



STP9NK65Z STP9NK65ZFP

N-channel 650 V, 1 Ω , 6.4 A, TO-220, TO-220FP
Zener-protected SuperMESH™ Power MOSFET

Features

| Order codes | V _{DSS} | R _{DS(on)} max. | I _D | P _w |
|-------------|------------------|-----------------------------|----------------|----------------|
| STP9NK65Z | 650 V | < 1.2 Ω | 6.4 A | 125 W |
| STP9NK65ZFP | 650 V | < 1.2 Ω | 6.4 A | 30 W |

- 100% avalanche tested
- Low input capacitance and gate charge
- Low gate input resistance
- Extremely high dv/dt and avalanche capabilities

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.

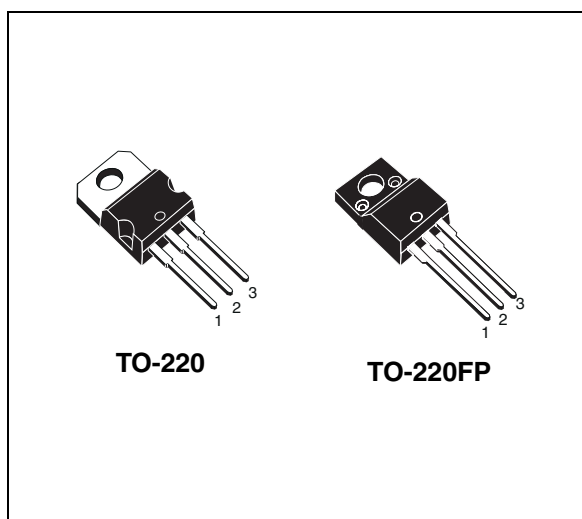


Figure 1. Internal schematic diagram

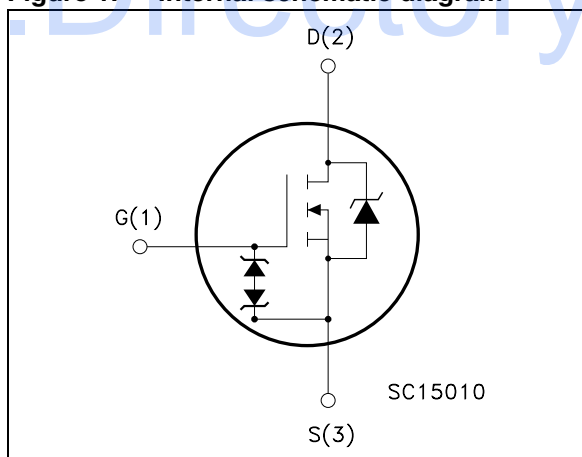


Table 1. Device summary

| Order codes | Marking | Package | Packaging |
|-------------|-----------|----------|-----------|
| STP9NK65Z | P9NK65Z | TO-220 | Tube |
| STP9NK65ZFP | P9NK65ZFP | TO-220FP | Tube |

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1 Electrical ratings

Table 2. Absolute maximum ratings

| Symbol | Parameter | Value | | Unit |
|--------------------|---|------------|---------------------|--------------------------------------|
| | | TO-220 | TO-220FP | |
| V_{DS} | Drain-source voltage ($V_{GS} = 0$) | 650 | | V |
| V_{GS} | Gate- source voltage | ± 30 | | V |
| I_D | Drain current (continuous) at $T_C = 25\text{ }^\circ\text{C}$ | 6.4 | 6.4 ⁽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) | 25.6 | 25.6 ⁽¹⁾ | A |
| P_{TOT} | Total dissipation at $T_C = 25\text{ }^\circ\text{C}$ | 125 | 30 | W |
| | Derating factor | 1 | 0.24 | W/ $^\circ\text{C}$ |
| $V_{ESD(G-S)}$ | Gate source ESD(HBM-C=100 pF, R=1.5 k Ω) | 4000 | | V |
| $dv/dt^{(3)}$ | Peak diode recovery voltage slope | 4.5 | | V/ns |
| V_{ISO} | Insulation withstand voltage (DC) | - | 2500 | V |
| T_j T_{stg} | Operating junction temperature Storage temperature | -55 to 150 | | $^\circ\text{C}$ $^\circ\text{C}$ |

1. Limited only by maximum temperature allowed
2. Pulse width limited by safe operating area
3. $I_{SD} \leq 6.4\text{ A}$, $di/dt \leq 200\text{ A}/\mu\text{s}$, $V_{DD} \leq 80\%V_{(BR)DSS}$

