

N-channel 950 V, 0.41 Ω typ., 12 A SuperMESH™ 5 Power MOSFETs in TO-220FP, TO-220 and TO-247 packages

Datasheet - production data

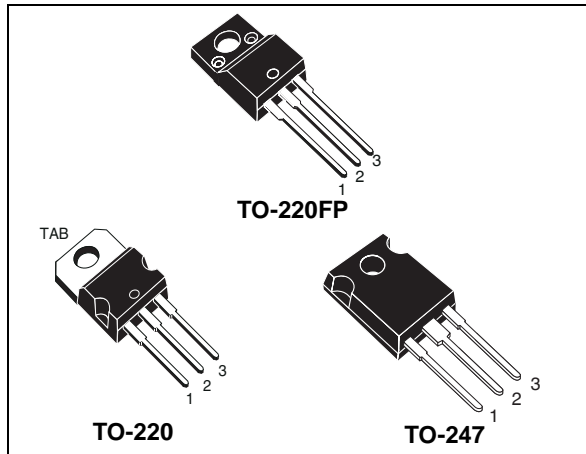
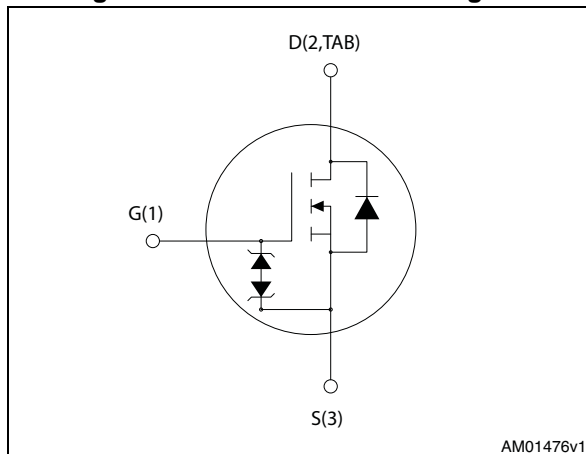


Figure 1. Internal schematic diagram



AM01476v1

Features

| Order codes | V_{DS} | $R_{DS(on)max}$ | I_D | P_{TOT} |
|-------------|----------|-----------------|-------|-----------|
| STF15N95K5 | 950 V | 0.5 Ω | 12 A | 30 W |
| STP15N95K5 | | | | 170 W |
| STW15N95K5 | | | | 170 W |

- TO-220 worldwide best $R_{DS(on)}$
- Worldwide best FOM (figure of merit)
- Ultra low gate charge
- 100% avalanche tested
- Zener-protected

Applications

- Switching applications

Description

These devices are N-channel Power MOSFETs developed using SuperMESH™ 5 technology. This revolutionary, avalanche-rugged, high voltage Power MOSFET technology is based on an innovative proprietary vertical structure. The result is a drastic reduction in on-resistance and ultra low gate charge for applications which require superior power density and high efficiency.

Table 1. Device summary

| Order codes | Marking | Package | Packaging |
|-------------|---------|----------|-----------|
| STF15N95K5 | 15N95K5 | TO-220FP | Tube |
| STP15N95K5 | 15N95K5 | TO-220 | |
| STW15N95K5 | 15N95K5 | TO-247 | |

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1 Electrical ratings

Table 2. Absolute maximum ratings

| Symbol | Parameter | Value | | Unit |
|----------------------|--|------------------|--------------------|------|
| | | TO-220 TO-247 | TO-220FP | |
| V_{GS} | Gate- source voltage | ± 30 | | V |
| I_D | Drain current (continuous) at $T_C = 25\text{ °C}$ | 12 | 12 ⁽¹⁾ | A |
| I_D | Drain current (continuous) at $T_C = 100\text{ °C}$ | 7.6 | 7.6 ⁽¹⁾ | A |
| $I_{DM}^{(2)}$ | Drain current (pulsed) | 48 | 48 ⁽¹⁾ | A |
| P_{TOT} | Total dissipation at $T_C = 25\text{ °C}$ | 170 | 30 | W |
| I_{AR} | Max current during repetitive or single pulse avalanche (pulse width limited by T_{jmax}) | 4 | | A |
| E_{AS} | Single pulse avalanche energy (starting $T_J = 25\text{ °C}$, $I_D = I_{AS}$, $V_{DD} = 50\text{ V}$) | 124 | | mJ |
| ESD | Gate-source human body model (R= 1,5 k Ω , C = 100 pF) | 2 | | kV |
| V_{ISO} | Insulation withstand voltage (RMS) from all three leads to external heat sink (t=1 s; $T_C = 25\text{ °C}$) | 2500 | | V |
| dv/dt ⁽³⁾ | Peak diode recovery voltage slope | 4.5 | | V/ns |
| dv/dt ⁽⁴⁾ | MOSFET dv/dt ruggedness | 50 | | V/ns |
| T_J T_{stg} | Operating junction temperature Storage temperature | -55 to 150 | | °C |

1. Limited by maximum junction temperature.
2. Pulse width limited by safe operating area.
3. $I_{SD} \leq 12$, $di/dt \leq 100\text{ A}/\mu\text{s}$, $V_{DS(peak)} \leq V_{(BR)DSS}$
4. $V_{DS} \leq 760\text{ V}$

