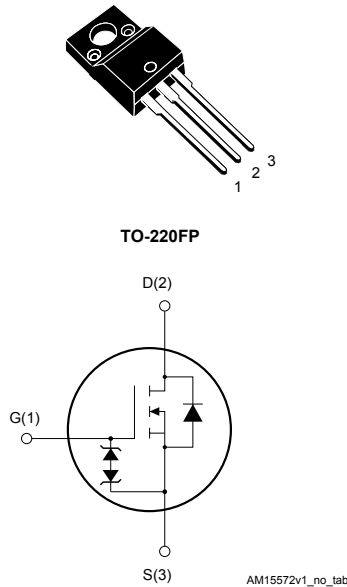


## N-channel 600 V, 0.230 $\Omega$ typ., 13 A, MDmesh™ M2 EP Power MOSFET in a TO-220FP package



### Features

Order code	$V_{DS}$	$R_{DS(on)}$ max	$I_D$
STF20N60M2-EP	600 V	0.278 $\Omega$	13 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
- Tailored for very high frequency converters ( $f > 150$  kHz)

### 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

STF20N60M2-EP

#### Product summary

<b>Order code</b>	STF20N60M2-EP
<b>Marking</b>	20N60M2EP
<b>Package</b>	TO-220FP
<b>Packing</b>	Tube

# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

Symbol	Parameter	Value	Unit
$V_{GS}$	Gate-source voltage	$\pm 25$	V
$V_{GS}$	Transient gate-source voltage ( $t_p \leq 10$ ns)	$\pm 35$	V
$I_D^{(1)}$	Drain current (continuous) at $T_C = 25$ °C	13	A
$I_D^{(1)}$	Drain current (continuous) at $T_C = 100$ °C	8	A
$I_{DM}^{(2)}$	Drain current (pulsed)	52	A
$P_{TOT}$	Total dissipation at $T_C = 25$ °C	25	W
$dv/dt^{(3)}$	Peak diode recovery voltage slope	15	V/ns
$dv/dt^{(4)}$	MOSFET $dv/dt$ ruggedness	50	V/ns
$V_{ISO}$	Insulation withstand voltage (RMS) from all three leads to external heat sink ( $t = 1$ s, $T_C = 25$ °C)	2.5	kV
$T_{stg}$	Storage temperature range	-55 to 150	°C
$T_j$	Operating junction temperature range		

1. Limited by maximum junction temperature
2. Pulse width limited by safe operating area.
3.  $I_{SD} \leq 13$  A,  $di/dt \leq 400$  A/ $\mu$ s,  $V_{DS(peak)} < V_{(BR)DSS}$ ,  $V_{DD} = 400$  V
4.  $V_{DS} \leq 480$  V

**Table 2. Thermal data**

Symbol	Parameter	Value	Unit
$R_{thj-case}$	Thermal resistance junction-case	5	°C/W
$R_{thj-amb}$	Thermal resistance junction-ambient	62.5	°C/W

**Table 3. Avalanche characteristics**

Symbol	Parameter	Value	Unit
$I_{AR}$	Avalanche current, repetitive or not repetitive (pulse width limited by $T_{jmax}$ )	2.7	A
$E_{AS}$	Single pulse avalanche energy (starting $T_j = 25$ °C, $I_D = I_{AR}$ , $V_{DD} = 50$ V)	138	mJ

## 2 Electrical characteristics

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

**Table 4. On/off states**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source breakdown voltage	$V_{GS} = 0\text{ V}$ , $I_D = 1\text{ mA}$	600			V
$I_{DSS}$	Zero gate voltage	$V_{GS} = 0\text{ V}$ , $V_{DS} = 600\text{ V}$			1	$\mu\text{A}$
	Drain current	$V_{GS} = 0\text{ V}$ , $V_{DS} = 600\text{ V}$ , $T_C = 125\text{ °C}^{(1)}$			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	$V_{GS} = 10\text{ V}$ , $I_D = 6.5\text{ A}$		0.230	0.278	$\Omega$

