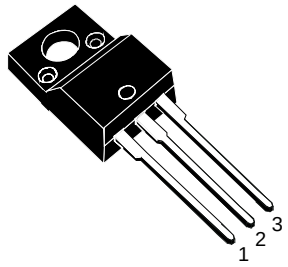
# STFU9N65M2

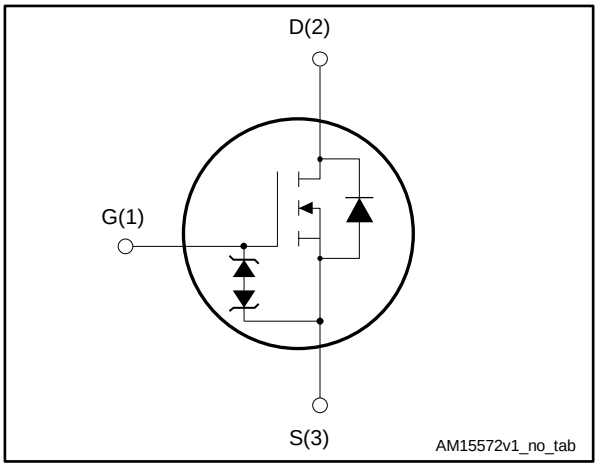
## N-channel 650 V, 0.79 Ω typ., 5 A MDmesh M2 Power MOSFET in a TO-220FP ultra narrow leads package

Datasheet - production data




**TO-220FP**
**ultra narrow leads**

**Figure 1: Internal schematic diagram**




## Features

| Order code | $V_{DS}$ | $R_{DS(on)}$ max. | $I_D$ |
|---|---|---|---|
| STFU9N65M2 | 650 V | 0.90 Ω | 5 A |

- Extremely low gate charge
- Excellent output capacitance ($C_{OSS}$) profile
- 100% avalanche tested
- Zener-protected

## Applications

- Switching applications

## Description

This device is an N-channel Power MOSFET developed using MDmesh™ M2 technology. Thanks to its strip layout and an improved vertical structure, the device exhibits low on-resistance and optimized switching characteristics, rendering it suitable for the most demanding high efficiency converters.

**Table 1: Device summary**

| Order code | Marking | Package | Packing |
|---|---|---|---|
| STFU9N65M2 | 9N65M2 | TO-220FP ultra narrow leads | Tube |

# Contents

# 1 Electrical ratings

**Table 2: Absolute maximum ratings**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{GS}$ | Gate-source voltage | ± 25 | V |
| $I_D$ (1) | Drain current (continuous) at $T_C$ = 25 °C | 5 | A |
| $I_D$ (1) | Drain current (continuous) at $T_C$ = 100 °C | 3.2 | A |
| $I_{DM}$ (2) | Drain current pulsed | 20 | A |
| $P_{TOT}$ | Total dissipation at $T_C$ = 25 °C | 20 | W |
| $V_{ISO}$ | Insulation withstand voltage (RMS) from all three leads to external heat sink (t=1 s;$T_C$=25 °C) | 2500 | V |
| dv/dt (3) | Peak diode recovery voltage slope | 15 | V/ns |
| dv/dt (4) | MOSFET dv/dt ruggedness | 50 | |
| $T_j$ | Operating junction temperature range | - 55 to 150 | °C |
| $T_{stg}$ | Storage temperature range | | |

**Notes:**

(1)Current limited by package.

(2)Pulse width limited by safe operating area.

