# STB4NK60Z, STB4NK60Z-1, STD4NK60Z STD4NK60Z-1, STP4NK60Z,STP4NK60ZFP

N-channel 600 V, 1.76 Ω, 4 A SuperMESH™ Power MOSFET in DPAK, D²PAK, IPAK, I²PAK, TO-220, TO-220FP

## Features

| Type | $V_{DSS}$ | $R_{DS(on)}$ max | $P_W$ | $I_D$ |
|---|---|---|---|---|
| STB4NK60Z | 600 V | < 2 Ω | 70 W | 4 A |
| STB4NK60Z-1 | 600 V | < 2 Ω | 70 W | 4 A |
| STD4NK60Z | 600 V | < 2 Ω | 70 W | 4 A |
| STD4NK60Z-1 | 600 V | < 2 Ω | 70 W | 4 A |
| STP4NK60Z | 600 V | < 2 Ω | 70 W | 4 A |
| STP4NK60ZFP | 600 V | < 2 Ω | 25 W | 4 A |

- 100% avalanche tested
- Very low intrinsic capacitances

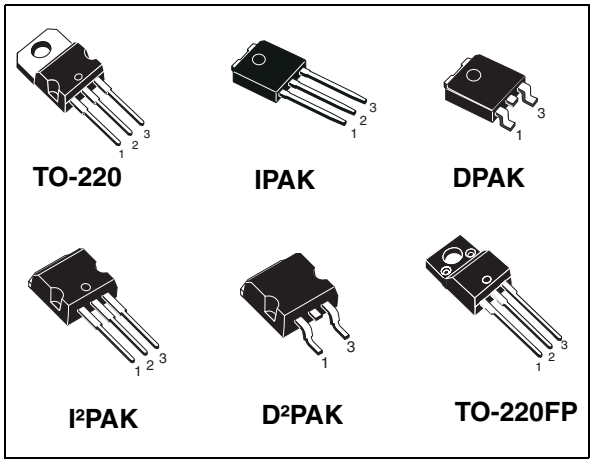
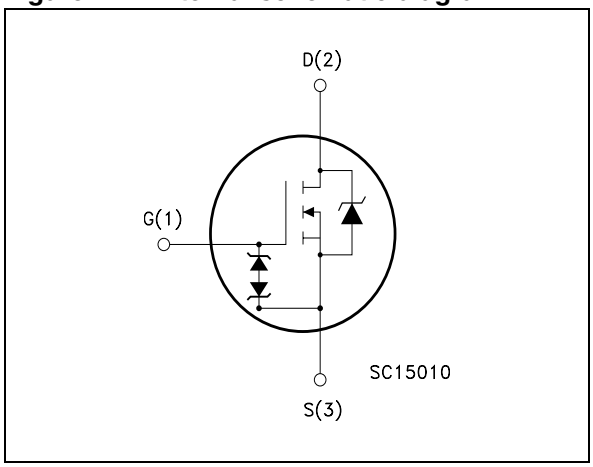



**Figure 1. Internal schematic diagram**




## Applications

- Switching applications

## Description

These devices are N-channel Zener-protected Power MOSFETs developed using STMicroelectronics' SuperMESH™ technology, achieved through optimization of ST's well established strip-based PowerMESH™ layout. In addition to a significant reduction in on-resistance, this device is designed to ensure a high level of dv/dt capability for the most demanding applications.

**Table 1. Device summary**

| Order codes | Marking | Package | Packaging |
|---|---|---|---|
| STB4NK60Z | B4NK60Z | D²PAK | Tape and reel |
| STB4NK60Z-1 | B4NK60Z | I²PAK | Tube |
| STD4NK60Z | D4NK60Z | DPAK | Tape and reel |
| STD4NK60Z-1 | D4NK60Z | IPAK | Tube |
| STP4NK60Z | P4NK60Z | TO-220 | Tube |
| STP4NK60ZFP | P4NK60ZFP | TO-220FP | Tube |

# Contents

# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol | Parameter | Value | | Unit |
|---|---|---|---|---|
| | | TO-220 - D²PAK DPAK-IPAK-I²PAK | TO-220FP | |
| $V_{DS}$ | Drain-source voltage ($V_{GS}$ = 0) | 600 | | V |
| $V_{GS}$ | Gate- source voltage | ± 30 | | V |
| $I_D$ | Drain current (continuous) at $T_C$ = 25 °C | 4 | 4 (1) | A |
| $I_D$ | Drain current (continuous) at $T_C$ = 100 °C | 2.5 | 2.5 (1) | A |
| $I_{DM}$ (2) | Drain current (pulsed) | 16 | 16 (1) | A |
| $P_{TOT}$ | Total dissipation at $T_C$ = 25 °C | 70 | 25 | W |
| | Derating factor | 0.56 | 0.2 | W/°C |
| $V_{ESD(G-S)}$ | Gate source ESD(HBM-C=100 pF, R=1.5 kΩ) | 3000 | | V |
| dv/dt (3) | Peak diode recovery voltage slope | 4.5 | | V/ns |
| $V_{ISO}$ | Insulation withstand voltage (RMS) from all three leads to external heat sink (t=1 s; $T_C$ = 25 °C) | - | 2500 | V |
| $T_{stg}$ | 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. $I_{SD} \leq 4$ A, di/dt $\leq 200$ A/µs, $V_{DD} \leq V_{(BR)DSS}$, $T_J \leq T_{JMAX.}$

**Table 3. Thermal data**

| Symbol | Parameter | Value | | | Unit |
|---|---|---|---|---|---|
| | | TO-220 D²PAK I²PAK | DPAK IPAK | TO-220FP | |
| $R_{thj\text{-}case}$ | Thermal resistance junction-case max | 1.78 | | 5 | °C/W |
| $R_{thj\text{-}amb}$ | Thermal resistance junction-ambient max | 62.5 | 100 | 62.5 | °C/W |
| $T_l$ | Maximum lead temperature for soldering purpose | 300 | | | °C |

**Table 4. Avalanche characteristics**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $I_{AR}$ | Avalanche current, repetitive or not-repetitive (pulse width limited by Tj Max) | 4 | A |
| $E_{AS}$ | Single pulse avalanche energy (starting $T_J$ = 25 °C, $I_D$=$I_{AR}$, $V_{DD}$= 50 V) | 120 | 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 | 600 | | | V |
| $I_{DSS}$ | Zero gate voltage drain current ($V_{GS}$ = 0)<br>$V_{DS}$ = Max rating<br>$V_{DS}$ = Max rating, $T_C$ = 125 °C | | | | 1<br>50 | µA<br>µA |
| $I_{GSS}$ | Gate-body leakage current ($V_{DS}$ = 0) | $V_{GS}$ = ± 20 V | | | ± 10 | µA |
| $V_{GS(th)}$ | Gate threshold voltage | $V_{DS}$ = $V_{GS}$, $I_D$ = 50 µA | 3 | 3.75 | 4.5 | V |
| $R_{DS(on)}$ | Static drain-source on resistance | $V_{GS}$ = 10 V, $I_D$ = 2 A | | 1.76 | 2 | Ω |

**Table 6. Dynamic**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $g_{fs}$ (1) | Forward transconductance | $V_{DS}$ = 15 V, $I_D$ = 2 A | | 3 | | S |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS}$ = 25 V, f = 1 MHz, $V_{GS}$ = 0 | | 510<br>67<br>13 | | pF<br>pF<br>pF |
| $C_{oss\ eq.}$ (2) | Equivalent output capacitance | $V_{DS}$ =0, $V_{DS}$ = 0 to 480 V | | 38.5 | | pF |
| $t_{d(on)}$<br>$t_r$<br>$t_{d(off)}$<br>$t_f$ | Turn-on delay time<br>Rise time<br>Turn-off delay time<br>Fall time | $V_{DD}$ = 300 V, $I_D$ = 2 A, $R_G$ = 4.7 Ω, $V_{GS}$ = 10 V (see *Figure 17*) | | 12<br>9.5<br>29<br>16.5 | | ns<br>ns<br>ns<br>ns |
| $t_{r(Voff)}$<br>$t_r$<br>$t_c$ | Off-voltage rise time<br>Fall time<br>Cross-over time | $V_{DD}$ = 480 V, $I_D$ = 4 A, $R_G$ = 4.7 Ω, $V_{GS}$ = 10 V (see *Figure 19*) | | 12<br>12<br>19.5 | | ns<br>ns<br>ns |
| $Q_g$<br>$Q_{gs}$<br>$Q_{gd}$ | Total gate charge<br>Gate-source charge<br>Gate-drain charge | $V_{DD}$ = 480 V, $I_D$ = 4 A, $V_{GS}$ = 10 V (see *Figure 18*) | | 18.8<br>3.8<br>9.8 | 26 | nC<br>nC<br>nC |

1. Pulsed: pulse duration=300µs, duty cycle 1.5%
2. $C_{oss\ eq.}$ is defined as a constant equivalent capacitance giving the same charging time as $C_{oss}$ when $V_{DS}$ increases from 0 to 80% $V_{DSS}$.

