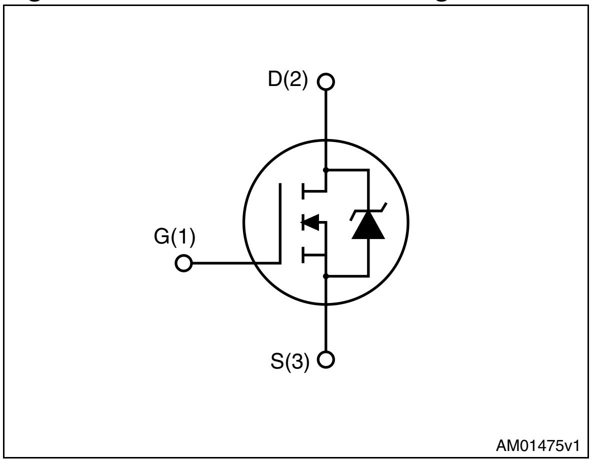



**Table 1. Device summary**

| Order codes | Marking | Package | Packaging |
|---|---|---|---|
| STB23NM50N | 23NM50N | D²PAK | Tape and reel |
| STF23NM50N | | TO-220FP | Tube |
| STP23NM50N | | TO-220 | |
| STW23NM50N | | TO-247 | |

# Contents

# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol | Parameter | Value | | | Unit |
|---|---|---|---|---|---|
| | | TO-220, D²PAK | TO-247 | TO-220FP | |
| $V_{DS}$ | Drain-source voltage ($V_{GS}$ = 0) | 500 | | | V |
| $V_{GS}$ | Gate- source voltage | ± 25 | | | V |
| $I_D$ | Drain current (continuous) at $T_C$ = 25 °C | 17 | | 17 (1) | A |
| $I_D$ | Drain current (continuous) at $T_C$ = 100 °C | 11 | | 11 (1) | A |
| $I_{DM}$ (2) | Drain current (pulsed) | 68 | | 68 (1) | A |
| $P_{TOT}$ | Total dissipation at $T_C$ = 25 °C | 125 | | 30 | W |
| $V_{ISO}$ | Insulation withstand voltage (RMS) from all three leads to external heat sink (t=1 s;$T_C$=25 °C) | | | 2500 | V |
| dv/dt (3) | Peak diode recovery voltage slope | 15 | | | V/ns |
| $T_{stg}$ | Storage temperature | -55 to 150 | | | °C |
| $T_j$ | Max. operating junction temperature | 150 | | | °C |

1. Limited only by maximum temperature allowed
2. Pulse width limited by safe operating area
3. $I_{SD}$ ≤ 8.5 A, di/dt ≤ 400 A/µs, $V_{DD}$ = 80% $V_{(BR)DSS}$

**Table 3. Thermal data**

| Symbol | Parameter | Value | | | | Unit |
|---|---|---|---|---|---|---|
| | | D²PAK | TO-247 | TO-220 | TO-220FP | |
| $R_{thj\text{-}case}$ | Thermal resistance junction-case max | 1 | | | 4.17 | °C/W |
| $R_{thj\text{-}pcb}$ (1) | Thermal resistance junction-pcb minimum footprint | 30 | | | | °C/W |
| $R_{thj\text{-}amb}$ | Thermal resistance junction-ambient max | | 62.5 | 50 | 62.5 | °C/W |
| $T_l$ | Maximum lead temperature for soldering purpose | | 300 | | | °C |

1. 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 Tj Max) | 6 | A |
| $E_{AS}$ | Single pulse avalanche energy (starting Tj = 25 °C, $I_D$ = $I_{AR}$, $V_{DD}$ = 50 V) | 470 | mJ |

# 2 Electrical characteristics

($T_{CASE}$=25 °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 mA, $V_{GS}$ = 0 | 500 | | | V |
| $I_{DSS}$ | Zero gate voltage drain current ($V_{GS}$ = 0) | $V_{DS}$ = max rating<br>$V_{DS}$ = max rating, @125 °C | | | 1<br>10 | µA<br>µA |
| $I_{GSS}$ | Gate-body leakage current ($V_{DS}$ = 0) | $V_{GS}$ = ± 20 V | | | 0.1 | µA |
| $V_{GS(th)}$ | Gate threshold voltage | $V_{DS}$ = $V_{GS}$, $I_D$ = 250 µA | 2 | 3 | 4 | V |
| $R_{DS(on)}$ | Static drain-source on resistance | $V_{GS}$ = 10 V, $I_D$ = 8.5 A | | 0.162 | 0.19 | Ω |

**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 V, f = 1 MHz,<br>$V_{GS}$ = 0 | - | 1330<br>84<br>4.8 | - | pF<br>pF<br>pF |
| $C_{oss\ eq.}$ (1) | Equivalent output capacitance | $V_{GS}$ = 0, $V_{DS}$ = 0 to 400 V | - | 210 | - | pF |
| $Q_g$<br>$Q_{gs}$<br>$Q_{gd}$ | Total gate charge<br>Gate-source charge<br>Gate-drain charge | $V_{DD}$ = 400 V, $I_D$ = 17 A,<br>$V_{GS}$ = 10 V,<br>*(see Figure 18)* | - | 45<br>7<br>24 | - | nC<br>nC<br>nC |
| $R_g$ | Gate input resistance | f=1 MHz Gate DC Bias=0<br>Test signal level=20 mV<br>open drain | - | 4.6 | - | Ω |