(3)$I_{SD}$ ≤ 5 A, di/dt ≤ 400 A/µs, $V_{DS}$ (peak) ≤ $V_{(BR)DSS}$, $V_{DD}$ = 400 V

(4)$V_{DS}$ ≤ 520 V

**Table 3: Thermal data**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $R_{thj\text{-}case}$ | Thermal resistance junction-case | 6.25 | °C/W |
| $R_{thj\text{-}amb}$ | Thermal resistance junction-ambient | 62.5 | °C/W |

**Table 4: Avalanche characteristics**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $I_{AR}$ | Avalanche current, repetitive or not repetitive (pulse width limited by $T_{jmax}$) | 1 | A |
| $E_{AS}$ | Single pulse avalanche energy (starting Tj = 25 °C, $I_D$ = $I_{AR}$, $V_{DD}$ = 50 V) | 105 | mJ |

# 2 Electrical characteristics

($T_{CASE}$ = 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 | $V_{GS}$ = 0 V, $I_D$ = 1 mA | 650 | | | V |
| $I_{DSS}$ | Zero gate voltage drain current | $V_{GS}$ = 0 V, $V_{DS}$ = 650 V | | | 1 | µA |
| | | $V_{GS}$ = 0 V, $V_{DS}$ = 650 V, Tc=125 °C(1) | | | 100 | µA |
| $I_{GSS}$ | Gate body leakage current | $V_{DS}$ = 0 V, $V_{GS}$ = ± 25 V | | | ±10 | µA |
| $V_{GS(th)}$ | Gate threshold voltage | $V_{DS}$ = $V_{GS}$, $I_D$ = 250 µA | 2 | 3 | 4 | V |
| $R_{DS(on)}$ | Static drain-source on-resistance | $V_{GS}$ = 10 V, $I_D$ = 2.5 A | | 0.79 | 0.90 | Ω |

**Notes:**

(1)Defined by design, not subject to production test.

**Table 6: Dynamic**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $C_{iss}$ | Input capacitance | $V_{GS}$ = 0 V, $V_{DS}$ = 100 V, f = 1MHz | - | 315 | - | pF |
| $C_{oss}$ | Output capacitance | | - | 18 | - | pF |
| $C_{rss}$ | Reverse transfer capacitance | | - | 1 | - | pF |
| $C_{oss\ eq}$(1) | Equivalent output capacitance | $V_{DS}$ = 0 V to 520 V, $V_{GS}$ = 0 V | - | 109 | - | pF |
| $R_G$ | Intrinsic gate resistance | f = 1 MHz, $I_D$ = 0 A | - | 6.6 | - | Ω |
| $Q_g$ | Total gate charge | $V_{DD}$ = 520 V, $I_D$ = 5 A $V_{GS}$ = 10 V (see *Figure 15: "Test circuit for gate charge behavior"*) | - | 10 | - | nC |
| $Q_{gs}$ | Gate-source charge | | - | 2.5 | - | nC |
| $Q_{gd}$ | Gate-drain charge | | - | 5 | - | nC |

**Notes:**

(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 |
|---|---|---|---|---|---|---|
| $t_{d(on)}$ | Turn-on delay time | $V_{DD}$ = 325 V, $I_D$ = 2.5 A, $R_G$ = 4.7 Ω $V_{GS}$ = 10 V (see *Figure 14: "Test circuit for resistive load switching times"* and *Figure 19: "Switching time waveform"*) | - | 7.5 | - | ns |
| $t_r$ | Rise time | | - | 6.6 | - | ns |
| $t_{d(off)}$ | Turn-off delay time | | - | 22.5 | - | ns |
| $t_f$ | Fall time | | - | 18 | - | ns |

