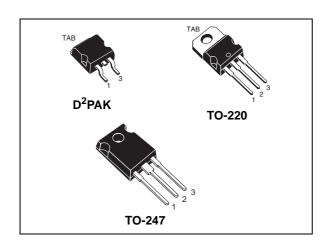


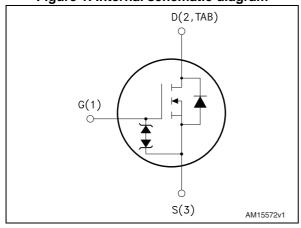
# STB28N60M2, STP28N60M2, STW28N60M2

N-channel 600 V, 0.135 Ω typ., 22 A MDmesh™ M2 Power MOSFETs in D<sup>2</sup>PAK, TO-220 and TO-247 packages

Datasheet - production data



#### Figure 1. Internal schematic diagram



#### **Features**

Order code	V <sub>DS</sub> @ T <sub>Jmax</sub>	R <sub>DS(on)</sub> max	I <sub>D</sub>
STB28N60M2			
STP28N60M2	650 V	0.150 Ω	22 A
STW28N60M2			

- Extremely low gate charge
- Excellent output capacitance (C<sub>oss</sub>) profile
- 100% avalanche tested
- Zener-protected

#### **Applications**

- · Switching applications
- LCC converters, resonant converters

## Description

These devices are N-channel Power MOSFETs developed using MDmesh™ M2 technology. Thanks to their strip layout and improved vertical structure, the devices exhibit low on-resistance and optimized switching characteristics, rendering them suitable for the most demanding high efficiency converters.

Table 1. Device summary

Order code	Marking	Package	Packaging
STB28N60M2		D <sup>2</sup> PAK	Tape and reel
STP28N60M2	28N60M2	TO-220	Tube
STW28N60M2		TO-247	Tube

This is information on a product in full production.

## **Contents**

1	Electrical ratings
2	Electrical characteristics
	2.1 Electrical characteristics (curves)
3	Test circuits
4	Package information
	4.1 D <sup>2</sup> PAK , package information
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6	Revision history



## 1 Electrical ratings

Table 2. Absolute maximum ratings

Symbol	Parameter	Value	Unit
$V_{GS}$	Gate-source voltage	± 25	V
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 25 °C	22	Α
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 100 °C	14	Α
I <sub>DM</sub> <sup>(1)</sup>	Drain current (pulsed)	88	Α
P <sub>TOT</sub>	Total dissipation at T <sub>C</sub> = 25 °C	170	W
dv/dt <sup>(2)</sup>	Peak diode recovery voltage slope	15	V/ns
dv/dt <sup>(3)</sup>	MOSFET dv/dt ruggedness	50	V/ns
T <sub>stg</sub>	Storage temperature	- 55 to 150	°C
Tj	Operating junction temperature	- 55 10 150	

- 1. Pulse width limited by safe operating area.
- 2.  $I_{SD} \le$  22 A, di/dt  $\le$  400 A/µs;  $V_{DS peak} < V_{(BR)DSS}$ ,  $V_{DD}$ = 400 V.
- 3.  $V_{DS} \le 480 \text{ V}$

Table 3. Thermal data

Symbol	Parameter		Value		Unit
Symbol	Farameter	D <sup>2</sup> PAK	TO-220	TO-247	Offic
R <sub>thj-case</sub>	Thermal resistance junction-case max		0.74		°C/W
R <sub>thj-pcb</sub>	Thermal resistance junction-pcb max <sup>(1)</sup>	30			°C/W
R <sub>thj-amb</sub>	Thermal resistance junction-ambient max		62.5	50	°C/W

1. When mounted on 1 inch2 FR-4, 2 Oz copper board

**Table 4. Avalanche characteristics** 

Symbol	Parameter	Value	Unit
I <sub>AR</sub>	Avalanche current, repetitive or not repetitive (pulse width limited by T <sub>jmax</sub> )	3.6	Α
E <sub>AS</sub>	Single pulse avalanche energy (starting $T_j$ =25°C, $I_D$ = $I_{AR}$ ; $V_{DD}$ =50 V)	350	mJ

