

N-channel 600 V, 0.72 Ω typ., 5.5 A MDmesh II Plus™ low Q_g
Power MOSFETs in TO-220FP and I²PAKFP packages

Datasheet - production data

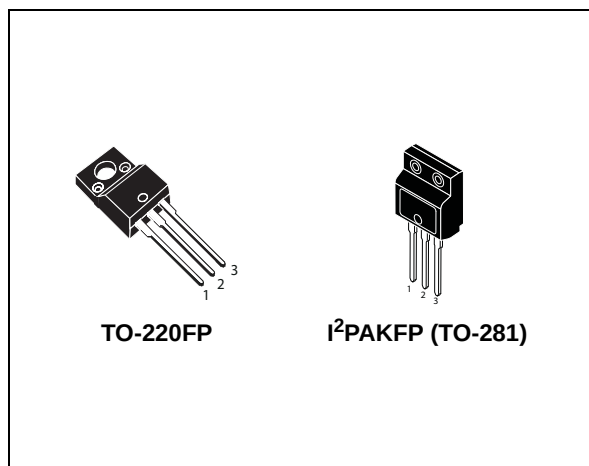
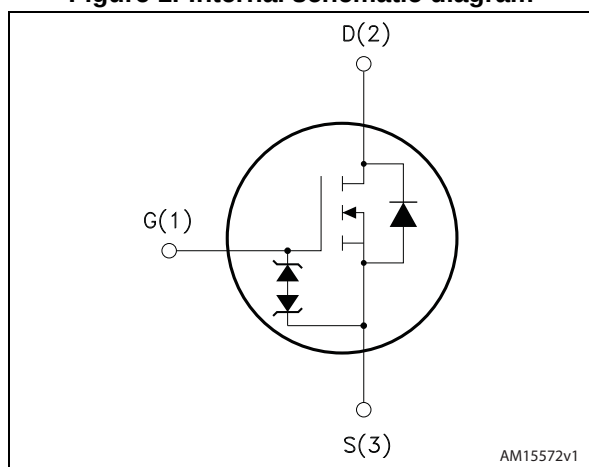


Figure 1. Internal schematic diagram



Features

Order codes	$V_{DS} @ T_{Jmax}$	$R_{DS(on) max}$	I_D
STF9N60M2	650 V	0.78 Ω	5.5 A
STFI9N60M2			

- Extremely low gate charge
- Lower $R_{DS(on)}$ x area vs previous generation
- Low gate input resistance
- 100% avalanche tested
- Zener-protected

Applications

- Switching applications

Description

These devices are N-channel Power MOSFETs developed using a new generation of MDmesh™ technology: MDmesh II Plus™ low Q_g . These revolutionary Power MOSFETs associate a vertical structure to the company's strip layout to yield one of the world's lowest on-resistance and gate charge. They are therefore suitable for the most demanding high efficiency converters.

Table 1. Device summary

Order codes	Marking	Package	Packaging
STF9N60M2	9N60M2	TO-220FP	Tube
STFI9N60M2		I ² PAKFP	

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1 Electrical ratings

Table 2. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{GS}	Gate-source voltage	± 25	V
I_D	Drain current (continuous) at $T_C = 25\text{ }^{\circ}\text{C}$	5.5 ⁽¹⁾	A
I_D	Drain current (continuous) at $T_C = 100\text{ }^{\circ}\text{C}$	3.6 ⁽¹⁾	A
$I_{DM}^{(1)}$	Drain current (pulsed)	22 ⁽¹⁾	A
P_{TOT}	Total dissipation at $T_C = 25\text{ }^{\circ}\text{C}$	20	W
V_{ISO}	Insulation withstand voltage (RMS) from all three leads to external heat sink ($t=1\text{ s}$; $T_C=25\text{ }^{\circ}\text{C}$)	2500	V
$dv/dt^{(2)}$	Peak diode recovery voltage slope	15	V/ns
$dv/dt^{(3)}$	MOSFET dv/dt ruggedness	50	
T_{stg}	Storage temperature	- 55 to 150	$^{\circ}\text{C}$
T_j	Max. operating junction temperature	150	

