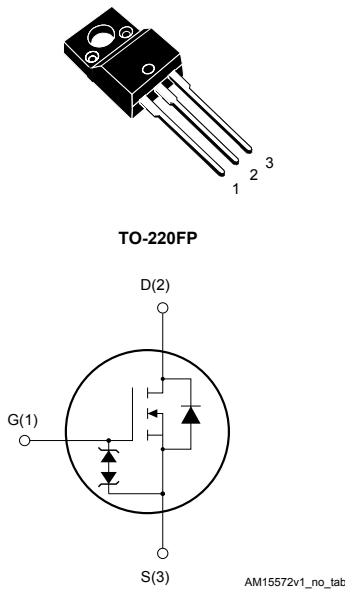


## N-channel 600 V, 0.550 $\Omega$ typ., 7.5 A MDmesh™ M2 EP Power MOSFET in a TO-220FP package



### Features

| Order code    | $V_{DS}$ | $R_{DS(on)}$ max. | $I_D$ |
|---------------|----------|-------------------|-------|
| STF11N60M2-EP | 600 V    | 0.595 $\Omega$    | 7.5 A |

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

### Applications

- Switching applications

### Description

This device is an N-channel Power MOSFET developed using MDmesh™ M2 enhanced performance (EP) technology. Thanks to its strip layout and an improved vertical structure, the device exhibits low on-resistance, optimized switching characteristics with very low turn-off switching losses, rendering it suitable for the most demanding very high frequency converters.

| Product status  |               |
|-----------------|---------------|
| STF11N60M2-EP   |               |
| Product summary |               |
| Order code      | STF11N60M2-EP |
| Marking         | 11N60M2EP     |
| Package         | TO-220FP      |
| Packing         | Tube          |

# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

| Symbol         | Parameter                                                                                                                               | Value      | Unit               |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------|------------|--------------------|
| $V_{GS}$       | Gate-source voltage                                                                                                                     | $\pm 25$   | V                  |
| $I_D$          | Drain current (continuous) at $T_C = 25\text{ }^{\circ}\text{C}$                                                                        | 7.5        | A                  |
|                | Drain current (continuous) at $T_C = 100\text{ }^{\circ}\text{C}$                                                                       | 4.7        | A                  |
| $I_{DM}^{(1)}$ | Drain current (pulsed)                                                                                                                  | 30         | A                  |
| $P_{TOT}$      | Total dissipation at $T_C = 25\text{ }^{\circ}\text{C}$                                                                                 | 25         | W                  |
| $dv/dt^{(2)}$  | Peak diode recovery voltage slope                                                                                                       | 15         | V/ns               |
| $dv/dt^{(3)}$  | MOSFET $dv/dt$ ruggedness                                                                                                               | 50         | V/ns               |
| $V_{ISO}$      | Insulation withstand voltage (RMS) from all three leads to external heat sink ( $t = 1\text{ s}$ , $T_C = 25\text{ }^{\circ}\text{C}$ ) | 2.5        | kV                 |
| $T_{stg}$      | Storage temperature range                                                                                                               | -55 to 150 | $^{\circ}\text{C}$ |
| $T_J$          | Operating junction temperature range                                                                                                    |            |                    |

1. Pulse width limited by safe operating area.
2.  $I_{SD} \leq 7.5\text{ A}$ ,  $di/dt \leq 400\text{ A}/\mu\text{s}$ ,  $V_{DS\text{ peak}} < V_{(BR)DSS}$ ,  $V_{DD} = 400\text{ V}$
3.  $V_{DS} \leq 480\text{ V}$

**Table 2. Thermal data**

| Symbol         | Parameter                           | Value | Unit                        |
|----------------|-------------------------------------|-------|-----------------------------|
| $R_{thj-case}$ | Thermal resistance junction-case    | 5     | $^{\circ}\text{C}/\text{W}$ |
| $R_{thj-amb}$  | Thermal resistance junction-ambient | 62.5  | $^{\circ}\text{C}/\text{W}$ |

**Table 3. Avalanche characteristics**

| Symbol   | Parameter                                                                                                              | Value | Unit |
|----------|------------------------------------------------------------------------------------------------------------------------|-------|------|
| $I_{AR}$ | Avalanche current, repetitive or not repetitive (pulse width limited by $T_{Jmax}$ )                                   | 2.4   | A    |
| $E_{AS}$ | Single pulse avalanche energy (starting $T_J = 25\text{ }^{\circ}\text{C}$ , $I_D = I_{AR}$ , $V_{DD} = 50\text{ V}$ ) | 115   | mJ   |

