# STF16NK60Z
# STP16NK60Z, STW16NK60Z

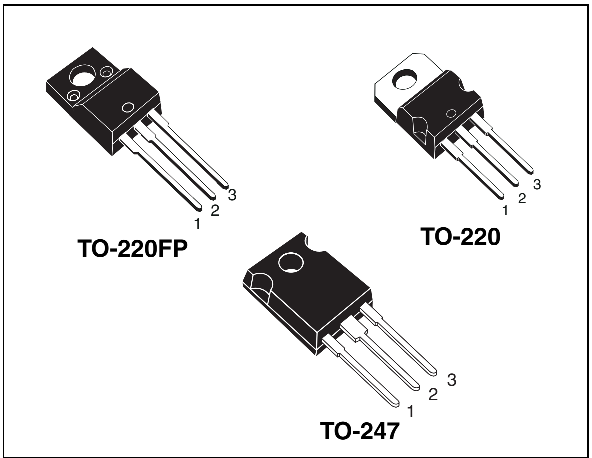
## N-channel 600 V, 038 Ω, 14 A, TO-220, TO-220FP, TO-247 Zener-protected SuperMESH™ Power MOSFET

## Features

| Type | $V_{DSS}$ | $R_{DS(on)}$ max | $I_D$ | Pw |
|---|---|---|---|---|
| STF16NK60Z | 600 V | < 0.42 Ω | 14 A[(1)] | 40 W |
| STP16NK60Z | 600 V | < 0.42 Ω | 14 A | 190 W |
| STW16NK60Z | 600 V | < 0.42 Ω | 14 A | 190 W |

1. Limited by package.

- 100% avalanche tested
- Extremely high dv/dt capability
- Gate charge minimized
- Very low intrinsic capacitances
- Very good manufacturing repeatability




## Application

- Switching applications

## Description

The new SuperMESH™ series of Power MOSFETS is the result of further design improvements on ST's well-established strip-based PowerMESH™ layout. In addition to significantly lower on-resistance, the device offers superior dv/dt capability to ensure optimal performance even in the most demanding applications. The SuperMESH™ devices further complement an already broad range of innovative high voltage MOSFETs, which includes the revolutionary MDmesh™ products.

**Figure 1. Internal schematic diagram**

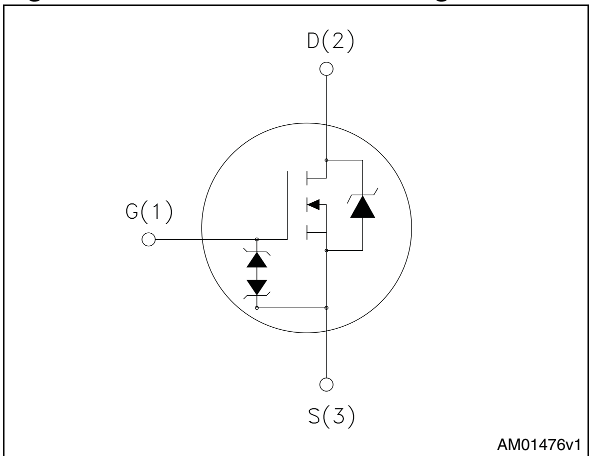



**Table 1. Device summary**

| Order codes | Marking | Package | Packaging |
|---|---|---|---|
| STF16NK60Z | F16NK60Z | TO-220FP | Tube |
| STP16NK60Z | P16NK60Z | TO-220 | |
| STW16NK60Z | W16NK60Z | TO-247 | |

# Contents

# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol | Parameter | Value | | Unit |
|---|---|---|---|---|
| | | TO-220 / TO-247 | 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 | 14 | 14 (1) | A |
| $I_D$ | Drain current (continuous) at $T_C$ = 100 °C | 8.8 | 8.8 (1) | A |
| $I_{DM}$ (2) | Drain current (pulsed) | 56 | 56(1) | A |
| $P_{TOT}$ | Total dissipation at $T_C$ = 25 °C | 190 | 40 | W |
| | Derating factor | 1.51 | | W/°C |
| $V_{ESD(G-S)}$ | Gate source ESD(HBM-C = 100 pF, R = 1.5 kΩ) | 6000 | | 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; Tc = 25 °C) | | 2500 | V |
| $T_{stg}$ | Storage temperature | -55 to 150 | | °C |
| $T_j$ | Max. operating junction temperature | 150 | | °C |

1. Limited by package
2. Pulse width limited by safe operating area
3. $I_{SD} \leq$ 14 A, di/dt $\leq$ 200 A/µs, $V_{DD}$ = 80% $V_{(BR)DSS}$

