# STF12N120K5, STFW12N120K5

## N-channel 1200 V, 0.62 Ω typ., 12 A MDmesh™ K5 Power MOSFETs in TO-220FP and TO-3PF packages

**Datasheet - production data**

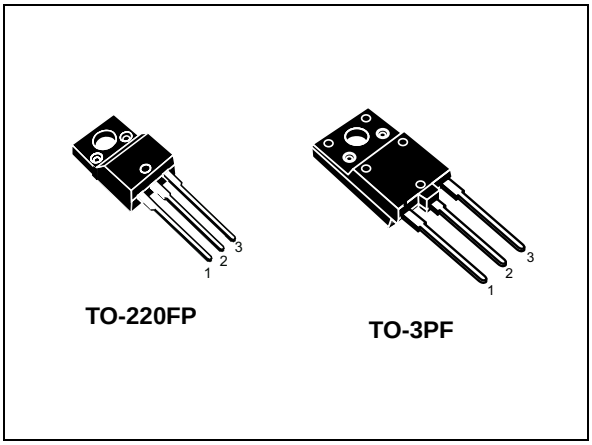
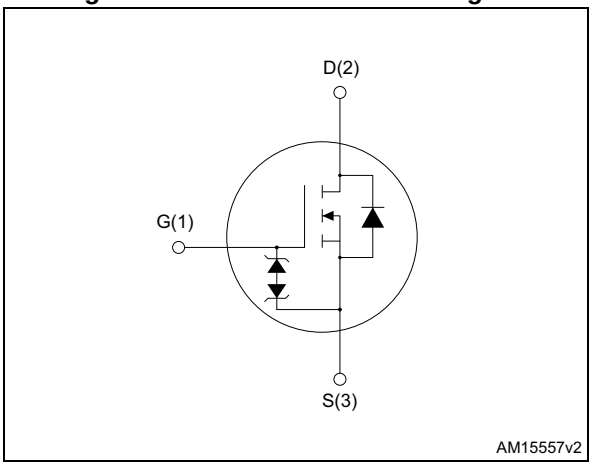



**Figure 1. Internal schematic diagram**




## Features

| Order code | $V_{DS}$ | $R_{DS(on)}$ max. | $I_D$ | $P_{TOT}$ |
|---|---|---|---|---|
| STF12N120K5 | 1200 V | 0.69 Ω | 12 A | 40 W |
| STFW12N120K5 | | | | 63 W |

- Industry's lowest $R_{DS(on)}$ x area
- Industry's best figure of merit (FoM)
- Ultra low gate charge
- 100% avalanche tested
- Zener-protected

## Applications

- Switching applications

## Description

These very high voltage N-channel Power MOSFETs are designed using MDmesh™ K5 technology based on an innovative proprietary vertical structure. The result is a dramatic reduction in on-resistance and ultra-low gate charge for applications requiring superior power density and high efficiency.

**Table 1. Device summary**

| Order code | Marking | Packages | Packing |
|---|---|---|---|
| STF12N120K5 | 12N120K5 | TO-220FP | Tube |
| STFW12N120K5 | | TO-3PF | |

# Contents

# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol | Parameter | Value | | Unit |
|---|---|---|---|---|
| | | TO-220FP | TO-3PF | |
| $V_{GS}$ | Gate-source voltage | ± 30 | | V |
| $I_D$ | Drain current at $T_C$ = 25 °C | 12 | | A |
| $I_D$ | Drain current at $T_C$ = 100 °C | 7.6 | | A |
| $I_{DM}$ (1) | Drain current (pulsed) | 48 | | A |
| $P_{TOT}$ | Total dissipation at $T_C$ = 25 °C | 40 | 63 | W |
| $V_{ISO}$ | Insulation withstand voltage (RMS) from all three leads to external heat sink (t = 1 s, $T_C$ = 25 °C) | 2500 | 3500 | V |
| $I_{AR}$ (2) | Max current during repetitive or single pulse avalanche | 4 | | A |
| $E_{AS}$ (3) | Single pulse avalanche energy | 215 | | mJ |
| dv/dt (4) | Peak diode recovery voltage slope | 4.5 | | V/ns |
| dv/dt (5) | MOSFET dv/dt ruggedness | 50 | | V/ns |
| $T_j$<br>$T_{stg}$ | Operating junction temperature<br>Storage temperature | - 55 to 150 | | °C |

1. Pulse width limited by safe operating area.
2. Pulse width limited by $T_{Jmax.}$
3. Starting $T_J$ = 25 °C, $I_D$=$I_{AS}$, $V_{DD}$= 50 V
4. $I_{SD} \leq$ 12 A, di/dt $\leq$ 100 A/µs, $V_{Peak} \leq V_{(BR)DSS}$
5. $V_{DS} \leq$ 960 V

**Table 3. Thermal data**

| Symbol | Parameter | Value | | Unit |
|---|---|---|---|---|
| | | TO-220FP | TO-3PF | |
| $R_{thj\text{-}case}$ | Thermal resistance junction-case max | 3.1 | 1.98 | °C/W |
| $R_{thj\text{-}amb}$ | Thermal resistance junction-amb max | 62.5 | 50 | °C/W |