### 2 Electrical characteristics

(T<sub>C</sub> = 25 °C unless otherwise specified)

Table 5. On /off states

Symbol	Parameter	Test conditions	Min.	Тур.	Max.	Unit
V <sub>(BR)DSS</sub>	Drain-source breakdown voltage	$I_D = 1 \text{ mA}, V_{GS} = 0$	600			V
1	Zero gate voltage	V <sub>DS</sub> = 600 V			1	μA
I <sub>DSS</sub>	drain current (V <sub>GS</sub> = 0)	V <sub>DS</sub> = 600 V, T <sub>C</sub> =125 °C			100	μA
I <sub>GSS</sub>	Gate-body leakage current (V <sub>DS</sub> = 0)	V <sub>GS</sub> = ± 25 V			±10	μΑ
V <sub>GS(th)</sub>	Gate threshold voltage	$V_{DS} = V_{GS}, I_{D} = 250 \mu A$	2	3	4	V
R <sub>DS(on)</sub>	Static drain-source on-resistance	V <sub>GS</sub> = 10 V, I <sub>D</sub> = 11 A		0.135	0.150	Ω

Table 6. Dynamic

Symbol	Parameter	Test conditions	Min.	Тур.	Max.	Unit
C <sub>iss</sub>	Input capacitance		-	1440	-	pF
C <sub>oss</sub>	Output capacitance	V <sub>DS</sub> = 100 V, f = 1 MHz,	-	70	-	pF
C <sub>rss</sub>	Reverse transfer capacitance	$V_{GS} = 0$	-	2	-	pF
Coss eq. (1)	Equivalent output capacitance	$V_{DS} = 0$ to 480 V, $V_{GS} = 0$	-	104	-	pF
R <sub>G</sub>	Intrinsic gate resistance	f = 1 MHz open drain	-	5.5	-	Ω
Qg	Total gate charge	V <sub>DD</sub> = 480 V, I <sub>D</sub> = 22 A,	-	36	-	nC
Q <sub>gs</sub>	Gate-source charge	V <sub>GS</sub> = 10 V	-	7.2	-	nC
Q <sub>gd</sub>	Gate-drain charge	(see Figure 17)	-	16	-	nC

<sup>1.</sup>  $C_{oss\ eq.}$  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.	Тур.	Max.	Unit
t <sub>d(on)</sub>	Turn-on delay time		-	14.5	-	ns
t <sub>r</sub>	Rise time	$V_{DD} = 300 \text{ V}, I_D = 11 \text{ A},$ $R_G = 4.7 \Omega, V_{GS} = 10 \text{ V}$	-	7.2	-	ns
t <sub>d(off)</sub>	Turn-off delay time	$[\kappa_G = 4.7 \Omega, \kappa_{GS} = 10 \text{ V}]$ (see <i>Figure 18</i> and <i>Figure 21</i> )	-	100	-	ns
t <sub>f</sub>	Fall time		-	8	-	ns



Table 8. Source drain diode

Symbol	Parameter	Test conditions	Min.	Тур.	Max.	Unit
I <sub>SD</sub>	Source-drain current		-		22	Α
I <sub>SDM</sub> <sup>(1)</sup>	Source-drain current (pulsed)		-		88	Α
V <sub>SD</sub> (2)	Forward on voltage	I <sub>SD</sub> = 22 A, V <sub>GS</sub> = 0	-		1.6	V
t <sub>rr</sub>	Reverse recovery time		-	350		ns
Q <sub>rr</sub>	Reverse recovery charge	$I_{SD} = 22 \text{ A, di/dt} = 100 \text{ A/µs}$ $V_{DD} = 60 \text{ V (see Figure 21)}$	-	4.7		μC
I <sub>RRM</sub>	Reverse recovery current	100 = 33 1 (333 1 igal 2 1)	-	27		Α
t <sub>rr</sub>	Reverse recovery time	I <sub>SD</sub> = 22 A, di/dt = 100 A/μs	-	451		ns
Q <sub>rr</sub>	Reverse recovery charge	$V_{DD} = 60 \text{ V}, T_j = 150 ^{\circ}\text{C}$	-	6.5		μC
I <sub>RRM</sub>	Reverse recovery current	(see <i>Figure 21</i> )	-	29		Α