1. Pulse width limited by safe operating area.
2. $I_{SD} \leq 5.5\text{ A}$, $di/dt \leq 400\text{ A}/\mu\text{s}$; $V_{DS\text{ peak}} < V_{(BR)DSS}$, $V_{DD}=400\text{ V}$
3. $V_{DS} \leq 480\text{ V}$

Table 3. Thermal data

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

Table 4. Avalanche characteristics

Symbol	Parameter	Value	Unit
I_{AR}	Avalanche current, repetitive or not repetitive (pulse width limited by T_{jmax})	2	A
E_{AS}	Single pulse avalanche energy (starting $T_j=25^{\circ}\text{C}$, $I_D=I_{AR}$; $V_{DD}=50$)	105	mJ

2 Electrical characteristics

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

Table 5. On /off states

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source breakdown voltage	$I_D = 1\text{ mA}$, $V_{GS} = 0$	600			V
I_{DSS}	Zero gate voltage drain current ($V_{GS} = 0$)	$V_{DS} = 600\text{ V}$			1	μA
		$V_{DS} = 600\text{ V}$, $T_C = 125\text{ °C}$			100	μA
I_{GSS}	Gate-body leakage current ($V_{DS} = 0$)	$V_{GS} = \pm 25\text{ V}$			± 10	μA
$V_{GS(th)}$	Gate threshold voltage	$V_{DS} = V_{GS}$, $I_D = 250\text{ }\mu\text{A}$	2	3	4	V
$R_{DS(on)}$	Static drain-source on-resistance	$V_{GS} = 10\text{ V}$, $I_D = 3\text{ A}$		0.72	0.78	Ω

Table 6. Dynamic

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
C_{iss}	Input capacitance	$V_{DS} = 100\text{ V}$, $f = 1\text{ MHz}$, $V_{GS} = 0$	-	320	-	pF
C_{oss}	Output capacitance		-	18	-	pF
C_{rss}	Reverse transfer capacitance		-	0.68	-	pF
$C_{oss\text{ eq.}}^{(1)}$	Equivalent output capacitance	$V_{DS} = 0\text{ to }480\text{ V}$, $V_{GS} = 0$	-	88	-	pF
R_G	Intrinsic gate resistance	$f = 1\text{ MHz}$ open drain	-	6.5	-	Ω
Q_g	Total gate charge	$V_{DD} = 480\text{ V}$, $I_D = 5.5\text{ A}$, $V_{GS} = 10\text{ V}$ (see Figure 15)	-	10	-	nC
Q_{gs}	Gate-source charge		-	2	-	nC
Q_{gd}	Gate-drain charge		-	5.1	-	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 7. Switching times

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 300\text{ V}$, $I_D = 3\text{ A}$, $R_G = 4.7\text{ }\Omega$, $V_{GS} = 10\text{ V}$ (see Figure 14 and Figure 19)	-	8.8	-	ns
t_r	Rise time		-	7.5	-	ns
$t_{d(off)}$	Turn-off delay time		-	22	-	ns
t_f	Fall time		-	13.5	-	ns

Table 8. Source drain diode

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{SD}	Source-drain current		-		5.5	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)		-		22	A
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 5.5 \text{ A}$, $V_{GS} = 0$	-		1.6	V
t_{rr}	Reverse recovery time	$I_{SD} = 5.5 \text{ A}$, $di/dt = 100 \text{ A}/\mu\text{s}$ $V_{DD} = 60 \text{ V}$ (see Figure 16)	-	265		ns
Q_{rr}	Reverse recovery charge		-	1.65		μC
I_{RRM}	Reverse recovery current		-	12.5		A
t_{rr}	Reverse recovery time	$I_{SD} = 5.5 \text{ A}$, $di/dt = 100 \text{ A}/\mu\text{s}$ $V_{DD} = 60 \text{ V}$, $T_j = 150 \text{ }^\circ\text{C}$ (see Figure 16)	-	377		ns
Q_{rr}	Reverse recovery charge		-	2.3		μC
I_{RRM}	Reverse recovery current		-	12.2		A