## 2 Electrical characteristics

$T_C = 25\text{ }^{\circ}\text{C}$  unless otherwise specified

**Table 4. On/off states**

| Symbol        | Parameter                         | Test conditions                                                                                         | Min. | Typ.  | Max.     | Unit          |
|---------------|-----------------------------------|---------------------------------------------------------------------------------------------------------|------|-------|----------|---------------|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage    | $V_{GS} = 0\text{ V}$ , $I_D = 1\text{ mA}$                                                             | 600  |       |          | V             |
| $I_{DSS}$     | Zero gate voltage drain current   | $V_{GS} = 0\text{ V}$ , $V_{DS} = 600\text{ V}$                                                         |      |       | 1        | $\mu\text{A}$ |
|               |                                   | $V_{GS} = 0\text{ V}$ , $V_{DS} = 600\text{ V}$ ,<br>$T_C = 125\text{ }^{\circ}\text{C}$ <sup>(1)</sup> |      |       | 100      | $\mu\text{A}$ |
| $I_{GSS}$     | Gate-body leakage current         | $V_{DS} = 0\text{ V}$ , $V_{GS} = \pm 25\text{ V}$                                                      |      |       | $\pm 10$ | $\mu\text{A}$ |
| $V_{GS(th)}$  | Gate threshold voltage            | $V_{DS} = V_{GS}$ , $I_D = 250\text{ }\mu\text{A}$                                                      | 3.25 | 4     | 4.75     | V             |
| $R_{DS(on)}$  | Static drain-source on-resistance | $V_{GS} = 10\text{ V}$ , $I_D = 3.75\text{ A}$                                                          |      | 0.550 | 0.595    | $\Omega$      |

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

**Table 5. Dynamic**

| Symbol                     | Parameter                     | Test conditions                                                                                                                                  | Min. | Typ. | Max. | Unit     |
|----------------------------|-------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|----------|
| $C_{iss}$                  | Input capacitance             | $V_{DS} = 100\text{ V}$ , $f = 1\text{ MHz}$ ,<br>$V_{GS} = 0\text{ V}$                                                                          | -    | 390  | -    | pF       |
| $C_{oss}$                  | Output capacitance            |                                                                                                                                                  | -    | 22   | -    | pF       |
| $C_{rss}$                  | Reverse transfer capacitance  |                                                                                                                                                  | -    | 0.7  | -    | pF       |
| $C_{oss\text{ eq.}}^{(1)}$ | Equivalent output capacitance | $V_{DS} = 0\text{ to }480\text{ V}$ , $V_{GS} = 0\text{ V}$                                                                                      | -    | 49   | -    | pF       |
| $R_G$                      | Intrinsic gate resistance     | $f = 1\text{ MHz}$ , $I_D = 0\text{ A}$                                                                                                          | -    | 9    | -    | $\Omega$ |
| $Q_g$                      | Total gate charge             | $V_{DD} = 480\text{ V}$ , $I_D = 7.5\text{ A}$ ,<br>$V_{GS} = 0\text{ to }10\text{ V}$<br>(see Figure 15. Test circuit for gate charge behavior) | -    | 12.4 | -    | nC       |
| $Q_{gs}$                   | Gate-source charge            |                                                                                                                                                  | -    | 2.1  | -    | nC       |
| $Q_{gd}$                   | Gate-drain charge             |                                                                                                                                                  | -    | 6    | -    | nC       |

1.  $C_{oss\text{ eq.}}$  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 6. Switching energy**

| Symbol      | Parameter                                           | Test conditions                                                                                      | Min. | Typ. | Max. | Unit          |
|-------------|-----------------------------------------------------|------------------------------------------------------------------------------------------------------|------|------|------|---------------|
| $E_{(off)}$ | Turn-off energy<br>(from 90% $V_{GS}$ to 0% $I_D$ ) | $V_{DD} = 400\text{ V}$ , $I_D = 1\text{ A}$ ,<br>$R_G = 4.7\text{ }\Omega$ , $V_{GS} = 10\text{ V}$ | -    | 2.5  | -    | $\mu\text{J}$ |
|             |                                                     | $V_{DD} = 400\text{ V}$ , $I_D = 3\text{ A}$ ,<br>$R_G = 4.7\text{ }\Omega$ , $V_{GS} = 10\text{ V}$ | -    | 9    | -    | $\mu\text{J}$ |