**Table 7. 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) | | | | 4<br>16 | A<br>A |
| $V_{SD}$(2) | Forward on voltage | $I_{SD}$ = 4 A, $V_{GS}$ = 0 | | | 1.6 | V |
| $t_{rr}$<br>$Q_{rr}$<br>$I_{RRM}$ | Reverse recovery time<br>Reverse recovery charge<br>Reverse recovery current | $I_{SD}$ = 4 A, di/dt = 100 A/µs<br>$V_{DD}$ = 24 V, Tj = 150 °C<br>(see *Figure 19*) | | 400<br>1700<br>8.5 | | ns<br>nC<br>A |

1. Pulsed: pulse duration = 300 µs, duty cycle 1.5%
2. Pulse width limited by safe operating area

**Table 8. Gate-source Zener diode**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $BV_{GSO}$ | Gate-source breakdown voltage | Igs=± 1 mA (open drain) | 30 | | | V |

The built-in back-to-back Zener diodes have specifically been designed to enhance not only the device's ESD capability, but also to make them safely absorb possible voltage transients that may occasionally be applied from gate to source. In this respect the Zener voltage is appropriate to achieve an efficient and cost-effective intervention to protect the device's integrity. These integrated Zener diodes thus avoid the usage of external components.

## 2.1 Electrical characteristics (curves)

**Figure 2. Safe operating area for TO-220 / DPAK / IPAK / D²PAK / I²PAK**

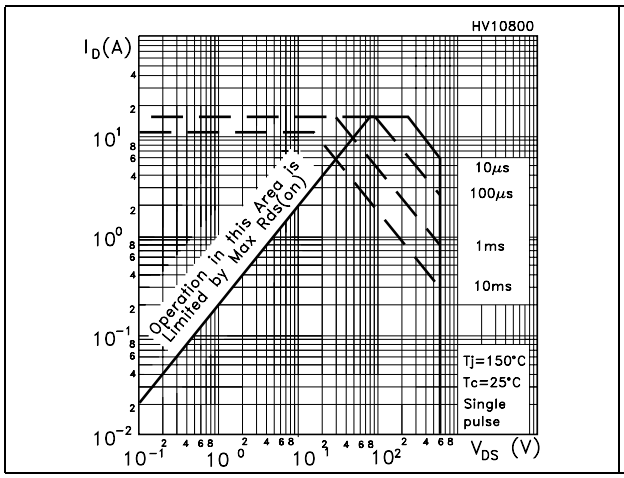