Table 3. Thermal data

| Symbol | Parameter | Value | | | Unit |
|----------------|--------------------------------------|--------|--------|----------|------|
| | | TO-220 | TO-247 | TO-220FP | |
| $R_{thj-case}$ | Thermal resistance junction-case max | 0.74 | | 4.2 | °C/W |
| $R_{thj-amb}$ | Thermal resistance junction-amb max | 62.5 | 50 | 62.5 | °C/W |

2 Electrical characteristics

($T_{CASE} = 25\text{ °C}$ unless otherwise specified)

Table 4. On/off states

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---------------|--|--|------|------|----------|---------------|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage | $I_D = 1\text{ mA}$, $V_{GS} = 0$ | 950 | | | V |
| I_{DSS} | Zero gate voltage drain current ($V_{GS} = 0$) | $V_{DS} = 950\text{ V}$, | | | 1 | μA |
| | | $V_{DS} = 950\text{ V}$, $T_c = 125\text{ °C}$ | | | 50 | μA |
| I_{GSS} | Gate body leakage current ($V_{DS} = 0$) | $V_{GS} = \pm 20\text{ V}$ | | | ± 10 | μA |
| $V_{GS(th)}$ | Gate threshold voltage | $V_{DS} = V_{GS}$, $I_D = 100\text{ }\mu\text{A}$ | 3 | 4 | 5 | V |
| $R_{DS(on)}$ | Static drain-source on-resistance | $V_{GS} = 10\text{ V}$, $I_D = 6\text{ A}$ | | 0.41 | 0.50 | Ω |

Table 5. Dynamic

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|-------------------|---------------------------------------|---|------|------|------|----------|
| C_{iss} | Input capacitance | $V_{DS} = 100\text{ V}$, $f = 1\text{ MHz}$, $V_{GS} = 0$ | - | 855 | - | pF |
| C_{oss} | Output capacitance | | - | 65 | | pF |
| C_{rss} | Reverse transfer capacitance | | - | 1 | | pF |
| $C_{o(tr)}^{(1)}$ | Equivalent capacitance time related | $V_{GS} = 0$, $V_{DS} = 0\text{ to }760\text{ V}$ | - | 104 | - | pF |
| $C_{o(er)}^{(2)}$ | Equivalent capacitance energy related | | - | 38 | - | pF |
| R_G | Intrinsic gate resistance | $f = 1\text{ MHz}$ open drain | - | 6 | - | Ω |
| Q_g | Total gate charge | $V_{DD} = 760\text{ V}$, $I_D = 12\text{ A}$ $V_{GS} = 10\text{ V}$ (see Figure 20) | - | 30 | - | nC |
| Q_{gs} | Gate-source charge | | - | 5 | - | nC |
| Q_{gd} | Gate-drain charge | | - | 22 | - | nC |

1. Time related 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}
2. energy related is defined as a constant equivalent capacitance giving the same stored energy as C_{oss} when V_{DS} increases from 0 to 80% V_{DSS}

Table 6. Switching times

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|--------------|--------------------|---|------|------|------|------|
| $t_{d(v)}$ | Voltage delay time | $V_{DD} = 475 \text{ V}$, $I_D = 6 \text{ A}$, $R_G = 4.7 \text{ } \Omega$, $V_{GS} = 10 \text{ V}$ (see Figure 22) | - | 23 | - | ns |
| $t_{r(v)}$ | Voltage rise time | | - | 20 | - | ns |
| $t_{f(i)}$ | Current fall time | | - | 62 | - | ns |
| $t_{c(off)}$ | Crossing time | | - | 11 | - | ns |

Table 7. Source drain diode

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|----------------|-------------------------------|--|------|------|------|---------------|
| I_{SD} | Source-drain current | | - | | 12 | A |
| I_{SDM} | Source-drain current (pulsed) | | 48 | A | | |
| $V_{SD}^{(1)}$ | Forward on voltage | $I_{SD} = 12 \text{ A}$, $V_{GS} = 0$ | - | | 1.5 | V |
| t_{rr} | Reverse recovery time | $I_{SD} = 12 \text{ A}$, $V_{DD} = 60 \text{ V}$ $di/dt = 100 \text{ A}/\mu\text{s}$, (see Figure 21) | - | 444 | | ns |
| Q_{rr} | Reverse recovery charge | | - | 7 | | μC |
| I_{RRM} | Reverse recovery current | | - | 32 | | A |
| t_{rr} | Reverse recovery time | $I_{SD} = 12 \text{ A}$, $V_{DD} = 60 \text{ V}$ $di/dt = 100 \text{ A}/\mu\text{s}$, $T_j = 150 \text{ }^\circ\text{C}$ (see Figure 21) | - | 630 | | ns |
| Q_{rr} | Reverse recovery charge | | - | 9.2 | | μC |
| I_{RRM} | Reverse recovery current | | - | 29 | | A |

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

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 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-220FP

