STF24N60M2, STFI24N60M2, STFW24N60M2

N-channel 600 V, 0.168 Ω typ., 18 A MDmesh II Plus™ low Q_g Power MOSFETs in TO-220FP, I^2PAKFP and TO-3PF packages

Datasheet – production data

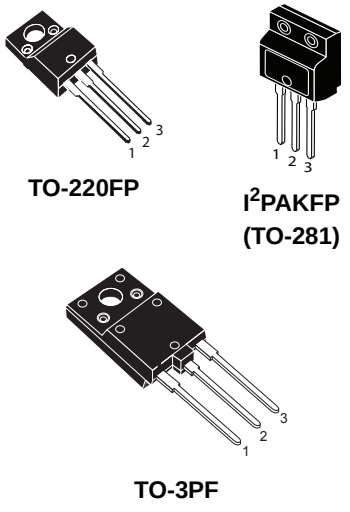
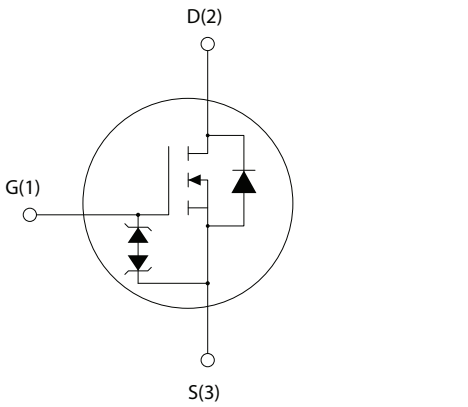


Figure 1. Internal schematic diagram



Features

Order codes	V_{DS} @ T_{Jmax}	$R_{DS(on)}$ max	I_D
STF24N60M2	650 V	0.19 Ω	18 A
STFI24N60M2			
STFW24N60M2			

- 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
- LLC converters, resonant converters

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
STF24N60M2	24N60M2	TO-220FP	Tube
STFI24N60M2		I^2PAKFP (TO-281)	
STFW24N60M2		TO-3PF	

Contents

1 Electrical ratings

Table 2. Absolute maximum ratings

Symbol	Parameter	Value		Unit
		TO-220FP, I^2PAKFP	TO-3PF	
V_{GS}	Gate-source voltage	± 25		V
I_D	Drain current (continuous) at T_C = 25 °C	18 (1)		A
I_D	Drain current (continuous) at T_C = 100 °C	12 (1)		A
I_{DM} (2)	Drain current (pulsed)	72 (1)		A
P_{TOT}	Total dissipation at T_C = 25 °C	30	48	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; Tc = 25 °C)	2500	3500	V
T_{stg}	Storage temperature	- 55 to 150		°C
T_j	Max. operating junction temperature			

1. Limited by maximum junction temperature.
2. Pulse width limited by safe operating area.
3. $I_{SD} \leq 18$ A, di/dt ≤ 400 A/μs; $V_{DS\ peak} < V_{(BR)DSS}$, $V_{DD} = 400$ V.
4. $V_{DS} \leq 480$ V

Table 3. Thermal data

Symbol	Parameter	Value		Unit
		TO-220FP, I^2PAKFP	TO-3PF	
$R_{thj\text{-}case}$	Thermal resistance junction-case max	4.2	2.6	°C/W
$R_{thj\text{-}amb}$	Thermal resistance junction-ambient max	62.5	50	°C/W

Table 4. Avalanche characteristics

Symbol	Parameter	Value	Unit
I_{AR}	Avalanche current, repetitive or not repetitive (pulse width limited by T_{jmax})	3.5	A
E_{AS}	Single pulse avalanche energy (starting T_j=25°C, I_D= I_{AR}; V_{DD}=50)	180	mJ

2 Electrical characteristics

(T_C = 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, I_D = 1 mA	600			V
I_{DSS}	Zero gate voltage drain current	V_{GS} = 0, V_{DS} = 600 V			1	µA
		V_{GS} = 0, V_{DS} = 600 V, T_C=125 °C			100	µA
I_{GSS}	Gate-body leakage current	V_{DS} = 0, 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 = 9 A		0.168	0.19	Ω

Table 6. Dynamic

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
C_{iss}	Input capacitance	V_{DS} = 100 V, f = 1 MHz, V_{GS} = 0	-	1060	-	pF
C_{oss}	Output capacitance		-	55	-	pF
C_{rss}	Reverse transfer capacitance		-	2.2	-	pF
$C_{oss\ eq.}$ (1)	Equivalent output capacitance	V_{DS} = 0 to 480 V, V_{GS} = 0	-	258	-	pF
R_G	Intrinsic gate resistance	f = 1 MHz, I_D=0	-	7	-	Ω
Q_g	Total gate charge	V_{DD} = 480 V, I_D = 18 A, V_{GS} = 10 V (see *Figure 16*)	-	29	-	nC
Q_{gs}	Gate-source charge		-	6	-	nC
Q_{gd}	Gate-drain charge		-	12	-	nC