Table 3. Thermal data

| Symbol | Parameter | Value | | Unit |
|----------------|--|--------|----------|---------------------------|
| | | TO-220 | TO-220FP | |
| $R_{thj-case}$ | Thermal resistance junction-case max | 1 | 4.2 | $^\circ\text{C}/\text{W}$ |
| $R_{thj-amb}$ | Thermal resistance junction-ambient max | 62.5 | | $^\circ\text{C}/\text{W}$ |
| T_l | Maximum lead temperature for soldering purpose | 300 | | $^\circ\text{C}$ |

Table 4. Avalanche characteristics

| Symbol | Parameter | Value | Unit |
|----------|--|-------|------|
| I_{AR} | Avalanche current, repetitive or not-repetitive (pulse width limited by T_{jmax}) | 6.4 | A |
| E_{AS} | Single pulse avalanche energy (starting $T_j=25\text{ }^\circ\text{C}$, $I_D=I_{AR}$, $V_{DD}=50\text{ V}$) | 200 | mJ |

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 ($V_{GS} = 0$) | $I_D = 1 \text{ mA}$ | 650 | | | V |
| I_{DSS} | Zero gate voltage drain current ($V_{GS} = 0$) | $V_{DS} = 650 \text{ V}$ $V_{DS} = 650 \text{ V}, @ 125^{\circ}C$ | | | 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 | $V_{GS} = 10 \text{ V}, I_D = 3.2 \text{ A}$ | | 1 | 1.2 | Ω |

Table 6. Dynamic

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|-------------------------------------|---|--|------|-------------------|------|----------------|
| $g_{fs}^{(1)}$ | Forward transconductance | $V_{DS} = 15 \text{ V}, I_D = 3.2 \text{ A}$ | - | 6 | - | S |
| C_{iss} C_{oss} C_{rss} | Input capacitance Output capacitance Reverse transfer capacitance | $V_{DS} = 25 \text{ V}, f = 1 \text{ MHz},$ $V_{GS} = 0$ | - | 1145 130 28 | - | pF pF pF |
| $C_{oss \text{ eq}}^{(2)}$ | Equivalent output capacitance | $V_{GS} = 0, V_{DS} = 0 \text{ to } 400 \text{ V}$ | - | 55 | - | pF |
| Q_g Q_{gs} Q_{gd} | Total gate charge Gate-source charge Gate-drain charge | $V_{DD} = 520 \text{ V}, I_D = 6.4 \text{ A},$ $V_{GS} = 10 \text{ V}$ (see Figure 3) | - | 41 7.5 22 | - | nC nC 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 | $V_{DD} = 325 \text{ V}, I_D = 3.2 \text{ A}$ $R_G = 4.7 \Omega, V_{GS} = 10 \text{ V}$ (see Figure 2) | - | 20 12 | - | ns ns |
| $t_{d(off)}$ t_f | Turn-off delay time Fall time | $V_{DD} = 325 \text{ V}, I_D = 3.2 \text{ A}$ $R_G = 4.7 \Omega, V_{GS} = 10 \text{ V}$ (See Figure 2) | - | 45 15 | - | ns ns |

Table 8. Source drain diode

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|-----------------|-------------------------------|--|------|------|------|------|
| I_{SD} | Source-drain current | | - | | 6.4 | A |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) | | - | | 25.6 | A |
| $V_{SD}^{(2)}$ | Forward on voltage | $I_{SD} = 6.4 \text{ A}, V_{GS} = 0$ | - | | 1.6 | V |
| t_{rr} | Reverse recovery time | $I_{SD} = 6.4 \text{ A},$ $di/dt = 100 \text{ A}/\mu\text{s}$ $V_{DD} = 50 \text{ V}, T_j = 150 \text{ }^\circ\text{C}$ (see Figure 4) | - | 400 | | ns |
| Q_{rr} | Reverse recovery charge | | | 2600 | | nC |
| I_{RRM} | Reverse recovery current | | | 13 | | 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 |
|------------------|-------------------------------|---|------|------|------|------|
| $BV_{GSO}^{(1)}$ | Gate-source breakdown voltage | $I_{GS} = \pm 1 \text{ mA}$ (open drain) | 30 | - | - | V |

1. 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.