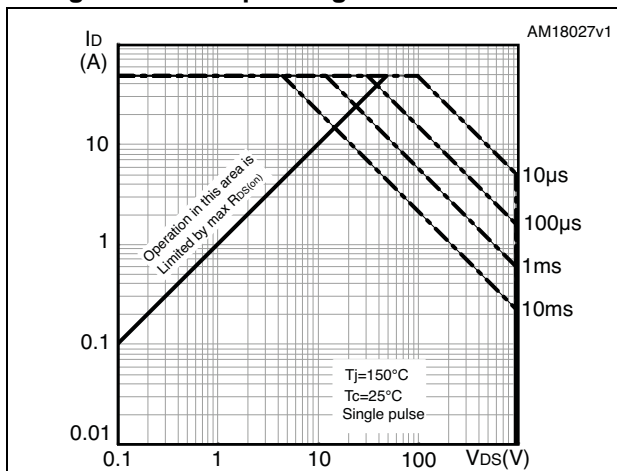


Figure 3. Thermal impedance for TO-220FP

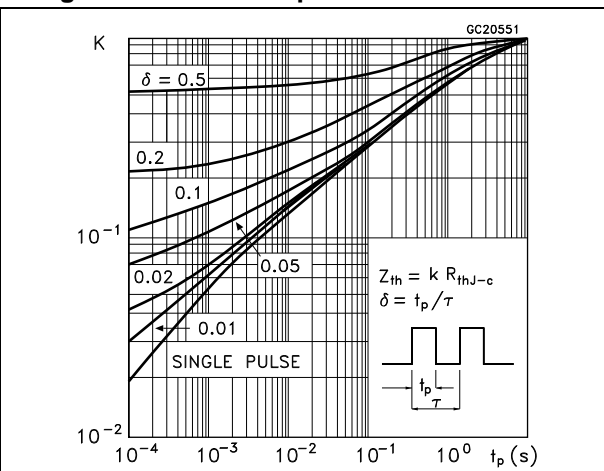


Figure 4. Safe operating area for TO-220

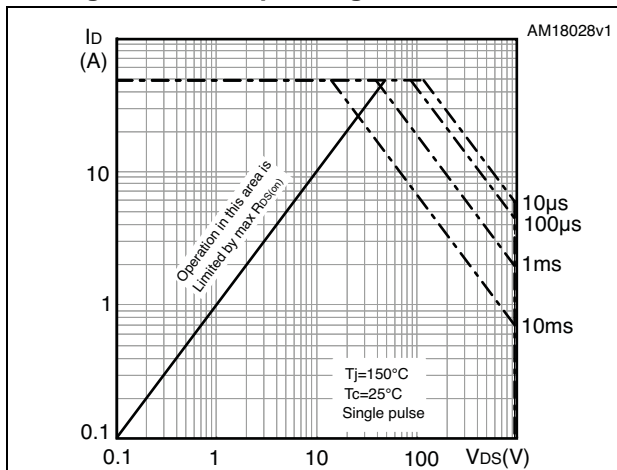


Figure 5. Thermal impedance for TO-220

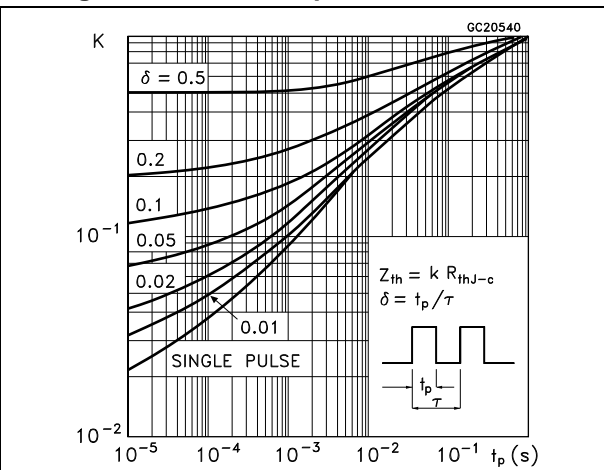


Figure 6. Safe operating area for TO-247

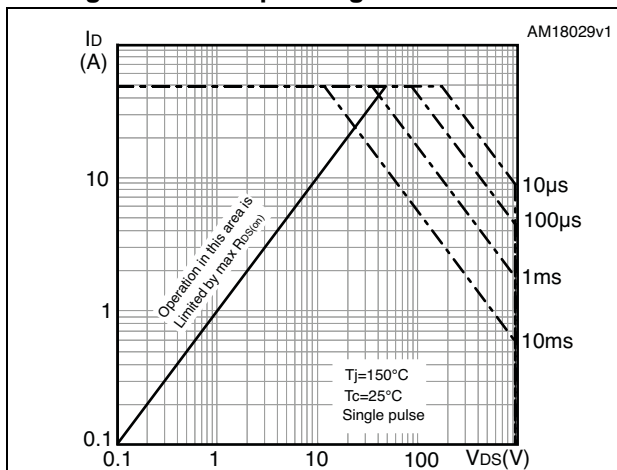


Figure 7. Thermal impedance for TO-247

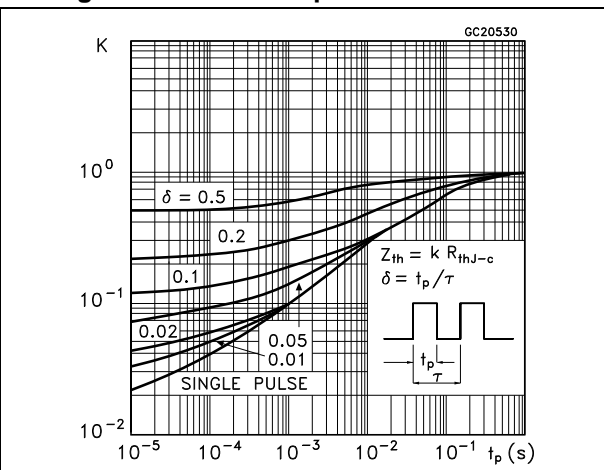