**Figure 3. Thermal impedance for TO-220 / DPAK / IPAK / D²PAK / I²PAK**

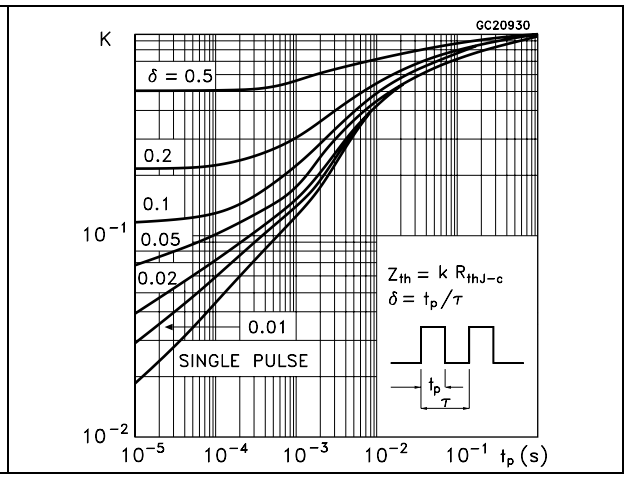



**Figure 4. Safe operating area for TO-220FP**

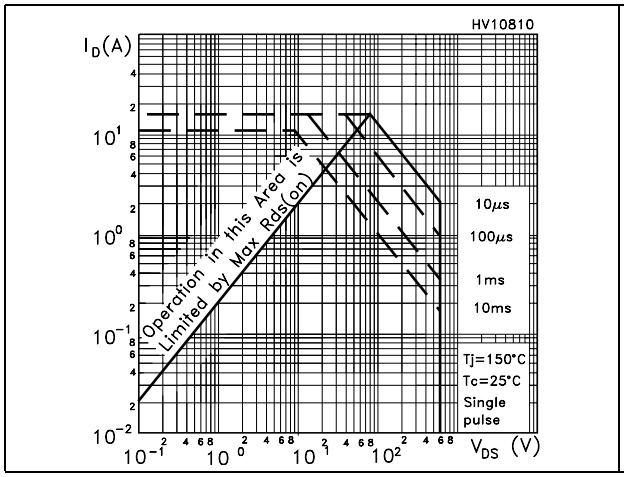



**Figure 5. Thermal impedance for TO-220FP**

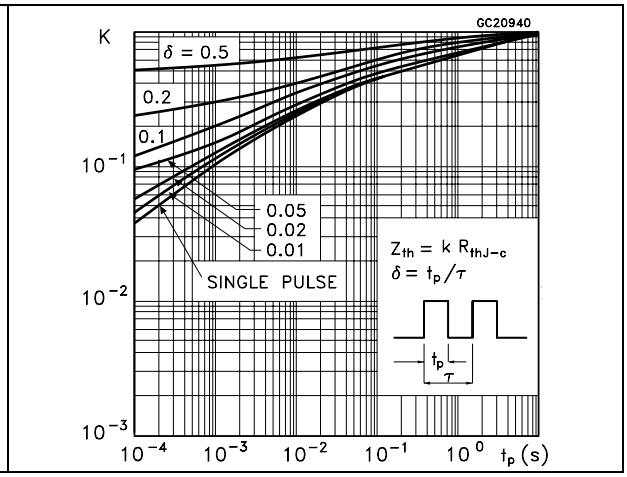



**Figure 6. Output characteristics**

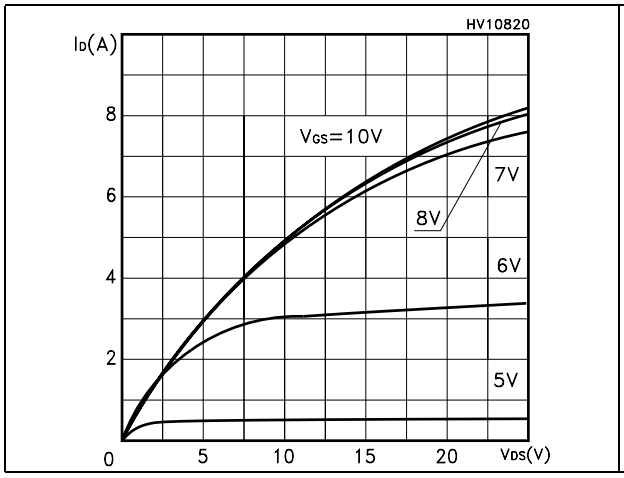



**Figure 7. Transfer characteristics**

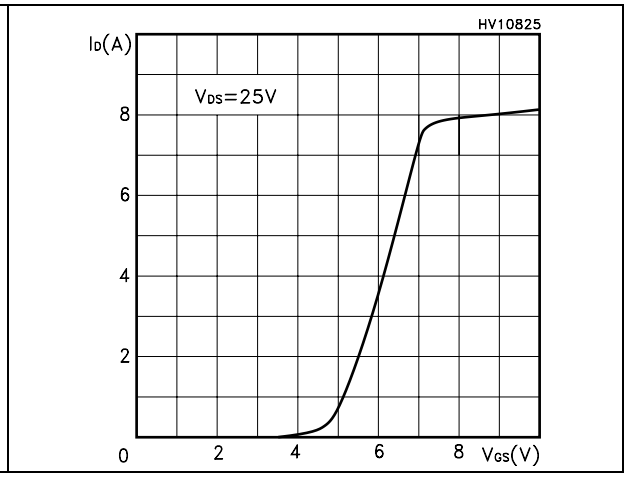


**Figure 8. Transconductance**

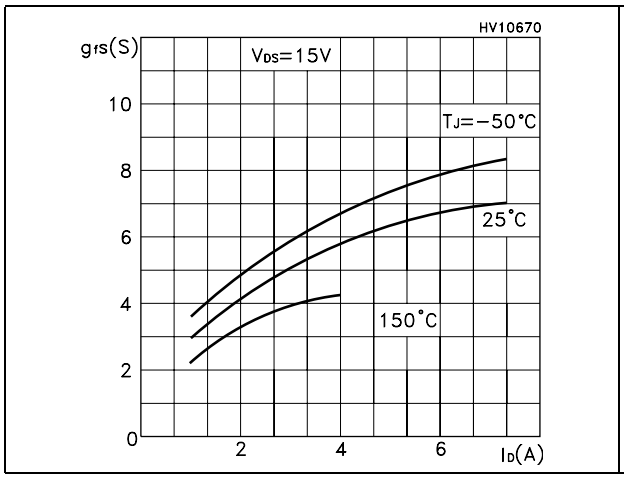



**Figure 9. Static drain-source on resistance**

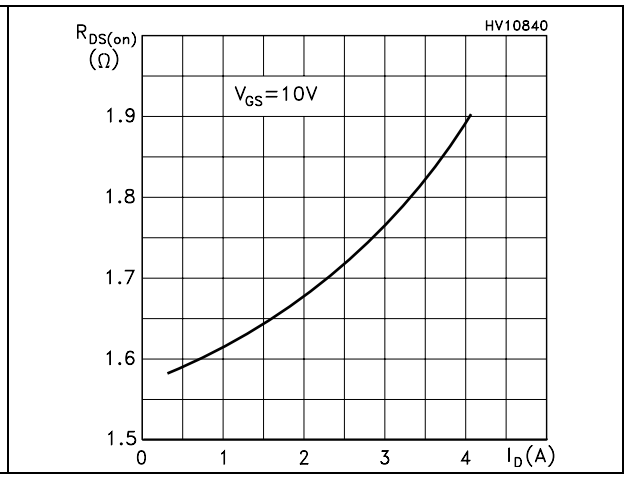



**Figure 10. Gate charge vs gate-source voltage**

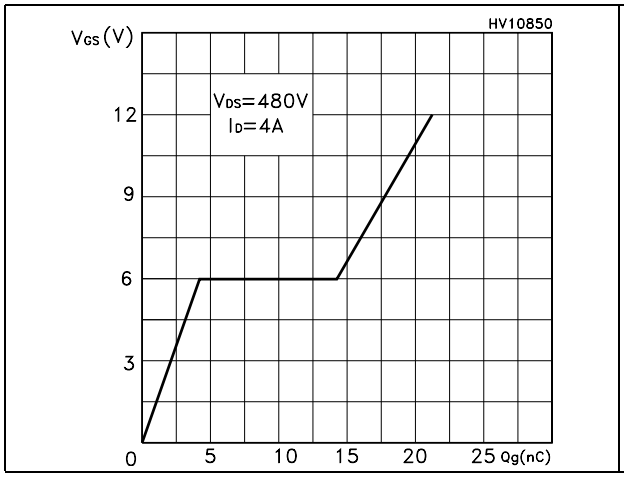



**Figure 11. Capacitance variations**

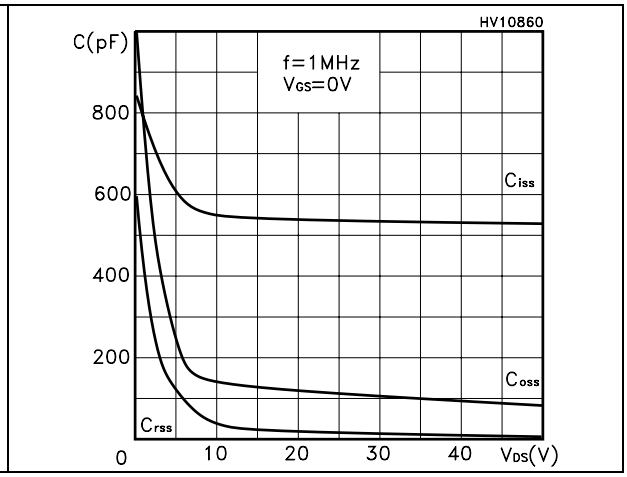



**Figure 12. Normalized gate threshold voltage vs temperature**

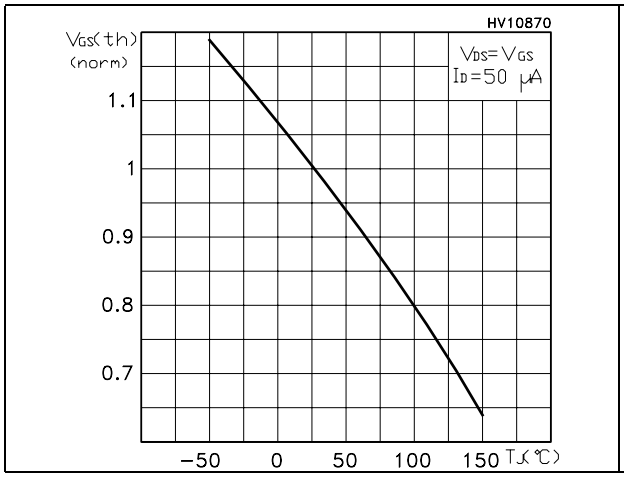



**Figure 13. Normalized $B_{VDSS}$ vs temperature**

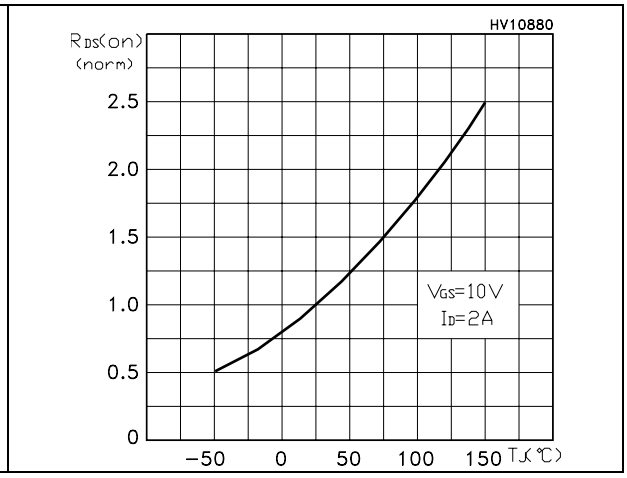


**Figure 14. Normalized on resistance vs temperature**

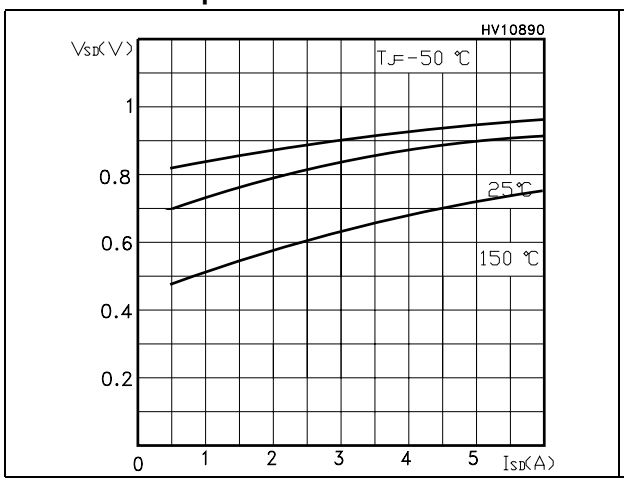



**Figure 15. Source-drain diode forward characteristic**

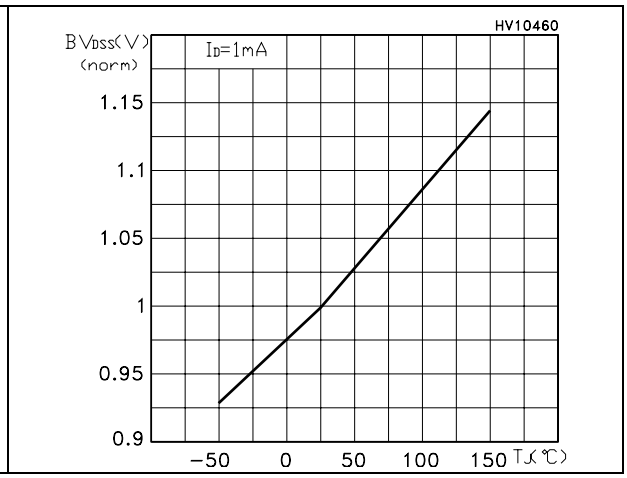
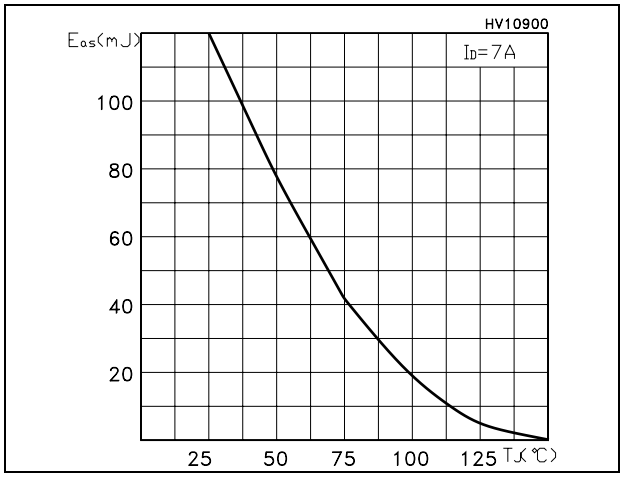