**Table 3. Thermal data**

| Symbol | Parameter | TO-220 | TO-247 | TO-220FP | Unit |
|---|---|---|---|---|---|
| $R_{thj-case}$ | Thermal resistance junction-case max | 0.66 | | 3.1 | °C/W |
| $R_{thj-amb}$ | Thermal resistance junction-ambient max | 62.5 | 50 | 62.5 | °C/W |
| $T_l$ | Maximum lead temperature for soldering purpose | 300 | | | °C |

**Table 4. Avalanche characteristics**

| Symbol | Parameter | Max value | Unit |
|---|---|---|---|
| $I_{AR}$ | Avalanche current, repetitive or not-repetitive (pulse width limited by $T_j$ max) | 14 | A |
| $E_{AS}$ | Single pulse avalanche energy (starting $T_j$ = 25 °C, $I_D$ = $I_{AR}$, $V_{DD}$ = 50 V) | 360 | mJ |

# 2 Electrical characteristics

($T_C$ = 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 | 620 | | | V |
| $I_{DSS}$ | Zero gate voltage drain current ($V_{GS}$ = 0) | $V_{DS}$ = 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, $I_D$ = 7 A | | 0.38 | 0.42 | 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 | $V_{DS}$ = 25 V, f = 1 MHz, $V_{GS}$ = 0 | - | 2650<br>285<br>62 | - | pF<br>pF<br>pF |
| $C_{OSS\ eq}$ (1) | Equivalent output capacitance | $V_{GS}$ = 0, $V_{DS}$ = 0 to 480 V | - | 158 | - | pF |
| $Q_g$<br>$Q_{gs}$<br>$Q_{gd}$ | Total gate charge<br>Gate-source charge<br>Gate-drain charge | $V_{DD}$ = 480 V, $I_D$ = 14 A,<br>$V_{GS}$ = 10 V<br>(see *Figure 19*) | - | 86<br>17<br>46 | - | nC<br>nC<br>nC |

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% $V_{DSS}$

**Table 7. Switching times**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max | Unit |
|---|---|---|---|---|---|---|
| $t_{d(on)}$<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 | $V_{DD}$ = 480 V, $I_D$ = 14 A,<br>$R_G$ = 4.7 Ω, $V_{GS}$ = 10 V<br>(see *Figure 18*) | - | 30<br>25<br>70<br>15 | - | 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) | | - | | 14<br>56 | A<br>A |
| $V_{SD}$ (2) | Forward on voltage | $I_{SD}$ = 14 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 | $I_{SD}$ = 14 A, di/dt = 100 A/µs<br>$V_{DD}$ = 100 V (see *Figure 23*) | - | 490<br>5.4<br>22 | | ns<br>nC<br>A |
| $t_{rr}$<br>$Q_{rr}$<br>$I_{RRM}$ | Reverse recovery time<br>Reverse recovery charge<br>Reverse recovery current | $I_{SD}$ = 14 A, di/dt = 100 A/µs<br>$V_{DD}$ = 100 V, $T_j$ = 150 °C<br>(see *Figure 23*) | - | 585<br>7<br>24 | | ns<br>nC<br>A |