Figure 8. Output characteristics

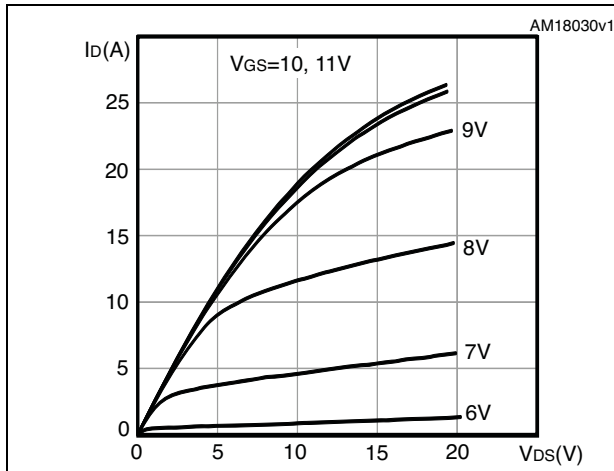


Figure 9. Transfer characteristics

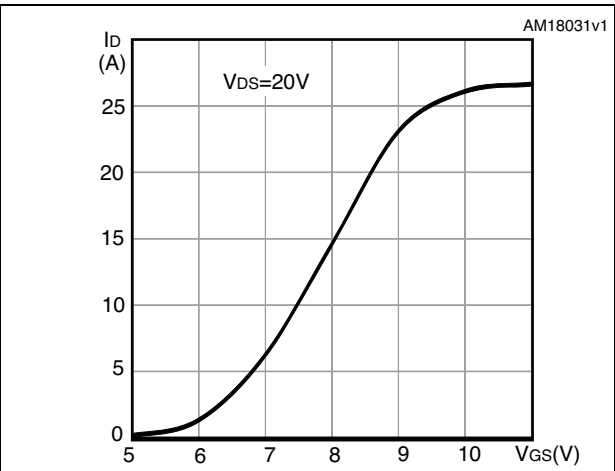


Figure 10. Gate charge vs gate-source voltage

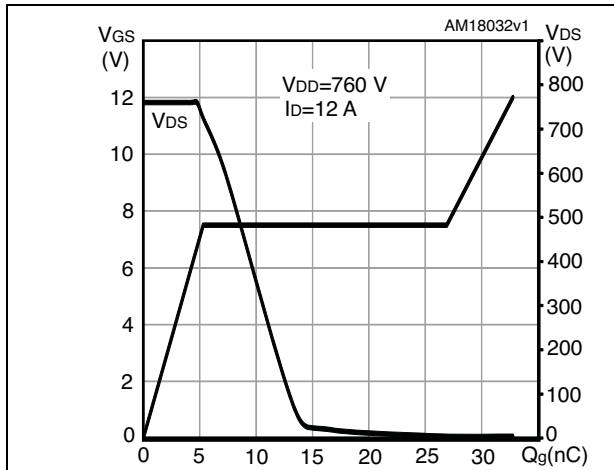


Figure 11. Static drain-source on-resistance

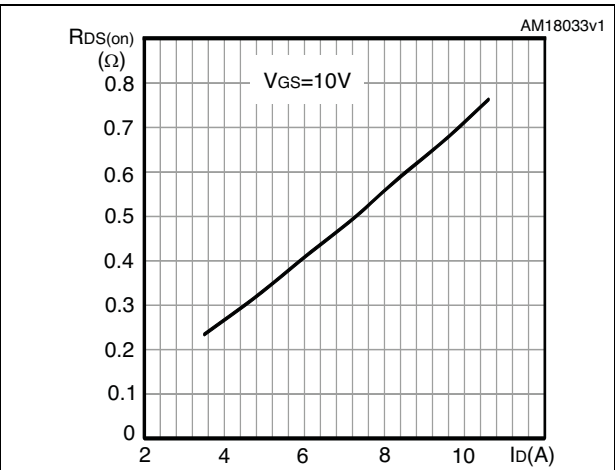


Figure 12. Capacitance variations

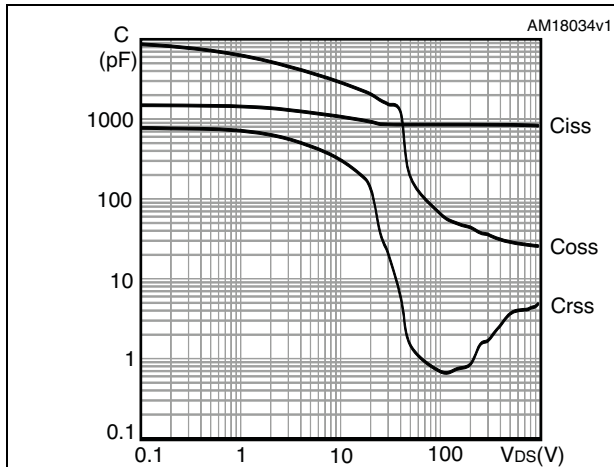


Figure 13. Output capacitance stored energy

