



STB9NK60Z, STP9NK60Z, STP9NK60ZFP

N-channel 600 V, 0.85 Ω typ., 7 A Zener-protected SuperMESH™ Power MOSFET in D²PAK, TO-220 and TO-220FP packages

Datasheet – production data

Features

| Order codes | V _{DS} | R _{DS(on) max} | I _D | P _{TOT} |
|-------------|-----------------|-------------------------|----------------|------------------|
| STB9NK60ZT4 | 600 V | 0.95 Ω | 7 A | 125 W |
| STP9NK60Z | | | | 30 W |
| STP9NK60ZFP | | | | |

- Extremely high dv/dt capability
- Improved ESD capability
- 100% avalanche tested
- Gate charge minimized
- Very low intrinsic capacitances

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.

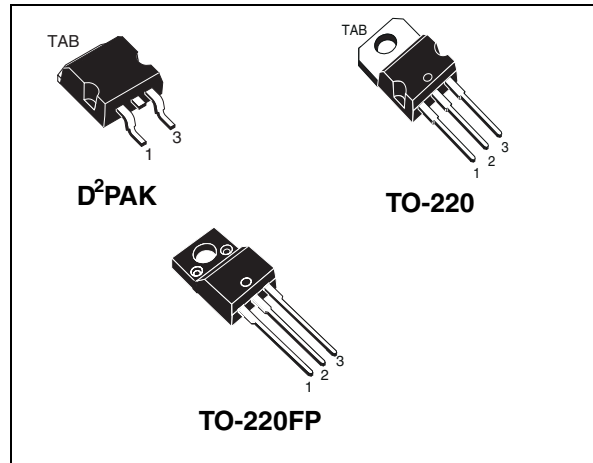


Figure 1. Internal schematic diagram

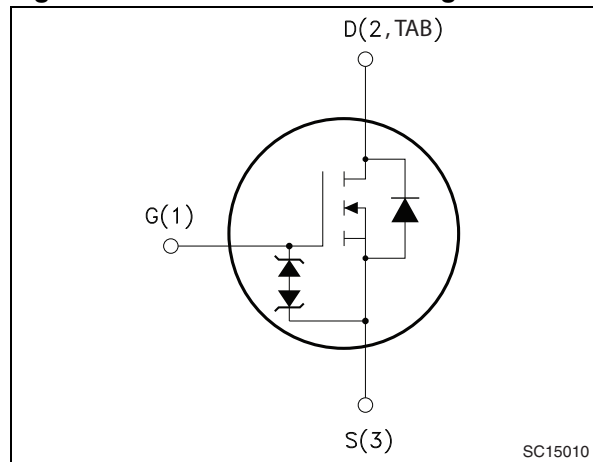


Table 1. Device summary

| Order codes | Marking | Package | Packaging |
|-------------|-----------|--------------------|-----------|
| STB9NK60ZT4 | B9NK60Z | D ² PAK | Tube |
| STP9NK60Z | P9NK60Z | TO-220 | |
| STP9NK60ZFP | P9NK60ZFP | TO-220FP | |

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1 Electrical ratings

Table 2. Absolute maximum ratings

| Symbol | Parameter | Value | | Unit |
|------------------------------------|---|----------------------------|--------------------|------|
| | | D ² PAK, TO-220 | TO-220FP | |
| V _{DS} | Drain-source voltage | 600 | | V |
| V _{GS} | Gate-source voltage | ± 30 | | V |
| I _D | Drain current (continuous) at T _C = 25°C | 7 | 7 ⁽¹⁾ | A |
| I _D | Drain current (continuous) at T _C =100°C | 4.4 | 4.4 ⁽¹⁾ | A |
| I _{DM} ⁽²⁾ | Drain current (pulsed) | 28 | 28 ⁽¹⁾ | A |
| P _{TOT} | Total dissipation at T _C = 25°C | 125 | 30 | W |
| | Derating Factor | 1 | 0.24 | W/°C |
| ESD | Gate-source human body model (R=1,5 kΩ, C=100 pF) | 4 | | kV |
| 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 _J T _{stg} | Operating junction temperature Storage temperature | -55 to 150 | | °C |

- Limited by maximum junction temperature
- Pulse width limited by safe operating area
- I_{SD} ≤ 7A, di/dt ≤ 200A/μs, V_{DD} ≤ V_{(BR)DSS}, T_J ≤ T_{JMAX}

Table 3. Thermal data

| Symbol | Parameter | Value | | | Unit |
|-----------------------|--|--------------------|--------|----------|------|
| | | D ² PAK | TO-220 | TO-220FP | |
| R _{thj-case} | Thermal resistance junction-case max | 1 | | 4.2 | °C/W |
| R _{thj-amb} | Thermal resistance junction-ambient max | | 62.5 | | °C/W |
| R _{thj-pcb} | Thermal resistance junction-pcb max ⁽¹⁾ | 30 | | | °C/W |

- When mounted on minimum footprint

Table 4. Avalanche characteristics

| Symbol | Parameter | Value | Unit |
|----------|--|-------|------|
| I_{AR} | Avalanche current, repetitive or not-repetitive ⁽¹⁾ | 7 | A |
| E_{AS} | Single pulse avalanche energy ⁽²⁾ | 235 | mJ |

1. Pulse width limited by $T_{j,Max}$

2. Starting $T_j=25\text{ °C}$, $I_D=I_{AR}$, $V_{DD}=50\text{ V}$

2 Electrical characteristics

($T_{CASE}=25^{\circ}C$ unless otherwise specified)