# 2 Electrical characteristics

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

**Table 4. On/off states**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage, ($V_{GS}$= 0) | $I_D$ = 1 mA | 1200 | | | V |
| $I_{DSS}$ | Zero gate voltage drain current ($V_{GS}$ = 0) | $V_{DS}$ = 1200 V | | | 1 | µA |
| | | $V_{DS}$ = 1200 V, Tc=125 °C | | | 50 | µA |
| $I_{GSS}$ | Gate body leakage current ($V_{DS}$ = 0) | $V_{GS}$ = ± 20 V | | | ±10 | µA |
| $V_{GS(th)}$ | Gate threshold voltage | $V_{DS}$ = $V_{GS}$, $I_D$ = 100 µA | 3 | 4 | 5 | V |
| $R_{DS(on)}$ | Static drain-source on resistance | $V_{GS}$ = 10 V, $I_D$= 6 A | | 0.62 | 0.69 | Ω |

**Table 5. Dynamic**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $C_{iss}$ | Input capacitance | $V_{DS}$ =100 V, f=1 MHz, $V_{GS}$=0 | - | 1370 | - | pF |
| $C_{oss}$ | Output capacitance | | - | 110 | - | pF |
| $C_{rss}$ | Reverse transfer capacitance | | - | 0.6 | - | pF |
| $C_{o(tr)}$(1) | Equivalent capacitance, time-related | $V_{GS}$ = 0, $V_{DS}$ = 0 to 960 V | - | 128 | - | pF |
| $C_{o(er)}$(2) | Equivalent capacitance, energy-related | | - | 42 | - | pF |
| $R_G$ | Intrinsic gate resistance | f = 1 MHz, $I_D$ = 0 | - | 3.5 | - | Ω |
| $Q_g$ | Total gate charge | $V_{DD}$ = 960 V, $I_D$ = 6 A $V_{GS}$ =10 V *(see Figure 18)* | - | 44.2 | - | nC |
| $Q_{gs}$ | Gate-source charge | | - | 7.3 | - | nC |
| $Q_{gd}$ | Gate-drain charge | | - | 30 | - | 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 |
|---|---|---|---|---|---|---|
| $t_{d(on)}$ | Turn-on delay time | $V_{DD}$ = 600 V, $I_D$ = 6 A, $R_G$=4.7 Ω, $V_{GS}$=10 V *(see Figure 20)* | - | 23 | - | ns |
| $t_r$ | Rise time | | - | 11 | - | ns |
| $t_{d(off)}$ | Turn-off delay time | | - | 68.5 | - | ns |
| $t_f$ | Fall time | | - | 18.5 | - | 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 A, $V_{GS}$=0 | - | | 1.5 | V |
| $t_{rr}$ | Reverse recovery time | $I_{SD}$= 12 A, $V_{DD}$= 60 V di/dt = 100 A/µs, *(see Figure 19)* | - | 630 | | ns |
| $Q_{rr}$ | Reverse recovery charge | | - | 12.6 | | µC |
| $I_{RRM}$ | Reverse recovery current | | - | 40 | | A |
| $t_{rr}$ | Reverse recovery time | $I_{SD}$= 12 A,$V_{DD}$= 60 V di/dt=100 A/µs, Tj=150 °C *(see Figure 19)* | - | 892 | | ns |
| $Q_{rr}$ | Reverse recovery charge | | - | 15.6 | | µC |
| $I_{RRM}$ | Reverse recovery current | | - | 35 | | A |

1. Pulsed: pulse duration = 300µs, 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 | $I_{GS}$ = ±1 mA, $I_D$ = 0 | 30 | - | | V |

The built-in back-to-back Zener diodes have been specifically designed to enhance the ESD capability of the device. The Zener voltage is appropriate for efficient and cost-effective intervention to protect the device integrity. These integrated Zener diodes thus eliminate the need for external components.