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

Table 9. 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**

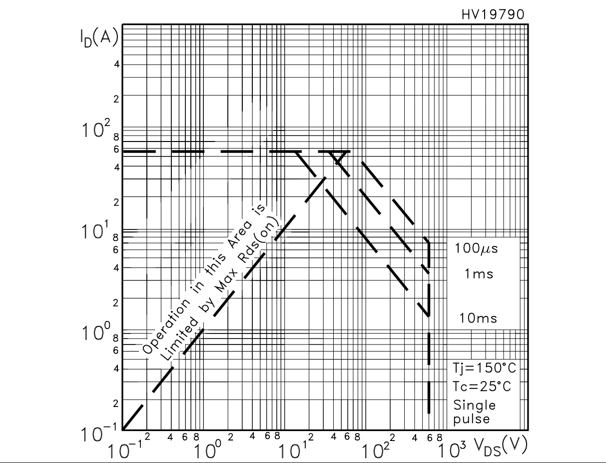



**Figure 3. Thermal impedance for TO-220**

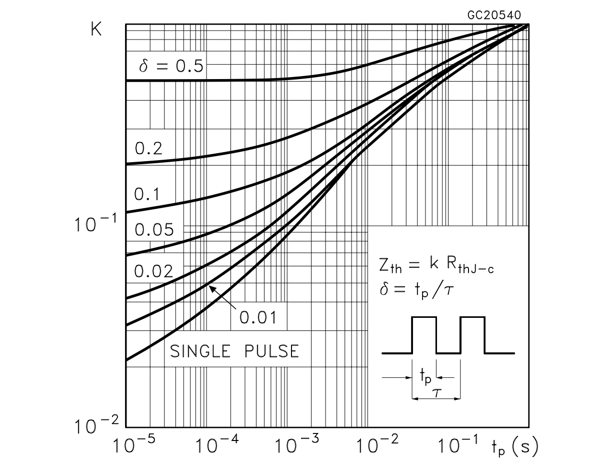



**Figure 4. Safe operating area for TO-220FP**

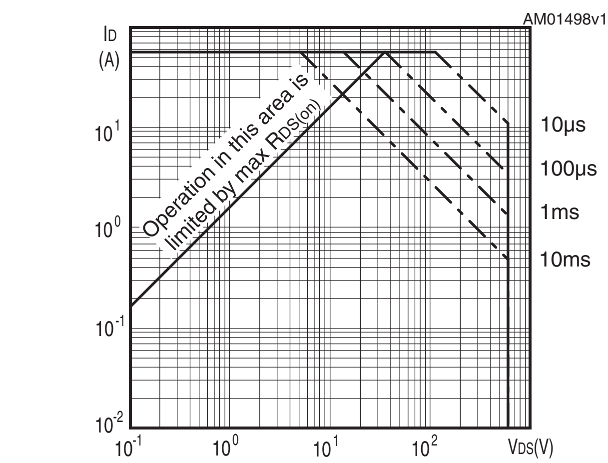



**Figure 5. Thermal impedance for TO-220FP**

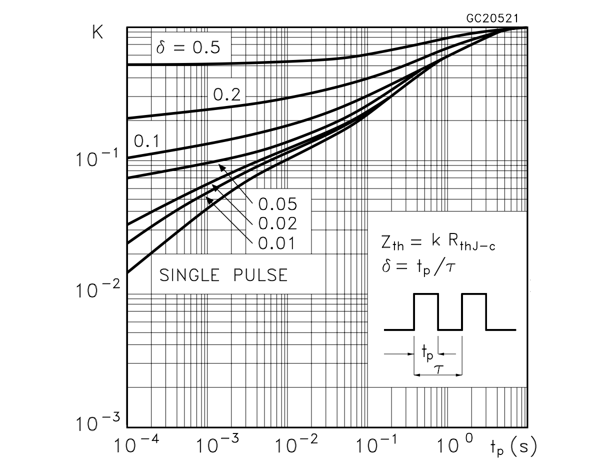



**Figure 6. Safe operating area for TO-247**

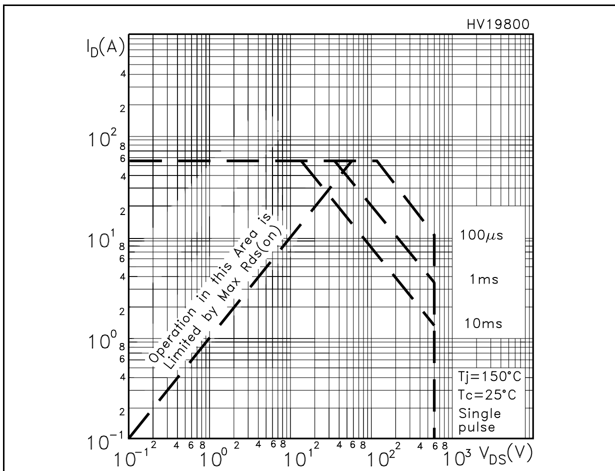