**Table 7. Switching times**

| Symbol       | Parameter           | Test conditions                                                                                                                                                                                              | Min. | Typ. | Max. | Unit |
|--------------|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|
| $t_{d(on)}$  | Turn-on delay time  | $V_{DD} = 300\text{ V}$ , $I_D = 3.75\text{ A}$ ,<br>$R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$<br>(see Figure 14. Test circuit for resistive load switching times and Figure 19. Switching time waveform) | -    | 9    | -    | ns   |
| $t_r$        | Rise time           |                                                                                                                                                                                                              | -    | 5.5  | -    | ns   |
| $t_{d(off)}$ | Turn-off-delay time |                                                                                                                                                                                                              | -    | 26   | -    | ns   |
| $t_f$        | Fall time           |                                                                                                                                                                                                              | -    | 8    | -    | ns   |

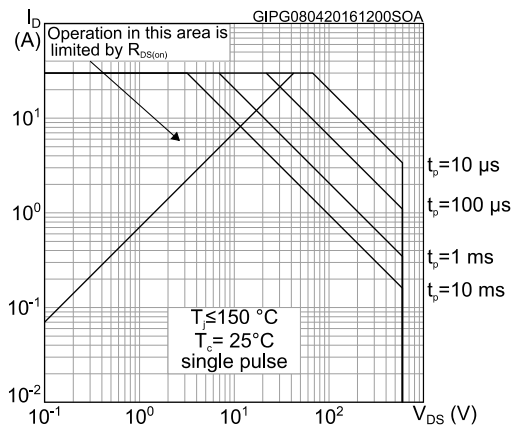
**Table 8. Source drain diode**

| Symbol          | Parameter                     | Test conditions                                                                                                                                                                                                     | Min. | Typ. | Max. | Unit          |
|-----------------|-------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|---------------|
| $I_{SD}$        | Source-drain current          |                                                                                                                                                                                                                     | -    |      | 7.5  | A             |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |                                                                                                                                                                                                                     | -    |      | 30   | A             |
| $V_{SD}^{(2)}$  | Forward on voltage            | $V_{GS} = 0\text{ V}$ , $I_{SD} = 7.5\text{ A}$                                                                                                                                                                     | -    |      | 1.6  | V             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 7.5\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ ,<br>$V_{DD} = 60\text{ V}$<br>(see Figure 16. Test circuit for inductive load switching and diode recovery times)                                     | -    | 192  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                                                                                                     | -    | 1.32 |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                                                                                                     | -    | 13.8 |      | A             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 7.5\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ ,<br>$V_{DD} = 60\text{ V}$ , $T_j = 150\text{ }^\circ\text{C}$<br>(see Figure 16. Test circuit for inductive load switching and diode recovery times) | -    | 262  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                                                                                                     | -    | 1.74 |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                                                                                                     | -    | 13.3 |      | A             |

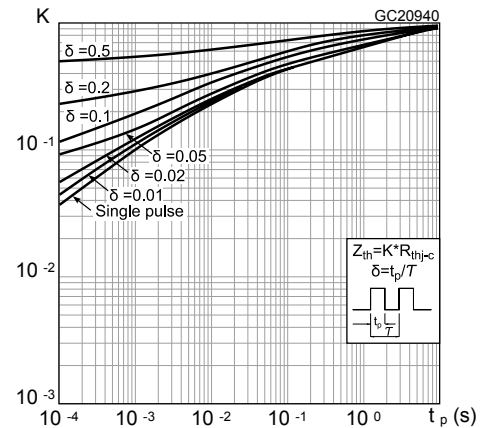
1. Pulse width is limited by safe operating area
2. Pulsed: pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%