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

**Table 5. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$C_{iss}$	Input capacitance	$V_{DS} = 100\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GS} = 0\text{ V}$	-	787	-	$\mu\text{F}$
$C_{oss}$	Output capacitance		-	50	-	
$C_{riss}$	Reverse transfer capacitance		-	1.2	-	
$C_{oss\ eq.}^{(1)}$	Equivalent output capacitance	$V_{DS} = 0\text{ to }480\text{ V}$ , $V_{GS} = 0\text{ V}$	-	89	-	$\mu\text{F}$
$R_G$	Intrinsic gate resistance	$f = 1\text{ MHz}$ , $I_D = 0\text{ A}$	-	5.9	-	$\Omega$
$Q_g$	Total gate charge	$V_{DD} = 480\text{ V}$ , $I_D = 13\text{ A}$ , $V_{GS} = 0\text{ to }10\text{ V}$ (see Figure 15. Test circuit for gate charge behavior)	-	22	-	nC
$Q_{gs}$	Gate-source charge		-	3.5	-	
$Q_{gd}$	Gate-drain charge		-	10.5	-	

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 6. Switching energy**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$E_{off}$	Turn-off energy (from 90% $V_{GS}$ to 0% $I_D$ )	$V_{DD} = 400\text{ V}$ , $I_D = 2\text{ A}$ , $R_G = 4.7\text{ }\Omega$ , $V_{GS} = 10\text{ V}$	-	7.2	-	$\mu\text{J}$
		$V_{DD} = 400\text{ V}$ , $I_D = 5\text{ A}$ , $R_G = 4.7\text{ }\Omega$ , $V_{GS} = 10\text{ V}$	-	20.4	-	$\mu\text{J}$

**Table 7. Switching times**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 300\text{ V}$ , $I_D = 6.5\text{ A}$ , $R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$ (see Figure 14. Test circuit for resistive load switching times and Figure 19. Switching time waveform)	-	10.5	-	ns
$t_r$	Rise time		-	5.2	-	ns
$t_{d(off)}$	Turn-off delay time		-	41	-	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		-		13	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)		-		52	A
$V_{SD}^{(2)}$	Forward on voltage	$V_{GS} = 0\text{ V}$ , $I_{SD} = 13\text{ A}$	-		1.6	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 13\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ , $V_{DD} = 60\text{ V}$ (see Figure 16. Test circuit for inductive load switching and diode recovery times )	-	230		ns
$Q_{rr}$	Reverse recovery charge		-	2.3		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current		-	20		A
$t_{rr}$	Reverse recovery time	$I_{SD} = 13\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ , $V_{DD} = 60\text{ V}$ , $T_j = 150\text{ }^\circ\text{C}$ (see Figure 16. Test circuit for inductive load switching and diode recovery times)	-	287		ns
$Q_{rr}$	Reverse recovery charge		-	2.9		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current		-	20.2		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