**Figure 16. Avalanche energy vs temperature**



# 3 Test circuits

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

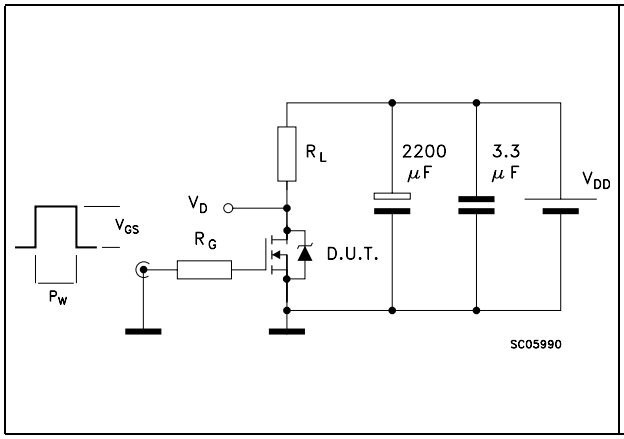



**Figure 18. Gate charge test circuit**

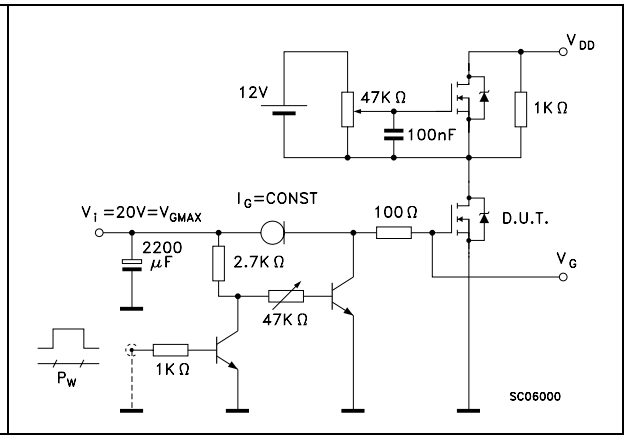



**Figure 19. Test circuit for inductive load switching and diode recovery times**

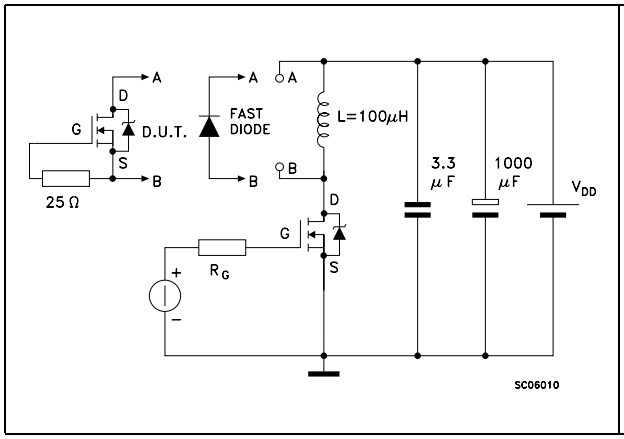



**Figure 20. Unclamped inductive load test circuit**

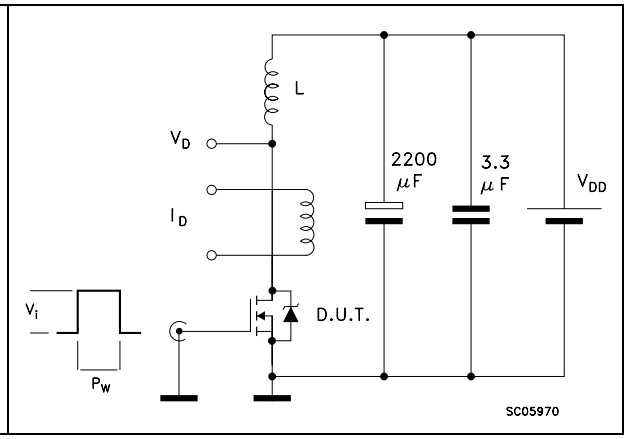



**Figure 21. Unclamped inductive waveform**

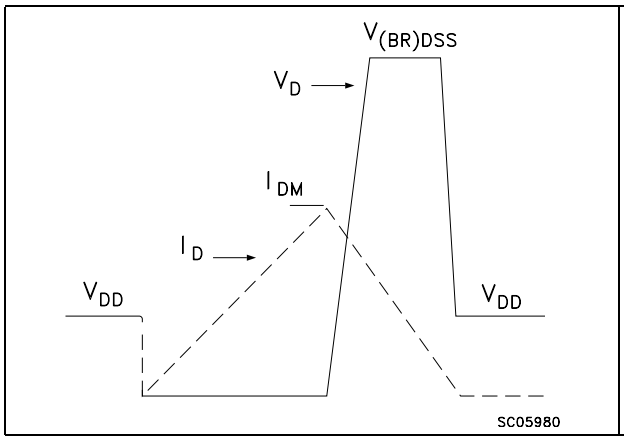
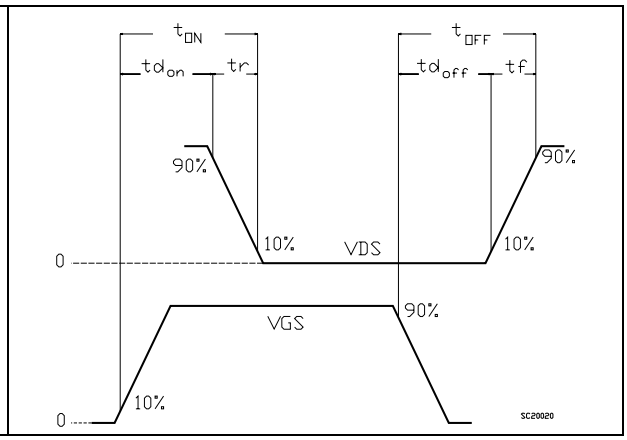