## 2.1 Electrical characteristics curves

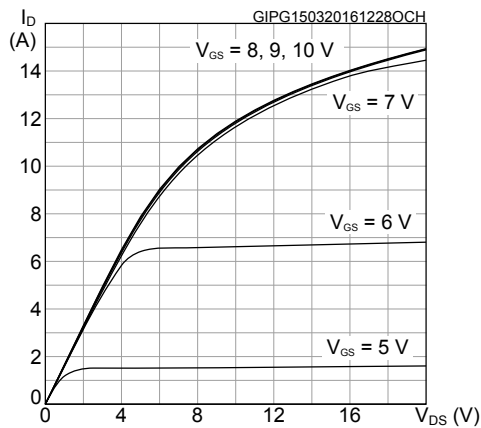
**Figure 1. Safe operating area**



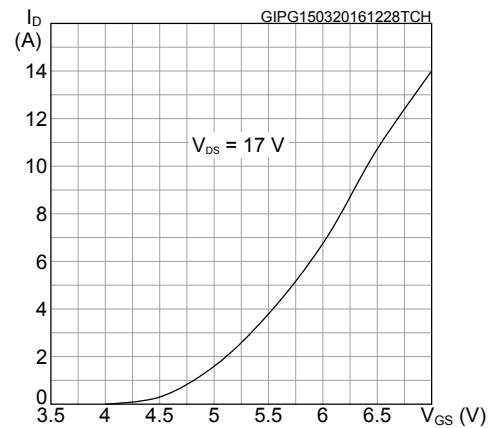
**Figure 2. Thermal impedance**



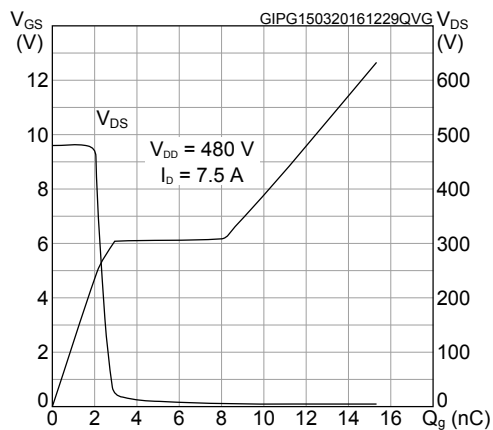
**Figure 3. Output characteristics**



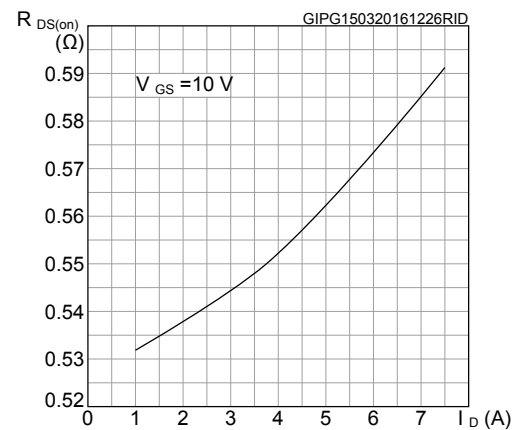
**Figure 4. Transfer characteristics**



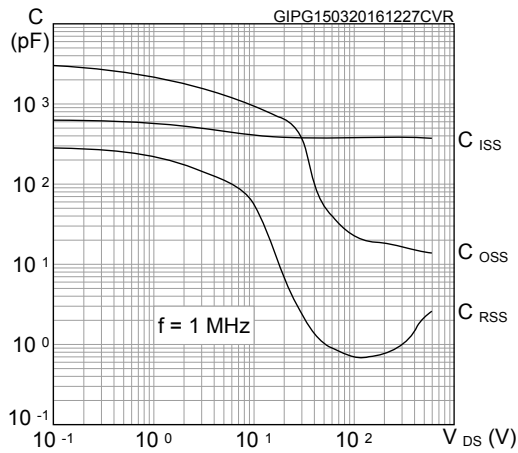
**Figure 5. Gate charge vs gate-source voltage**



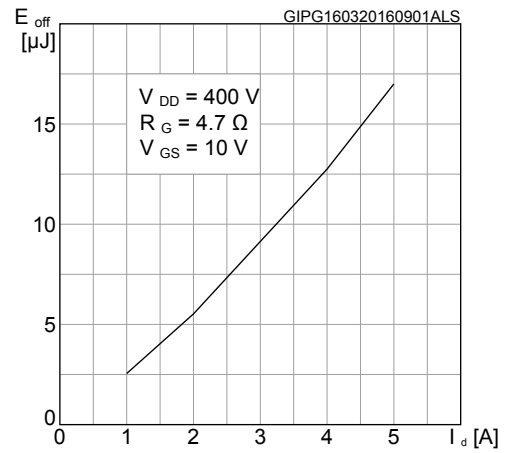
**Figure 6. Static drain-source on-resistance**