1. $C_{oss\ eq.}$ 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 |
|---|---|---|---|---|---|---|
| $t_{c(off)}$<br>$t_{r(v)}$<br>$t_{d(off)}$<br>$t_{f(i)}$ | Turn-off crossing time<br>Voltage rise time<br>Turn-off delay time<br>Current fall time | $V_{DD}$ = 250 V, $I_D$ = 17 A<br>$R_G$ = 4.7 Ω $V_{GS}$ = 10 V<br>*(see Figure 17)* | - | 6.6<br>19<br>71<br>29 | - | ns<br>ns<br>ns<br>ns |

**Table 8. Source drain diode**

| Symbol | Parameter | Test conditions | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|
| $I_{SD}$<br>$I_{SDM}$ (1) | Source-drain current<br>Source-drain current (pulsed) | | - | | 17<br>68 | A<br>A |
| $V_{SD}$ (2) | Forward on voltage | $I_{SD}$ = 17 A, $V_{GS}$ = 0 | - | | 1.3 | V |
| $t_{rr}$<br>$Q_{rr}$<br>$I_{RRM}$ | Reverse recovery time<br>Reverse recovery charge<br>Reverse recovery current | $I_{SD}$ = 17 A, di/dt = 100 A/µs<br>$V_{DD}$ = 60 V<br>*(see Figure 22)* | - | 286<br>3700<br>26 | | ns<br>nC<br>A |
| $t_{rr}$<br>$Q_{rr}$<br>$I_{RRM}$ | Reverse recovery time<br>Reverse recovery charge<br>Reverse recovery current | $I_{SD}$ = 17 A, di/dt = 100 A/µs<br>$V_{DD}$ = 60 V, $T_j$ = 150 °C<br>*(see Figure 22)* | - | 350<br>4800<br>27 | | ns<br>nC<br>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, D²PAK**