3 Test circuits

Figure 2. Switching times test circuit for resistive load

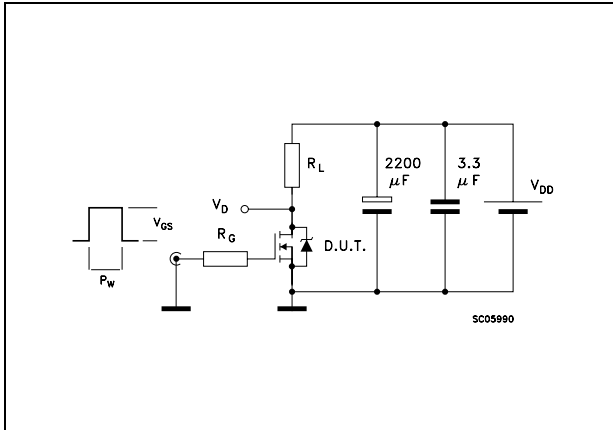


Figure 3. Gate charge test circuit

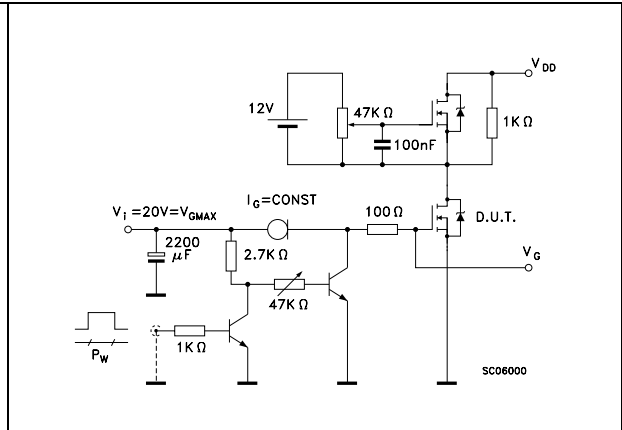


Figure 4. Test circuit for inductive load switching and diode recovery times

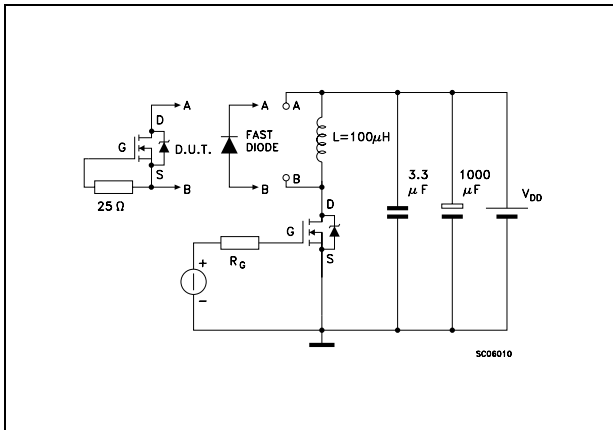


Figure 5. Unclamped Inductive load test circuit

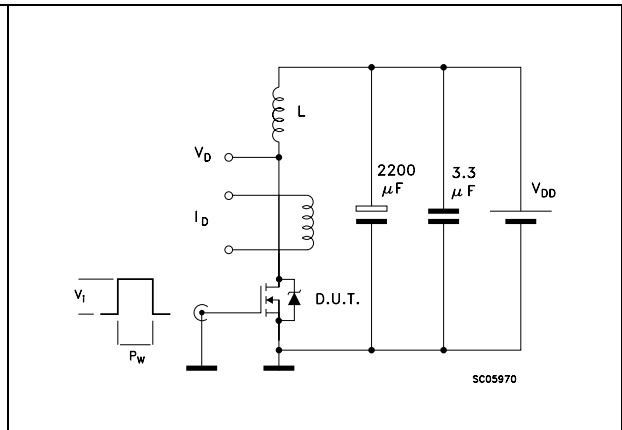


Figure 6. Unclamped inductive waveform

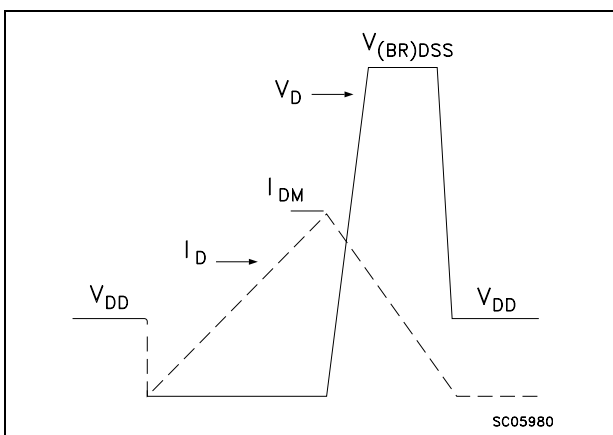
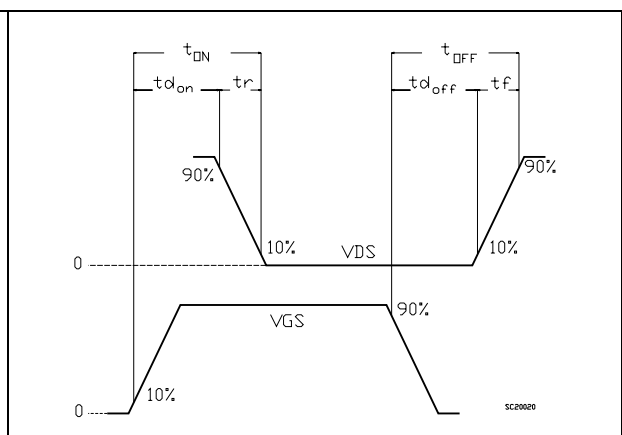