Table 5. On/off states

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---------------|--|---|------|------|----------|--------------------------------|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage $V_{GS}=0$ | $I_D = 1 \text{ mA}$ | 600 | | | V |
| I_{DSS} | Zero gate voltage drain current ($V_{GS} = 0$) | $V_{DS} = 600 \text{ V}$, $V_{DS} = 600 \text{ V}$, $T_C = 125^{\circ}C$ | | | 1 50 | μA μA |
| I_{GSS} | Gate body leakage current ($V_{DS} = 0$) | $V_{GS} = \pm 20 \text{ V}$ | | | ± 10 | μA |
| $V_{GS(th)}$ | Gate threshold voltage | $V_{DS} = V_{GS}$, $I_D = 100 \mu\text{A}$ | 3 | 3.75 | 4.5 | V |
| $R_{DS(on)}$ | Static drain-source on-resistance | $V_{GS} = 10 \text{ V}$, $I_D = 3.5 \text{ A}$ | | 0.85 | 0.95 | Ω |

Table 6. Dynamic

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|----------------------------|-------------------------------|--|------|------|------|------|
| $g_{fs}^{(1)}$ | Forward transconductance | $V_{DS} = 15 \text{ V}$, $I_D = 3.5 \text{ A}$ | - | 5.3 | | S |
| C_{iss} | Input capacitance | $V_{DS} = 25 \text{ V}$, $f = 1 \text{ MHz}$, $V_{GS} = 0$ | - | 1110 | | pF |
| C_{oss} | Output capacitance | | | 135 | | pF |
| C_{rss} | Reverse transfer capacitance | | | 30 | | pF |
| $C_{oss \text{ eq}}^{(2)}$ | Equivalent output capacitance | $V_{GS} = 0$, $V_{DS} = 0 \text{ V to } 480 \text{ V}$ | - | 72 | | pF |
| Q_g | Total gate charge | $V_{DD} = 480 \text{ V}$, $I_D = 7 \text{ A}$ | | 38 | 53 | nC |
| Q_{gs} | Gate-source charge | $V_{GS} = 10 \text{ V}$ | - | 7 | | nC |
| Q_{gd} | Gate-drain charge | (see Figure 18) | | 21 | | nC |

1. Pulsed: pulse duration=300 μs , duty cycle 1.5%

2. $C_{oss \text{ eq}}$ is defined as a constant equivalent capacitance giving the same charging time as C_{oss} when V_{DS} increases from 0 to 80% V_{DSS}

Table 7. Switching times

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|-----------------------|----------------------------------|--|------|----------|------|----------|
| $t_{d(on)}$ t_r | Turn-on delay time Rise time | $V_{DD}=300\text{ V}$, $I_D=3.5\text{ A}$, $R_G=4.7\ \Omega$, $V_{GS}=10\text{ V}$ (see Figure 19) | - | 19 17 | - | ns ns |
| $t_{d(off)}$ t_f | Turn-off delay time Fall time | $V_{DD}=300\text{ V}$, $I_D=3.5\text{ A}$, $R_G=4.7\ \Omega$, $V_{GS}=10\text{ V}$ (see Figure 19) | - | 43 15 | - | ns ns |

Table 8. Gate-source zener diode

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---------------|-------------------------------|--------------------------------------|------|------|------|------|
| $V_{(BR)GSO}$ | Gate-source breakdown voltage | $I_{GS} = \pm 1\text{ mA}$, $I_D=0$ | 30 | - | - | V |

The built-in back-to-back Zener diodes have been specifically designed to enhance not only the device's ESD capability, but also to make them capable of safely absorbing any voltage transients that may occasionally be applied from gate to source. In this respect, the Zener voltage is appropriate to achieve efficient and cost-effective protection of device integrity. The integrated Zener diodes thus eliminate the need for external components.

Table 9. Source drain diode

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|-----------------|-------------------------------|--|------|------|------|---------------|
| I_{SD} | Source-drain current | | - | | 7 | A |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) | | - | | 28 | A |
| $V_{SD}^{(2)}$ | Forward on voltage | $I_{SD}=7\text{ A}$, $V_{GS}=0$ | - | | 1.6 | V |
| t_{rr} | Reverse recovery time | $I_{SD}=7\text{ A}$, | - | 480 | | ns |
| Q_{rr} | Reverse recovery charge | $di/dt = 100\text{ A}/\mu\text{s}$, | - | 3.5 | | μC |
| I_{RRM} | Reverse recovery current | $V_{DD}=30\text{ V}$, $T_j=150\text{ }^\circ\text{C}$ | | 14.5 | | 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 D²PAK and TO-220