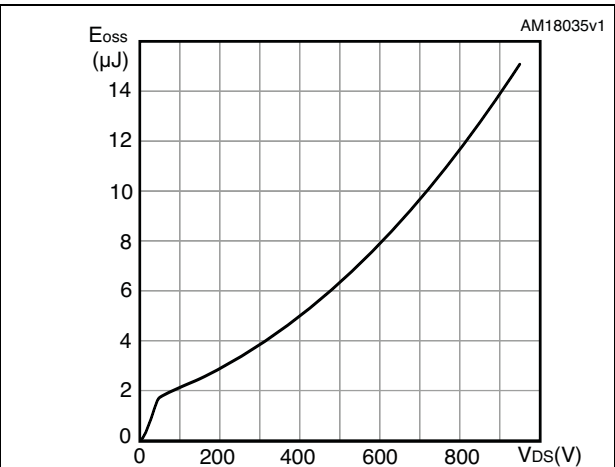


Figure 14. Normalized gate threshold voltage vs temperature

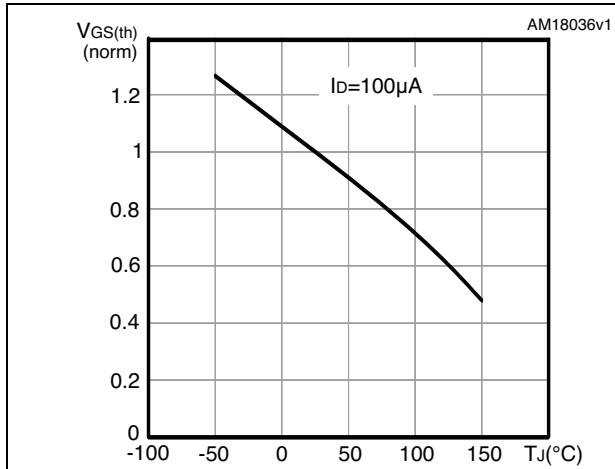


Figure 15. Normalized on-resistance vs temperature

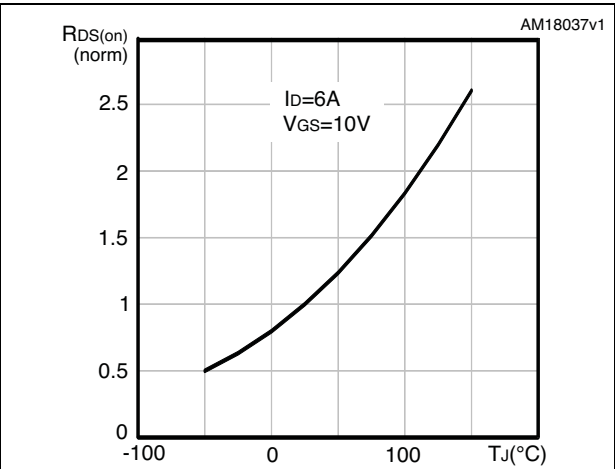


Figure 16. Normalized V_{DS} vs temperature

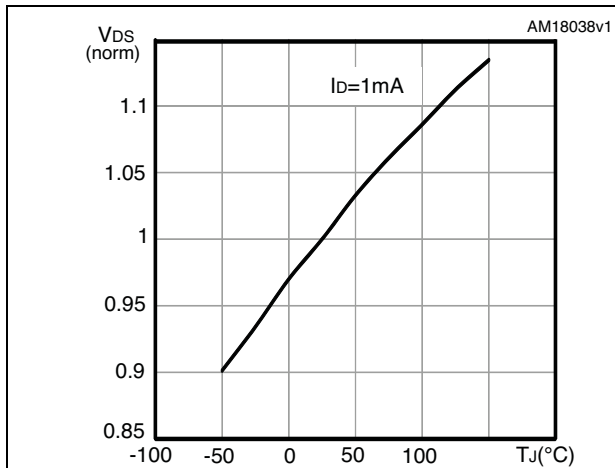


Figure 17. Source-drain diode forward characteristics

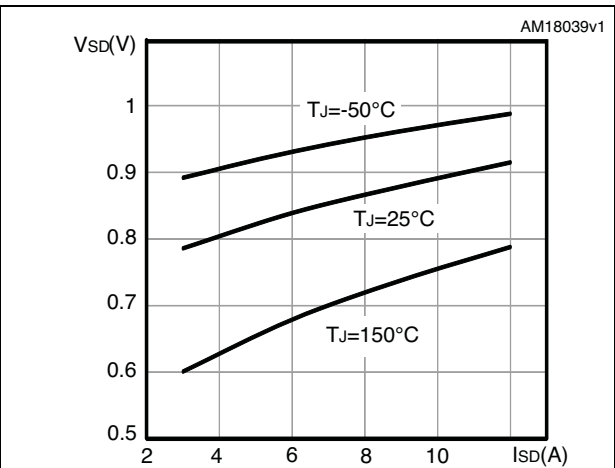
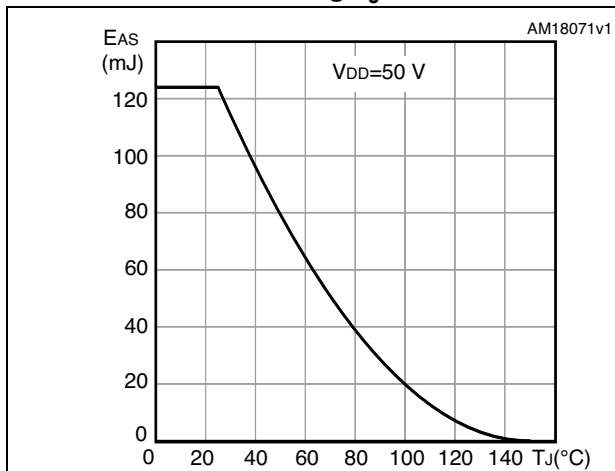