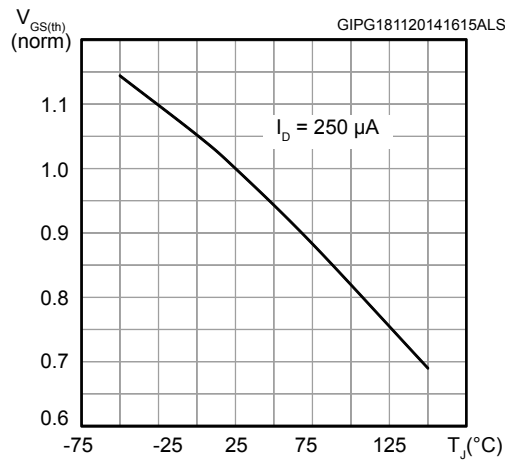
**Figure 7. Capacitance variations**



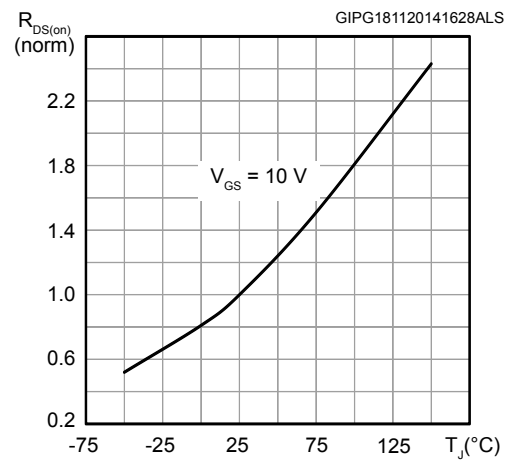
**Figure 8. Turn-off switching energy vs drain current**



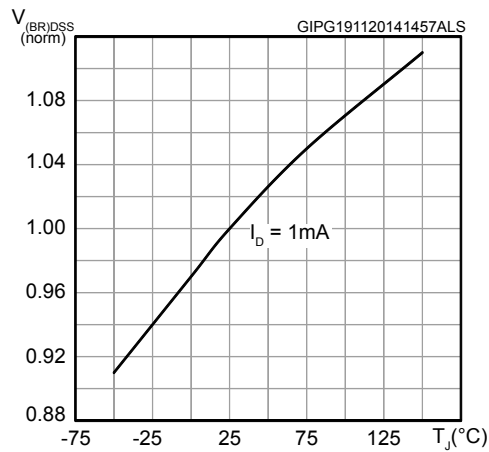
**Figure 9. Normalized gate threshold voltage vs temperature**



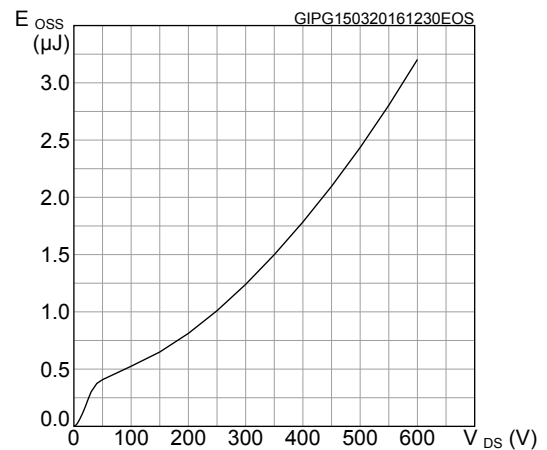
**Figure 10. Normalized on-resistance vs temperature**



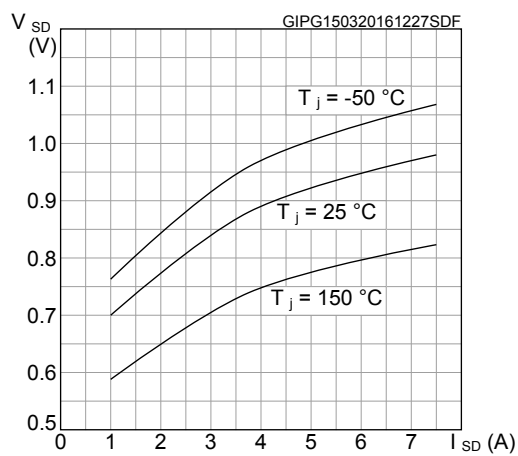
**Figure 11. Normalized  $V_{(BR)DSS}$  vs temperature**