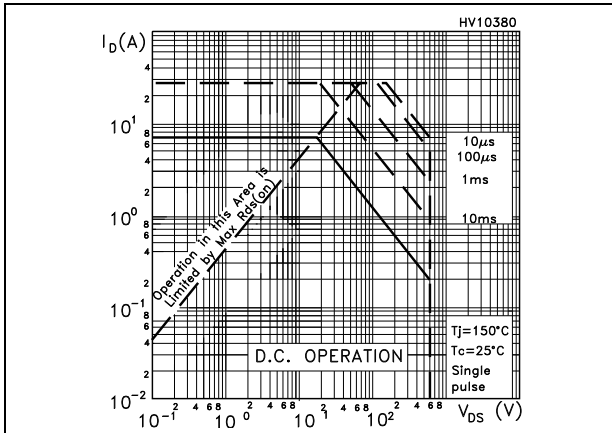


Figure 3. Thermal impedance for D²PAK and TO-220

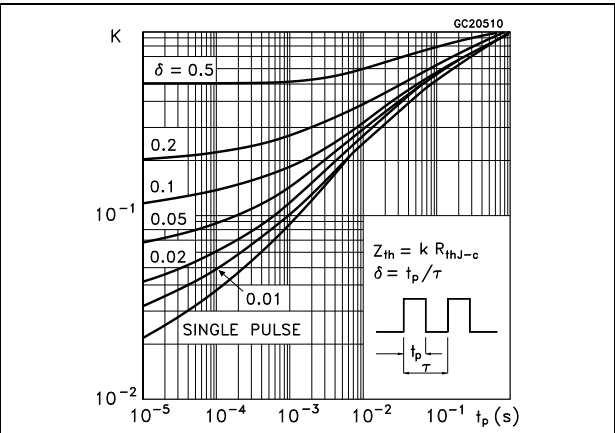


Figure 4. Safe operating area for TO-220FP

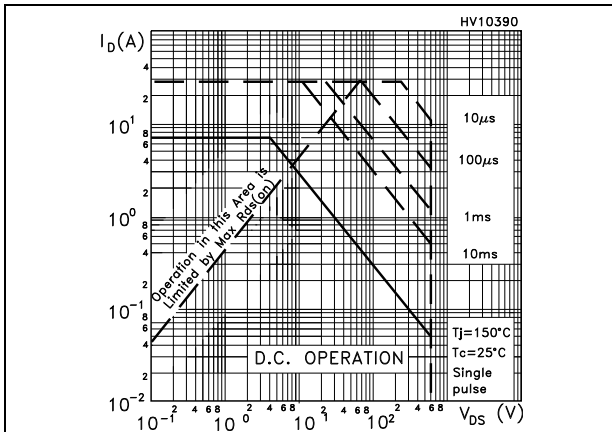


Figure 5. Thermal impedance for TO-220FP

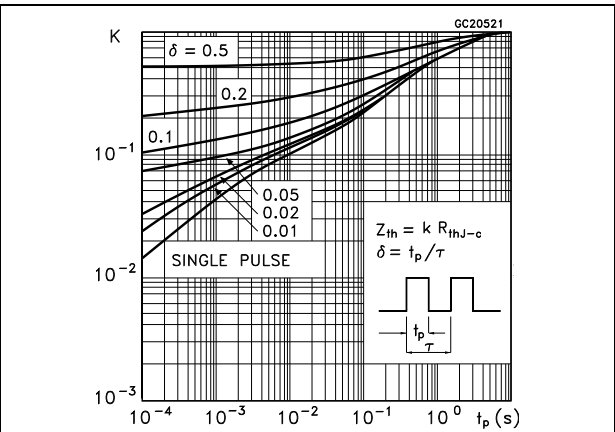


Figure 6. Output characteristics

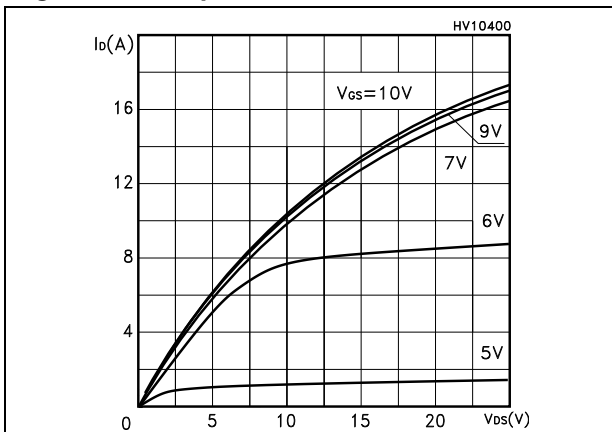


Figure 7. Transfer characteristics