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

#### 2.1 Electrical characteristics (curves)

Figure 2. Safe operating area for D<sup>2</sup>PAK and TO-220

Figure 3. Thermal impedance for D<sup>2</sup>PAK and TO-220

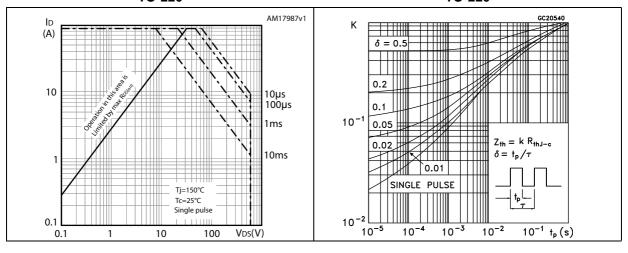


Figure 4. Safe operating area for TO-247

Figure 5. Thermal impedance for TO-247

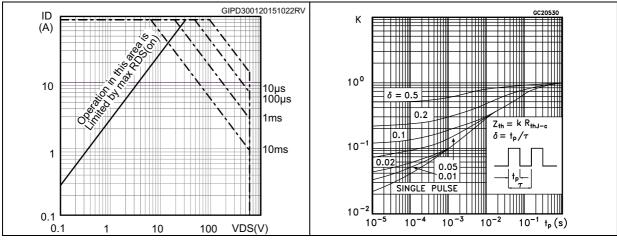


Figure 6. Output characteristics

Figure 7. Transfer characteristics

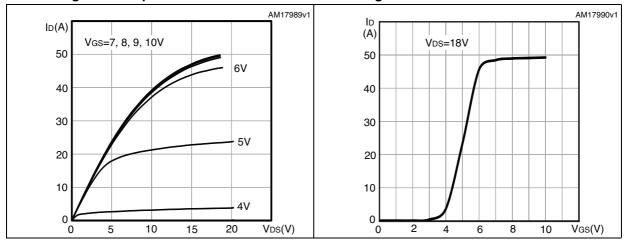
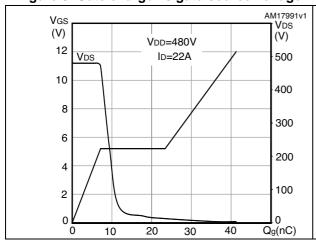


Figure 8. Gate charge vs gate-source voltage

Figure 9. Static drain-source on-resistance



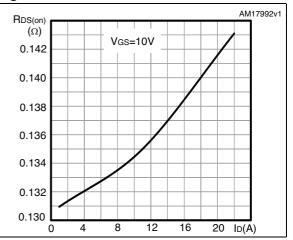
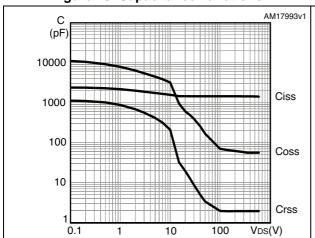


Figure 10. Capacitance variations

Figure 11. Output capacitance stored energy



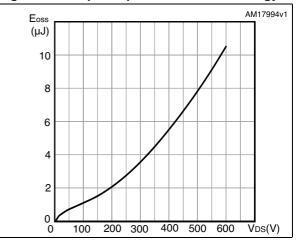
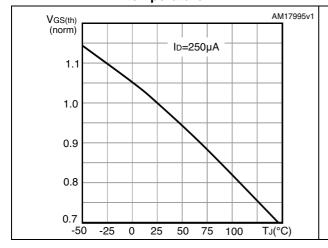
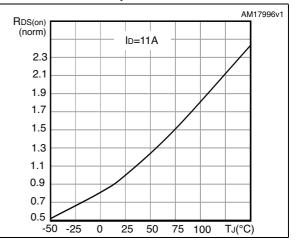