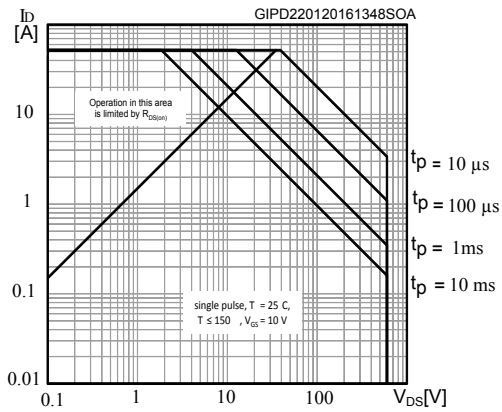


Figure 2. Thermal impedance

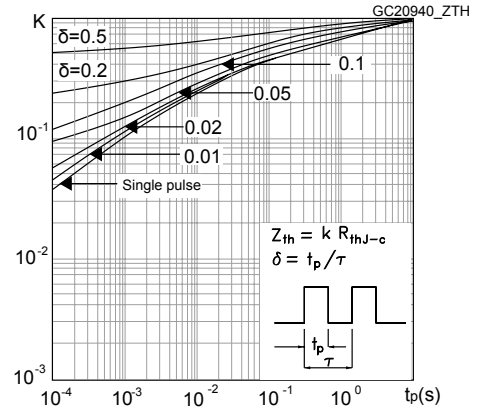


Figure 3. Output characteristics

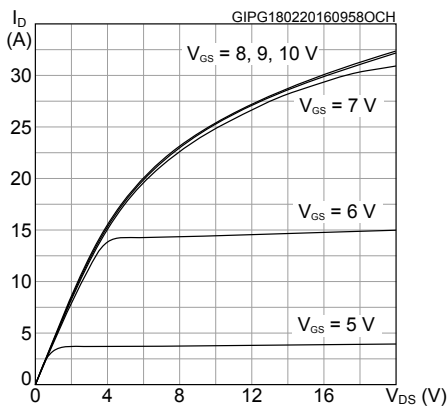


Figure 4. Transfer characteristics

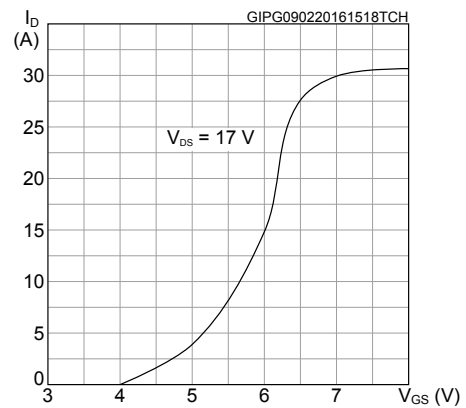


Figure 5. Gate charge vs gate-source voltage

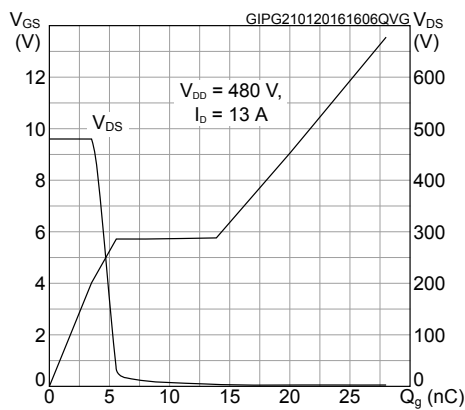
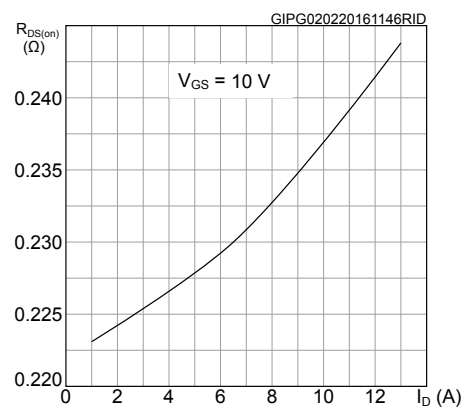
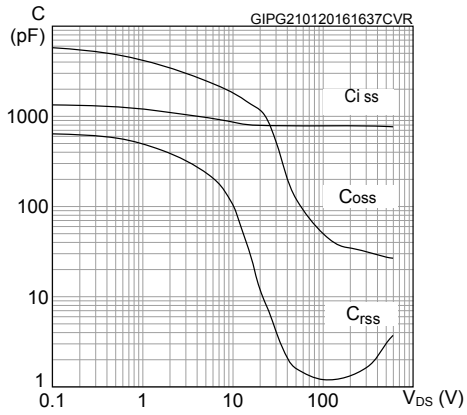