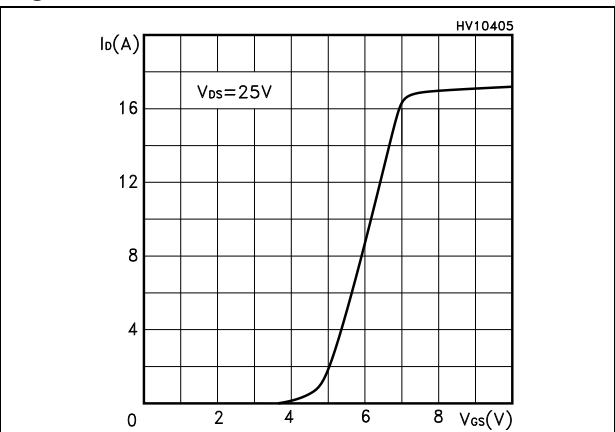


Figure 8. Transconductance

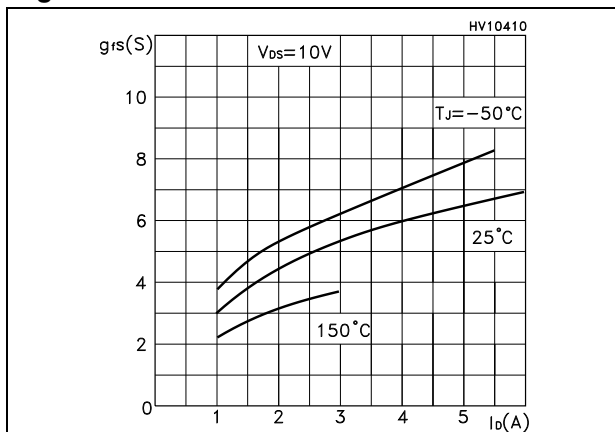


Figure 9. Static drain-source on-resistance

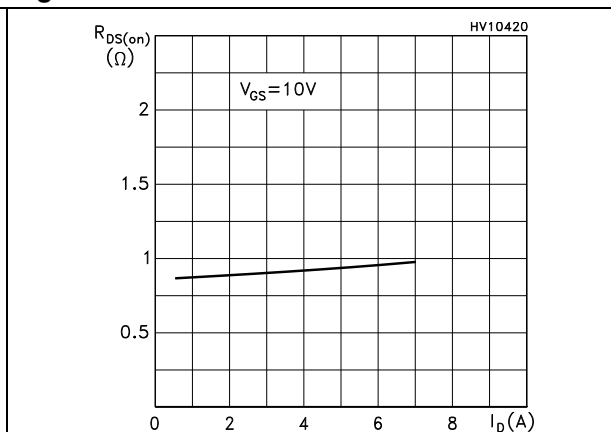


Figure 10. Gate charge vs gate-source voltage

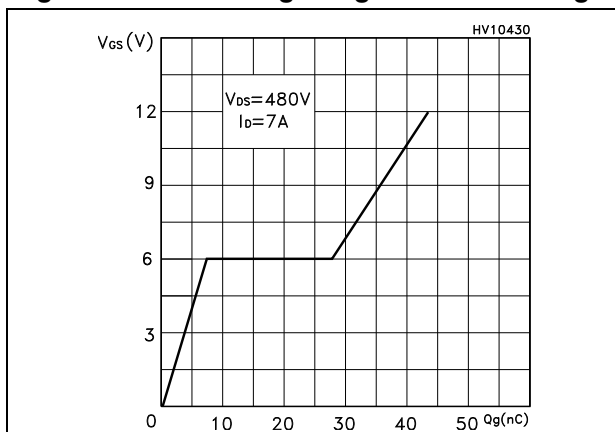


Figure 11. Capacitance variations

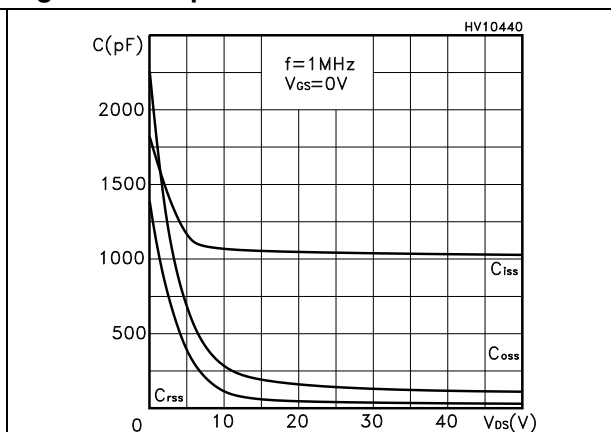