## 2.1 Electrical characteristics (curves)

**Figure 2. Safe operating area for TO-220FP**

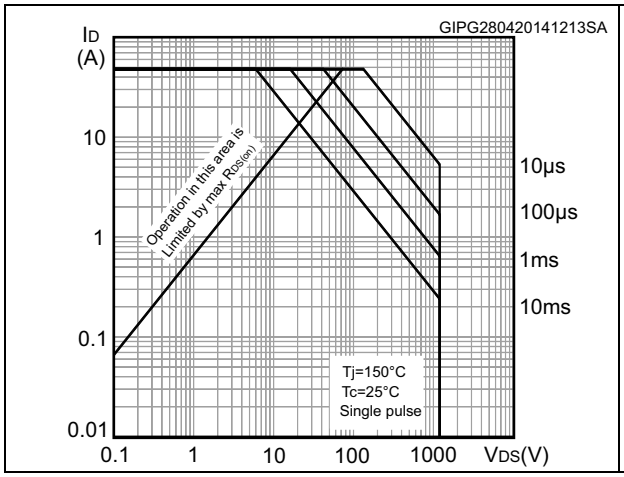



**Figure 3. Thermal impedance for TO-220FP**

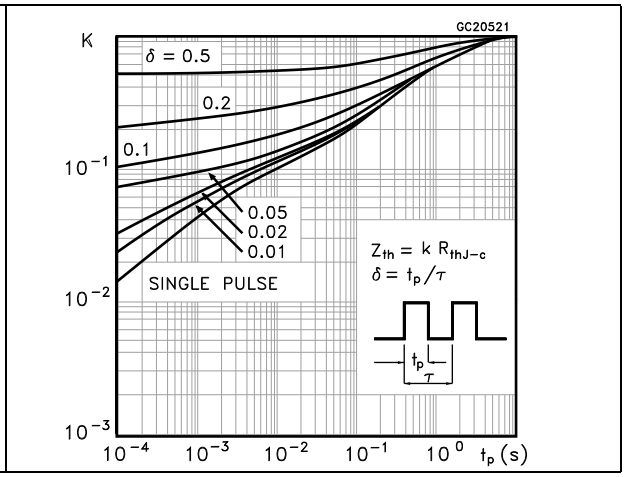



**Figure 4. Safe operating area for TO-3PF**

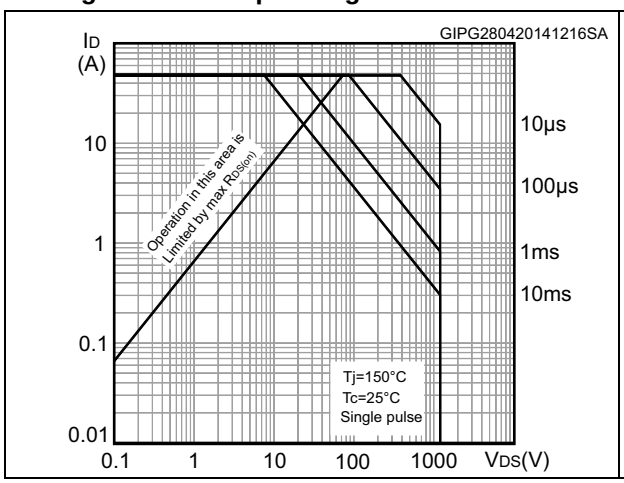



**Figure 5. Thermal impedance for TO-3PF**

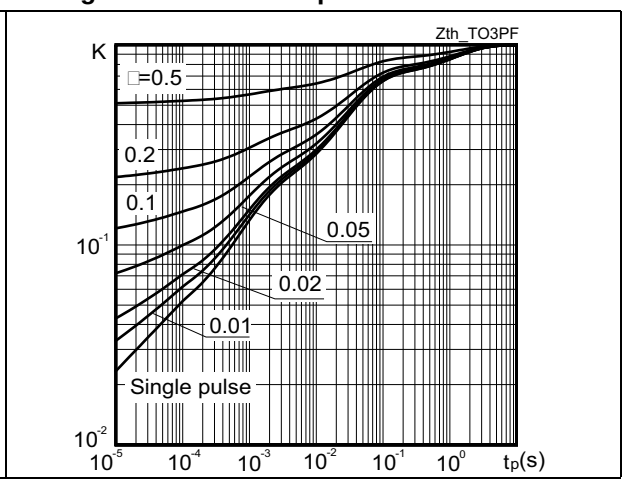



**Figure 6. Output characteristics**

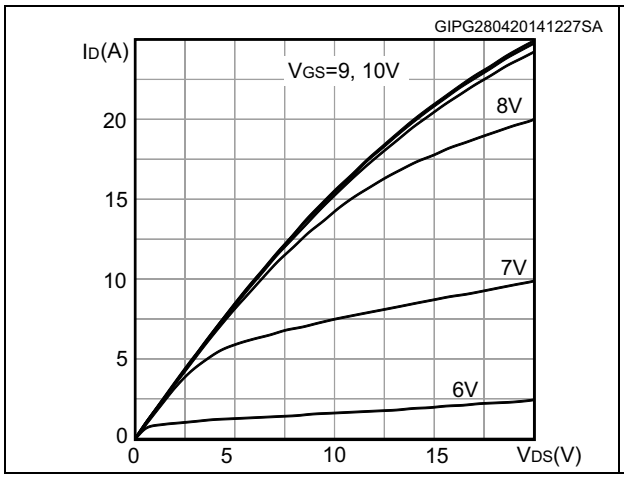