**Table 8: Source drain diode**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $I_{SD}$ | Source-drain current | | - | | 5 | A |
| $I_{SDM}$(1) | Source-drain current (pulsed) | | - | | 10 | A |
| $V_{SD}$(2) | Forward on voltage | $I_{SD}$ = 5 A, $V_{GS}$ = 0 V | - | | 1.6 | V |
| $t_{rr}$ | Reverse recovery time | $I_{SD}$ = 5 A, $V_{DD}$ = 60 V di/dt = 100 A/µs, (see *Figure 16: "Test circuit for inductive load switching and diode recovery times"*) | - | 276 | | ns |
| $Q_{rr}$ | Reverse recovery charge | | - | 1.7 | | µC |
| $I_{RRM}$ | Reverse recovery current | | - | 12.5 | | A |
| $t_{rr}$ | Reverse recovery time | $I_{SD}$ = 5 A,$V_{DD}$ = 60 V di/dt = 100 A/µs, Tj = 150 °C (see *Figure 16: "Test circuit for inductive load switching and diode recovery times"*) | - | 312 | | ns |
| $Q_{rr}$ | Reverse recovery charge | | - | 1.9 | | µC |
| $I_{RRM}$ | Reverse recovery current | | - | 12.4 | | A |

**Notes:**

(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**

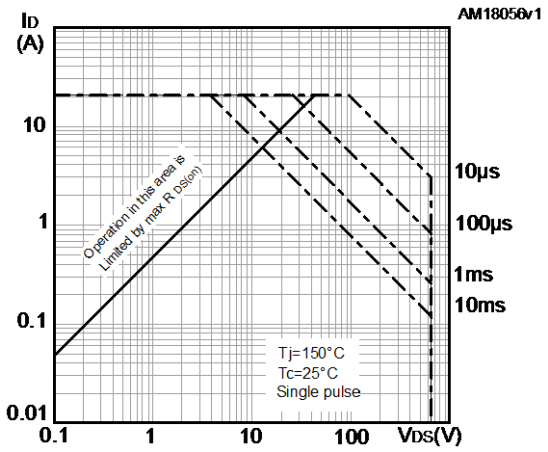



**Figure 3: Thermal Impedance**

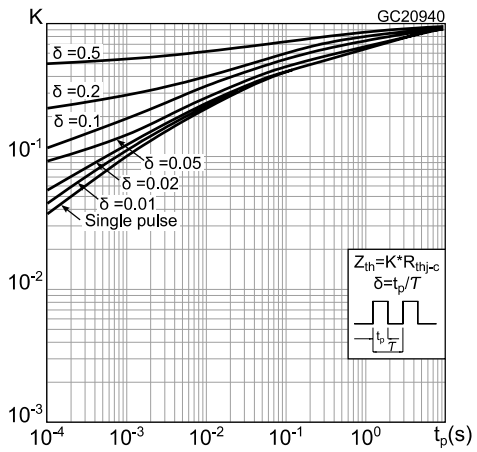



**Figure 4: Output characteristics**

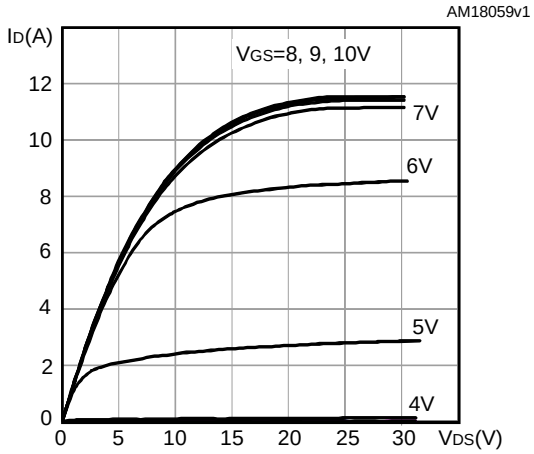



**Figure 5: Transfer characteristics**

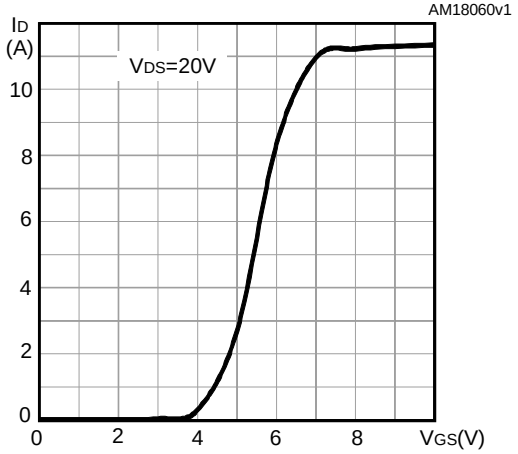