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} = 300 V, I_D = 9 A, R_G = 4.7 Ω, V_{GS} = 10 V (see *Figure 16* and *21*)	-	14	-	ns
t_r	Rise time		-	9	-	ns
$t_{d(off)}$	Turn-off delay time		-	60	-	ns
t_f	Fall time		-	15	-	ns

Table 8. Source drain diode

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{SD} (1)	Source-drain current		-		18	A
I_{SDM} (1),(2)	Source-drain current (pulsed)		-		72	A
V_{SD} (3)	Forward on voltage	I_{SD} = 18 A, V_{GS} = 0	-		1.6	V
t_{rr}	Reverse recovery time	I_{SD} = 18 A, di/dt = 100 A/µs V_{DD} = 60 V (see *Figure 18*)	-	332		ns
Q_{rr}	Reverse recovery charge		-	4		µC
I_{RRM}	Reverse recovery current		-	24		A
t_{rr}	Reverse recovery time	I_{SD} = 18 A, di/dt = 100 A/µs V_{DD} = 60 V, T_j = 150 °C (see *Figure 18*)	-	450		ns
Q_{rr}	Reverse recovery charge		-	5.5		µC
I_{RRM}	Reverse recovery current		-	25		A

1. The value is rated according to $R_{thj\text{-}case}$ and limited by package.
2. Pulse width limited by safe operating area
3. Pulsed: pulse duration = 300 µs, duty cycle 1.5%