**Figure 7. Transfer characteristics**

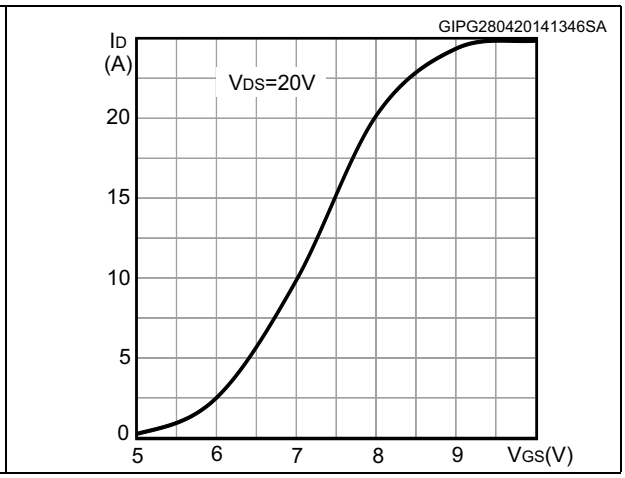


**Figure 8. Gate charge vs gate-source voltage**

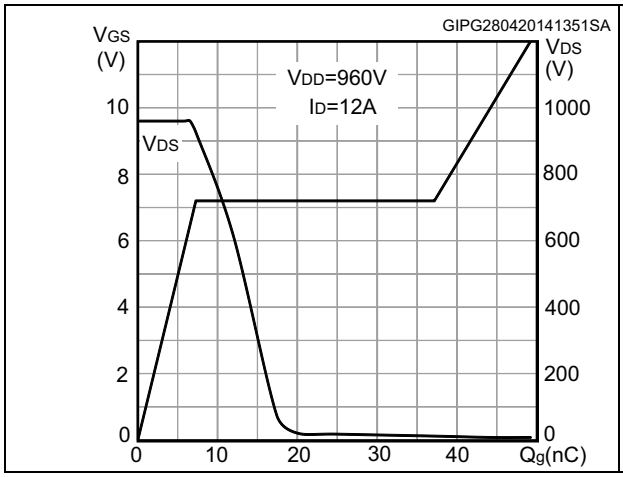



**Figure 9. Static drain-source on-resistance**

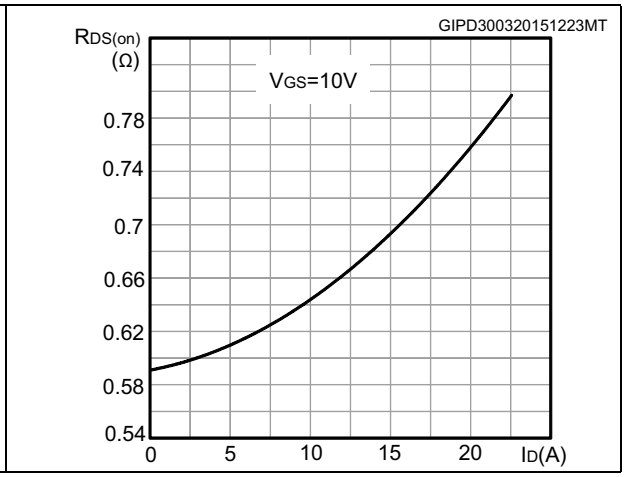



**Figure 10. Capacitance variations**

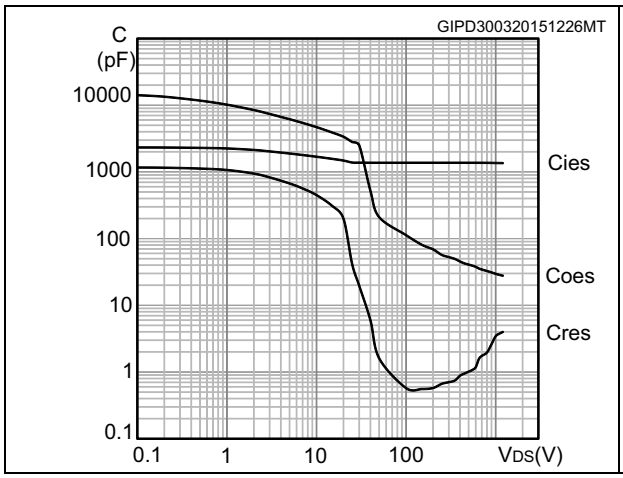



**Figure 11. Output capacitance stored energy**

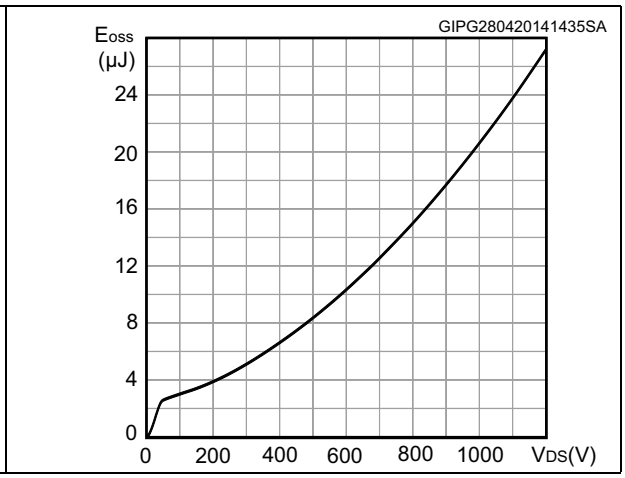