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

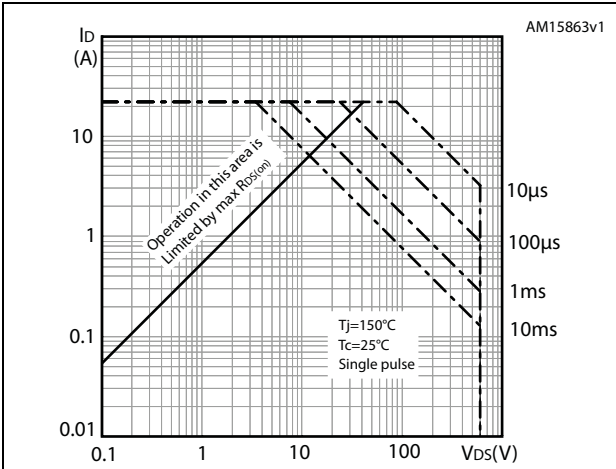


Figure 3. Thermal impedance

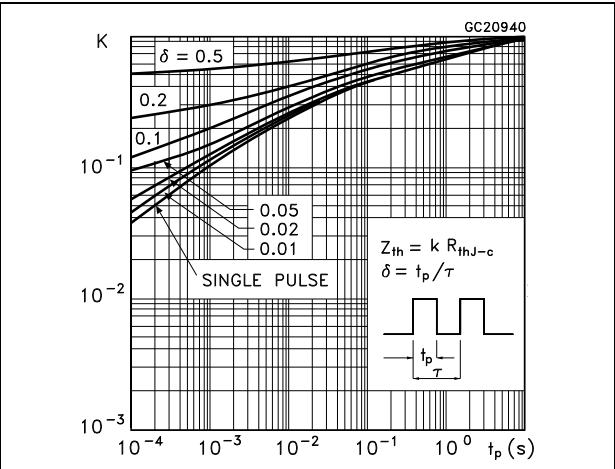


Figure 4. Output characteristics

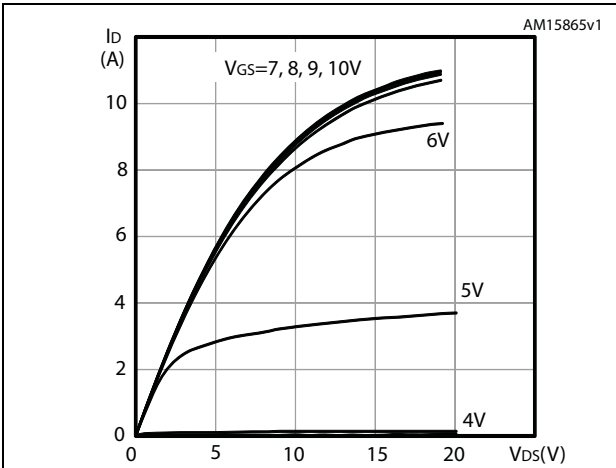


Figure 5. Transfer characteristics

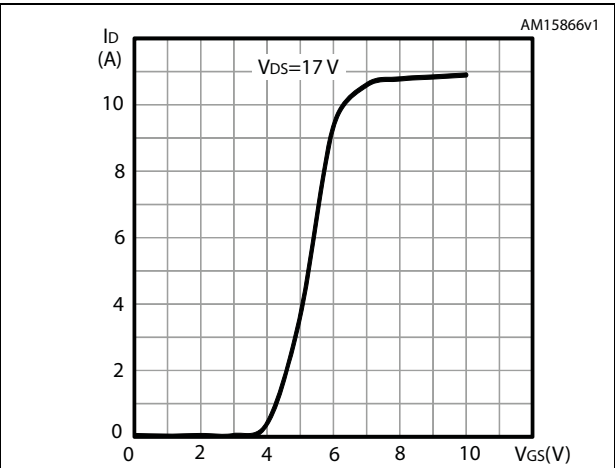