2.1 Electrical characteristics (curves)

Figure 2. Safe operating area for TO-220FP and I²PAKFP

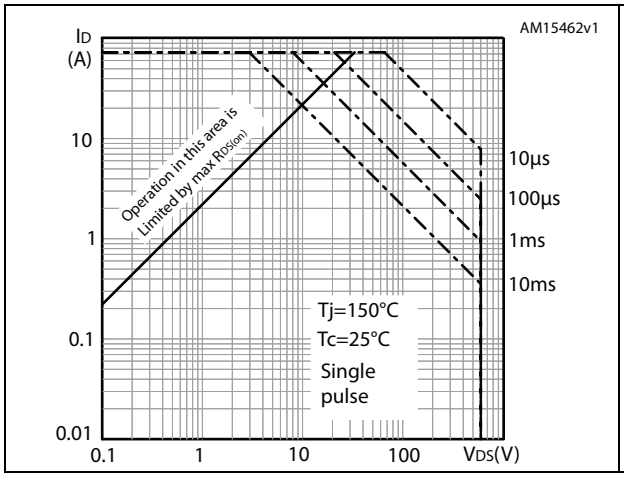


Figure 3. Thermal impedance for TO-220FP and I²PAKFP

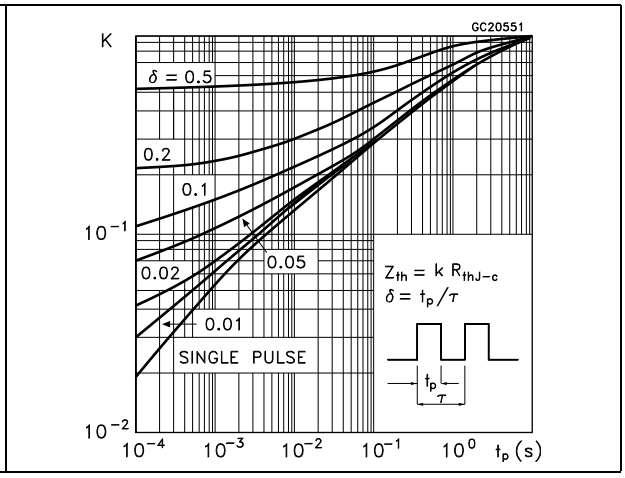


Figure 4. Safe operating area for TO-3PF

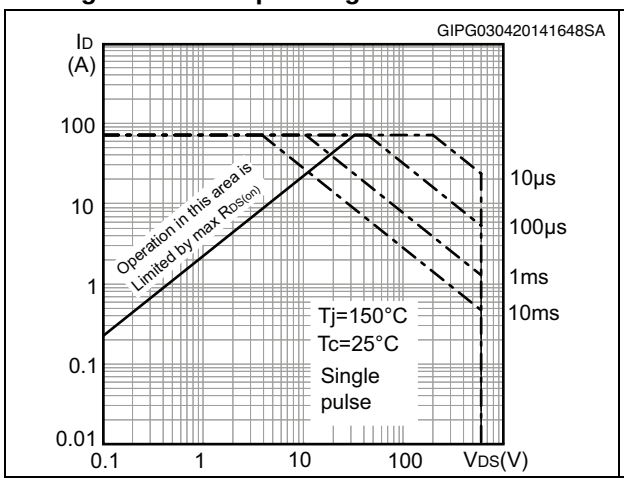


Figure 5. Thermal impedance for TO-3PF

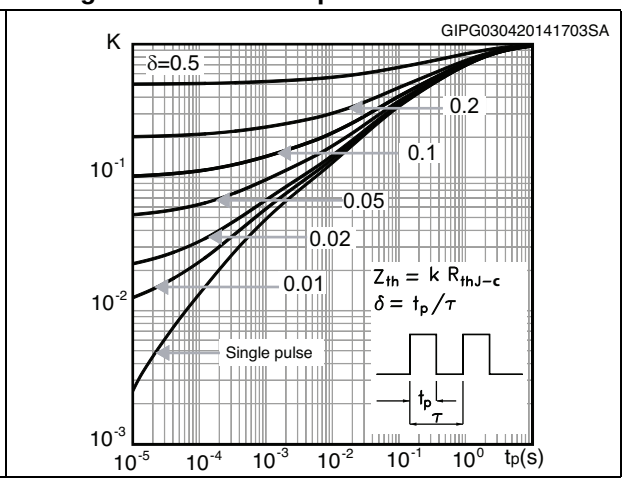