**Figure 12. Normalized gate threshold voltage vs temperature**

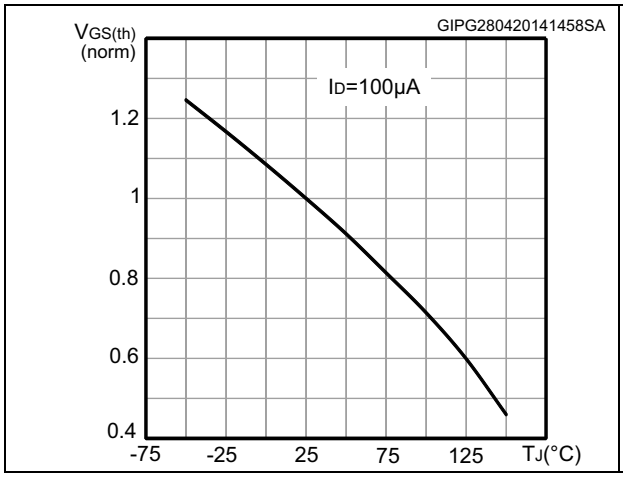



**Figure 13. Normalized on-resistance vs temperature**

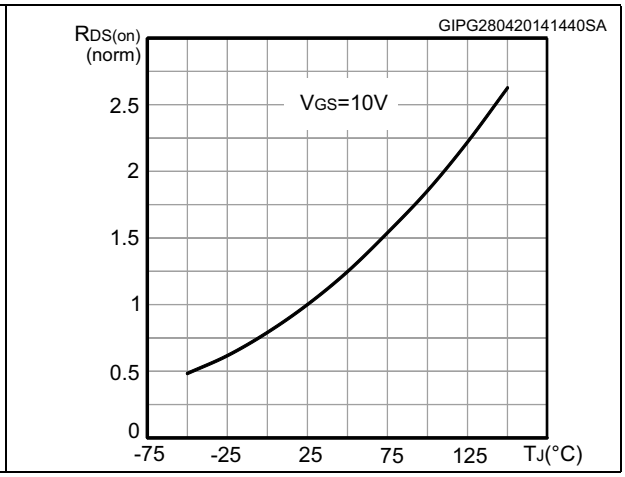


**Figure 14. Normalized $V_{(BR)DSS}$ vs temperature**

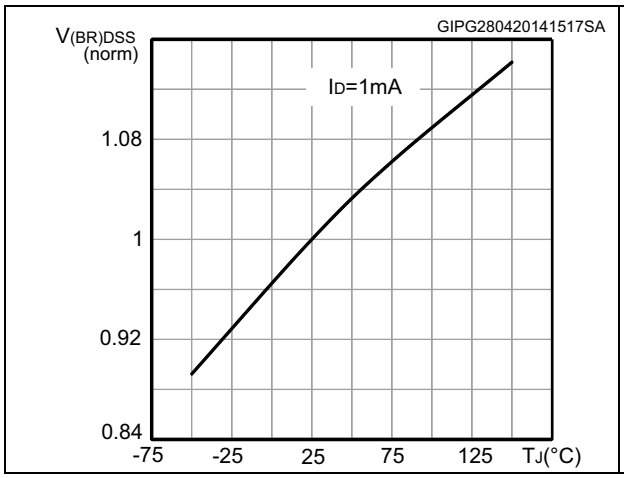



**Figure 15. Source-drain diode forward characteristics**

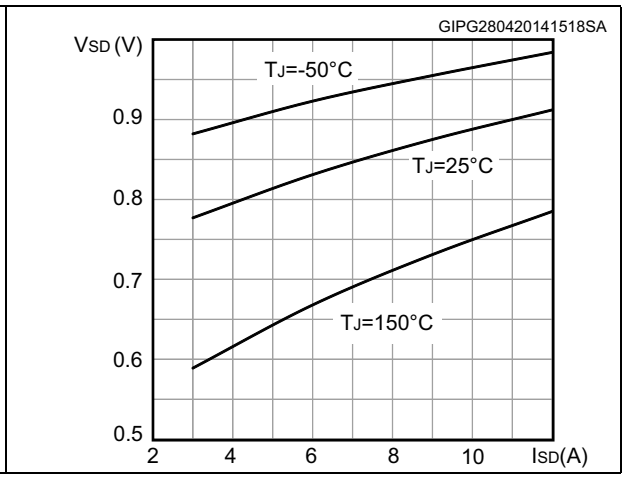
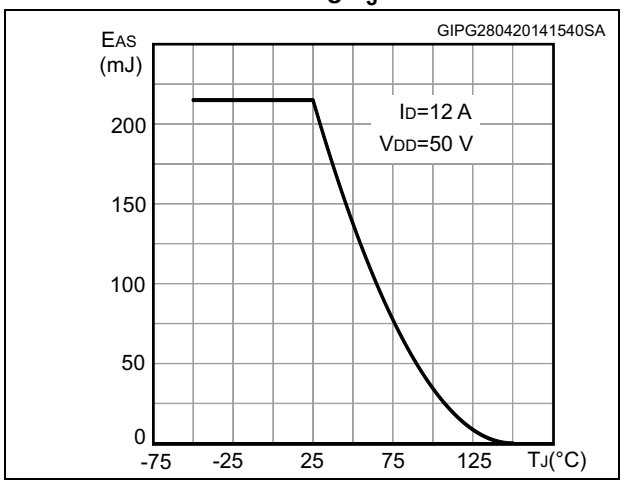