**Figure 7. Thermal impedance for TO-247**

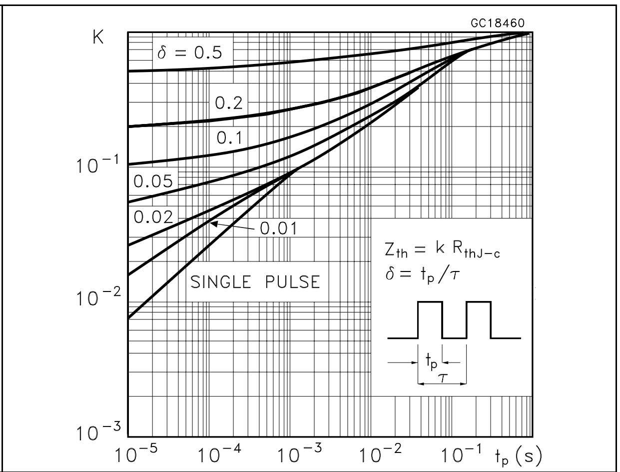


**Figure 8. Output characteristics**

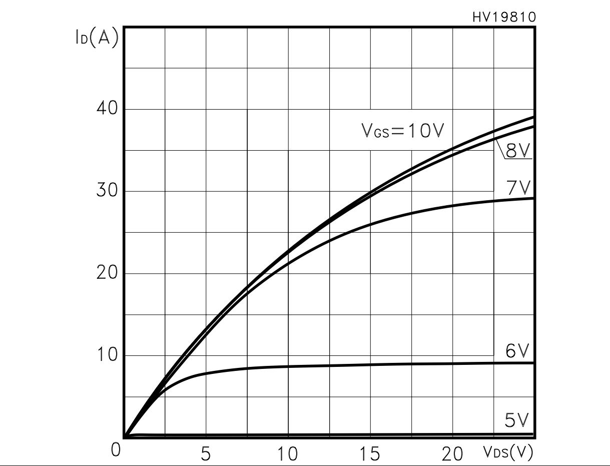



**Figure 9. Transfer characteristics**

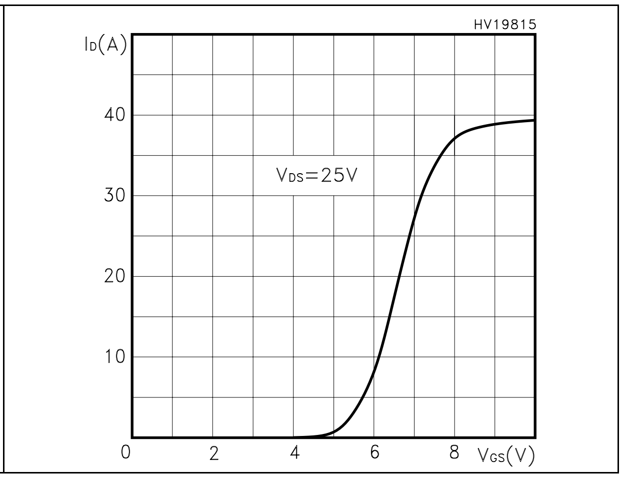



**Figure 10. Normalized $BV_{DSS}$ vs temperature**

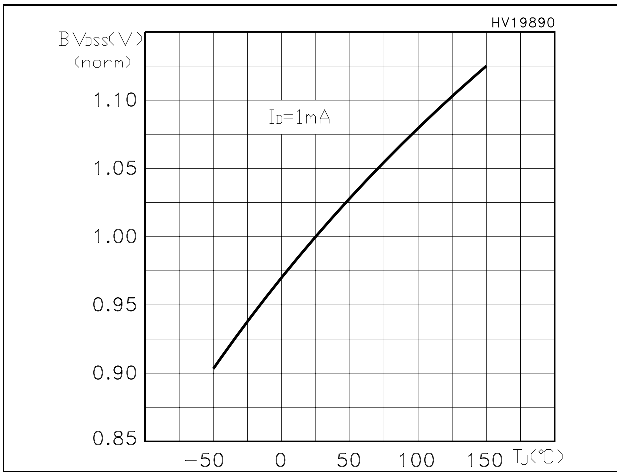



**Figure 11. Static drain-source on resistance**

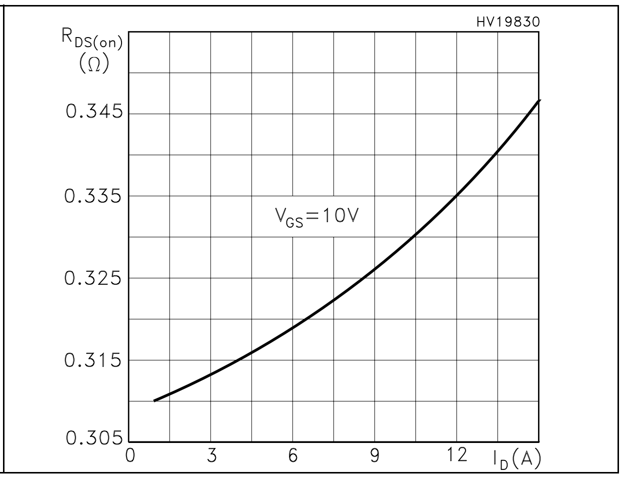