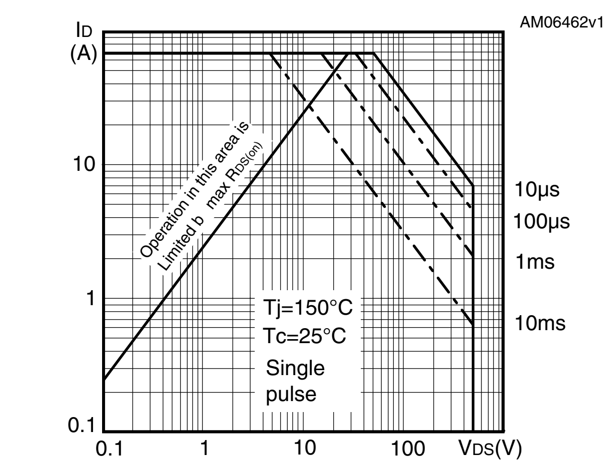



**Figure 3. Thermal impedance for TO-220, D²PAK**

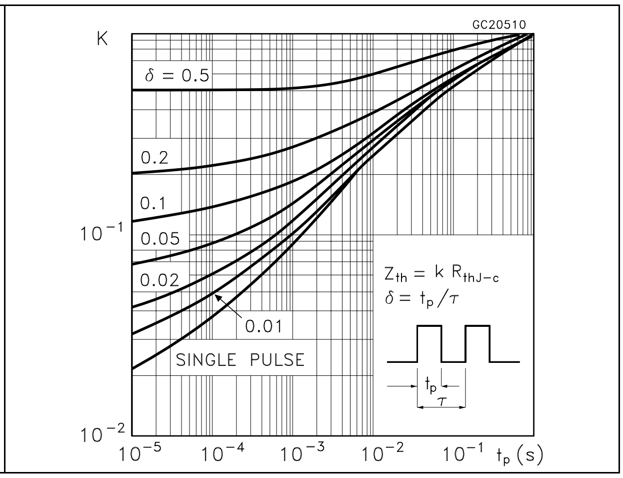



**Figure 4. Safe operating area for TO-220FP**

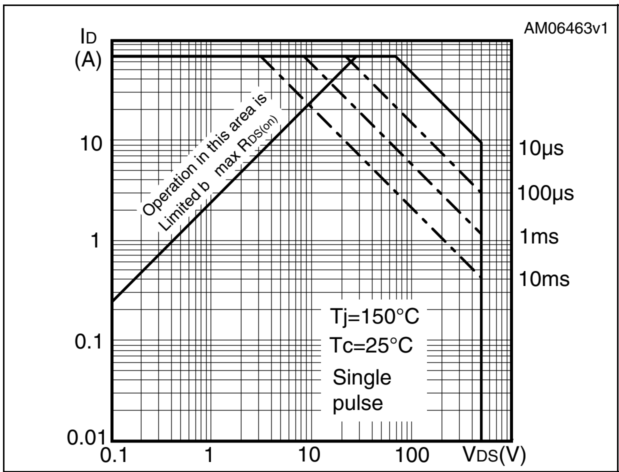



**Figure 5. Thermal impedance for TO-220FP**

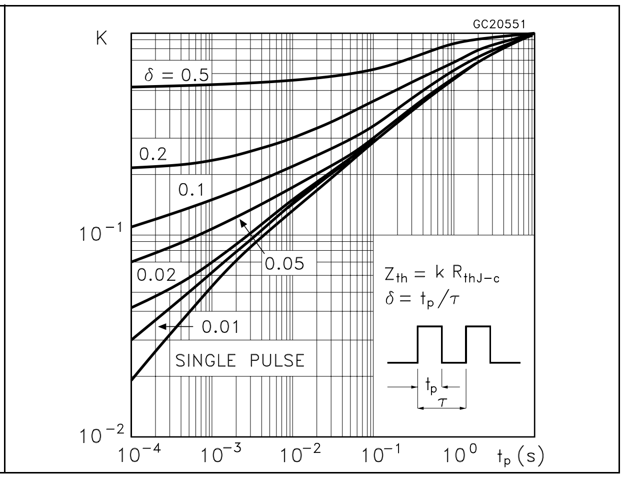



**Figure 6. Safe operating area for TO-247**

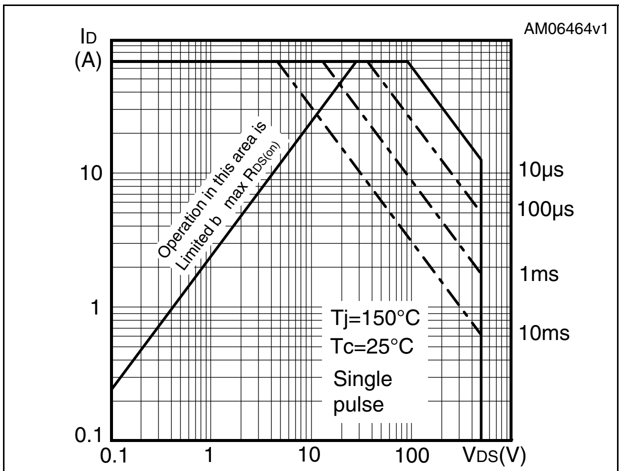



**Figure 7. Thermal impedance for TO-247**

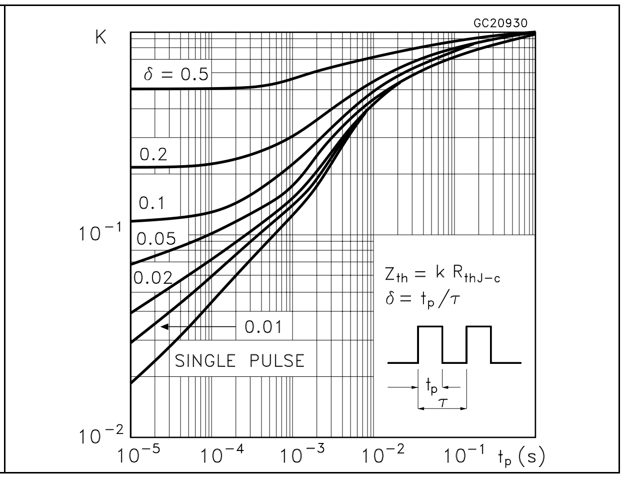


**Figure 8. Output characteristics**

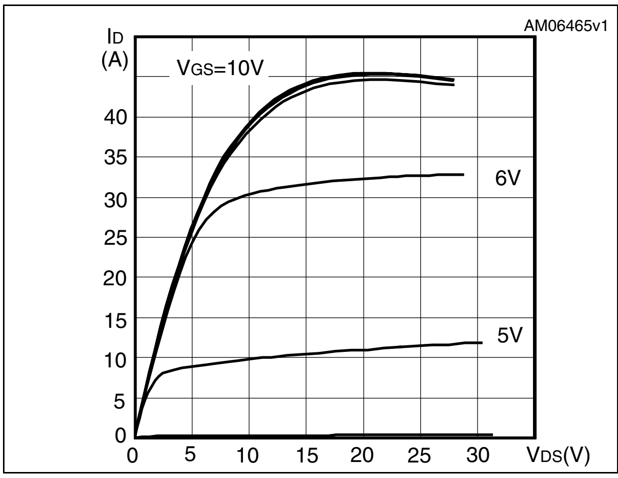



**Figure 9. Transfer characteristics**

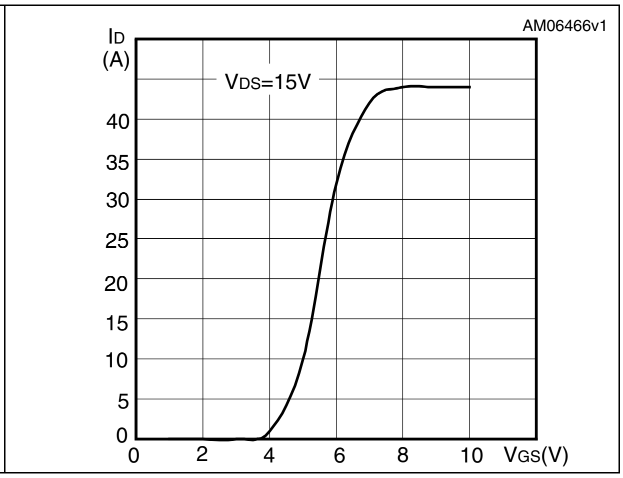