Figure 12. Normalized gate threshold voltage vs temperature

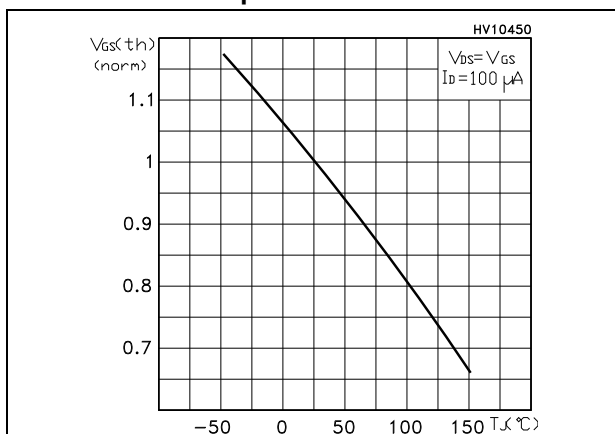


Figure 13. Normalized on-resistance vs temperature

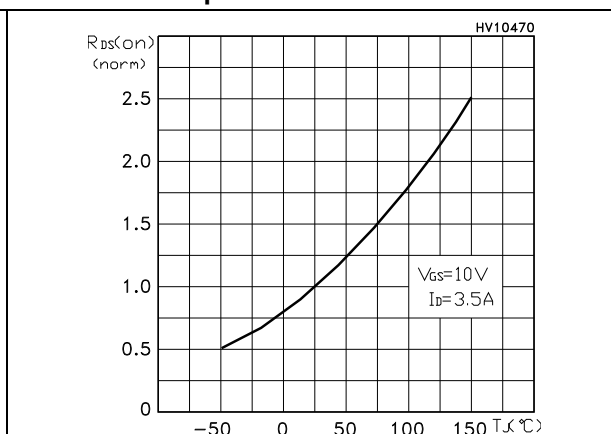


Figure 14. Source-drain diode forward characteristics

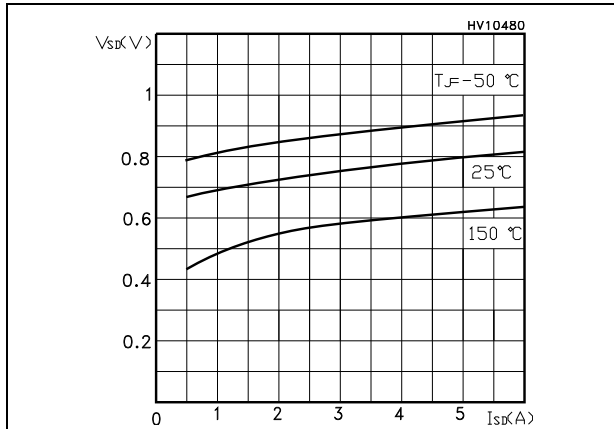


Figure 15. Normalized B_{VDSS} vs temperature

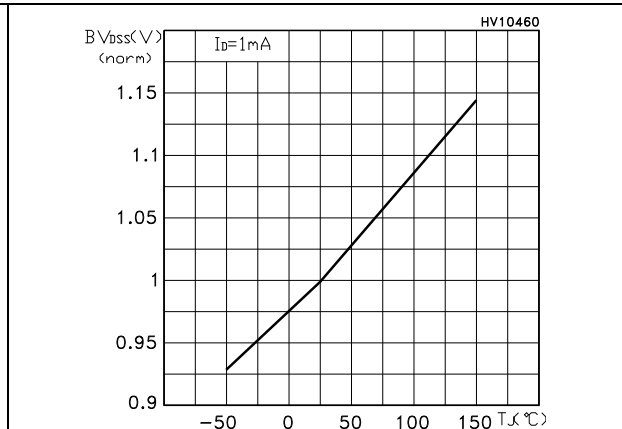
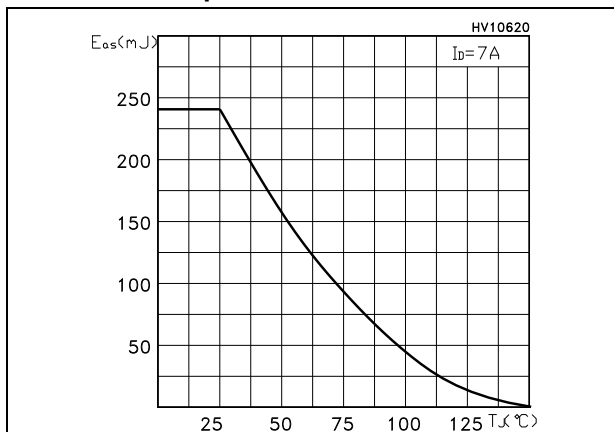