**Figure 12. Gate charge vs gate-source voltage**

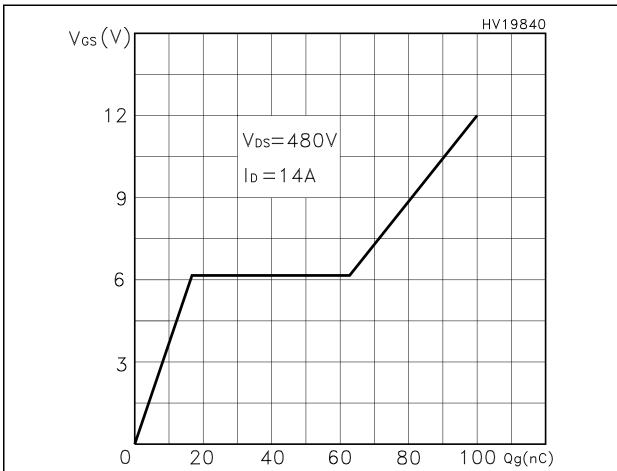



**Figure 13. Capacitance variations**

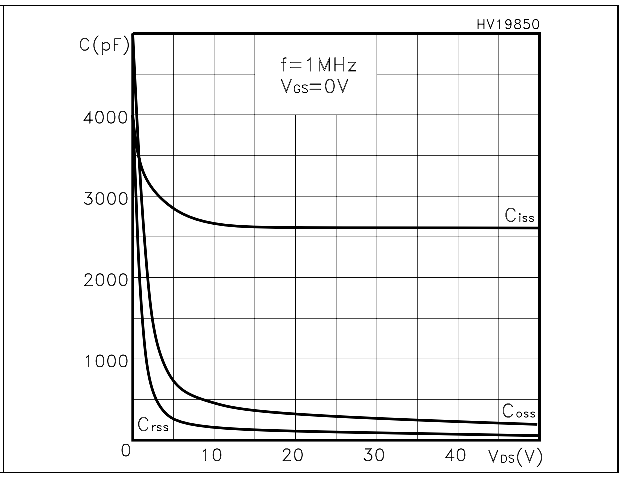


**Figure 14. Normalized gate threshold voltage vs temperature**

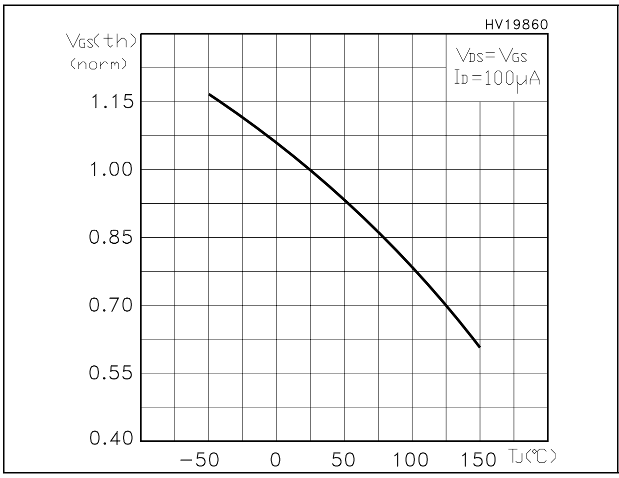



**Figure 15. Normalized on resistance vs temperature**

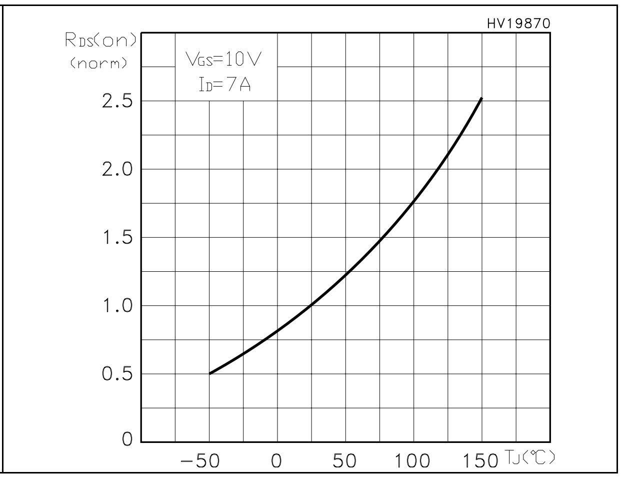



**Figure 16. Source-drain diode forward characteristics**

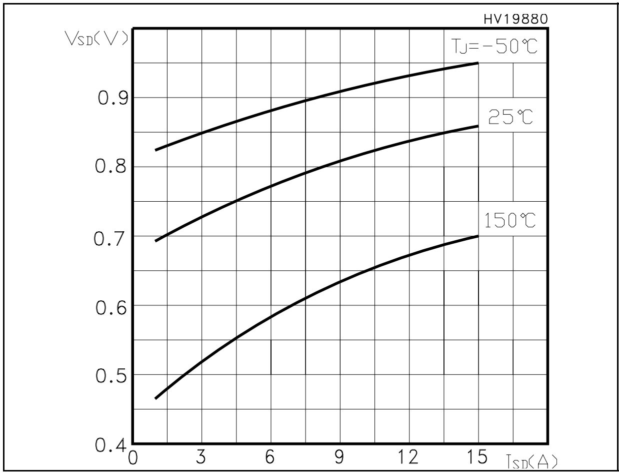
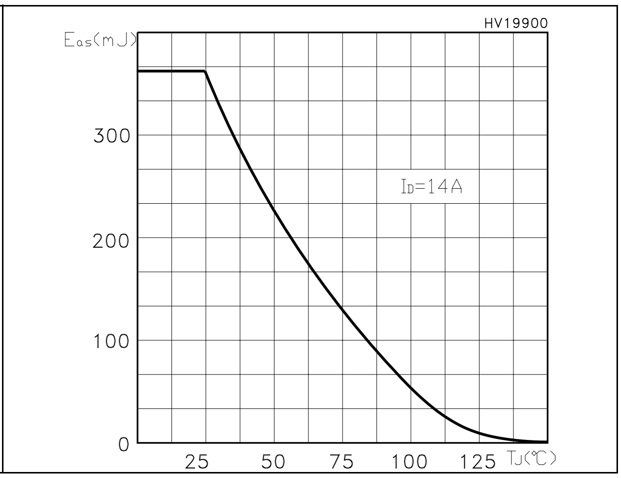