**Figure 10. Gate charge vs gate-source voltage**

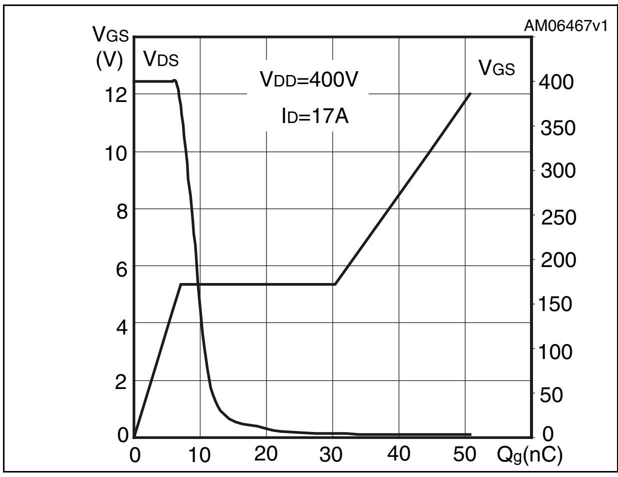



**Figure 11. Static drain-source on resistance**

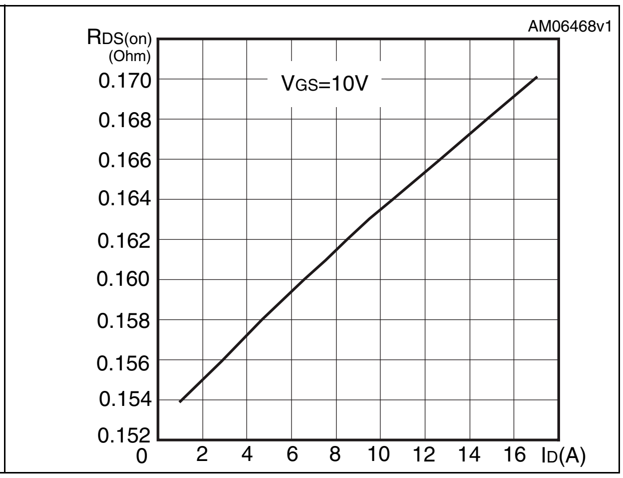



**Figure 12. Capacitance variations**

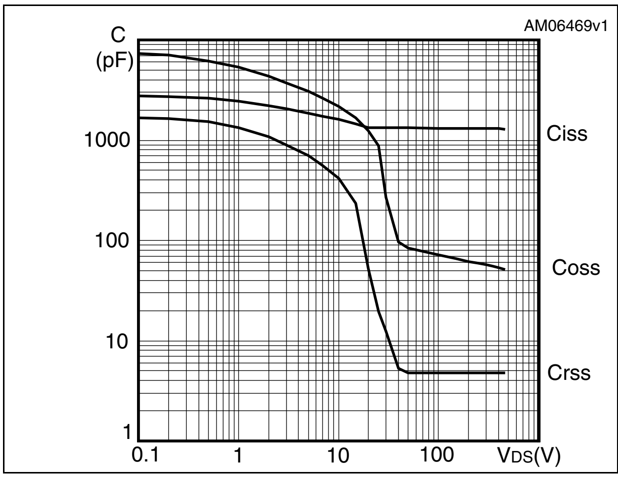



**Figure 13. Output capacitance stored energy**

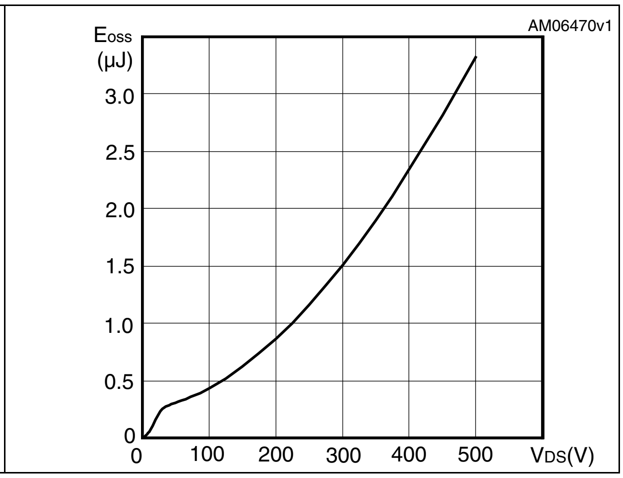


**Figure 14. Normalized gate threshold voltage vs temperature**

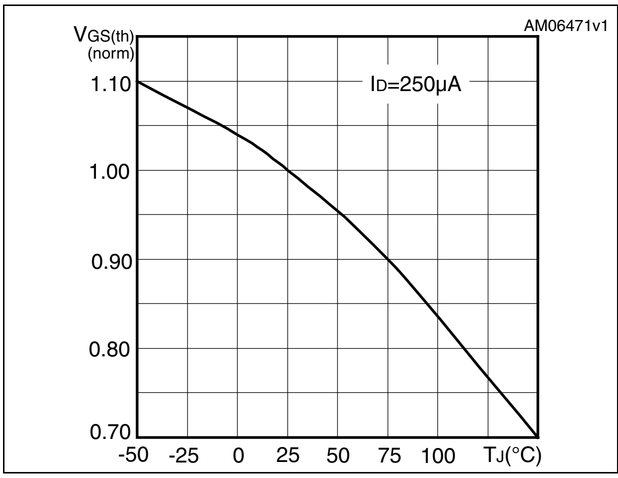



**Figure 15. Normalized on resistance vs temperature**

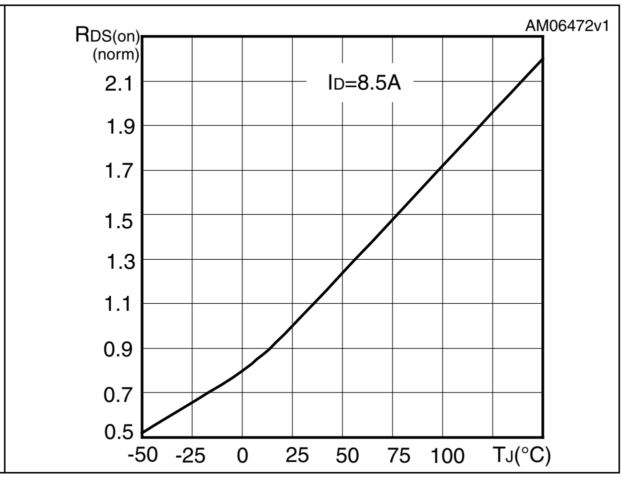
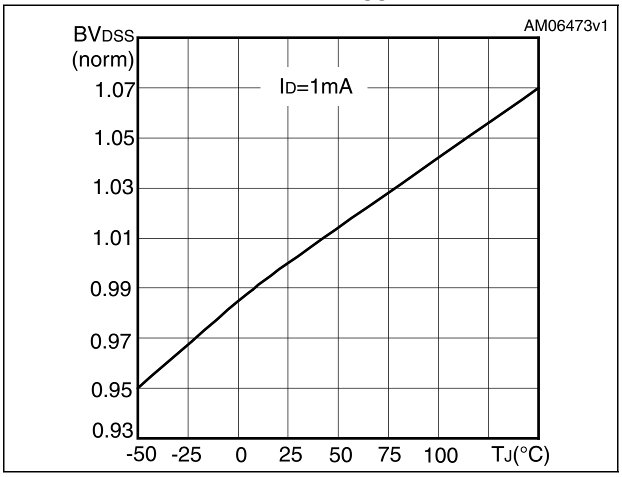