Figure 7. Switching time waveform



3.1 Electrical characteristics (curves)

Figure 8. Safe operating area for TO-220

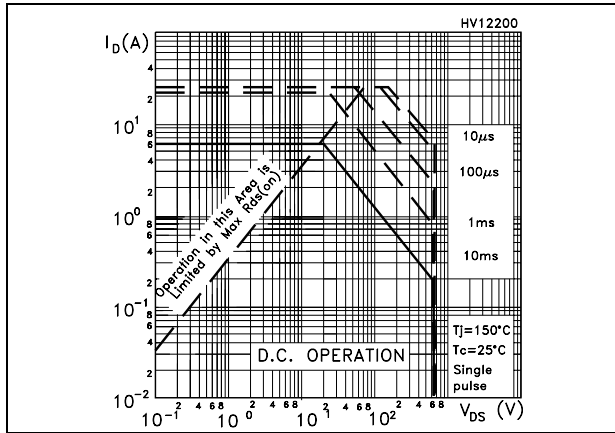


Figure 9. Thermal impedance for TO-220

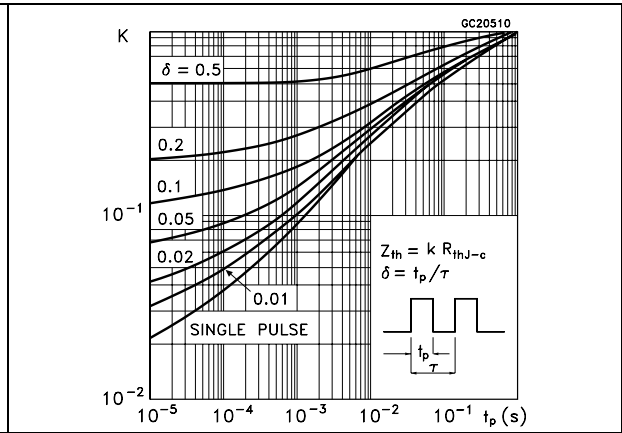


Figure 10. Safe operating area for TO-220FP

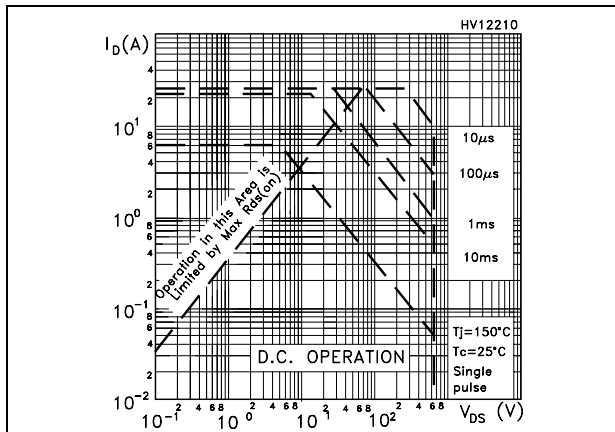


Figure 11. Thermal impedance for TO-220FP

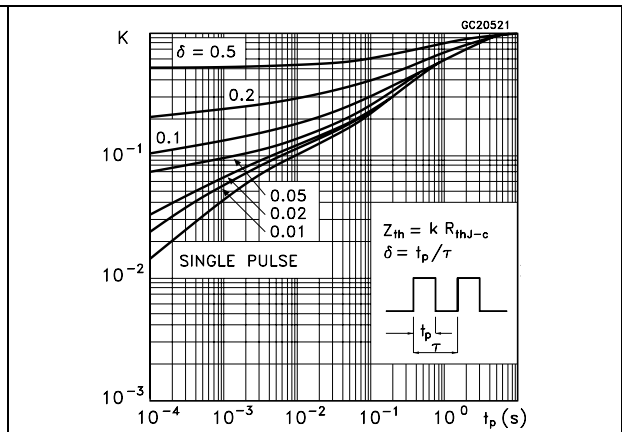


Figure 12. Output characteristics

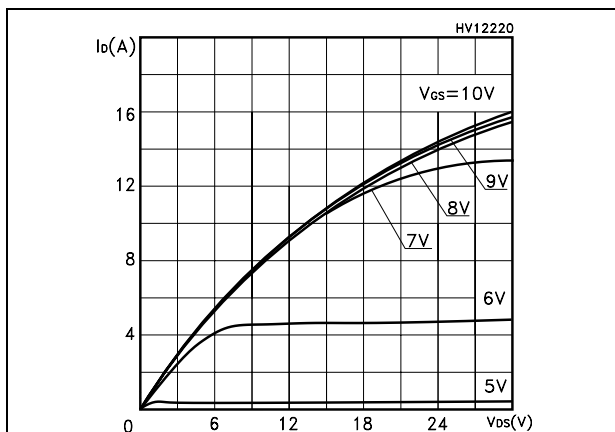