Figure 16. Maximum avalanche energy vs temperature



3 Test circuits

Figure 17. Switching times test circuit for resistive load

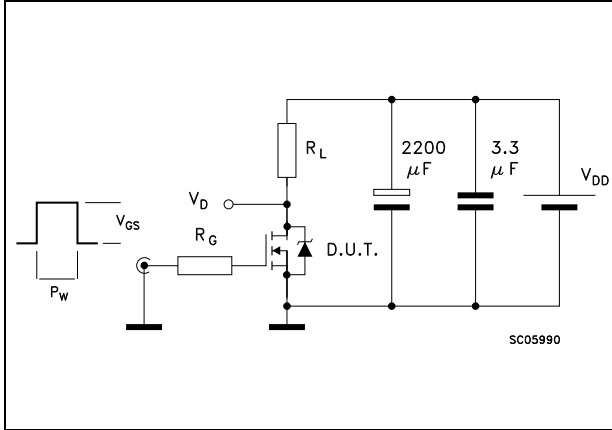


Figure 18. Gate charge test circuit

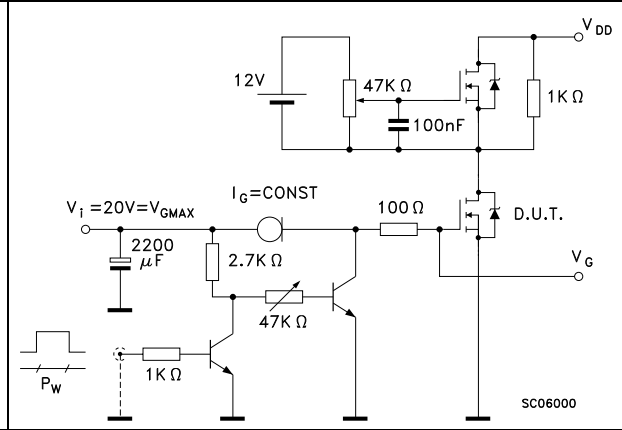


Figure 19. Test circuit for inductive load switching and diode recovery times

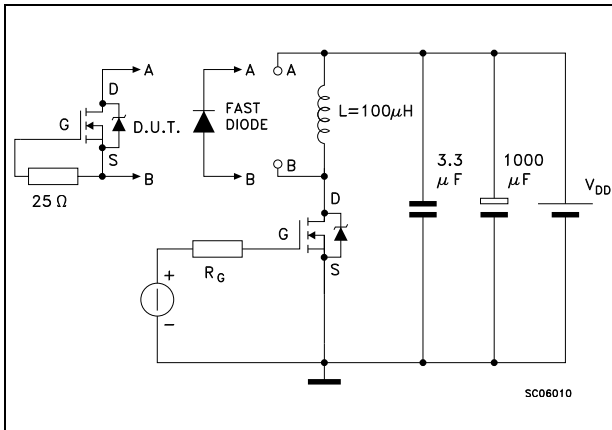


Figure 20. Unclamped Inductive load test circuit

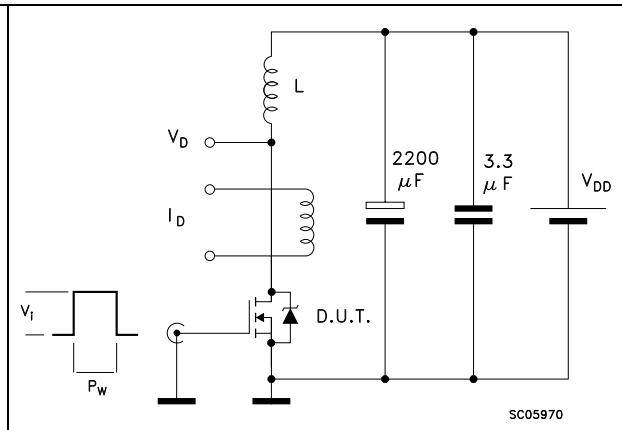


Figure 21. Unclamped inductive waveform

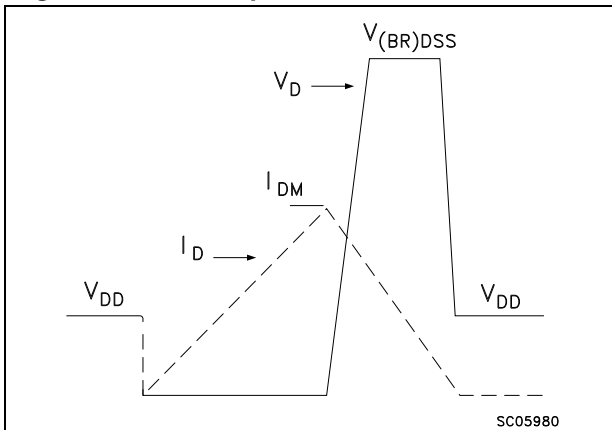
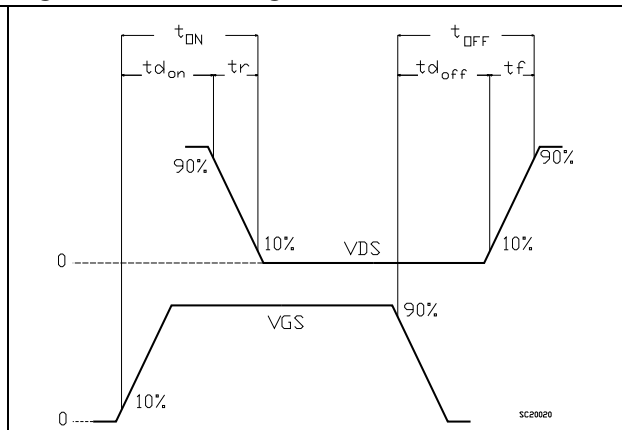


Figure 22. Switching time waveform



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 10. 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 23. D²PAK (TO-263) drawing