**Figure 6: Gate charge vs gate-source voltage**

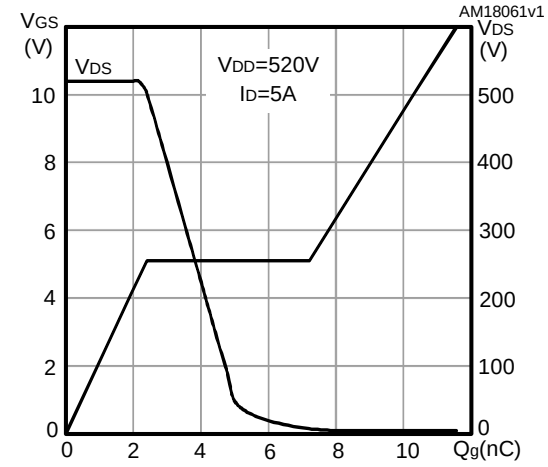



**Figure 7: Static drain-source on-resistance**

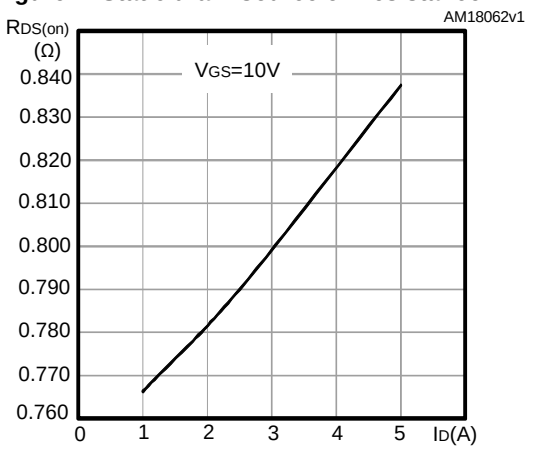


**Figure 8: Capacitance variations**

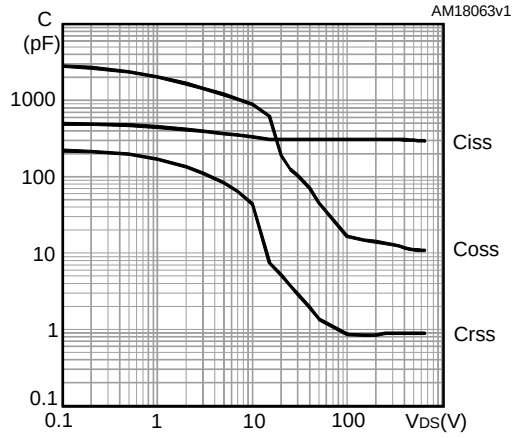



**Figure 9: Output capacitance stored energy**

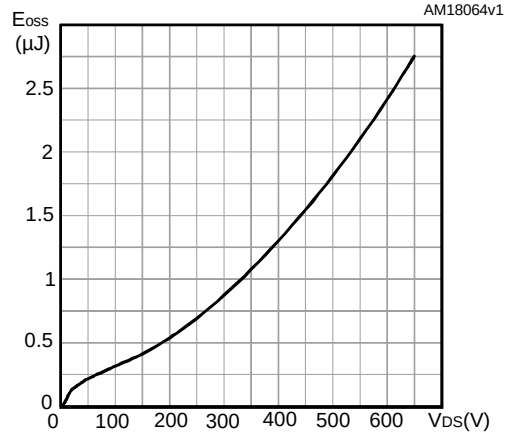



**Figure 10: Normalized gate threshold voltage vs temperature**

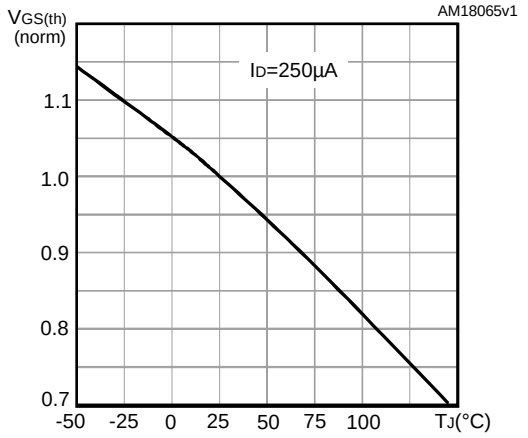



**Figure 11: Normalized on-resistance vs temperature**

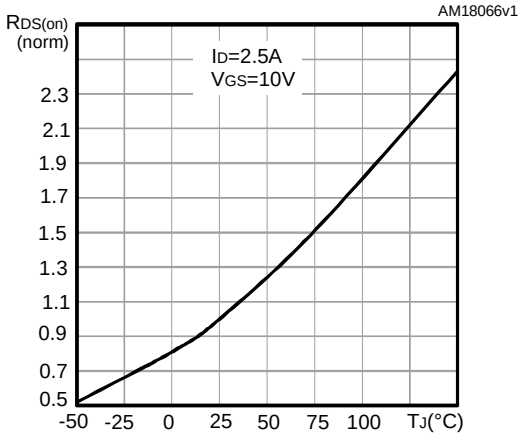



**Figure 12: Normalized V(BR)DSS vs temperature**

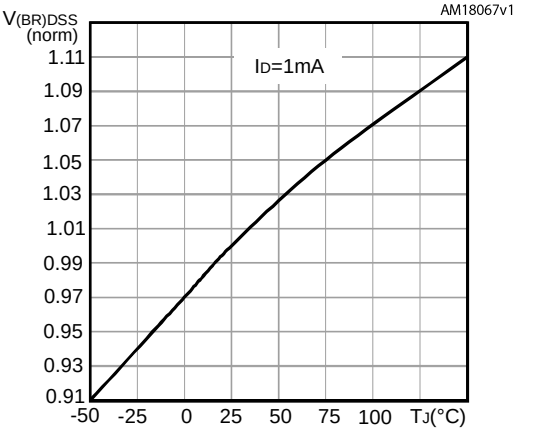
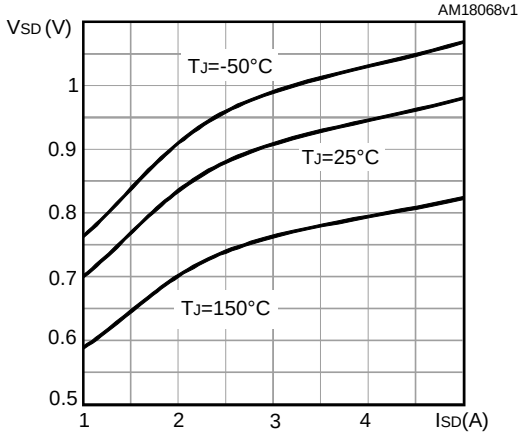