Figure 6. Gate charge vs gate-source voltage

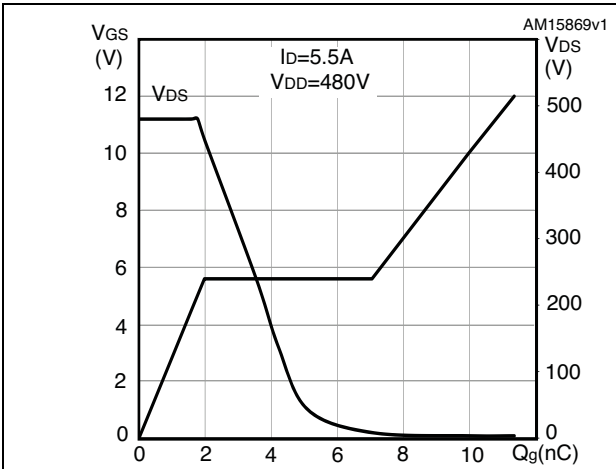


Figure 7. Static drain-source on-resistance

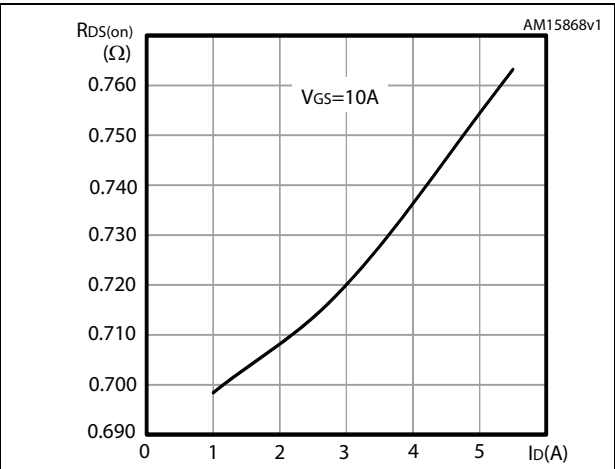


Figure 8. Capacitance variations

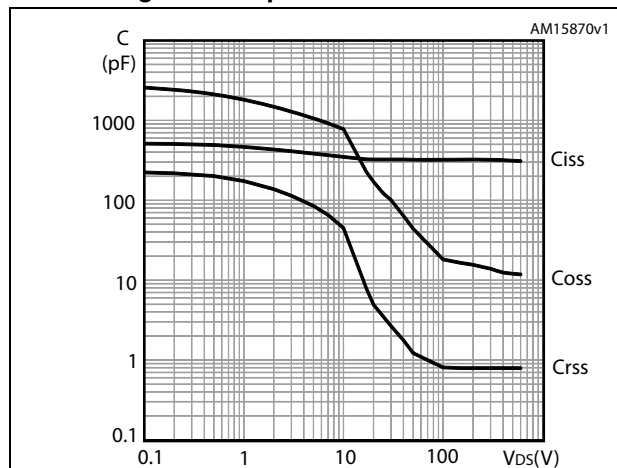


Figure 9. Output capacitance stored energy