Figure 6. Output characteristics

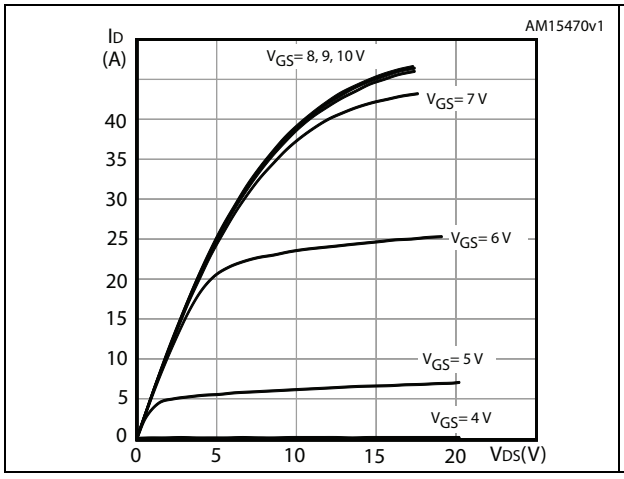


Figure 7. Transfer characteristics

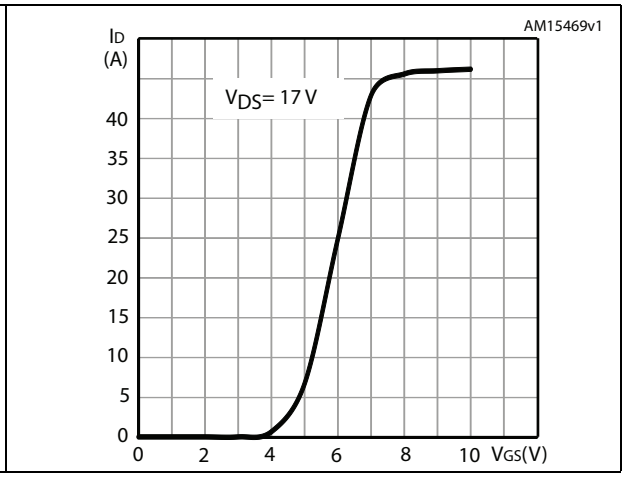


Figure 8. Gate charge vs gate-source voltage

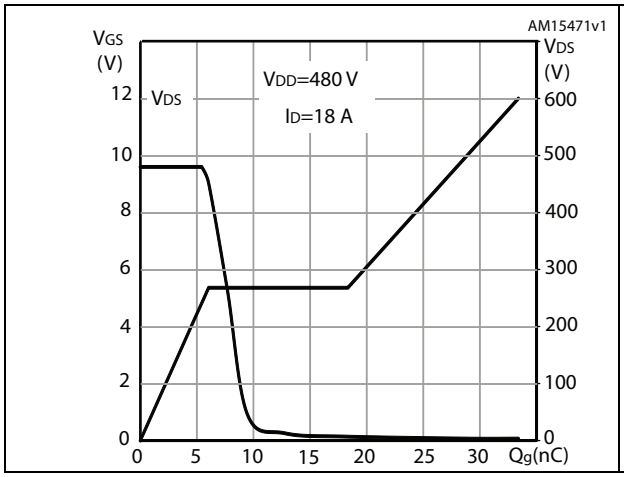


Figure 9. Static drain-source on-resistance

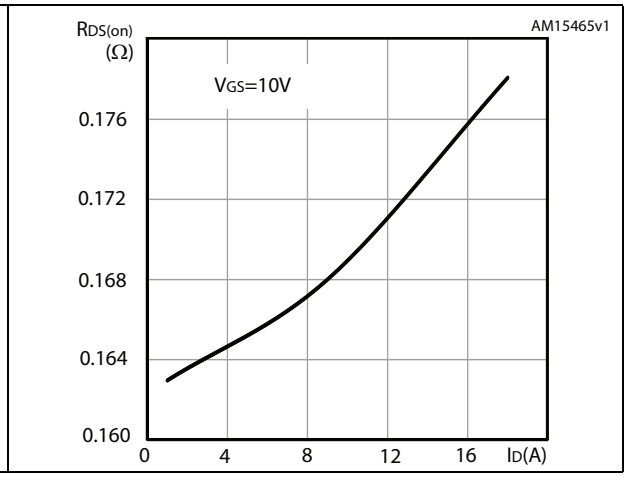


Figure 10. Capacitance variations

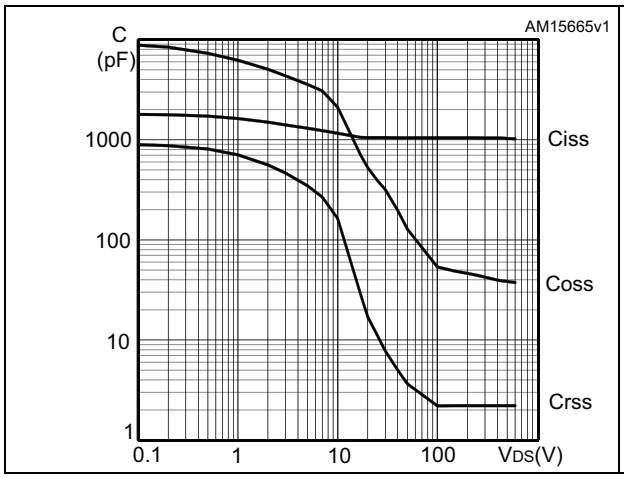