**Figure 17. Maximum avalanche energy vs temperature**



# 3 Test circuits

**Figure 18. Switching times test circuit for resistive load**

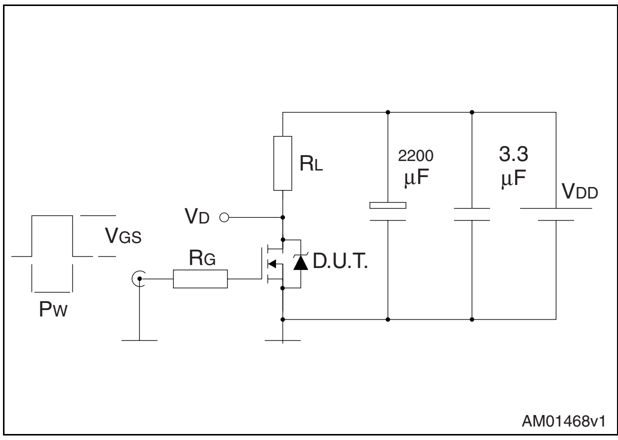



**Figure 19. Gate charge test circuit**

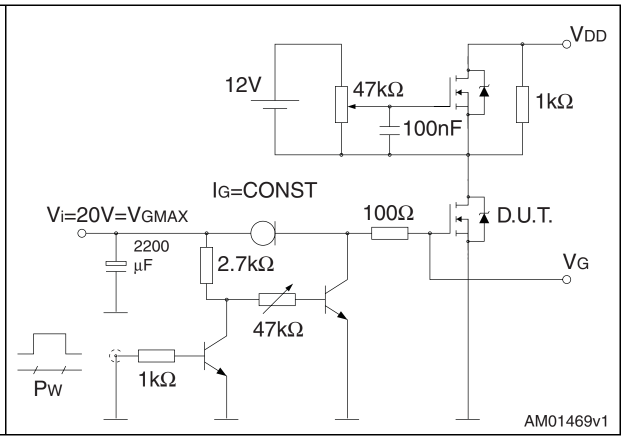



**Figure 20. Test circuit for inductive load switching and diode recovery times**

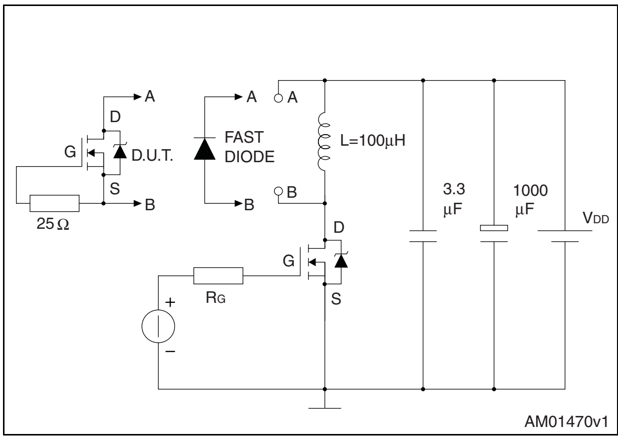