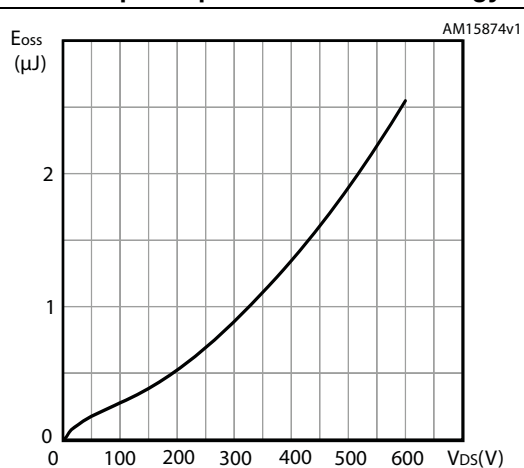


Figure 10. Normalized gate threshold voltage vs temperature

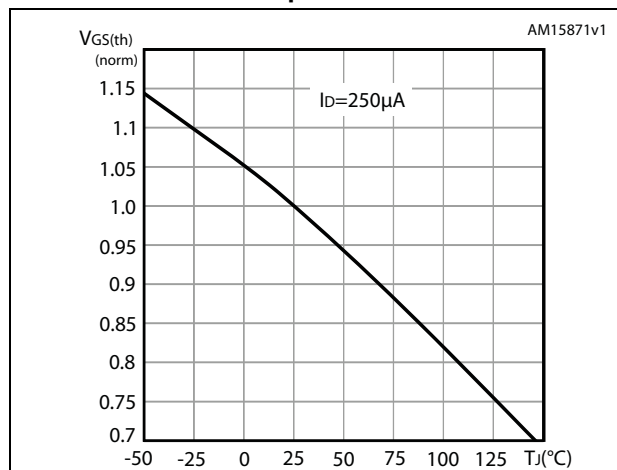


Figure 11. Normalized on-resistance vs temperature

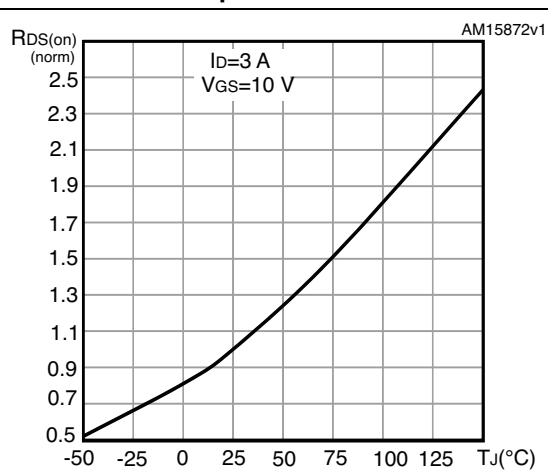
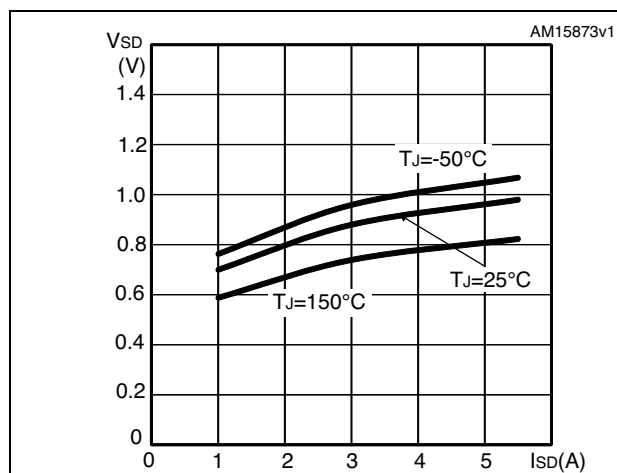
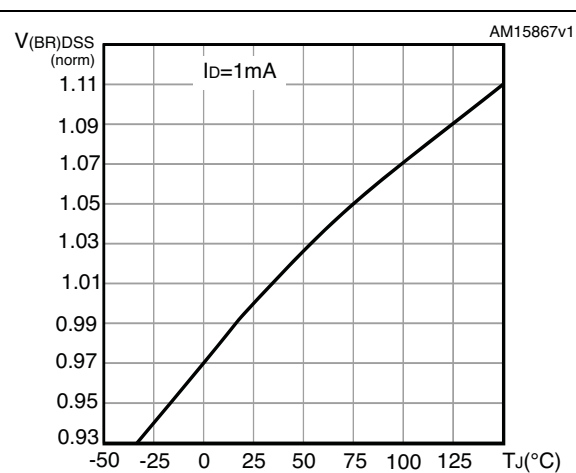