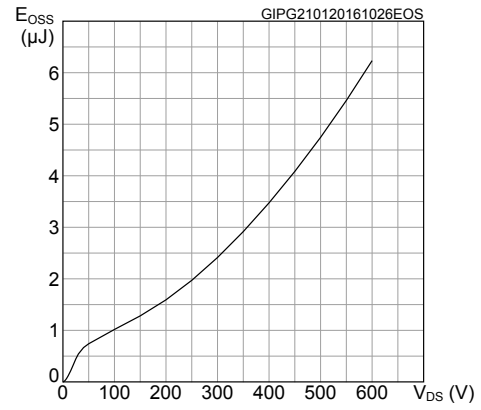
Figure 6. Static drain-source on-resistance



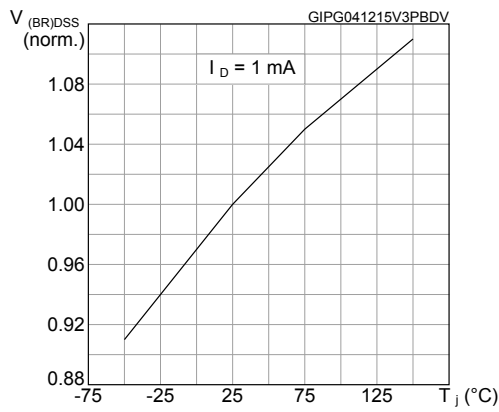
**Figure 7. Capacitance variations**



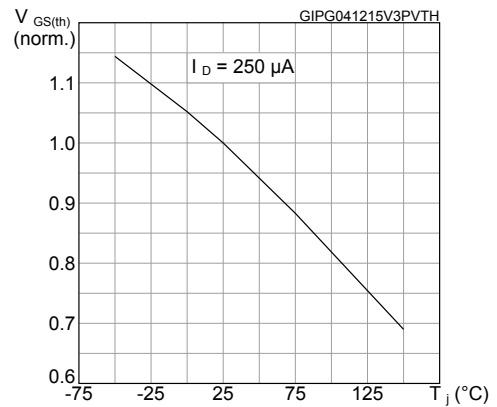
**Figure 8. Output capacitance stored energy**



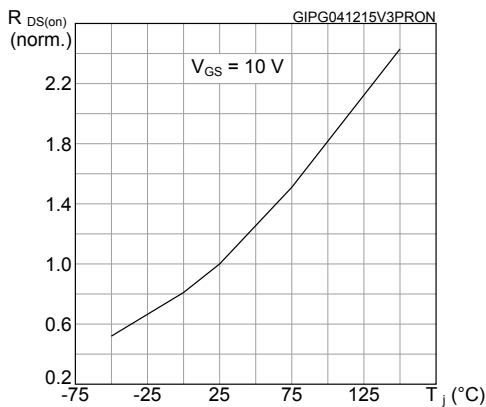
**Figure 9. Normalized V<sub>(BR)DSS</sub> vs temperature**



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



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



**Figure 12. Source-drain diode forward characteristics**

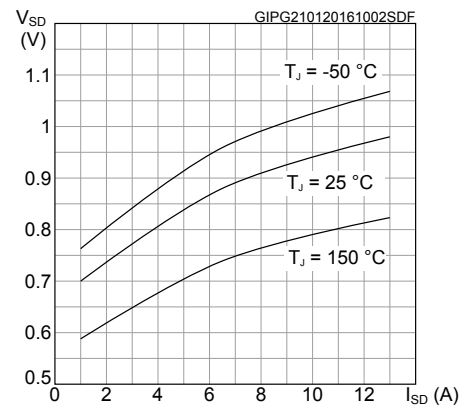
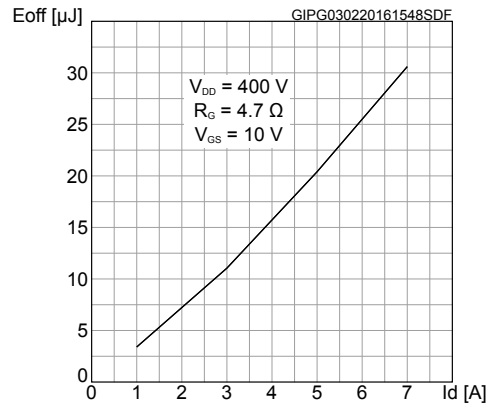
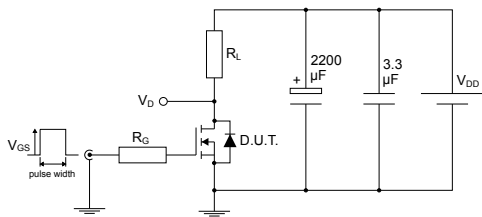