**Figure 16. Normalized $B_{VDSS}$ vs temperature**



# 3 Test circuits

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

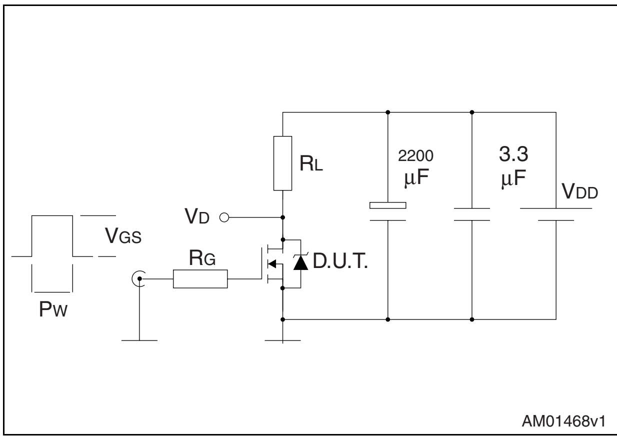



**Figure 18. Gate charge test circuit**

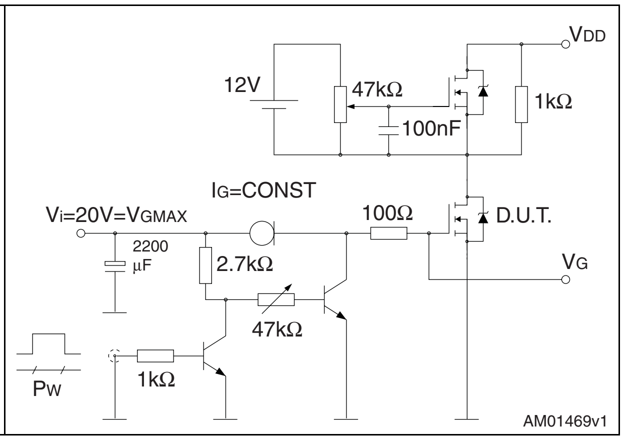



**Figure 19. Test circuit for inductive load switching and diode recovery times**

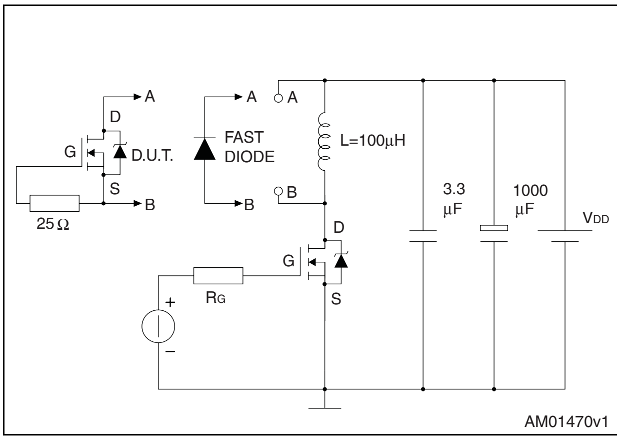



**Figure 20. Unclamped inductive load test circuit**

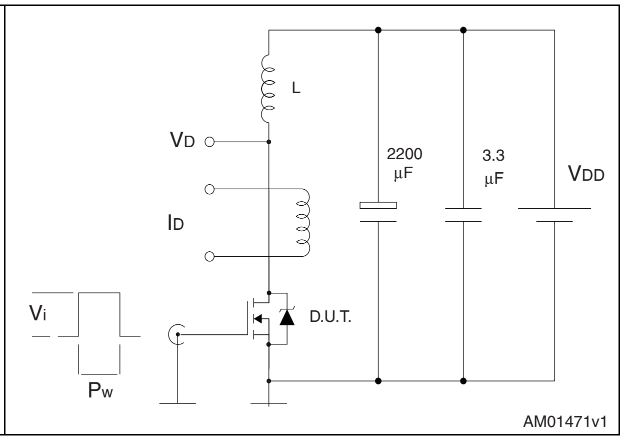



**Figure 21. Unclamped inductive waveform**

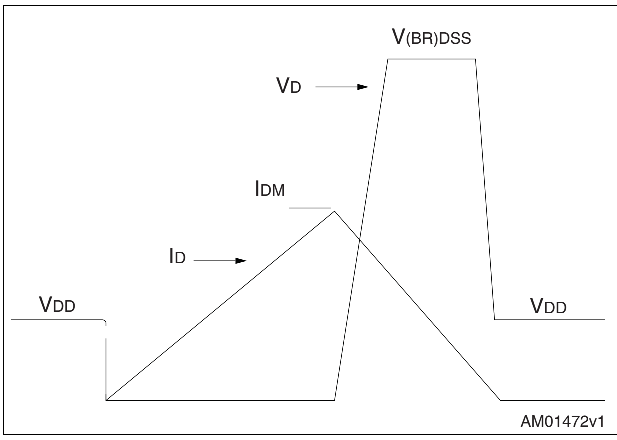
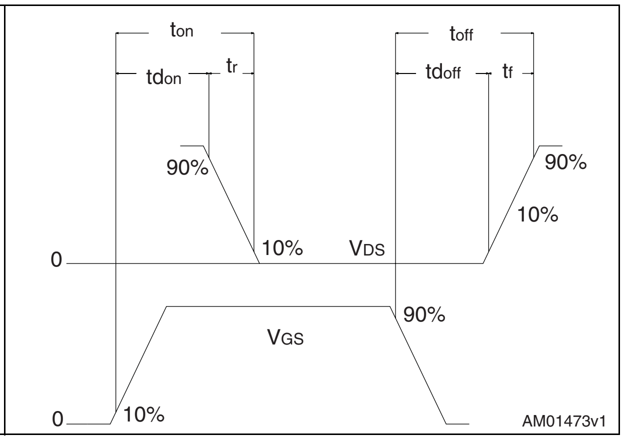