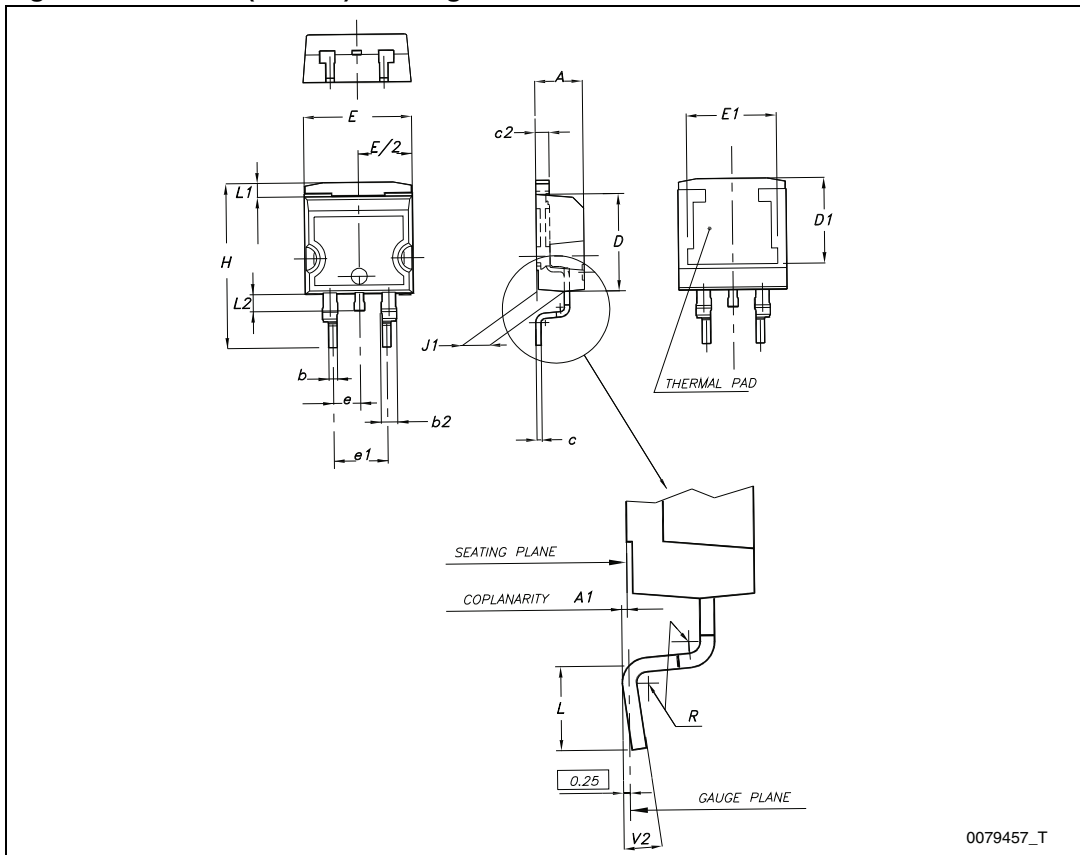
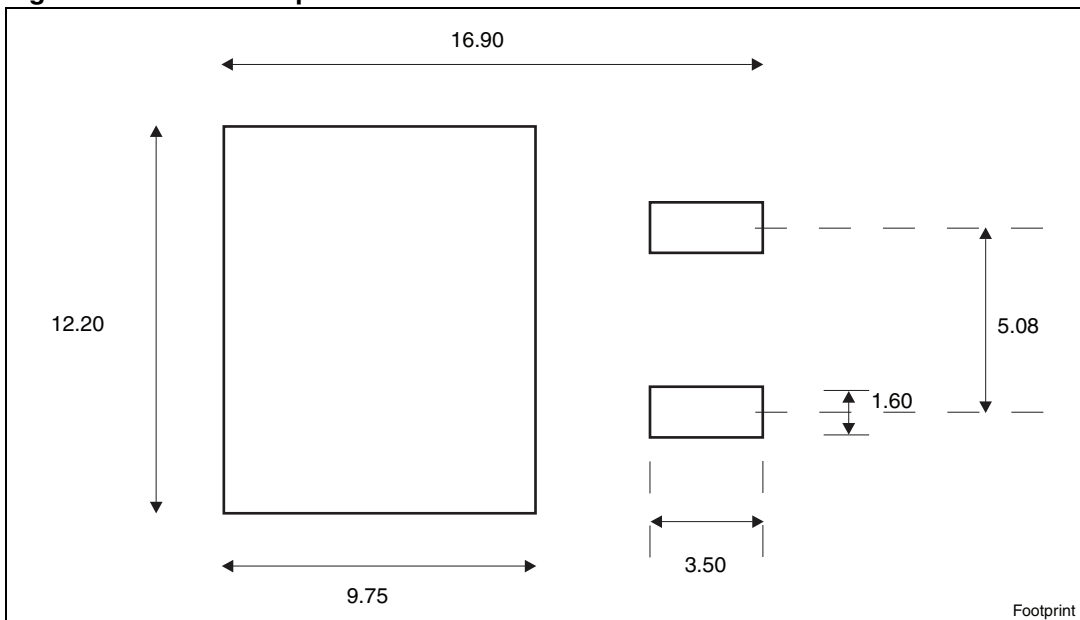


Figure 24. D²PAK footprint^(a)



a. All dimension are in millimeters

Table 11. 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 | |
| ØP | 3.75 | | 3.85 |
| Q | 2.65 | | 2.95 |