**Figure 21. Unclamped inductive load test circuit**

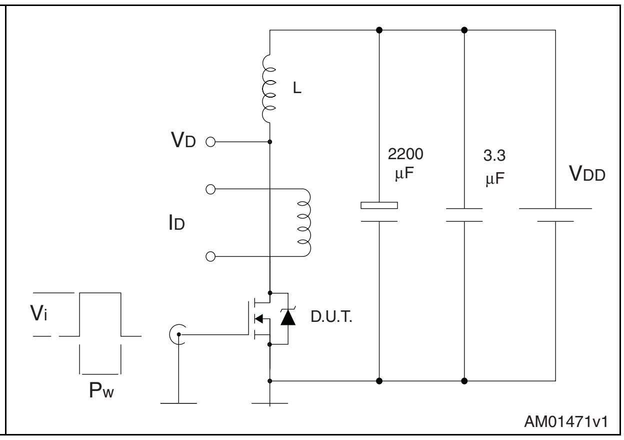



**Figure 22. Unclamped inductive waveform**

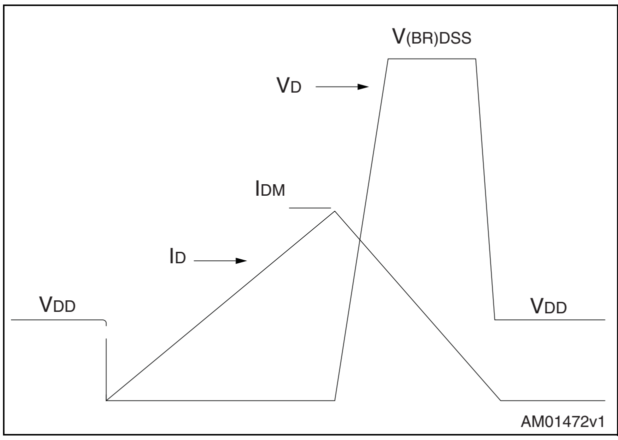
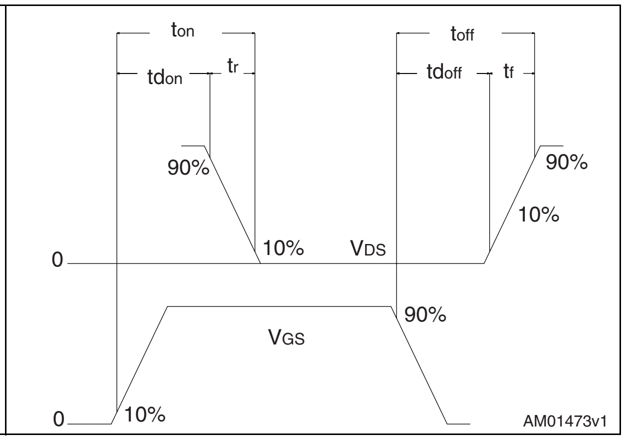



**Figure 23. Switching time waveform**



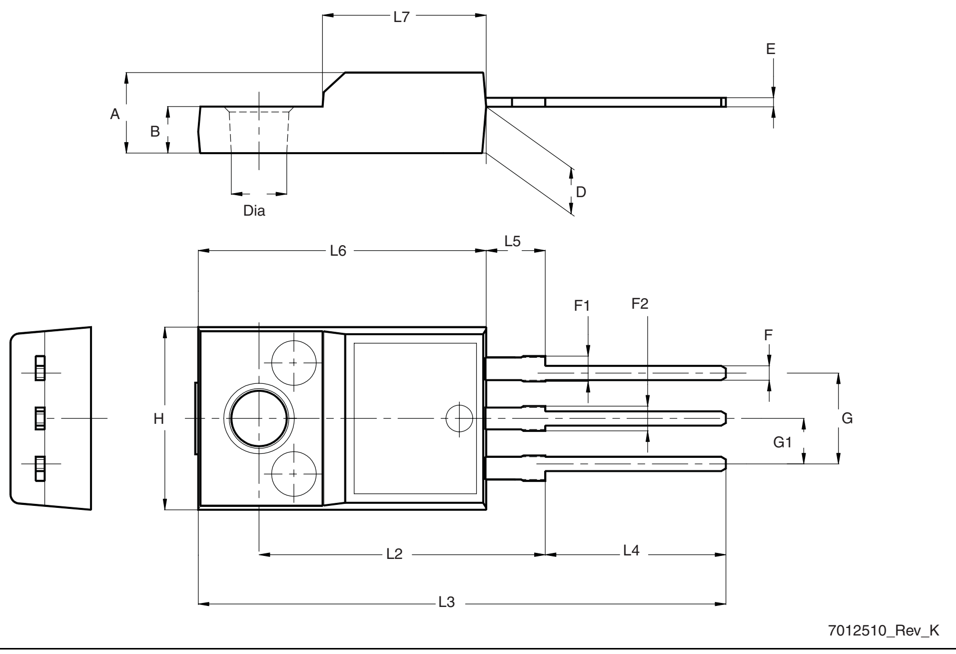
# 4 Package mechanical data

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 10. TO-220FP mechanical data