**Figure 22. Switching time waveform**



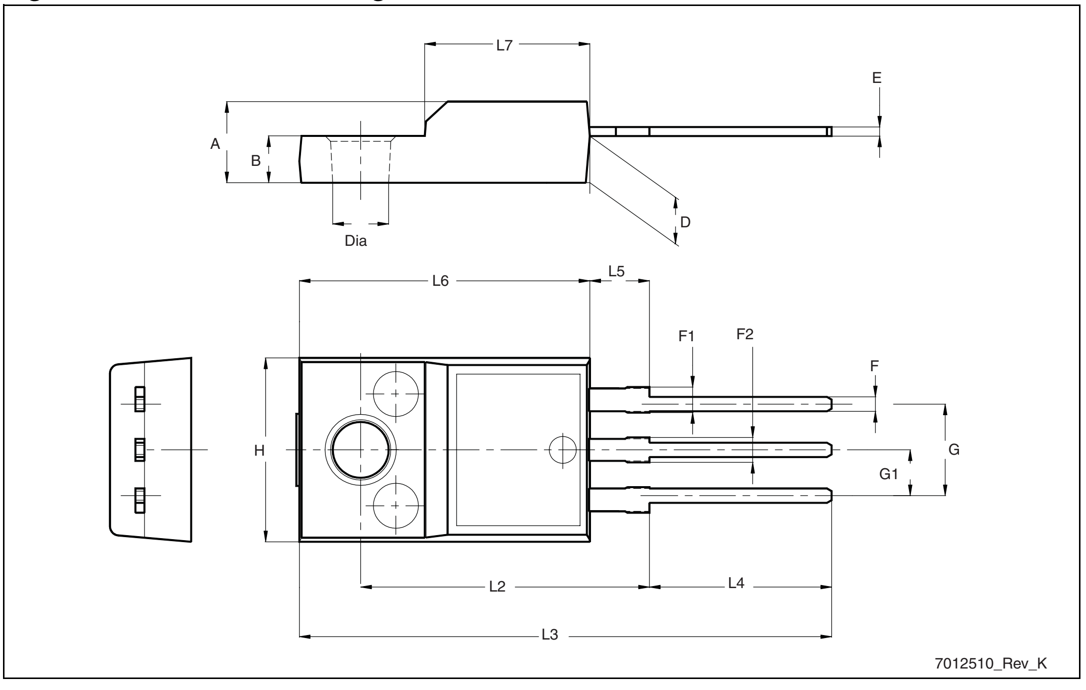
# 4 Package mechanical data

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

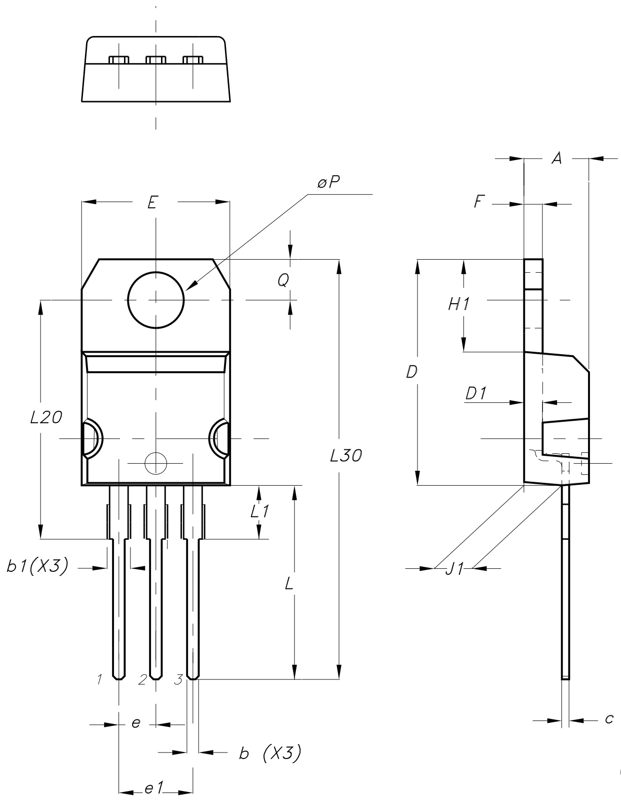
| Dim. | mm | | |
|---|---|---|---|
| | Min. | Typ. | Max. |
| A | 4.4 | | 4.6 |
| B | 2.5 | | 2.7 |
| D | 2.5 | | 2.75 |
| E | 0.45 | | 0.7 |
| F | 0.75 | | 1 |
| F1 | 1.15 | | 1.70 |
| F2 | 1.15 | | 1.70 |
| G | 4.95 | | 5.2 |
| G1 | 2.4 | | 2.7 |
| H | 10 | | 10.4 |
| L2 | | 16 | |
| L3 | 28.6 | | 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