**Figure 22. Switching time waveform**



# 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-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 |

**Figure 23. TO-220 type A drawing**

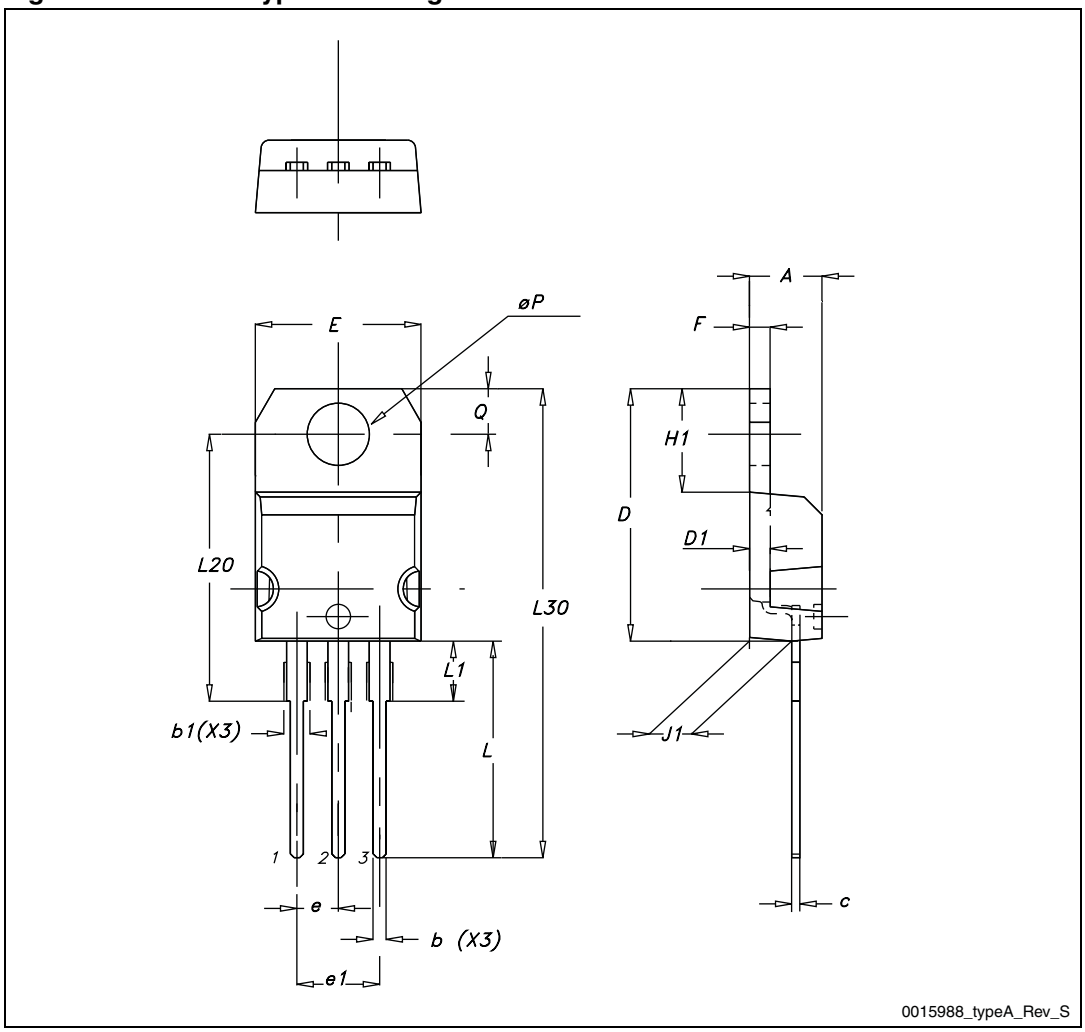


**Table 10. TO-220FP mechanical data**

| 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 24. TO-220FP drawing**

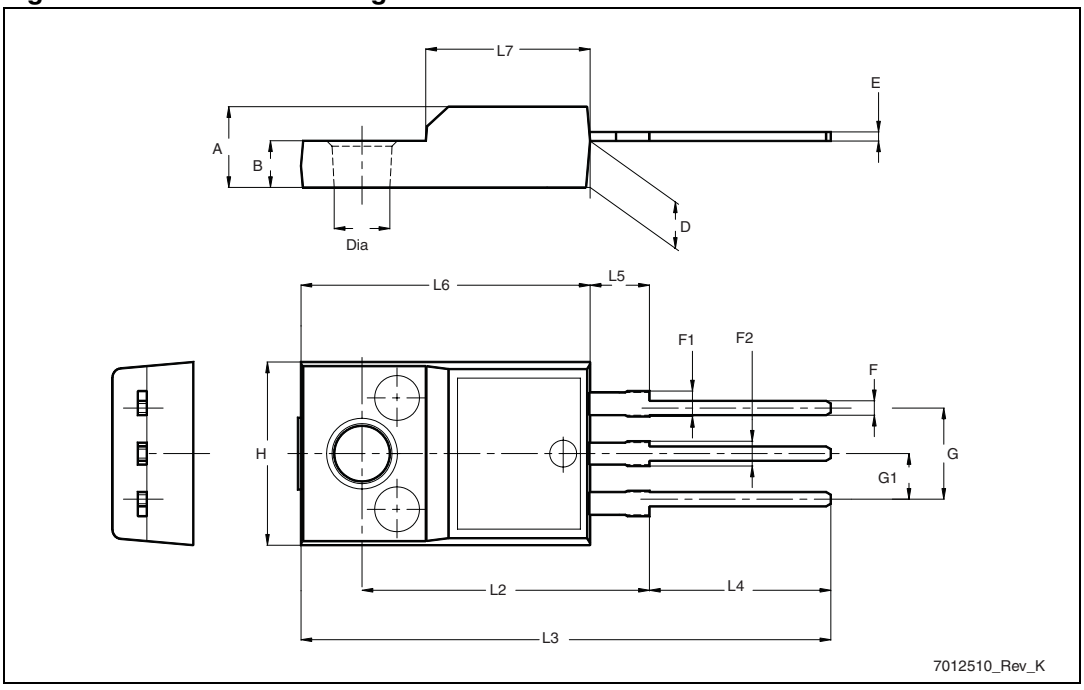


Table 11. I²PAK (TO-262) mechanical data

| DIM. | mm. | | |
|---|---|---|---|
| | min. | typ | max. |
| A | 4.40 | | 4.60 |
| A1 | 2.40 | | 2.72 |
| b | 0.61 | | 0.88 |
| b1 | 1.14 | | 1.70 |
| c | 0.49 | | 0.70 |
| c2 | 1.23 | | 1.32 |
| D | 8.95 | | 9.35 |
| e | 2.40 | | 2.70 |
| e1 | 4.95 | | 5.15 |
| E | 10 | | 10.40 |
| L | 13 | | 14 |
| L1 | 3.50 | | 3.93 |
| L2 | 1.27 | | 1.40 |

**Figure 25. I²PAK (TO-262) drawing**

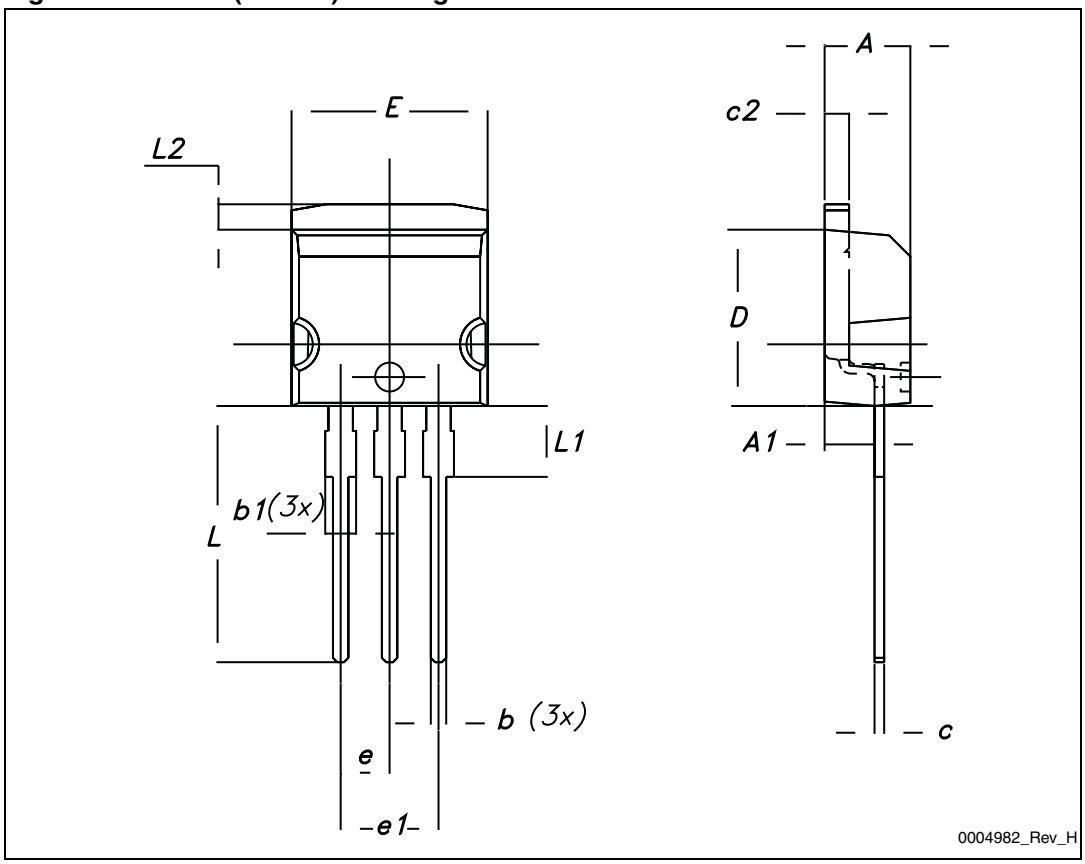


Table 12. D²PAK (TO-263) mechanical data

| Dim. | mm | | |
|---|---|---|---|
| | Min. | Typ. | Max. |
| A | 4.40 | | 4.60 |
| A1 | 0.03 | | 0.23 |
| b | 0.70 | | 0.93 |
| b2 | 1.14 | | 1.70 |
| c | 0.45 | | 0.60 |
| c2 | 1.23 | | 1.36 |
| D | 8.95 | | 9.35 |
| D1 | 7.50 | | |
| E | 10 | | 10.40 |
| E1 | 8.50 | | |
| e | | 2.54 | |
| e1 | 4.88 | | 5.28 |
| H | 15 | | 15.85 |
| J1 | 2.49 | | 2.69 |
| L | 2.29 | | 2.79 |
| L1 | 1.27 | | 1.40 |
| L2 | 1.30 | | 1.75 |
| R | | 0.4 | |
| V2 | 0° | | 8° |