Figure 13. Transfer characteristics

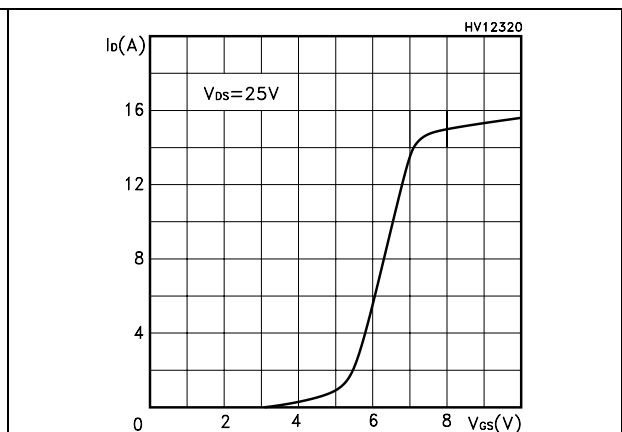


Figure 14. Transconductance

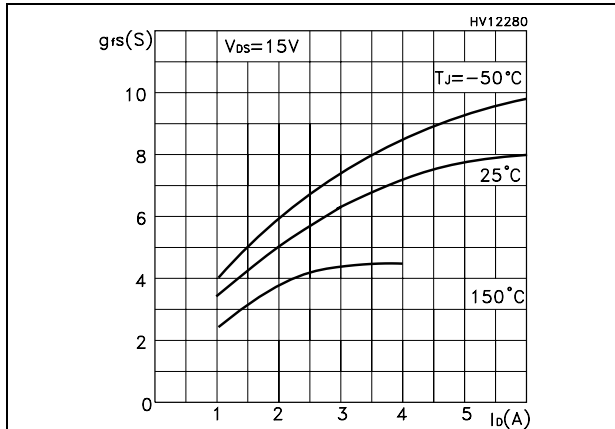


Figure 15. Static drain-source on resistance

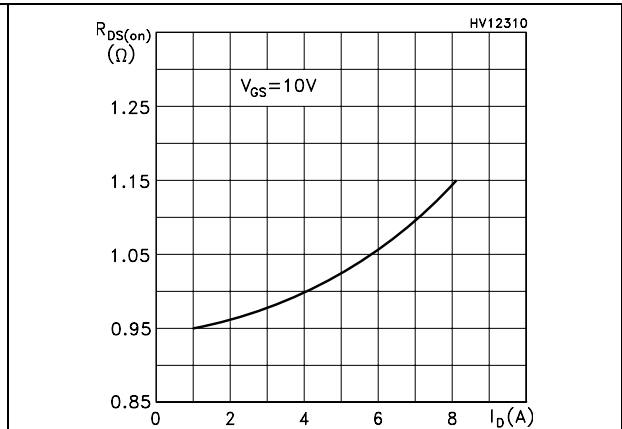


Figure 16. Gate charge vs gate-source voltage

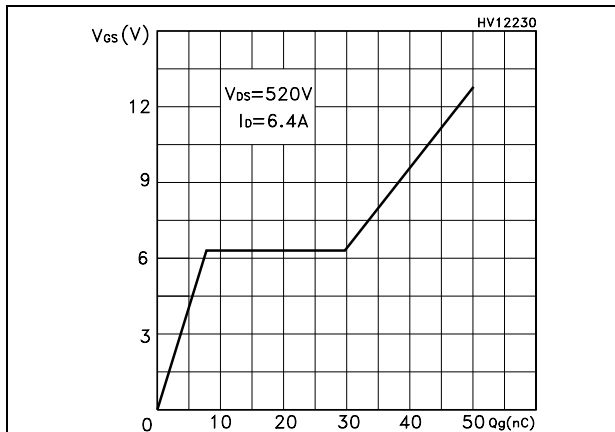


Figure 17. Capacitance variations

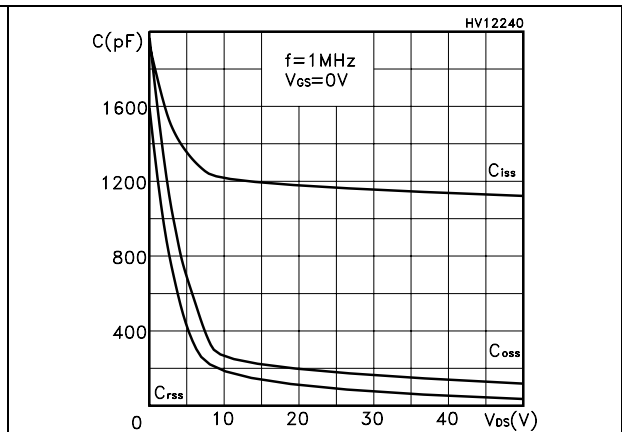


Figure 18. Normalized gate threshold voltage vs temperature

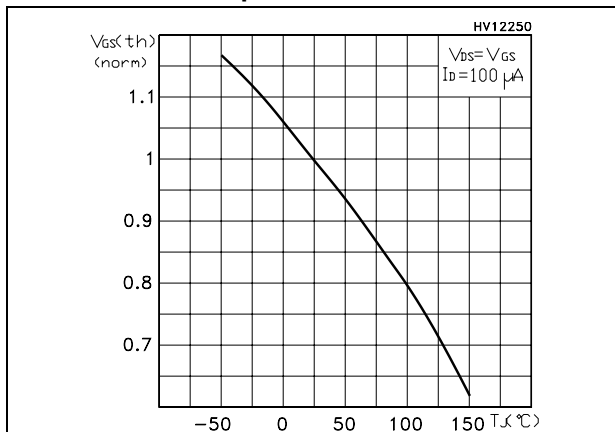