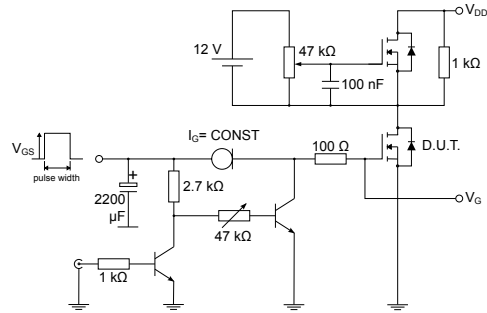
Figure 13. Turn-off switching energy vs drain current



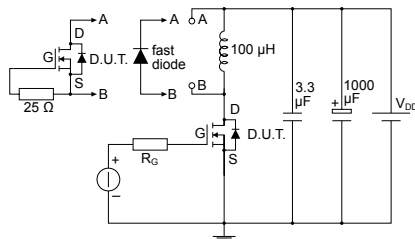
### 3 Test circuits

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


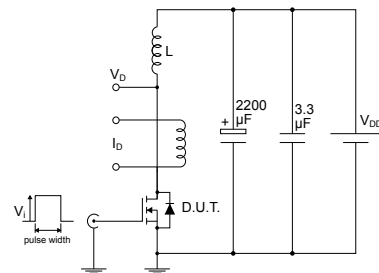
AM01468v1

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


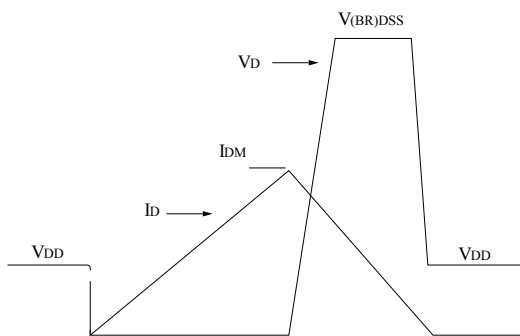
AM01469v1

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


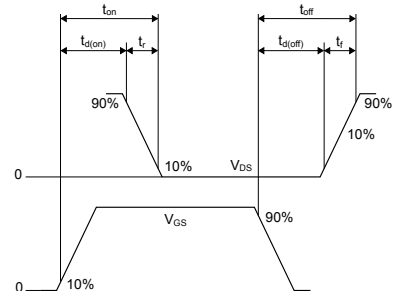
AM01470v1

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


AM01471v1

**Figure 18. Unclamped inductive waveform**


AM01472v1

**Figure 19. Switching time waveform**


AM01473v1



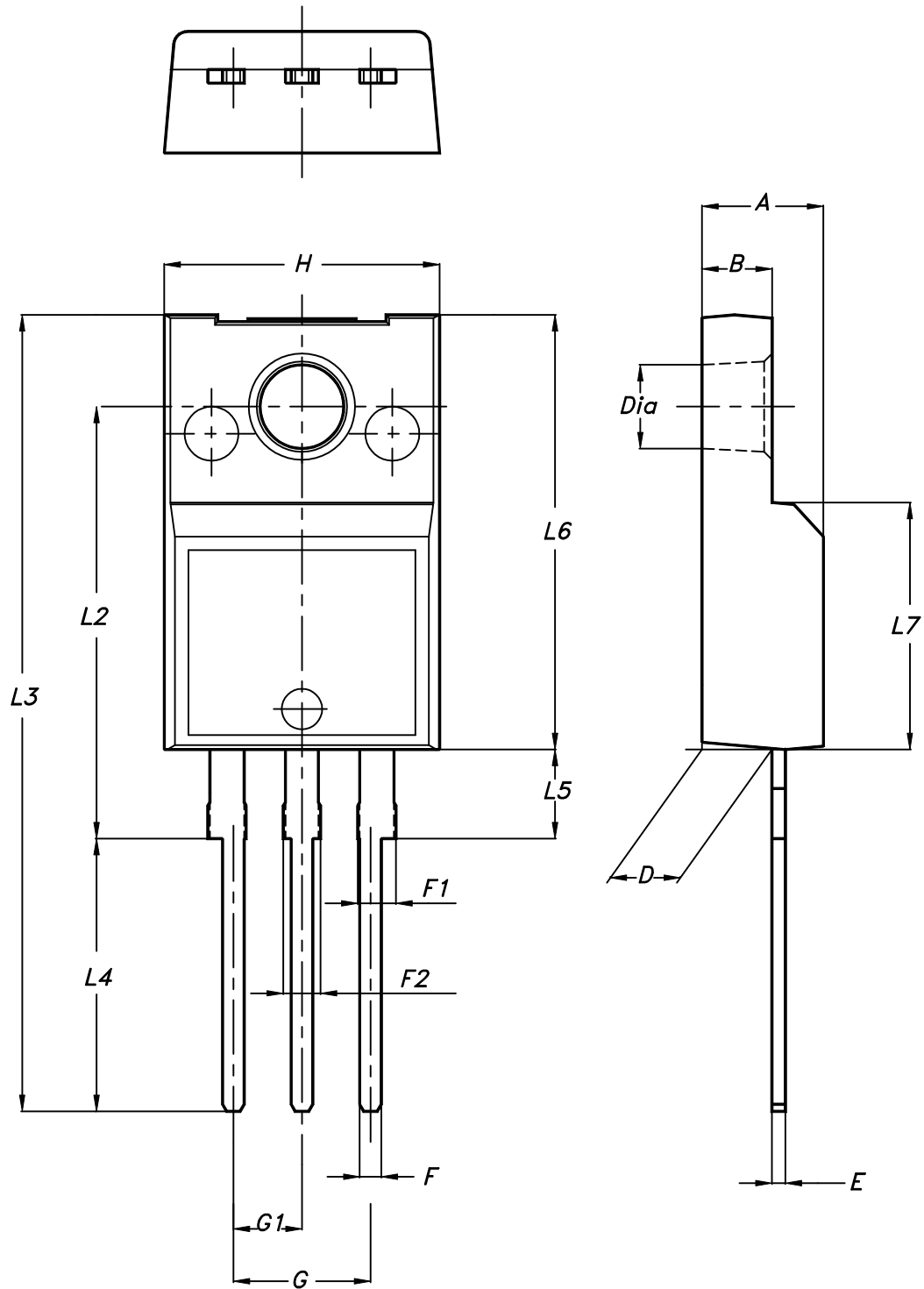
## 4 Package information

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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
29-Feb-2016	1	First release.
18-Aug-2016	2	Modified: <i>Table 2: "Absolute maximum ratings"</i> Minor text changes
02-Mar-2018	3	Removed maturity status indication from cover page. The document status is production data. Updated <i>Table 1. Absolute maximum ratings</i> , <i>Table 4. On/off states</i> and <i>Table 5. Dynamic</i> . 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> . Minor text changes.
04-Jun-2018	4	Modified <a href="#">Table 1. Absolute maximum ratings</a> . Modified <a href="#">Figure 1. Safe operating area</a> . Modified <a href="#">Table 8. Source-drain diode</a> . Minor text changes.

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