Figure 18. Maximum avalanche energy vs starting T_J



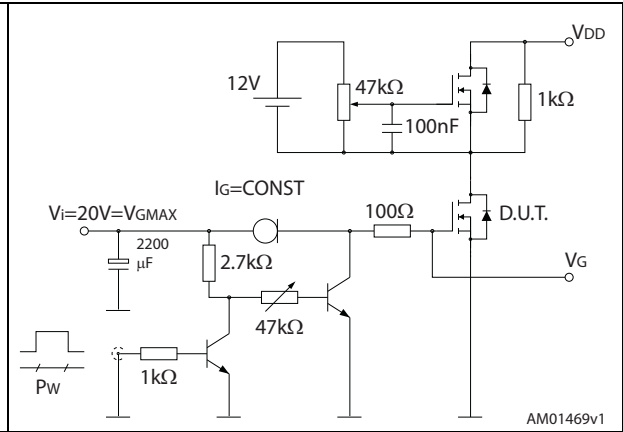
3 Test circuits

Figure 19. Switching times test circuit for resistive load



AM01468v1

Figure 20. Gate charge test circuit



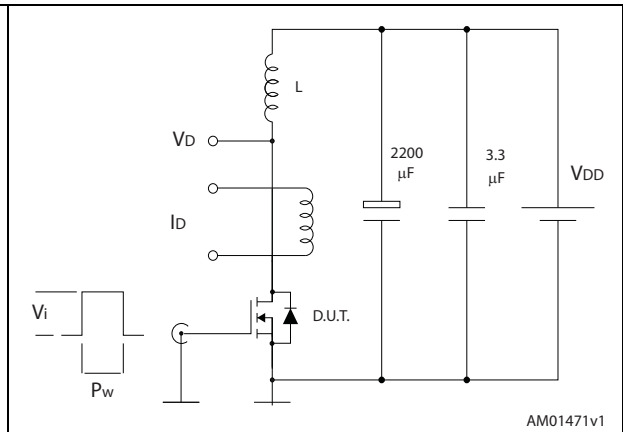
AM01469v1

Figure 21. Test circuit for inductive load switching and diode recovery times



AM01470v1

Figure 22. Unclamped inductive load test circuit



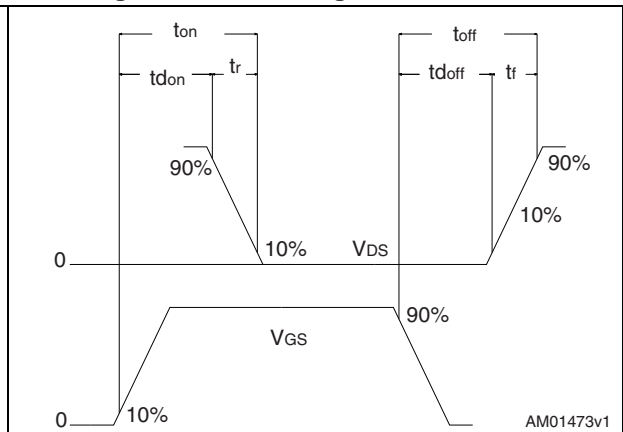
AM01471v1

Figure 23. Unclamped inductive waveform



AM01472v1

Figure 24. Switching time waveform



AM01473v1

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.