**Figure 26. D²PAK (TO-263) drawing**

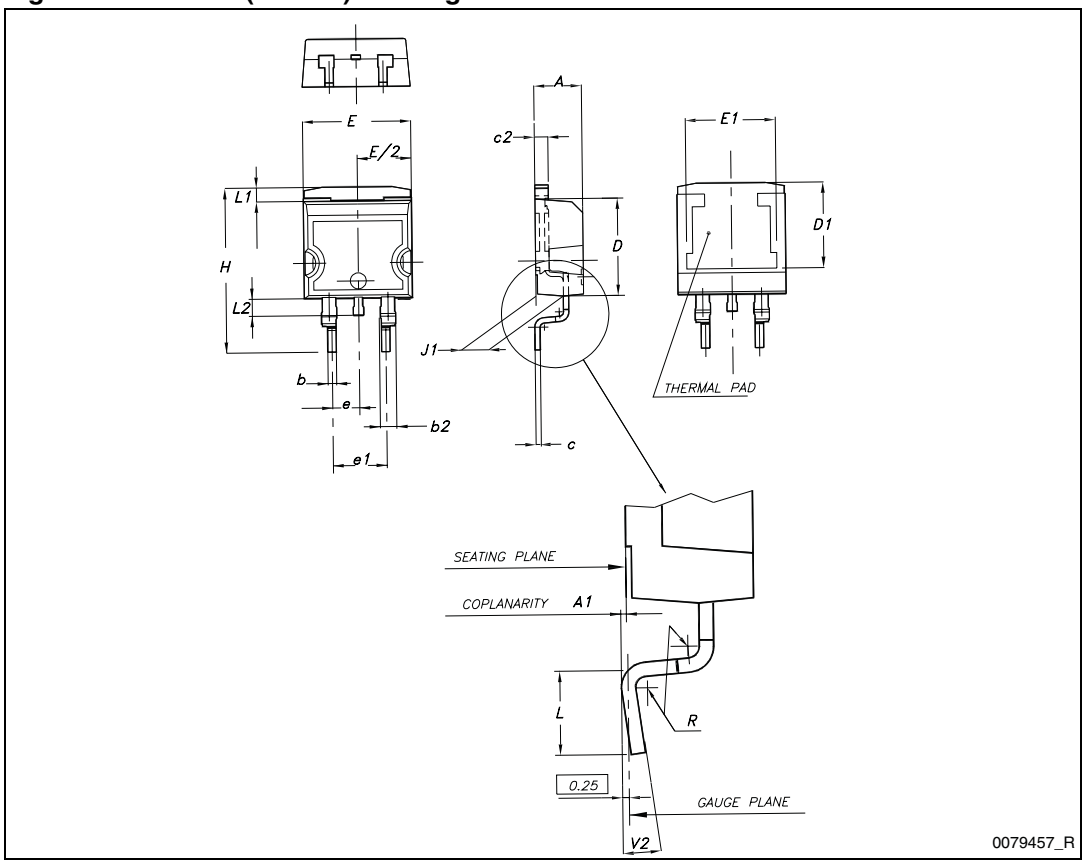
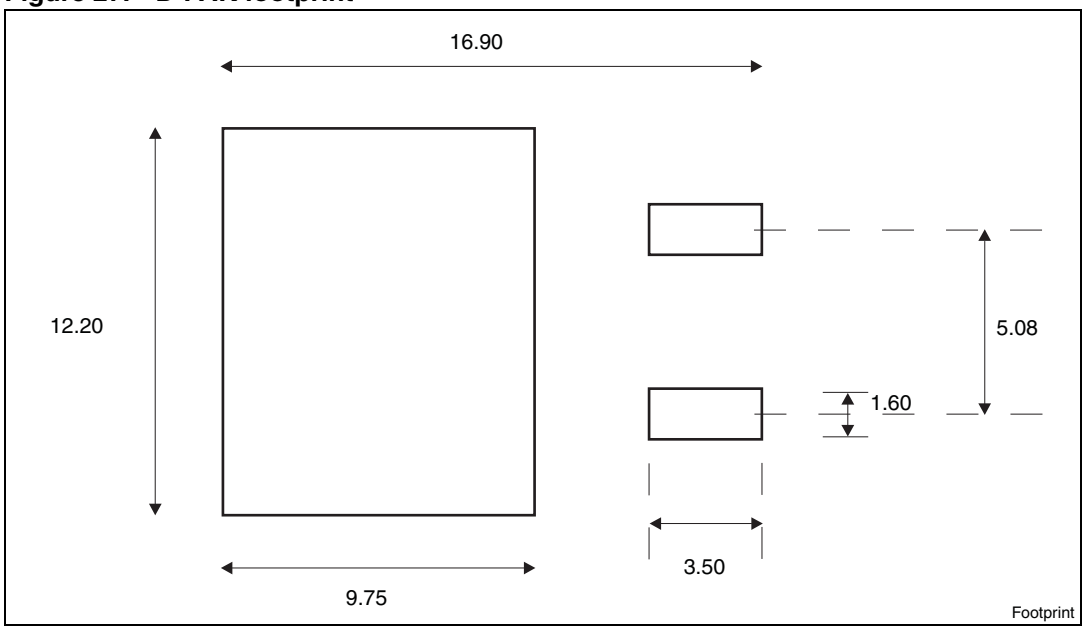



**Figure 27. D²PAK footprint[a]**




a. All dimension are in millimeters

Table 13. 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 | | 0.3 | |
| 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 $^{o}$ | |

**Figure 28. IPAK (TO-251) drawing**

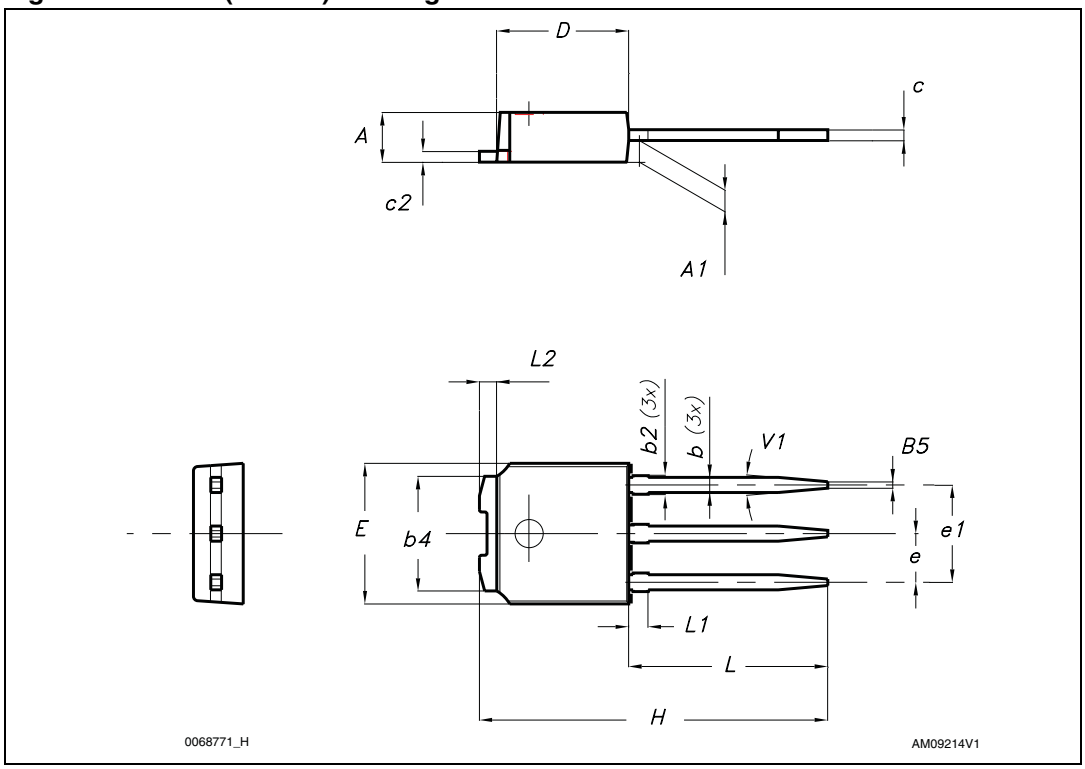


Table 14. DPAK (TO-252) mechanical data

| 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 | | 1.50 |
| L1 | | 2.80 | |
| L2 | | 0.80 | |
| L4 | 0.60 | | 1 |
| R | | 0.20 | |
| V2 | 0° | | 8° |