**Figure 13: Source-drain diode forward characteristics**



# 3 Test circuits

**Figure 14: Test circuit for resistive load switching times**

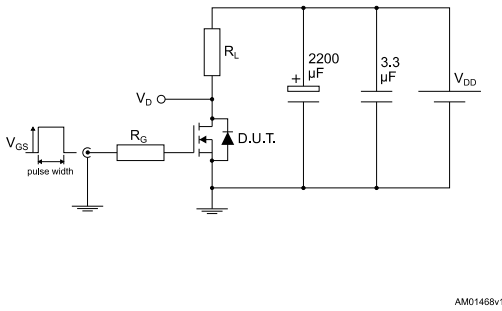



**Figure 15: Test circuit for gate charge behavior**

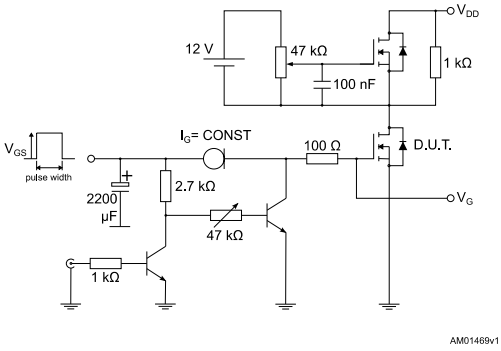



**Figure 16: Test circuit for inductive load switching and diode recovery times**

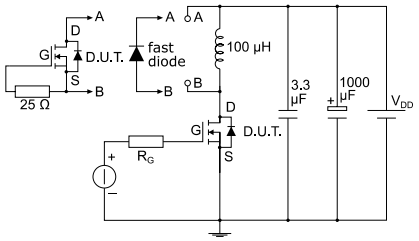



**Figure 17: Unclamped inductive load test circuit**

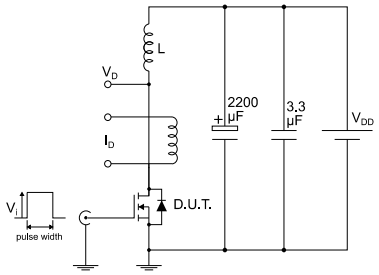



**Figure 18: Unclamped inductive waveform**

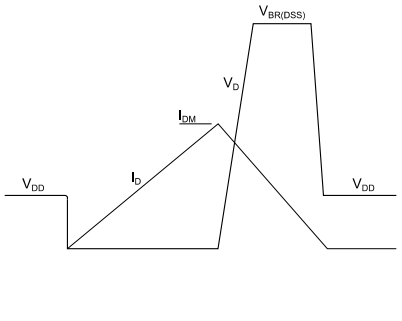
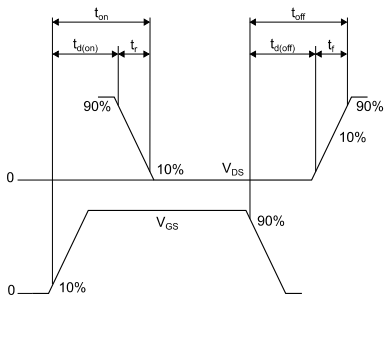