Figure 25. TO-220FP drawing

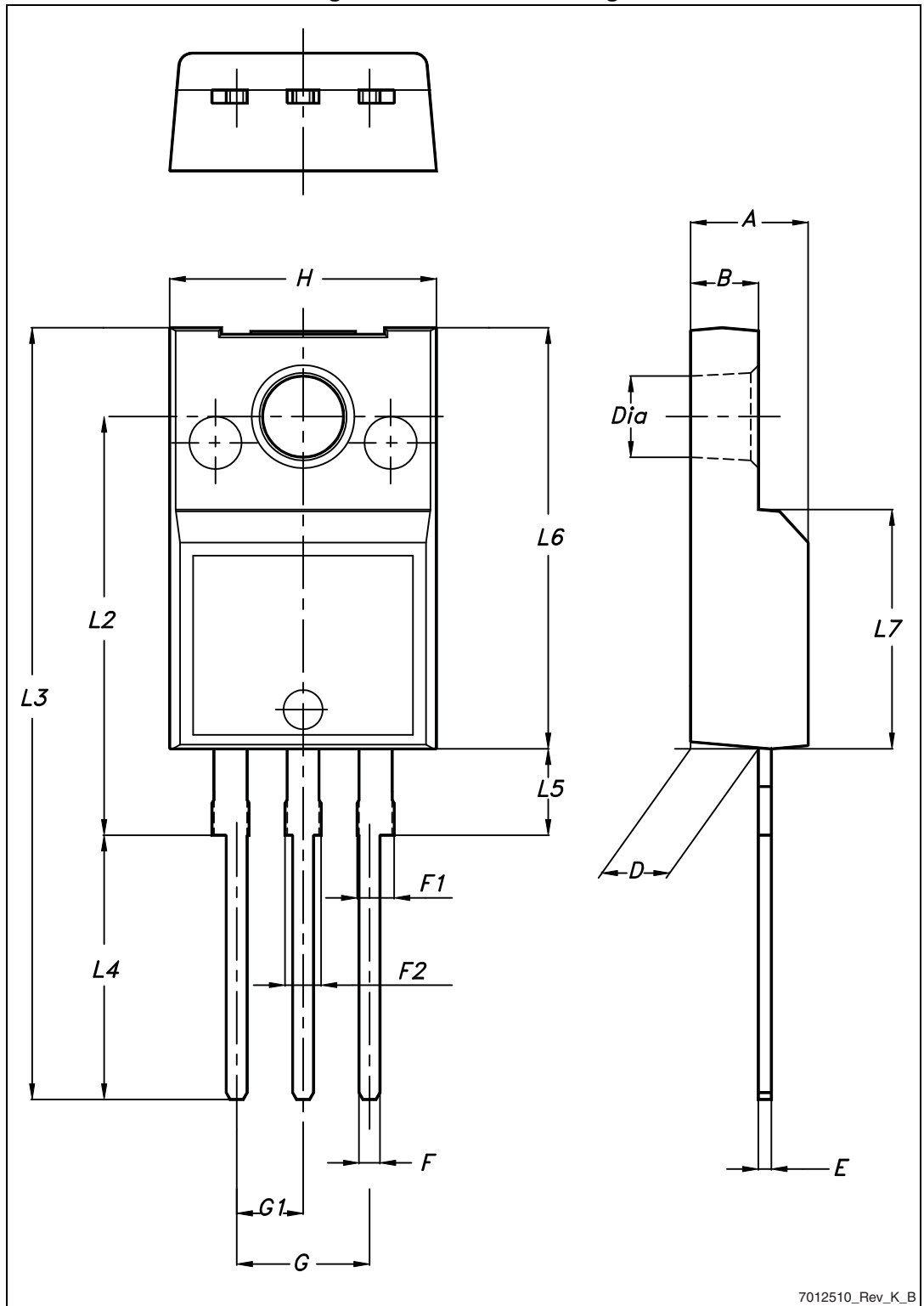


Table 9. TO-220FP mechanical data

| 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 26. TO-220 type A drawing