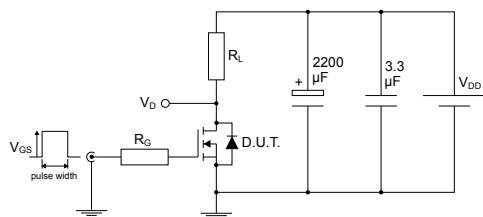
**Figure 12. Output capacitance stored energy**



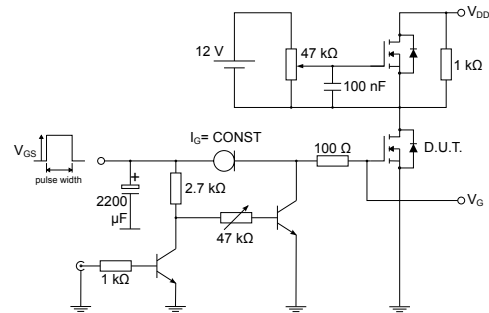
**Figure 13. Source-drain diode forward characteristics**



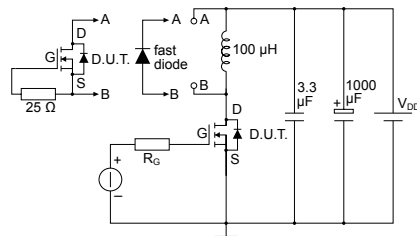
### 3 Test circuits

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


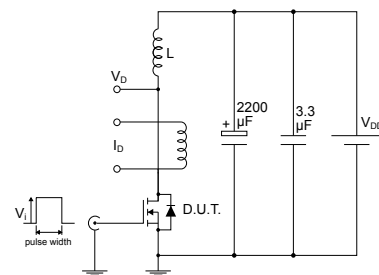
AM01468v1

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


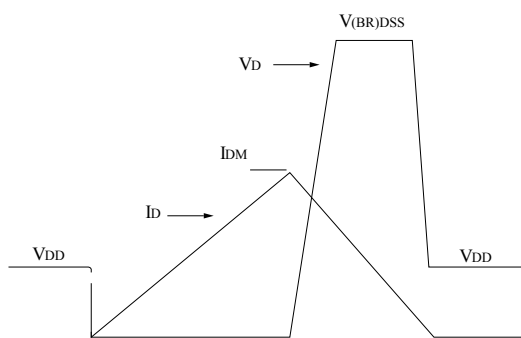
AM01469v1

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


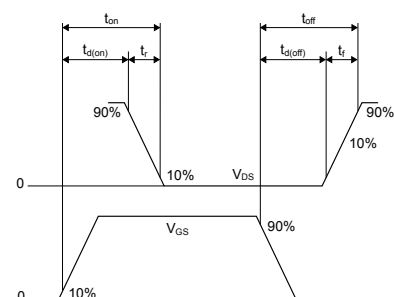
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**Figure 17. Unclamped inductive load test circuit**