Figure 11. Output capacitance stored energy

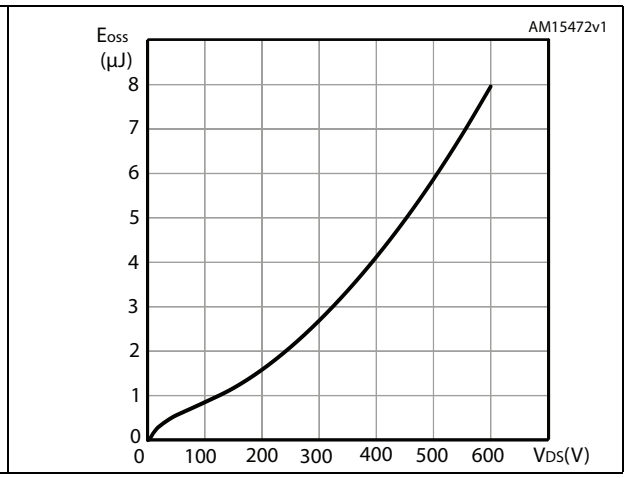


Figure 12. Normalized gate threshold voltage vs temperature

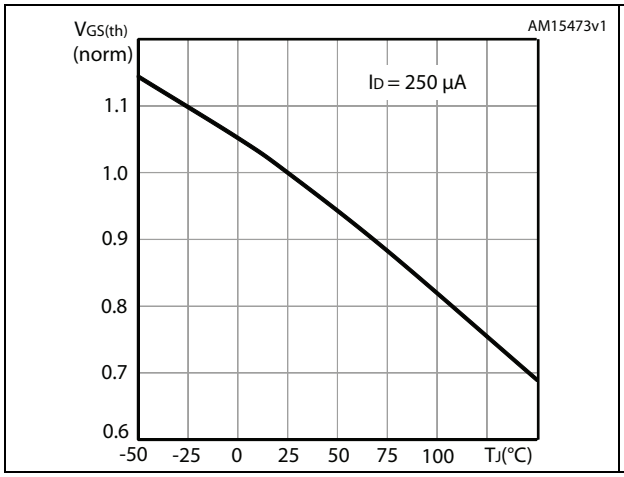


Figure 13. Normalized on-resistance vs temperature

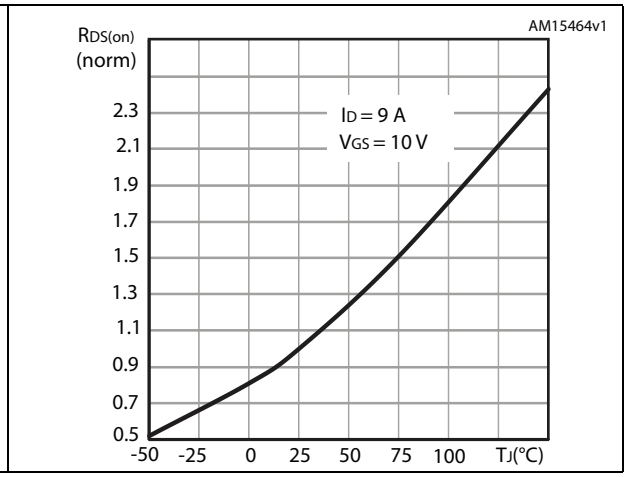


Figure 14. Source-drain diode forward characteristics

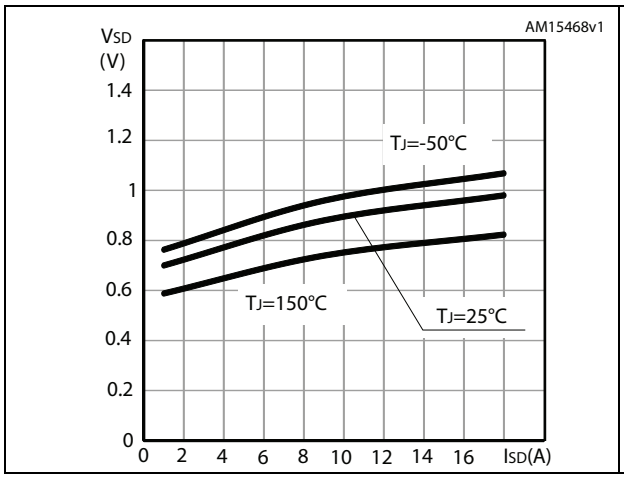
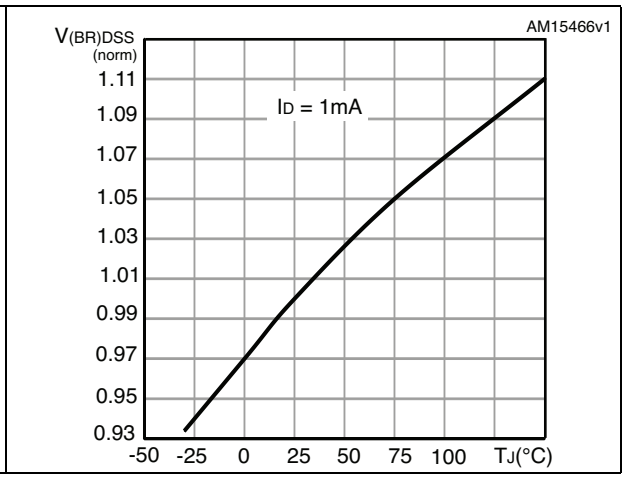