Figure 25. TO-220 type A drawing

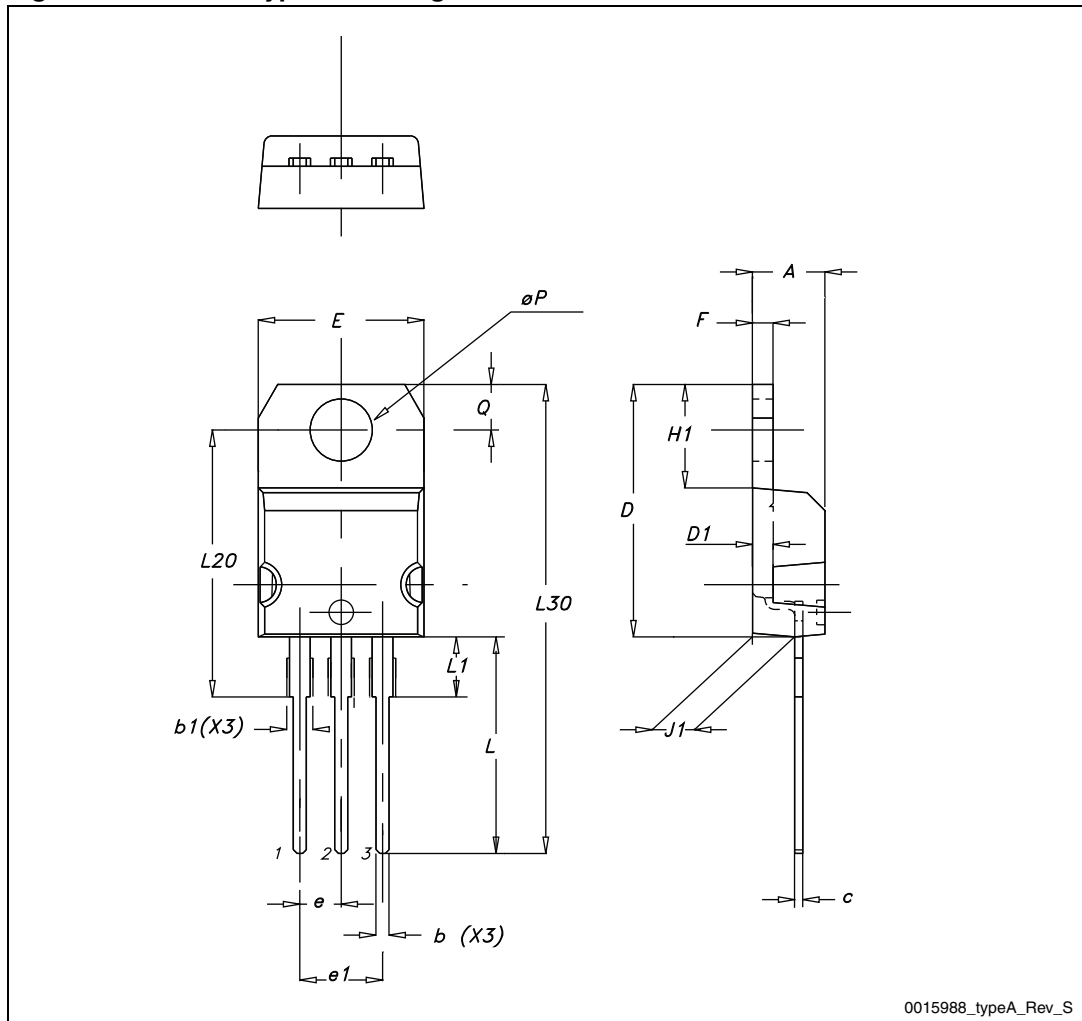
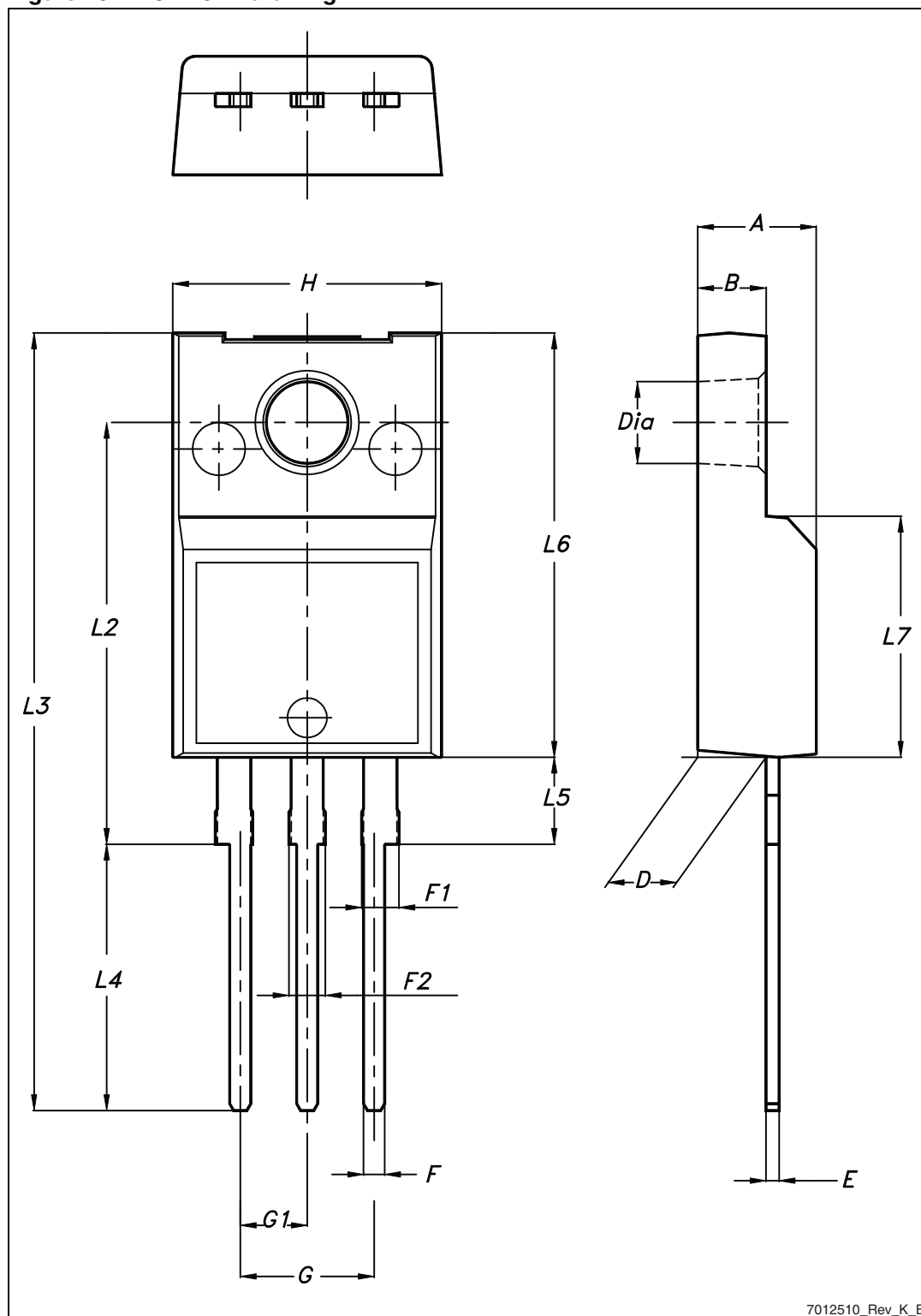


Table 12. TO-220FP mechanical data

| 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 26. TO-220FP drawing



7012510_Rev_K_B

5 Revision history

Table 13. Document revision history

| Date | Revision | Changes |
|-------------|----------|---|
| 31-Jan-2013 | 3 | – Minor text changes – The part number STB9NK60Z-1 has been moved to a separate datasheet – Updated: Section 4: Package mechanical data . |

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