Figure 12. Source-drain diode forward characteristics

Figure 13. Normalized $V_{(BR)DSS}$ vs temperature

4 Package mechanical data

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4.1 TO-220FP, STF9N60M2

Figure 20. TO-220FP drawing

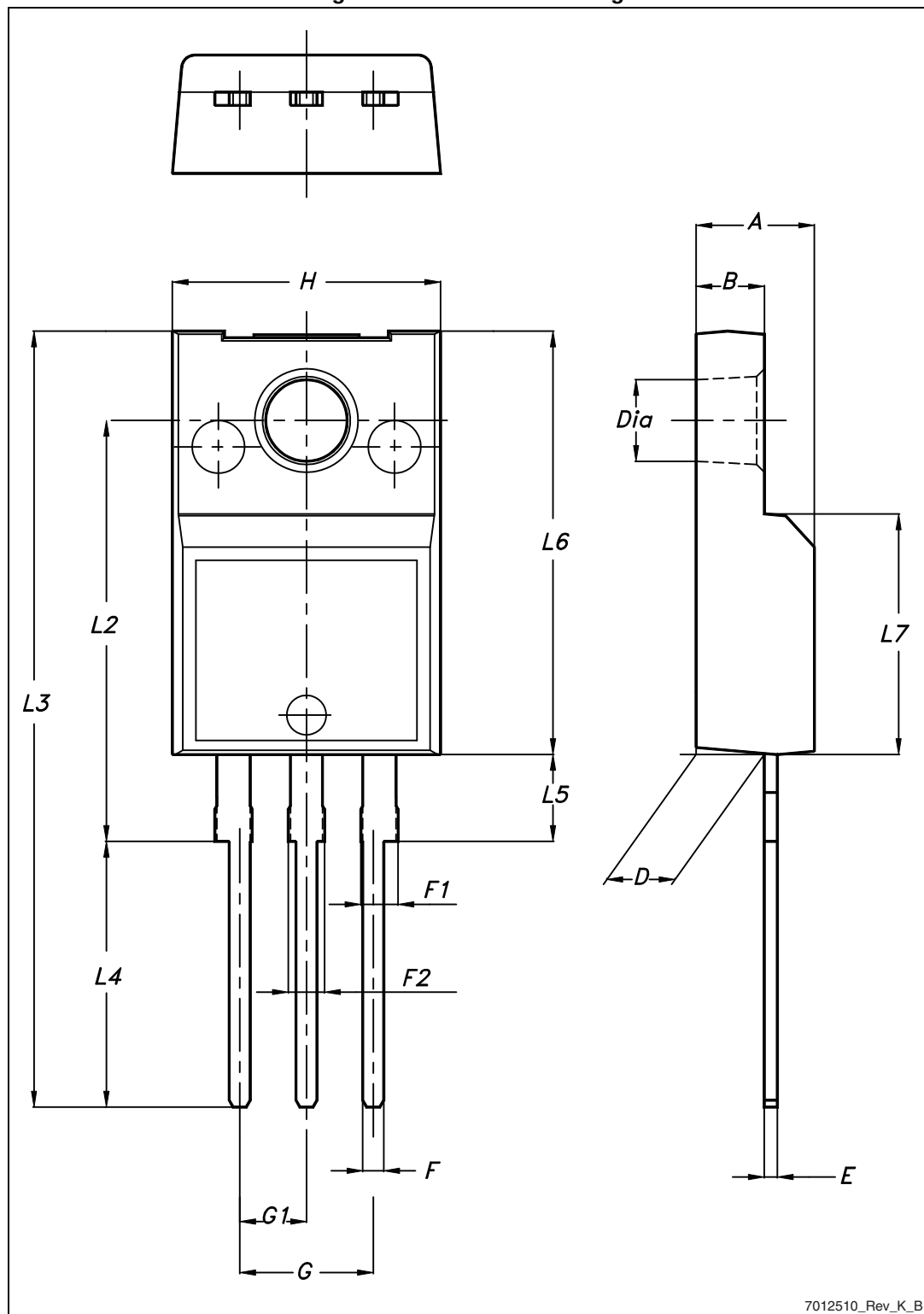


Table 9. TO-220FP mechanical data

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

4.2 I²PAKFP (TO-281), STF19N60M2

Figure 21. I²PAKFP (TO-281) drawing

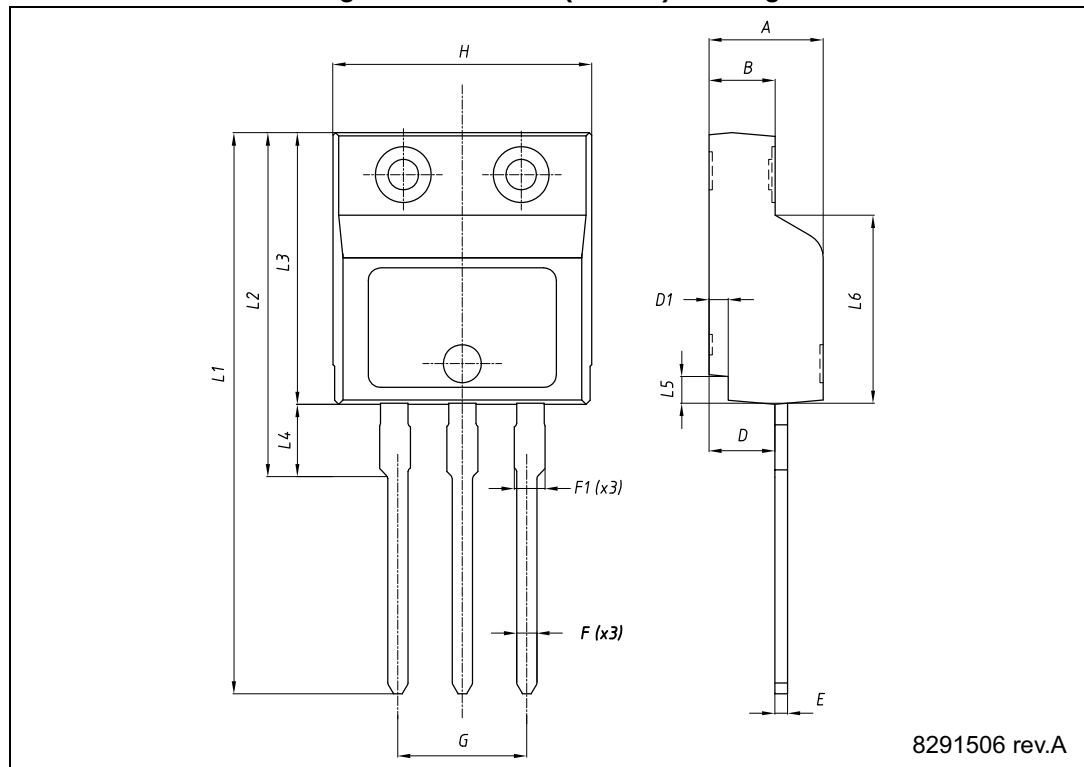


Table 10. I²PAKFP (TO-281) mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	4.40	-	4.60
B	2.50		2.70
D	2.50		2.75
D1	0.65		0.85
E	0.45		0.70
F	0.75		1.00
F1			1.20
G	4.95		5.20
H	10.00		10.40
L1	21.00		23.00
L2	13.20		14.10
L3	10.55		10.85
L4	2.70		3.20
L5	0.85		1.25
L6	7.30		7.50

5 Revision history

Table 11. Document revision history

Date	Revision	Changes
03-Jun-2013	1	First release. The part number was previously included in datasheet DocID024399.
10-Mar-2014	2	Added: I ² PAKFP package Minor text changes

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