**Figure 16. Maximum avalanche energy vs starting $T_J$**



# 3 Test circuits

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

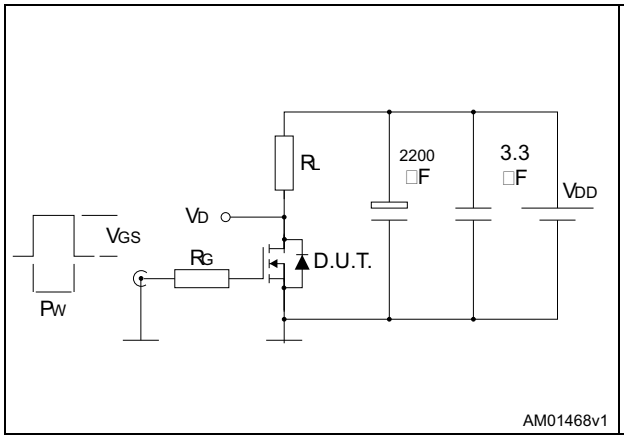



**Figure 18. Gate charge test circuit**

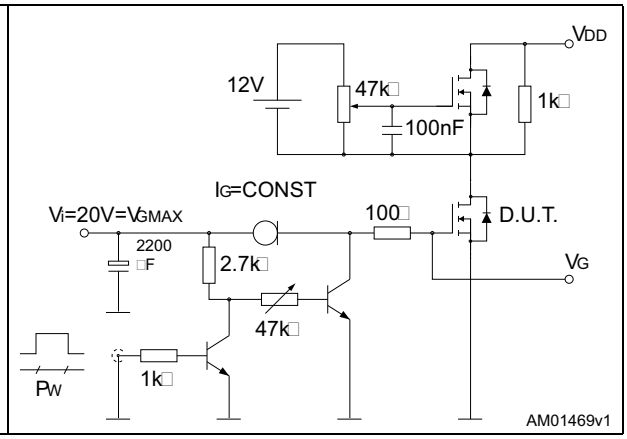



**Figure 19. Test circuit for inductive load switching and diode recovery times**

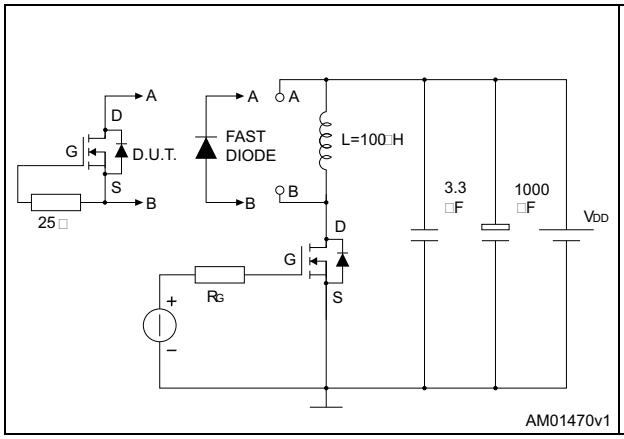



**Figure 20. Unclamped inductive load test circuit**

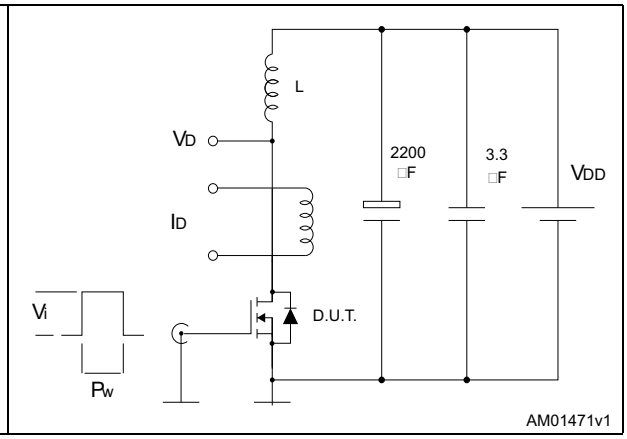



**Figure 21. Unclamped inductive waveform**

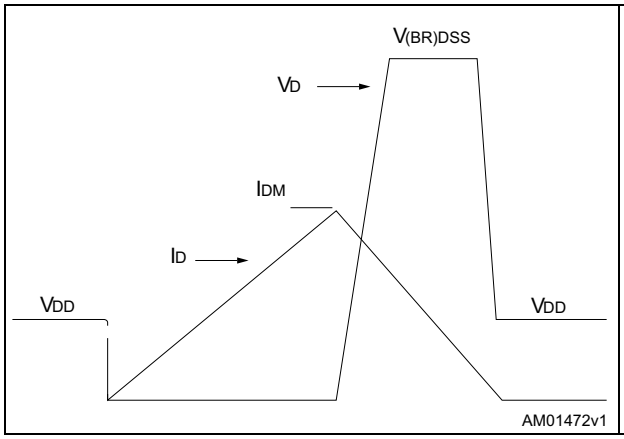
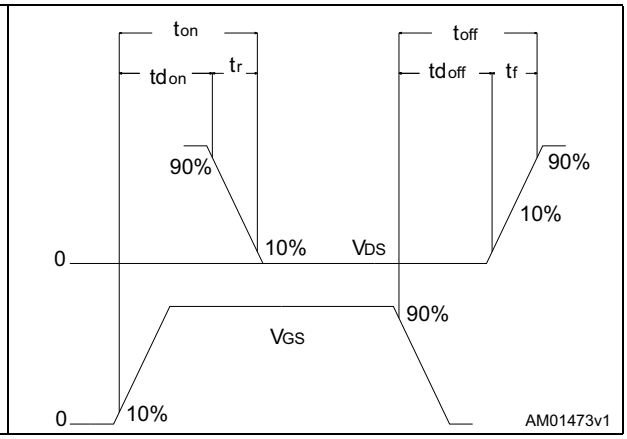