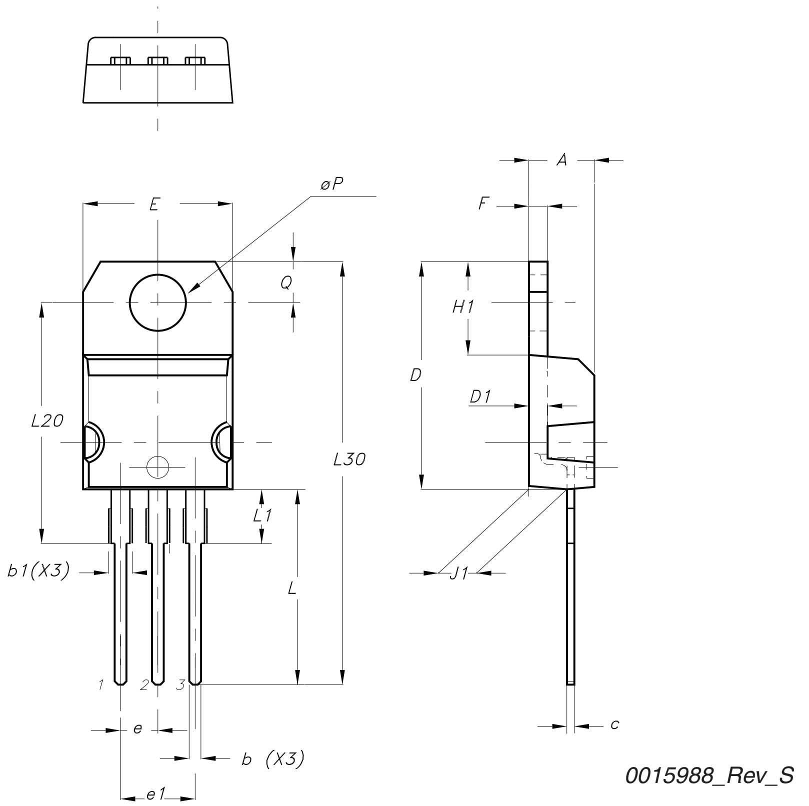
| Dim. | mm | | |
|---|---|---|---|
| | Min. | Typ. | Max. |
| A | 4.4 | | 4.6 |
| B | 2.5 | | 2.7 |
| D | 2.5 | | 2.75 |
| E | 0.45 | | 0.7 |
| F | 0.75 | | 1 |
| F1 | 1.15 | | 1.70 |
| F2 | 1.15 | | 1.70 |
| G | 4.95 | | 5.2 |
| G1 | 2.4 | | 2.7 |
| H | 10 | | 10.4 |
| L2 | | 16 | |
| L3 | 28.6 | |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



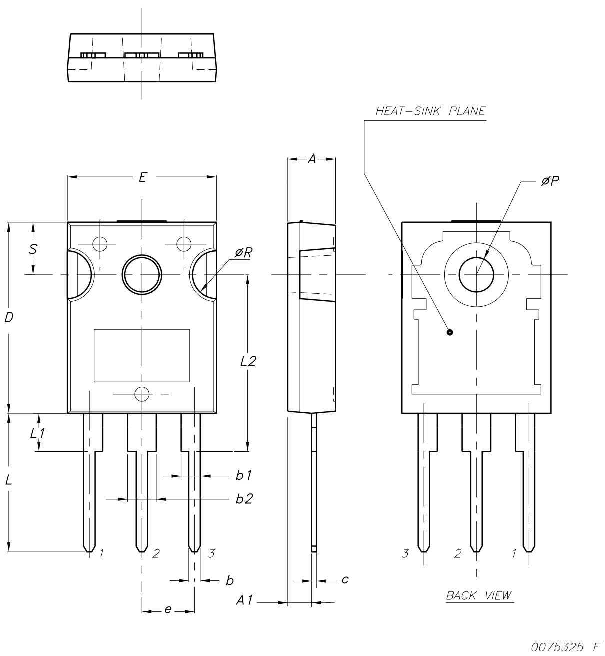
## TO-220 type A mechanical data

| 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-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 | |



# 5 Revision history

Table 11. Document revision history

| Date | Revision | Changes |
|---|---|---|
| 11-Sep-2006 | 3 | |
| 07-Jun-2007 | 4 | Added statement for ECOPACK®. |
| 04-Dec-2009 | 5 | Updated packages mechanical data. |