Figure 15. Normalized $V_{(BR)DSS}$ vs temperature



3 Test circuits

Figure 16. Switching times test circuit for resistive load

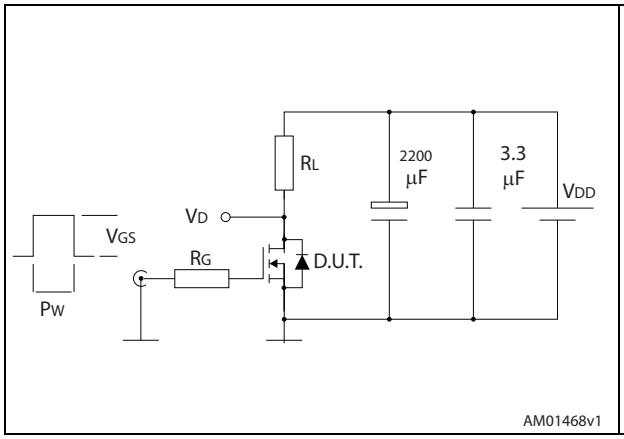


Figure 17. Gate charge test circuit

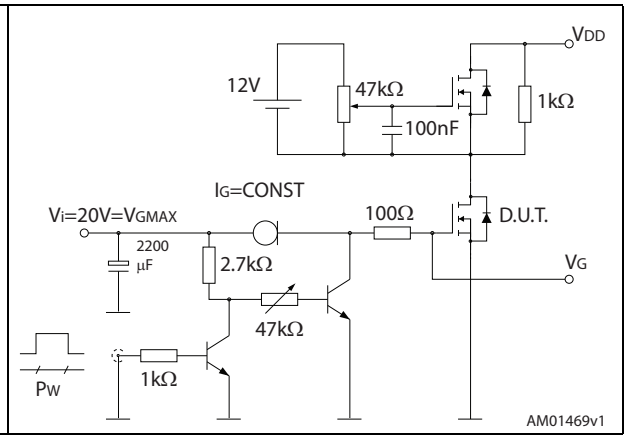


Figure 18. Test circuit for inductive load switching and diode recovery times

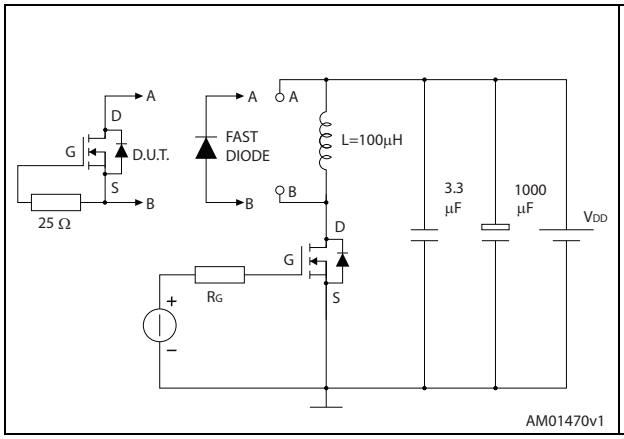


Figure 19. Unclamped inductive load test circuit

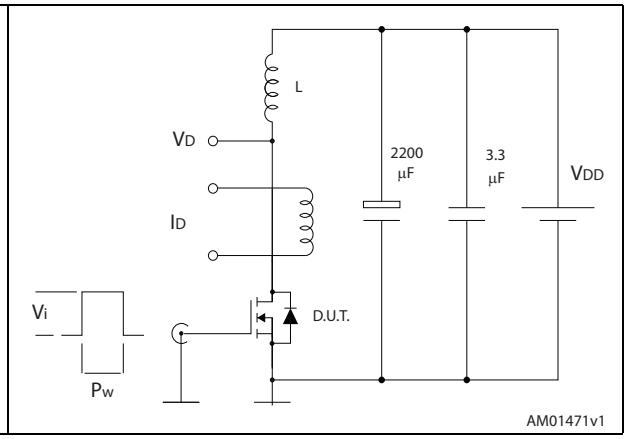


Figure 20. Unclamped inductive waveform

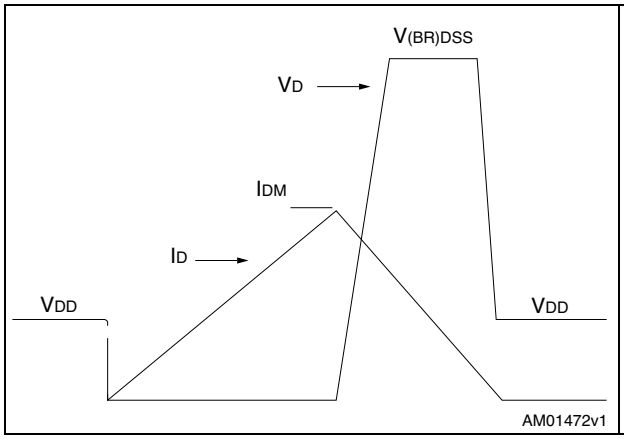
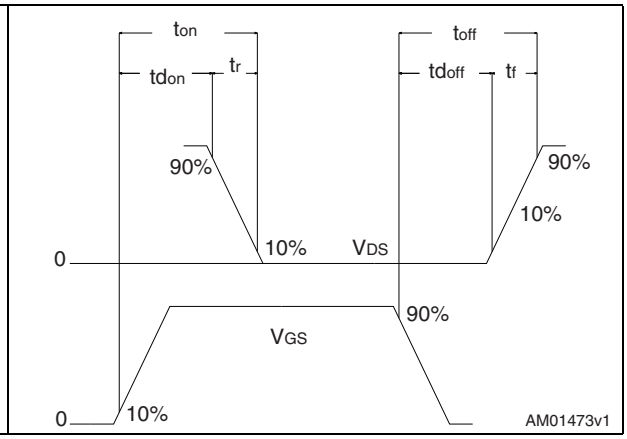