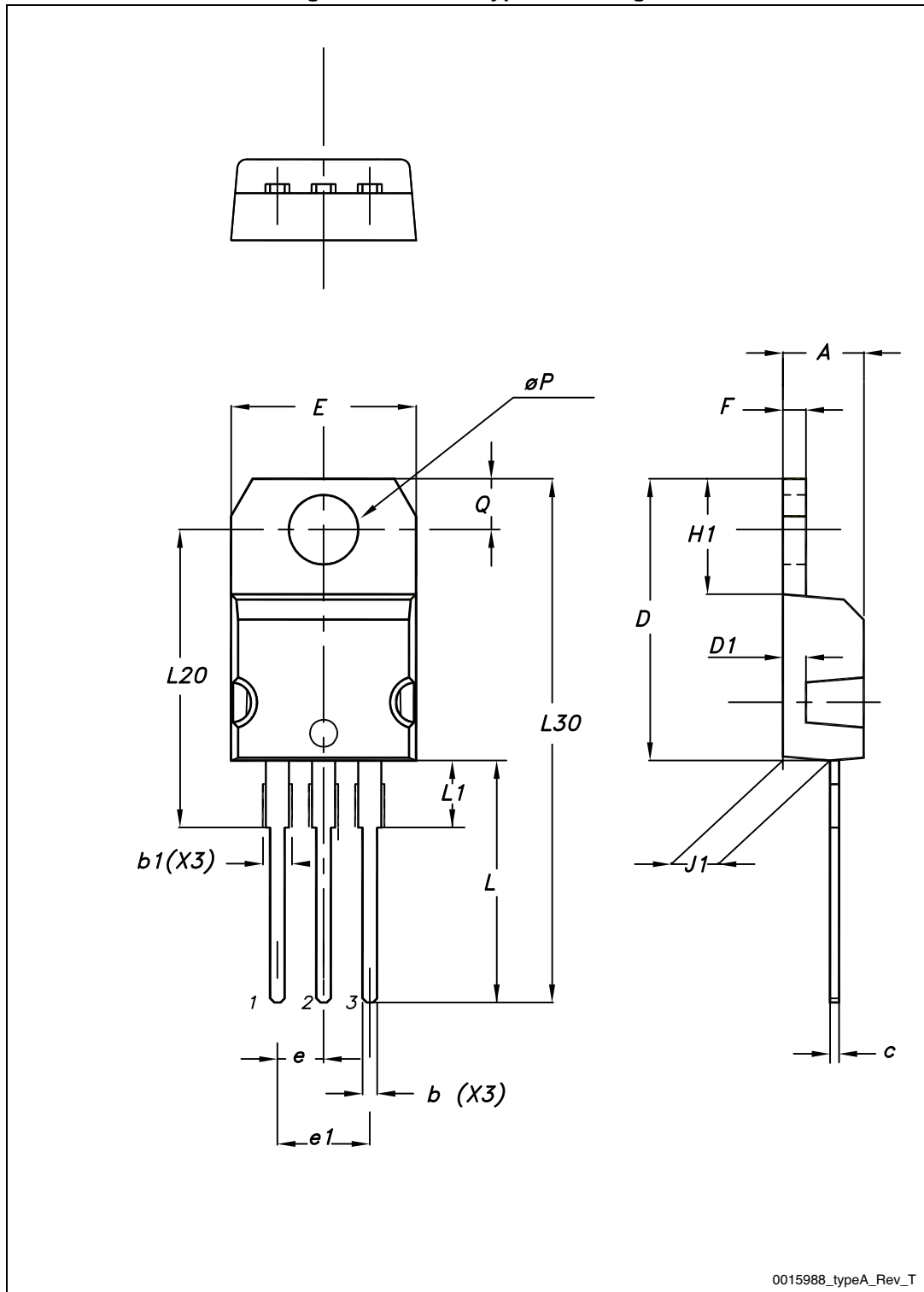
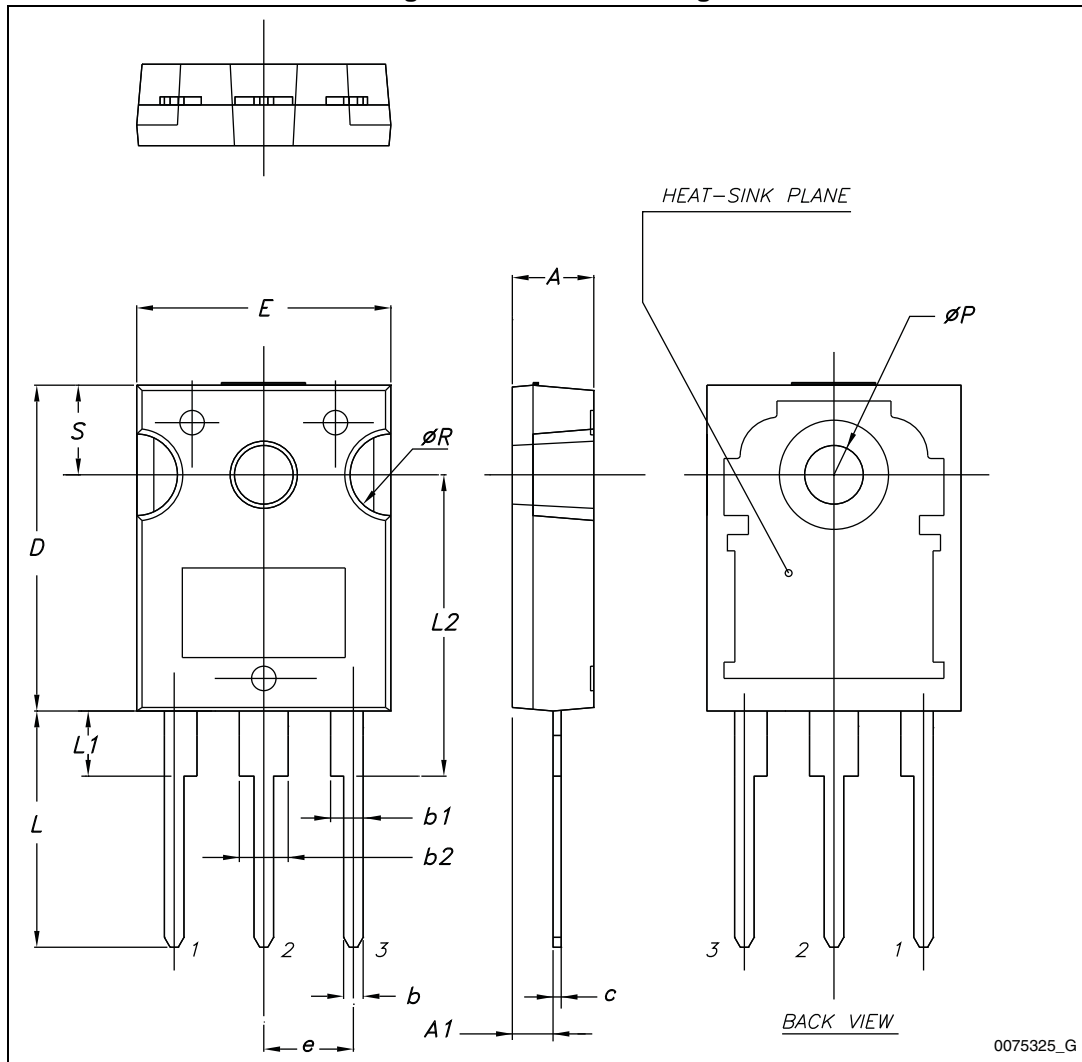


Table 10. TO-220 type A mechanical data

| 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 | |
| ØP | 3.75 | | 3.85 |
| Q | 2.65 | | 2.95 |

Figure 27. TO-247 drawing



0075325_G

Table 11. 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 |

Table 11. TO-247 mechanical data (continued)

| Dim. | mm. | | |
|------|-------|-------|-------|
| | Min. | Typ. | Max. |
| e | 5.30 | 5.45 | 5.60 |
| L | 14.20 | | 14.80 |
| L1 | 3.70 | | 4.30 |
| L2 | | 18.50 | |
| ØP | 3.55 | | 3.65 |
| ØR | 4.50 | | 5.50 |
| S | 5.30 | 5.50 | 5.70 |

5 Revision history

Table 12. Document revision history

| Date | Revision | Changes |
|-------------|----------|--|
| 20-Sep-2013 | 1 | First release. |
| 07-Feb-2014 | 2 | <ul style="list-style-type: none">– Modified: I_{AR} and E_{AS} values in Table 2– Added: note 4 in Table 2– Modified: $R_{thj-case}$ values in Table 3– Modified: typical values in Table 5, 6 and 7– Added: Section 2.1: Electrical characteristics (curves)– Updated: Figure 19, 20, 21 and 22– Minor text changes |

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