**Figure 22. Switching time waveform**



# 4 Package information

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.

## 4.1 TO-220FP, package information

Figure 23. TO-220FP package outline

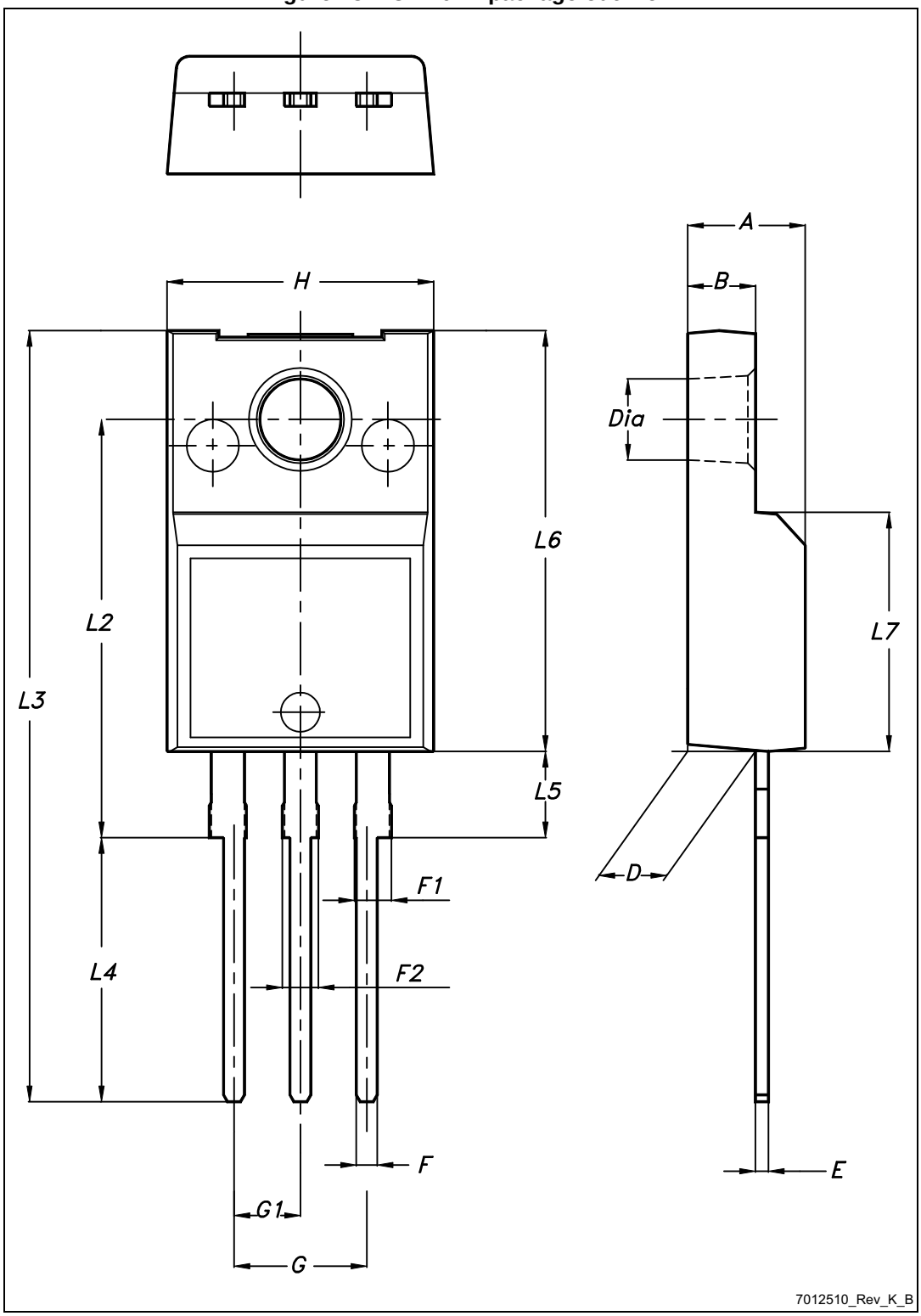


**Table 9. TO-220FP mechanical data**

| 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 |
| Ø | 3 | | 3.2 |

## 4.2 TO-3PF, package outline

**Figure 24. TO-3PF package outline**

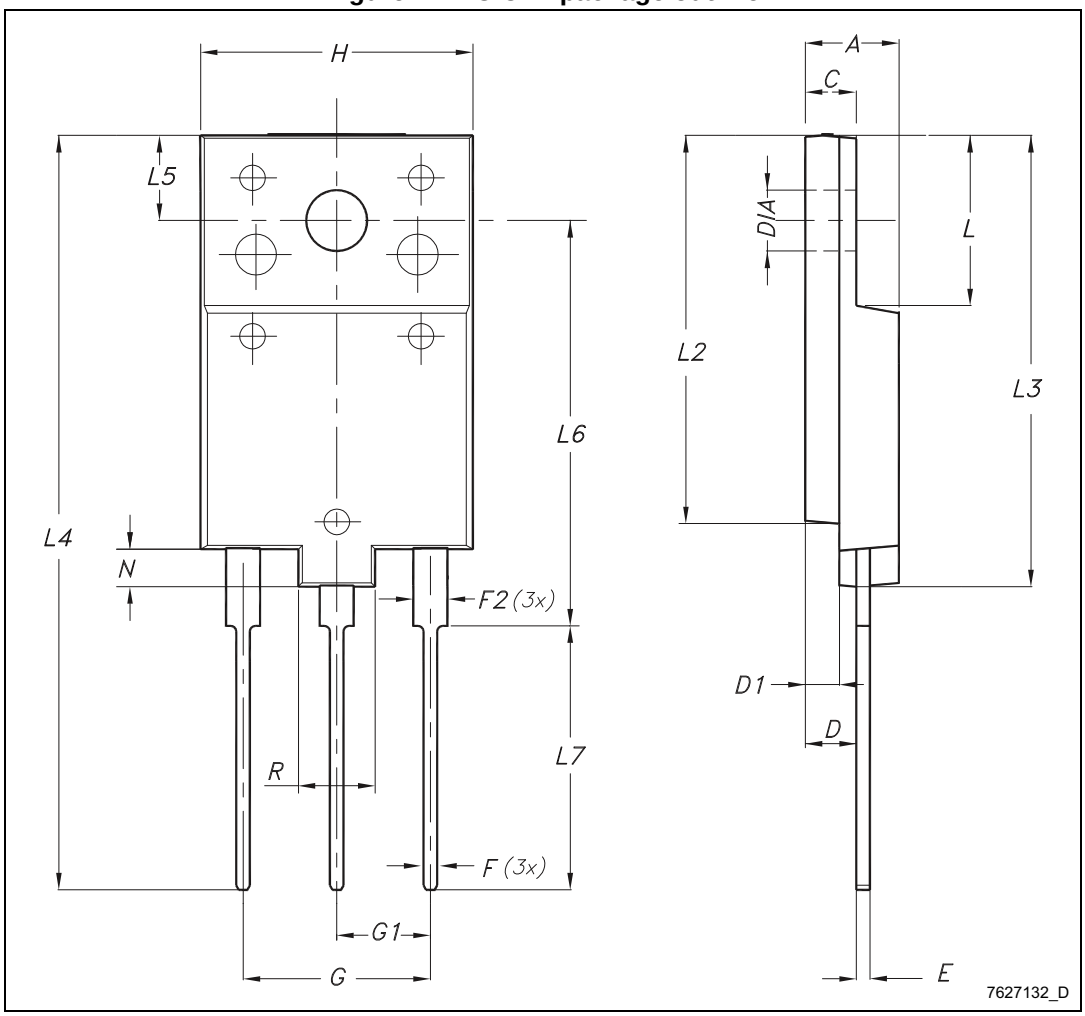


**Table 10. TO-3PF mechanical data**

| Dim. | mm | | |
|---|---|---|---|
| | Min. | Typ. | Max. |
| A | 5.30 | | 5.70 |
| C | 2.80 | | 3.20 |
| D | 3.10 | | 3.50 |
| D1 | 1.80 | | 2.20 |
| E | 0.80 | | 1.10 |
| F | 0.65 | | 0.95 |
| F2 | 1.80 | | 2.20 |
| G | 10.30 | | 11.50 |
| G1 | | 5.45 | |
| H | 15.30 | | 15.70 |
| L | 9.80 | 10 | 10.20 |
| L2 | 22.80 | | 23.20 |
| L3 | 26.30 | | 26.70 |
| L4 | 43.20 | | 44.40 |
| L5 | 4.30 | | 4.70 |
| L6 | 24.30 | | 24.70 |
| L7 | 14.60 | | 15 |
| N | 1.80 | | 2.20 |
| R | 3.80 | | 4.20 |
| ∅ | 3.40 | | 3.80 |

# 5 Revision history

Table 11. Document revision history

| Date | Revision | Changes |
|---|---|---|
| 22-May-2014 | 1 | First release. Part number (STFW12N120K5) previously included in datasheet DocID022133 |
| 11-May-2015 | 2 | Updated title, features and description.<br>Updated *Table 4.: On/off states* and *Table 5.: Dynamic*.<br>Updated *Figure 9.: Static drain-source on-resistance* and *Figure 10.: Capacitance variations*<br>Minor text changes. |