**Figure 19: Switching time waveform**



# 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 ultra narrow leads package information

**Figure 20: TO-220FP ultra narrow leads package outline**

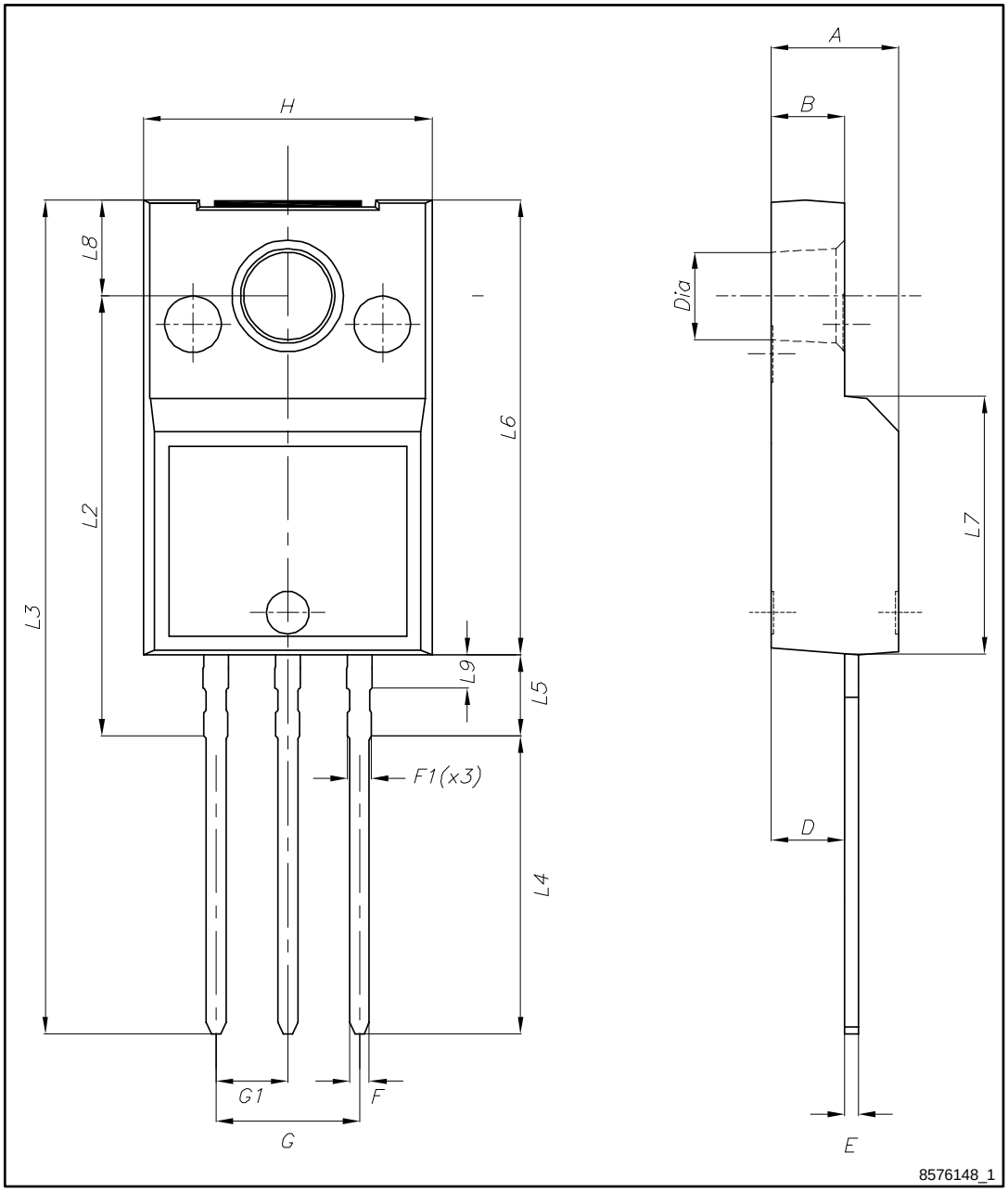


Table 9: TO-220FP ultra narrow leads mechanical data

| Dim. | mm | | |
|---|---|---|---|
| | Min. | Typ. | Max. |
| A | 4.40 | | 4.60 |
| B | 2.50 | | 2.70 |
| D | 2.50 | | 2.75 |
| E | 0.45 | | 0.60 |
| F | 0.65 | | 0.75 |
| F1 | - | | 0.90 |
| G | 4.95 | | 5.20 |
| G1 | 2.40 | 2.54 | 2.70 |
| H | 10.00 | | 10.40 |
| L2 | 15.10 | | 15.90 |
| L3 | 28.50 | | 30.50 |
| L4 | 10.20 | | 11.00 |
| L5 | 2.50 | | 3.10 |
| L6 | 15.60 | | 16.40 |
| L7 | 9.00 | | 9.30 |
| L8 | 3.20 | | 3.60 |
| L9 | - | | 1.30 |
| Dia. | 3.00 | | 3.20 |

# 5 Revision history

Table 10: Document revision history

| Date | Revision | Changes |
|---|---|---|
| 04-Aug-2016 | 1 | First release. |
| 08-Sep-2016 | 2 | Document status updated from preliminary to production data. |

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