**Figure 29. DPAK (TO-252) drawing**

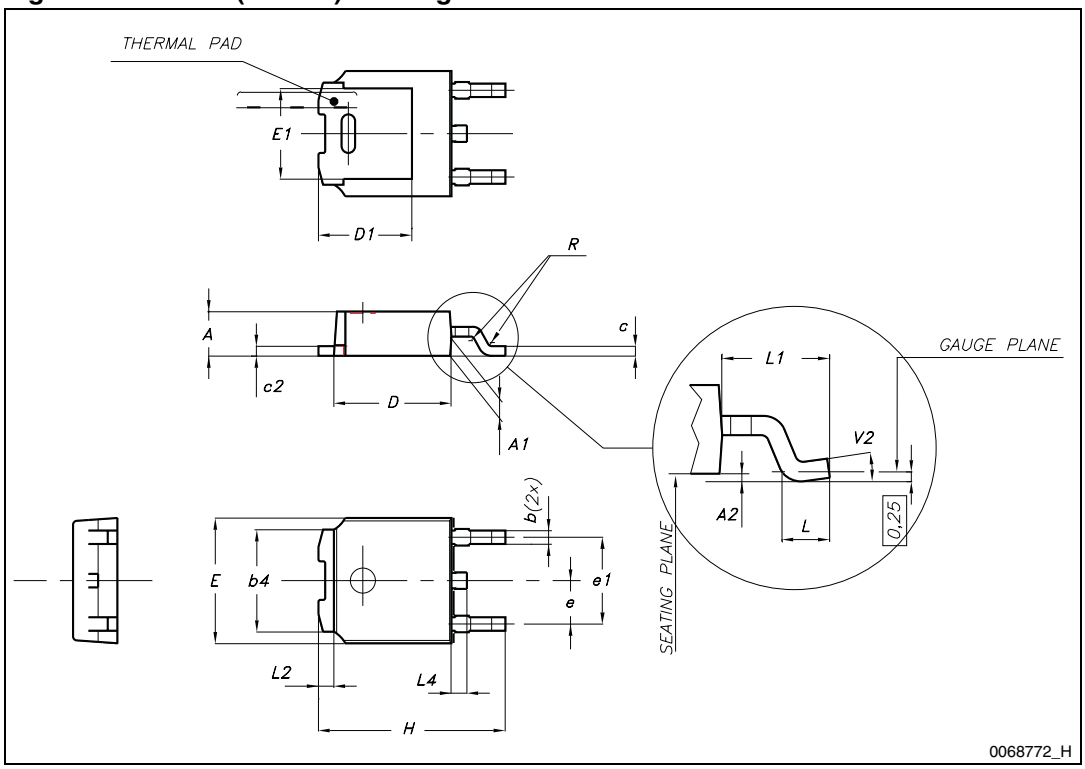
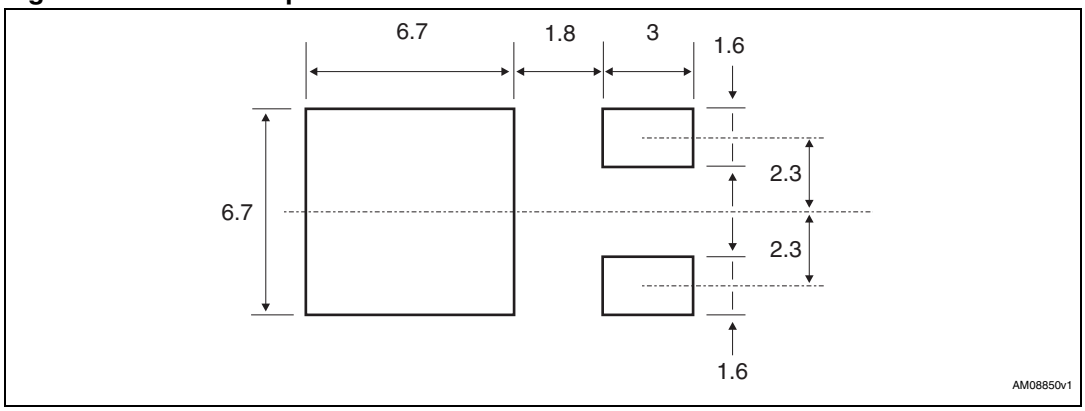