Figure 19. Normalized on resistance vs temperature

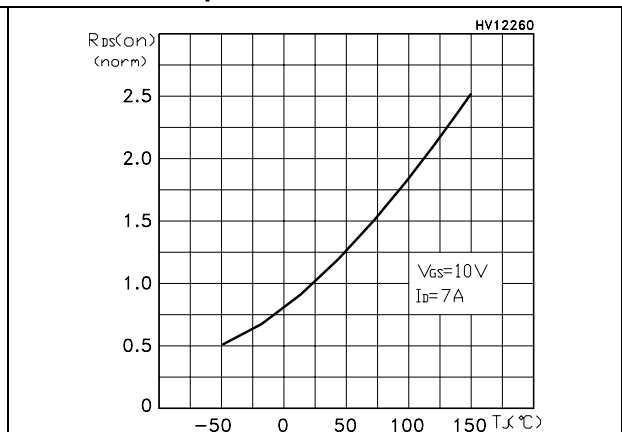


Figure 20. Source-drain diode forward characteristics

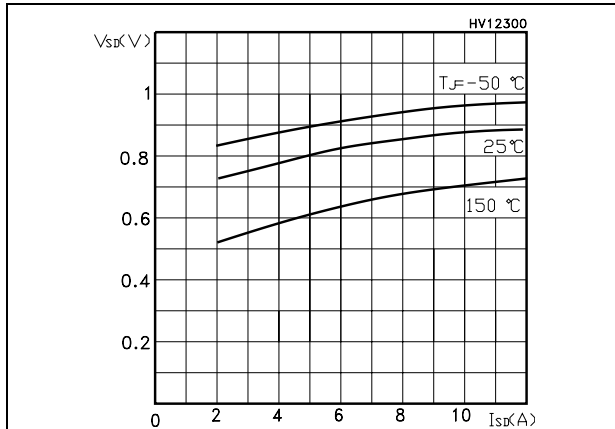


Figure 21. Normalized BV_{DSS} vs temperature

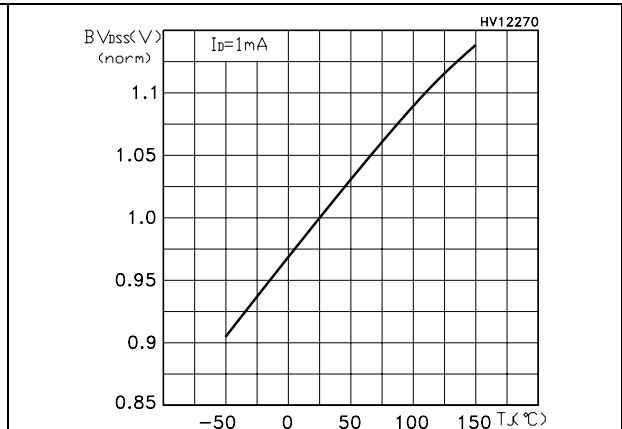
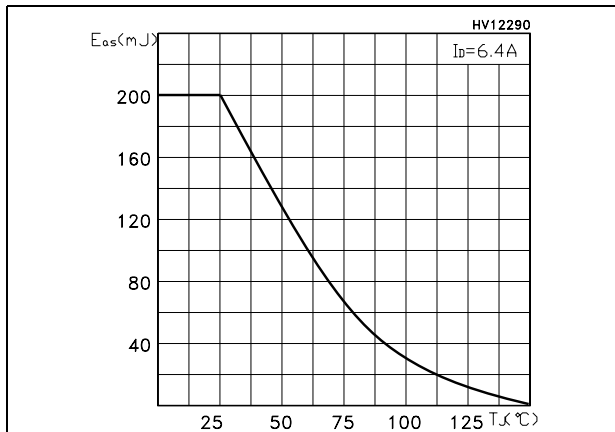


Figure 22. Maximum avalanche energy vs temperature



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-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