AM01471v1

**Figure 18. Unclamped inductive waveform**


AM01472v1

**Figure 19. Switching time waveform**


AM01473v1

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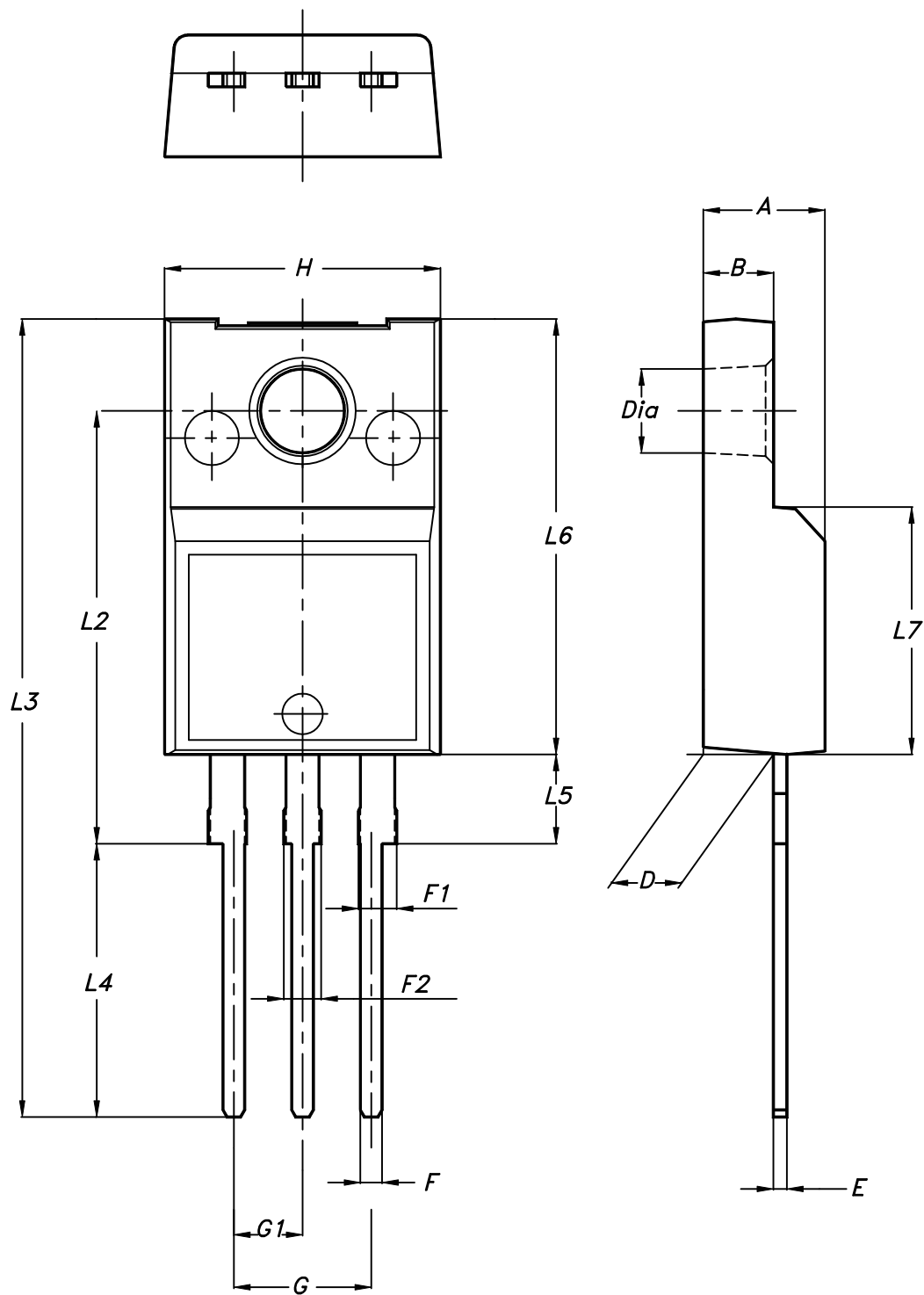
## 4 Package information

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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](http://www.st.com). ECOPACK® is an ST trademark.

## 4.1 TO-220FP package information

Figure 20. TO-220FP package outline



7012510\_Rev\_12\_B

**Table 9. TO-220FP package 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  |

## Revision history

**Table 10. Document revision history**

| Date        | Revision | Changes                                                                                                                                                                                                                                                                                                                                                                                                                        |
|-------------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 11-Apr-2016 | 1        | First release.                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 07-Oct-2016 | 2        | Document status changed from preliminary to production data.                                                                                                                                                                                                                                                                                                                                                                   |
| 02-Mar-2018 | 3        | Removed document maturity status from cover page.<br>Updated <i>Table 1. Absolute maximum ratings</i> , <i>Table 4. On/off states</i> , <i>Table 5. Dynamic</i> and <i>Table 8. Source drain diode</i> .<br>Updated <i>Figure 1. Safe operating area</i> , <i>Figure 3. Output characteristics</i> , <i>Figure 4. Transfer characteristics</i> and <i>Figure 5. Gate charge vs gate-source voltage</i> .<br>Minor text changes |
| 23-Apr-2018 | 4        | Modified <i>Table 1. Absolute maximum ratings</i> , <i>Table 5. Dynamic</i> and <i>Table 8. Source drain diode</i> .<br>Modified <i>Figure 1. Safe operating area</i> .<br>Minor text changes.                                                                                                                                                                                                                                 |

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