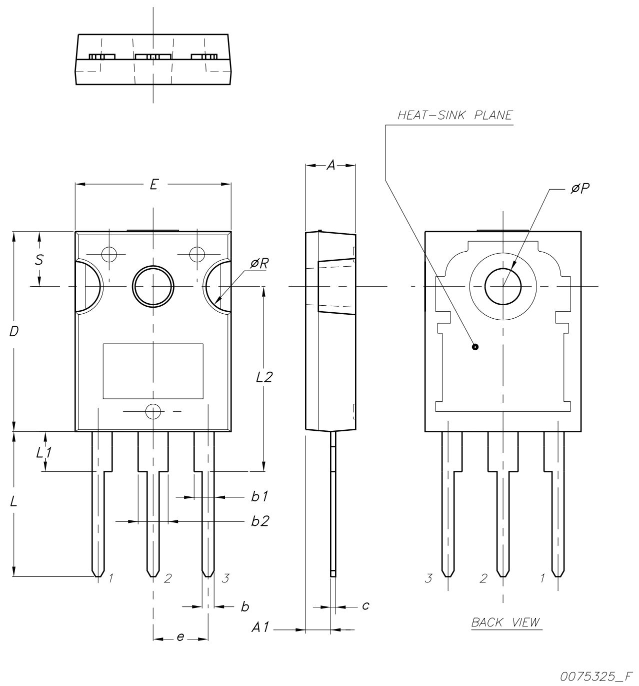
| Dim | mm | | |
|---|---|---|---|
| | Min | Typ | Max |
| A | 4.40 | | 4.60 |
| b | 0.61 | | 0.88 |
| b1 | 1.14 | | 1.70 |
| c | 0.48 | | 0.70 |
| D | 15.25 | | 15.75 |
| D1 | | 1.27 | |
| E | 10 | | 10.40 |
| e | 2.40 | | 2.70 |
| e1 | 4.95 | | 5.15 |
| F | 1.23 | | 1.32 |
| H1 | 6.20 | | 6.60 |
| 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 |




0015988_Rev_S

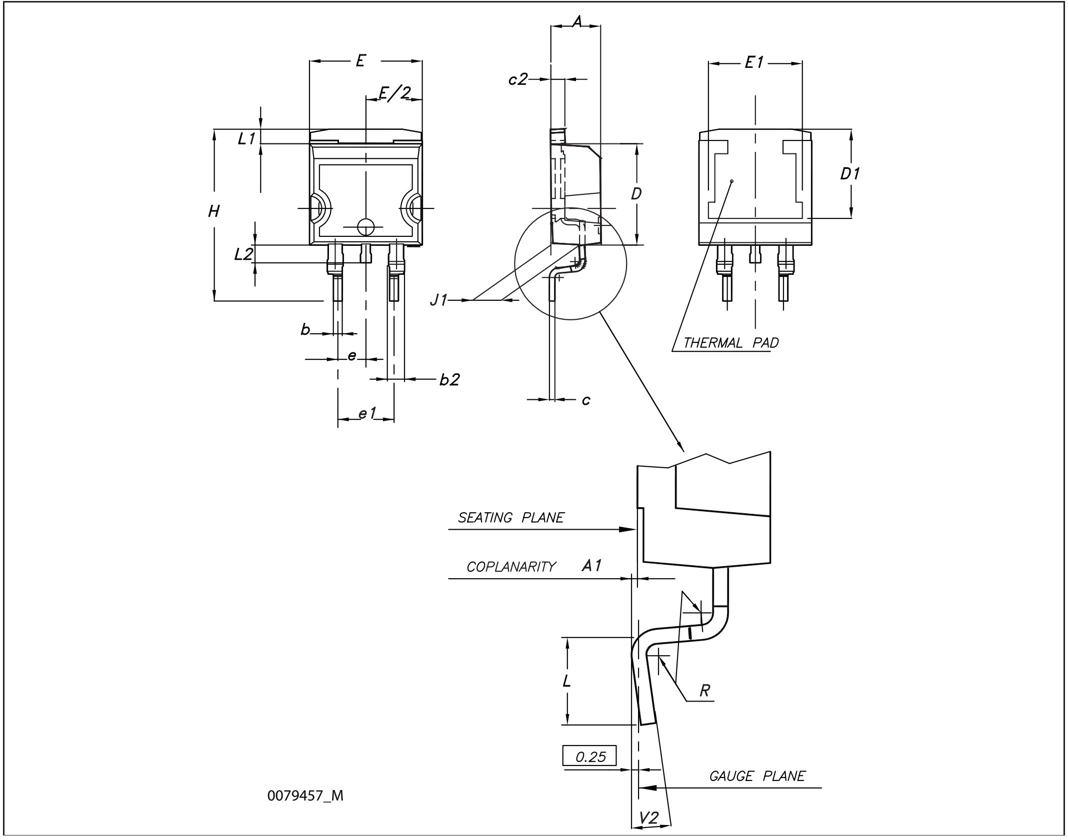
**TO-247 mechanical data**

| Dim. | mm. | | |
|---|---|---|---|
| | Min. | Typ. | Max. |
| A | 4.85 | | 5.15 |
| A1 | 2.20 | | 2.60 |
| b | 1.0 | | 1.40 |
| b1 | 2.0 | | 2.40 |
| b2 | 3.0 | | 3.40 |
| c | 0.40 | | 0.80 |
| D | 19.85 | | 20.15 |
| E | 15.45 | | 15.75 |
| e | | 5.45 | |
| L | 14.20 | | 14.80 |
| L1 | 3.70 | | 4.30 |
| L2 | | 18.50 | |
| øP | 3.55 | | 3.65 |
| øR | 4.50 | | 5.50 |
| S | | 5.50 | |