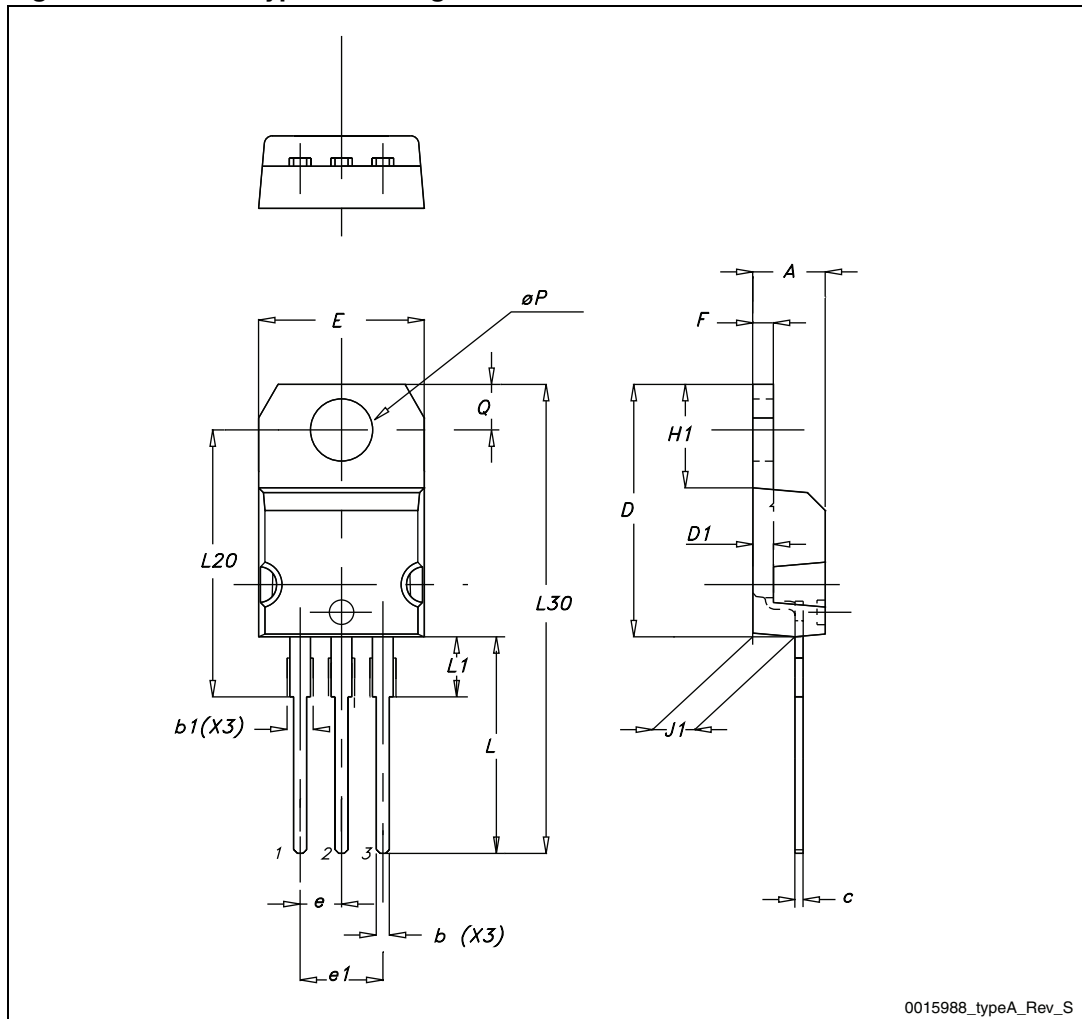
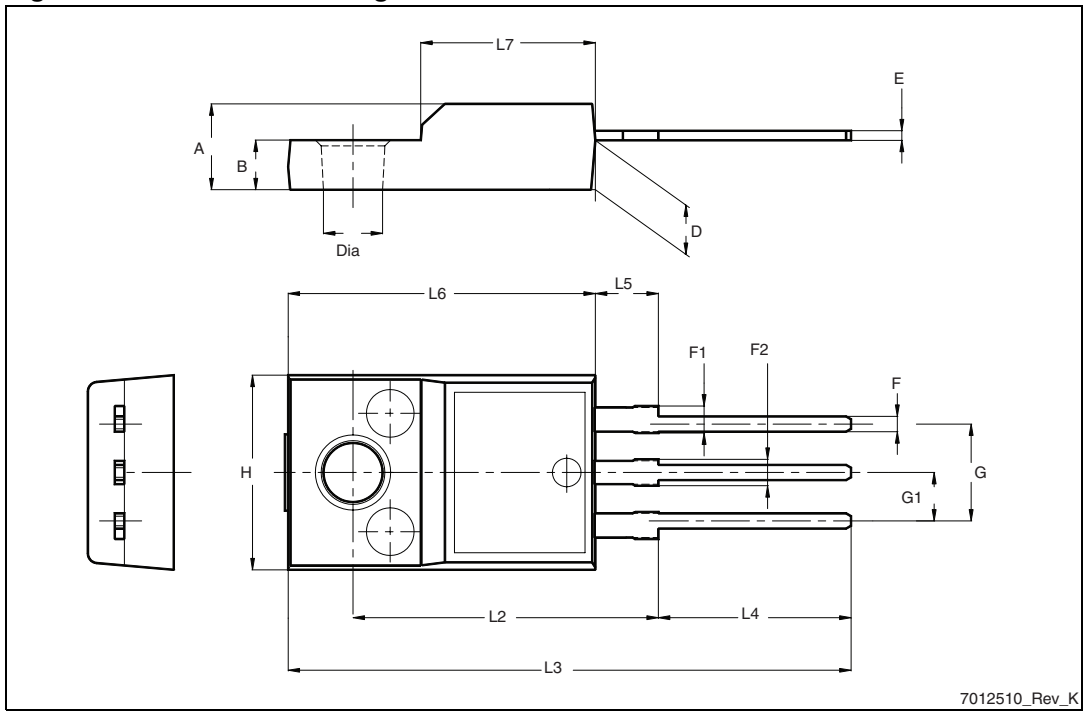


Table 11. TO-220FP mechanical data

| 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



5 Revision history

Table 12. Document revision history

| Date | Revision | Changes |
|-------------|----------|---|
| 11-Sep-2006 | 2 | Complete version |
| 19-Dec-2007 | 3 | The document has been reformatted |
| 26-Jan-2012 | 4 | <ul style="list-style-type: none">– Minor text changes– Modified: <i>Features</i> in cover page– Updated: <i>Section 4: Package mechanical data</i> |

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