Figure 21. Switching time waveform



4 Package mechanical data

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, STF24N60M2

Figure 22. TO-220FP drawing

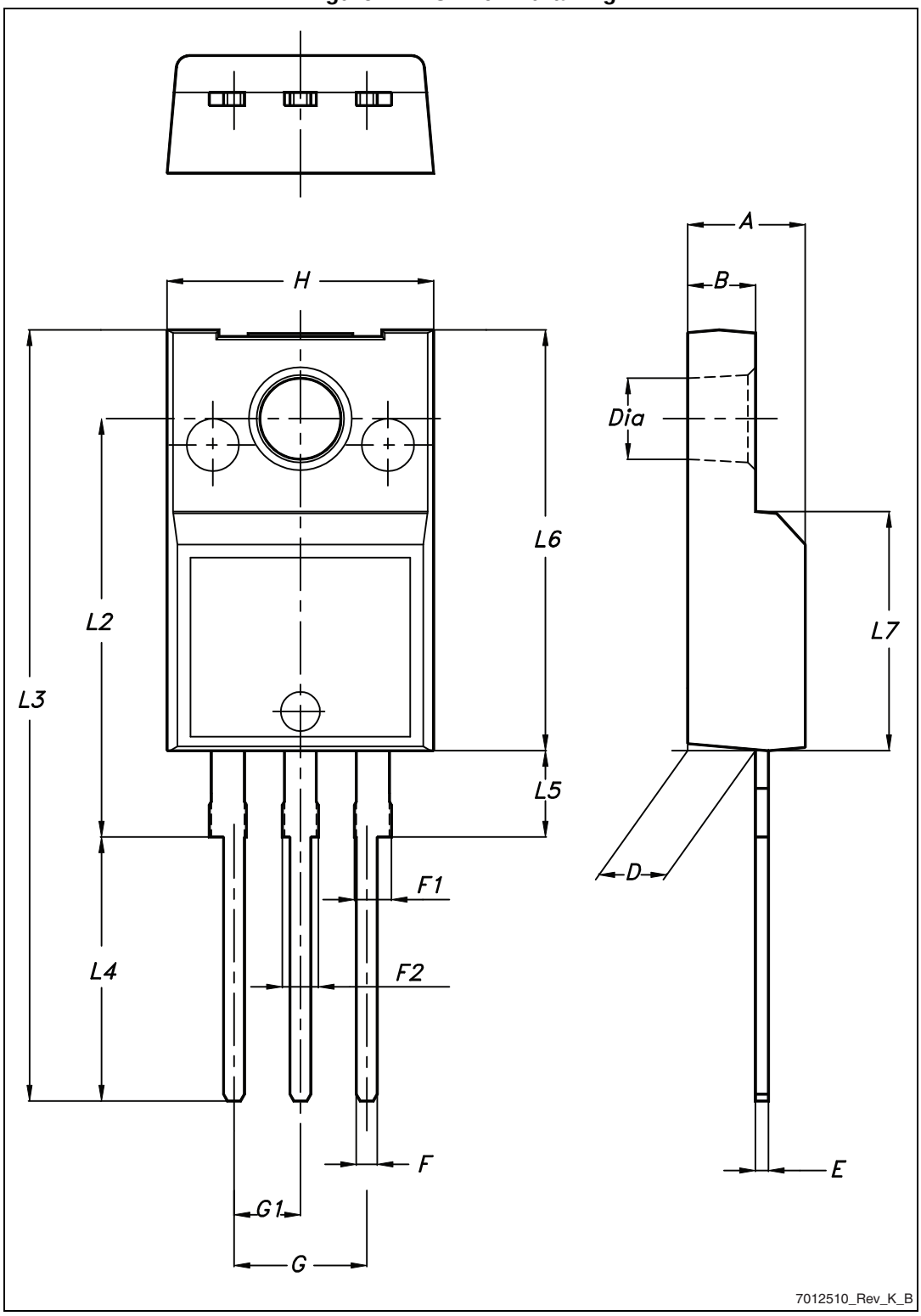


Table 9. TO-220FP mechanical data

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, STFI24N60M2

Figure 23. I²PAKFP (TO-281) drawing

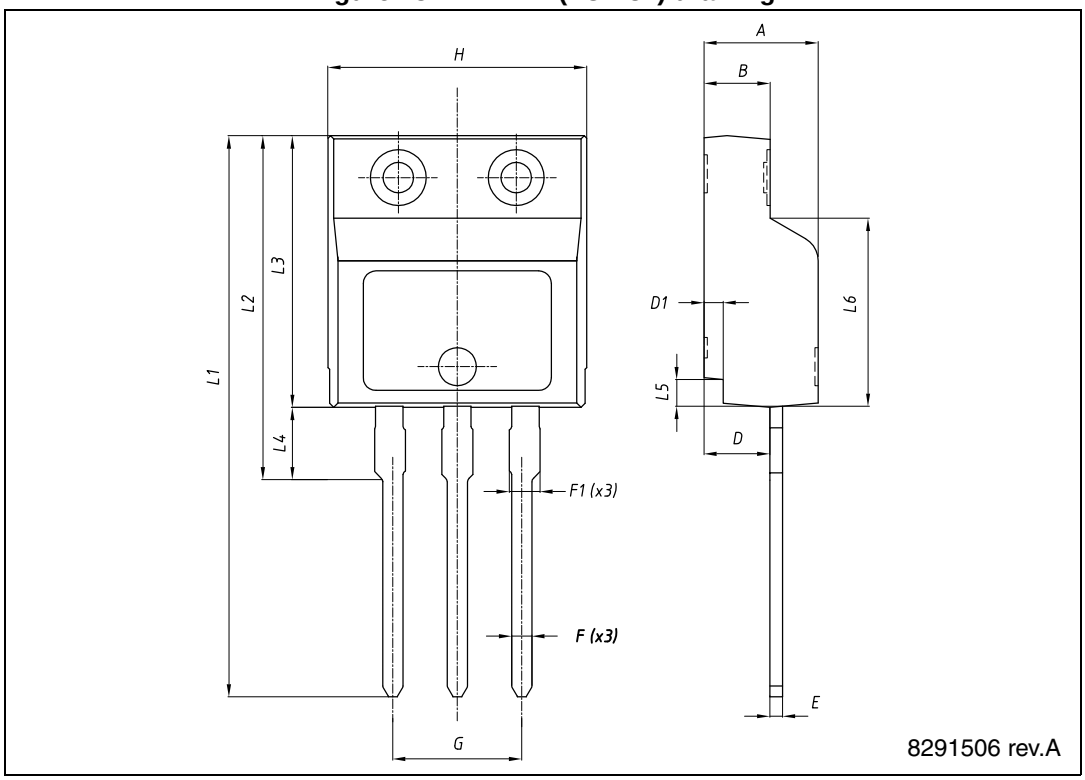


Table 10. I^2PAKFP (TO-281) mechanical data

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

4.3 TO-3PF, STFW24N60M2

Figure 24. TO-3PF drawing

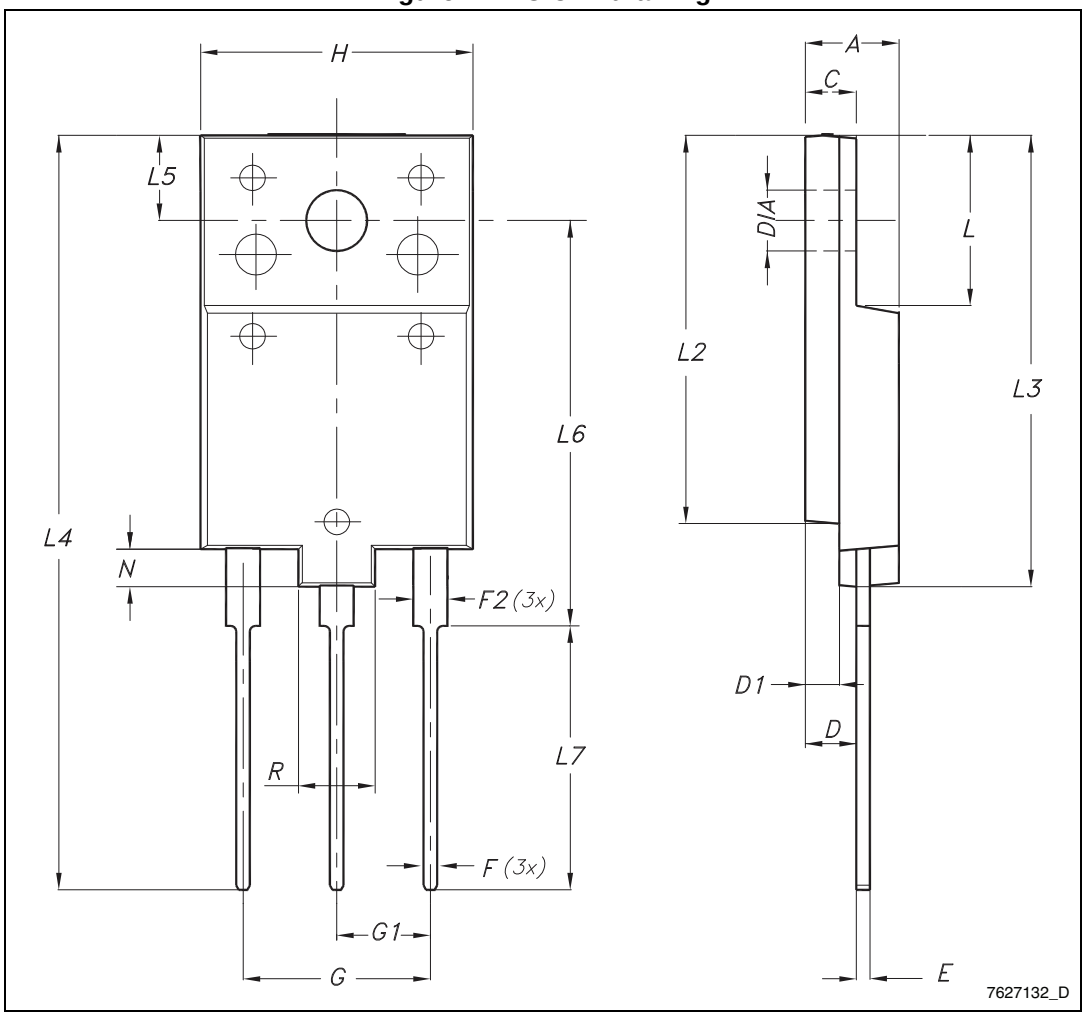


Table 11. TO-3PF mechanical data

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
Dia	3.40		3.80

5 Revision history

Table 12. Document revision history

Date	Revision	Changes
10-Dec-2012	1	First release.
20-Dec-2012	2	Added MOSFET dv/dt ruggedness in *Table 2: Absolute maximum ratings*.
14-Jan-2013	3	Modified: *Figure 16*, *17*
28-May-2013	4	– Modified: *Figure 16*, *17*, *18* and *19* – Minor text changes
28-Feb-2014	5	– Modified: $R_{thj\text{-}case}$ value in *Table 3* – Modified: *Figure 12* – Minor text changes
07-Apr-2014	6	– Added: TO-3PF package – Added: *Section 4.3: TO-3PF, STFW24N60M2* – Minor text changes