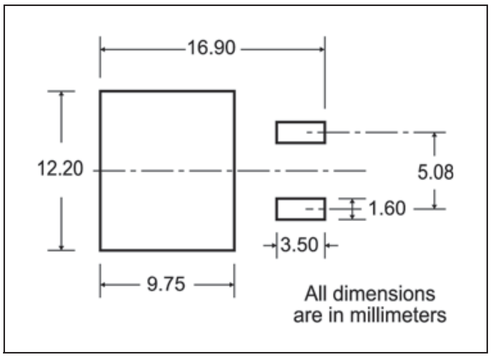
$D^2PAK$ (TO-263) mechanical data

| Dim | mm | | | inch | | |
|---|---|---|---|---|---|---|
| | Min | Typ | Max | Min | Typ | Max |
| A | 4.40 | | 4.60 | 0.173 | | 0.181 |
| A1 | 0.03 | | 0.23 | 0.001 | | 0.009 |
| b | 0.70 | | 0.93 | 0.027 | | 0.037 |
| b2 | 1.14 | | 1.70 | 0.045 | | 0.067 |
| c | 0.45 | | 0.60 | 0.017 | | 0.024 |
| c2 | 1.23 | | 1.36 | 0.048 | | 0.053 |
| D | 8.95 | | 9.35 | 0.352 | | 0.368 |
| D1 | 7.50 | | | 0.295 | | |
| E | 10 | | 10.40 | 0.394 | | 0.409 |
| E1 | 8.50 | | | 0.334 | | |
| e | | 2.54 | | | 0.1 | |
| e1 | 4.88 | | 5.28 | 0.192 | | 0.208 |
| H | 15 | | 15.85 | 0.590 | | 0.624 |
| J1 | 2.49 | | 2.69 | 0.099 | | 0.106 |
| L | 2.29 | | 2.79 | 0.090 | | 0.110 |
| L1 | 1.27 | | 1.40 | 0.05 | | 0.055 |
| L2 | 1.30 | | 1.75 | 0.051 | | 0.069 |
| R | | 0.4 | | | 0.016 | |
| V2 | 0° | | 8° | 0° | | 8° |

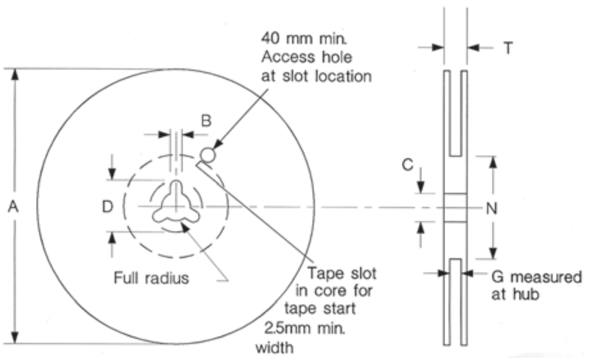


# 5 Package mechanical data

D$^2$PAK FOOTPRINT




TAPE AND REEL SHIPMENT



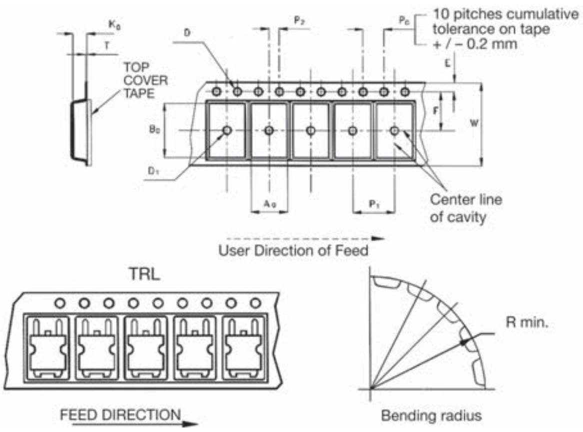

REEL MECHANICAL DATA

| 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 | | 0795 | |
| G | 24.4 | 26.4 | 0.960 | 1.039 |
| N | 100 | | 3.937 | |
| T | | 30.4 | | 1.197 |

| BASE QTY | BULK QTY |
|---|---|
| 1000 | 1000 |

TAPE MECHANICAL DATA

| DIM. | mm | | inch | |
|---|---|---|---|---|
| | MIN. | MAX. | MIN. | MAX. |
| A0 | 10.5 | 10.7 | 0.413 | 0.421 |
| B0 | 15.7 | 15.9 | 0.618 | 0.626 |
| D | 1.5 | 1.6 | 0.059 | 0.063 |
| D1 | 1.59 | 1.61 | 0.062 | 0.063 |
| E | 1.65 | 1.85 | 0.065 | 0.073 |
| F | 11.4 | 11.6 | 0.449 | 0.456 |
| K0 | 4.8 | 5.0 | 0.189 | 0.197 |
| P0 | 3.9 | 4.1 | 0.153 | 0.161 |
| P1 | 11.9 | 12.1 | 0.468 | 0.476 |
| P2 | 1.9 | 2.1 | 0.075 | 0.082 |
| R | 50 | | 1.574 | |
| T | 0.25 | 0.35 | 0.0098 | 0.0137 |
| W | 23.7 | 24.3 | 0.933 | 0.956 |



# 6 Revision history

**Table 10. Document revision history**

| Date | Revision | Changes |
|---|---|---|
| 11-Dec-2009 | 1 | First release. |
| 26-May-2010 | 2 | Document status promoted from preliminary data to datasheet. |
| 16-Sep-2010 | 3 | Added new value in *Figure 14*, *Figure 15* and *Figure 16*. |