**Figure 30. DPAK footprint[b]**




b. All dimension are in millimeters

# 5 Packaging mechanical data

**Table 15. 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 31. Tape for DPAK (TO-252)**

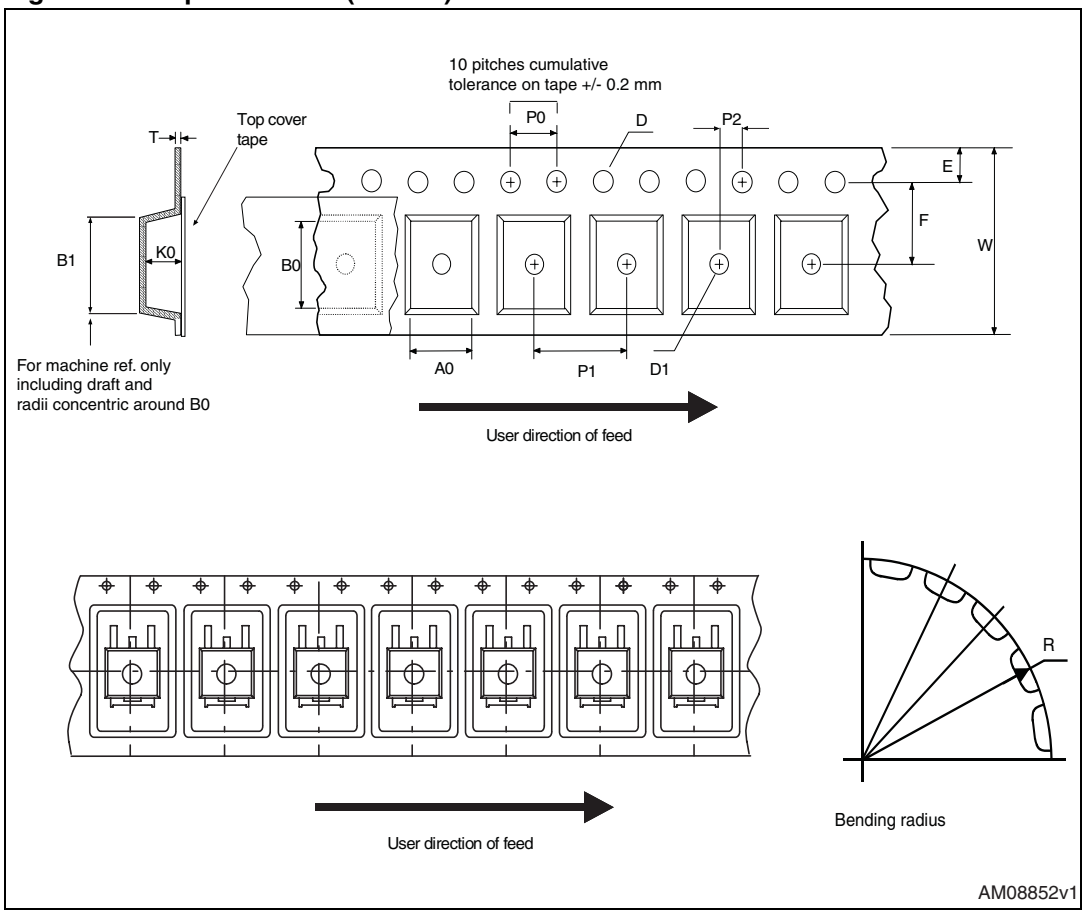



**Figure 32. Reel for DPAK (TO-252)**

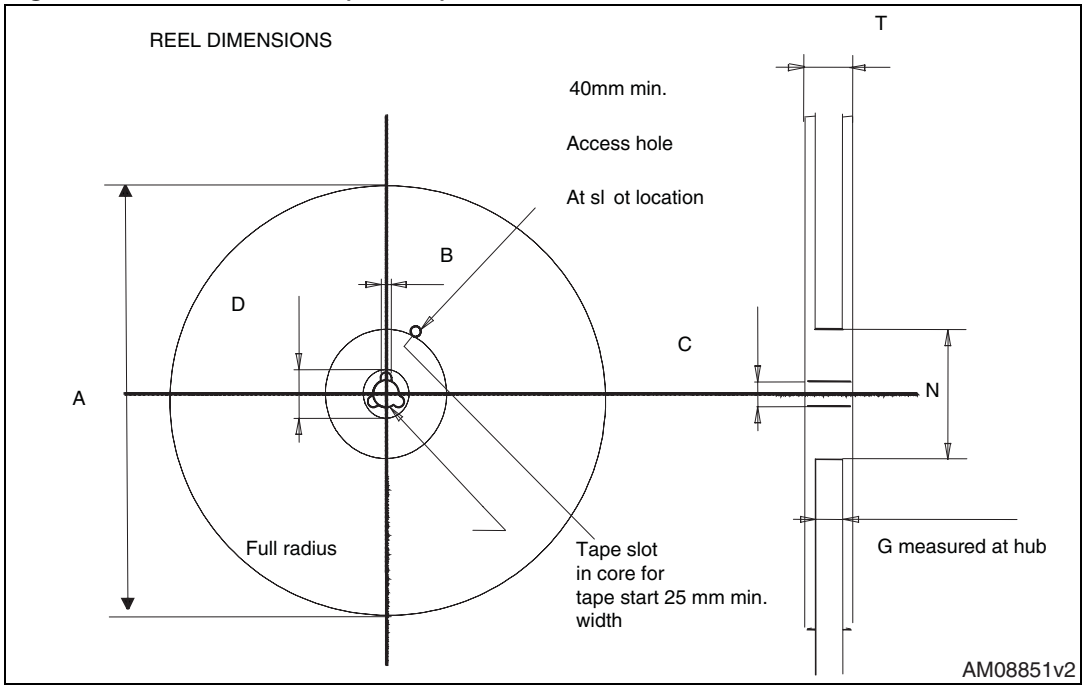


Table 16. D²PAK (TO-263) tape and reel mechanical data

| Tape | | | Reel | | |
|---|---|---|---|---|---|
| Dim. | mm | | Dim. | mm | |
| | Min. | Max. | | Min. | Max. |
| A0 | 10.5 | 10.7 | A | | 330 |
| B0 | 15.7 | 15.9 | B | 1.5 | |
| D | 1.5 | 1.6 | C | 12.8 | 13.2 |
| D1 | 1.59 | 1.61 | D | 20.2 | |
| E | 1.65 | 1.85 | G | 24.4 | 26.4 |
| F | 11.4 | 11.6 | N | 100 | |
| K0 | 4.8 | 5.0 | T | | 30.4 |
| P0 | 3.9 | 4.1 | | | |
| P1 | 11.9 | 12.1 | Base qty | | 1000 |
| P2 | 1.9 | 2.1 | Bulk qty | | 1000 |
| R | 50 | | | | |
| T | 0.25 | 0.35 | | | |
| W | 23.7 | 24.3 | | | |

**Figure 33. Tape for D²PAK (TO-263)**

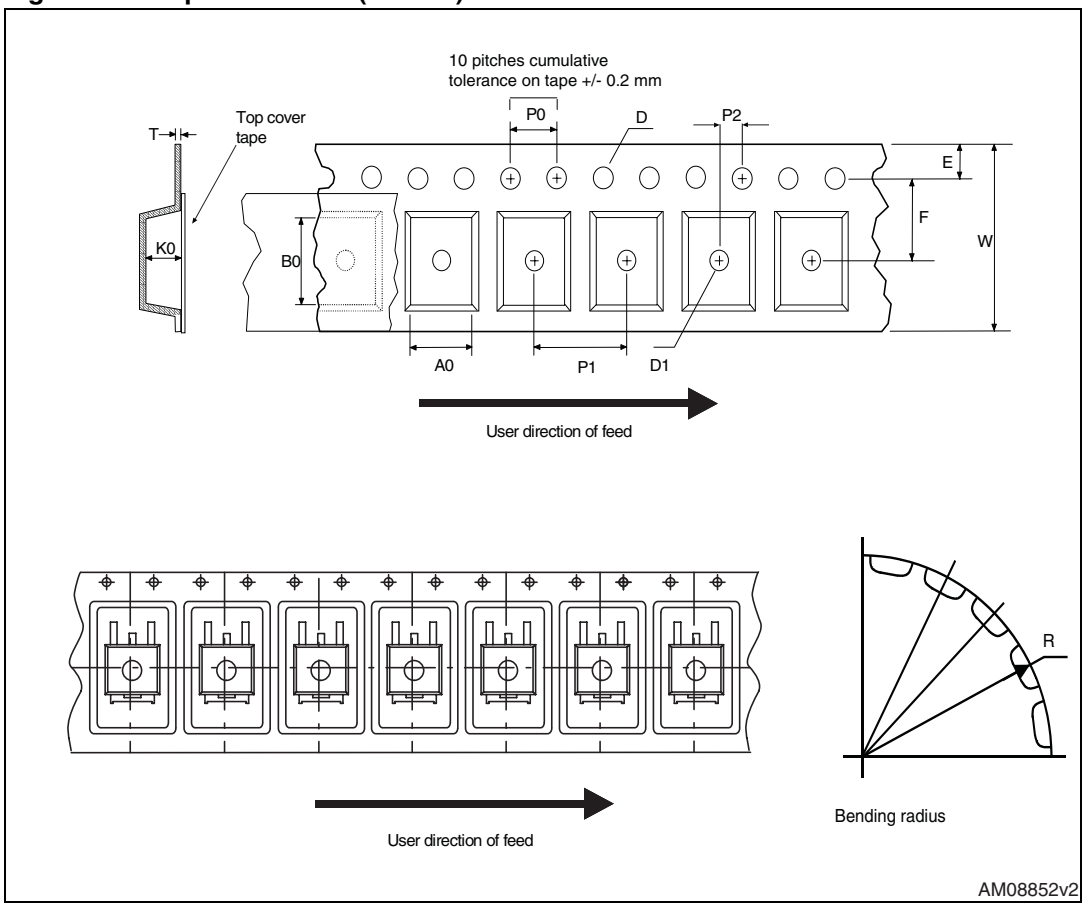
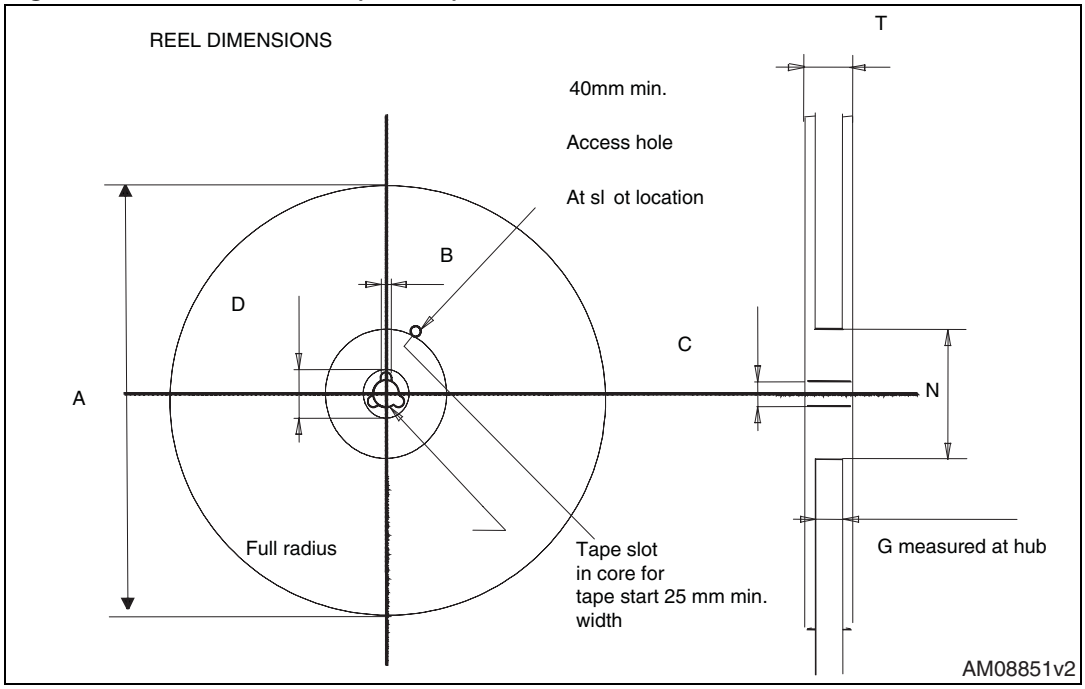



**Figure 34. Reel for D²PAK (TO-263)**



# 6 Revision history

**Table 17. Document revision history**

| Date | Revision | Changes |
|---|---|---|
| 25-Oct-2006 | 4 | Document reformatted no content change. |
| 04-Mar-2008 | 5 | Modified TO-220 and TO-220FP mechanical data. |
| 16-Apr-2008 | 6 | Minor text changes to improve readability. |
| 11-Jul-2011 | 7 | Updated package mechanical data *Section 4* and packaging mechanical data *Section 5*. |

**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.



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**