Figure 12. Normalized gate threshold voltage vs temperature

Figure 13. Normalized on-resistance vs temperature

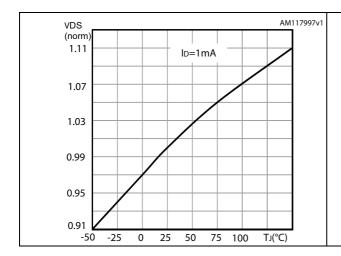


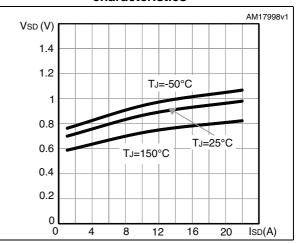


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Figure 14. Normalized  $V_{DS}$  vs temperature

Figure 15. Source-drain diode forward characteristics





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#### 3 Test circuits

Figure 16. Switching times test circuit for resistive load

Figure 17. Gate charge test circuit

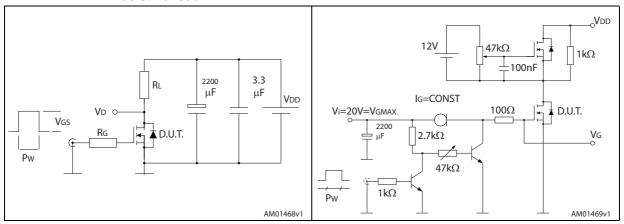


Figure 18. Test circuit for inductive load switching and diode recovery times

Figure 19. Unclamped inductive load test circuit

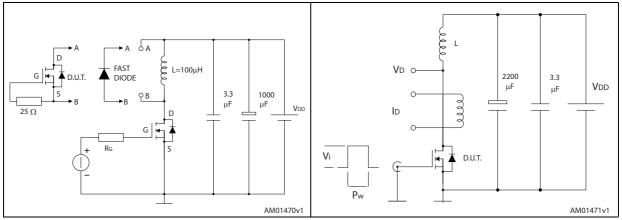
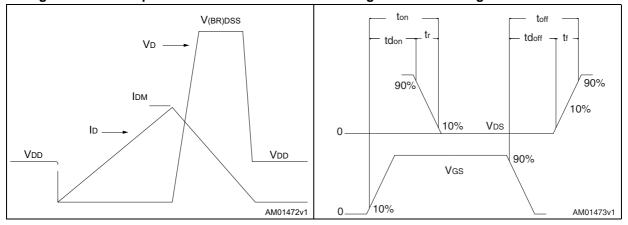


Figure 20. Unclamped inductive waveform

Figure 21. Switching time waveform





## 4 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK<sup>®</sup> packages, depending on their level of environmental compliance. ECOPACK<sup>®</sup> specifications, grade definitions and product status are available at: <a href="https://www.st.com">www.st.com</a>. ECOPACK<sup>®</sup> is an ST trademark.

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## 4.1 D<sup>2</sup>PAK , package information

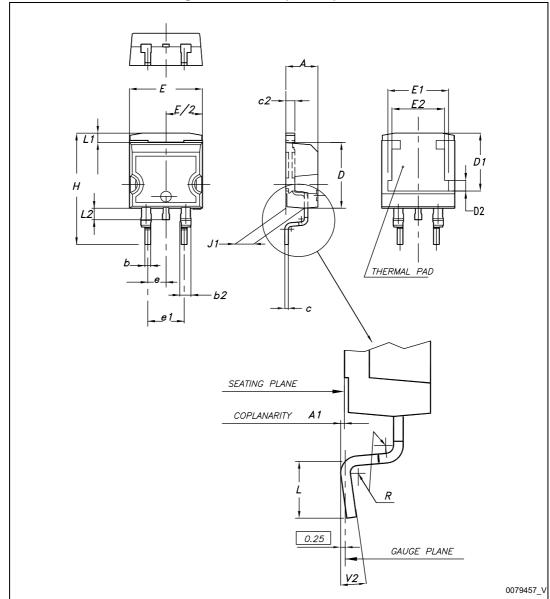


Figure 22. D<sup>2</sup>PAK (TO-263) outline

Table 9. D<sup>2</sup>PAK (TO-263) mechanical data

Dim		mm	
Dim.	Min.	Тур.	Max.
Α	4.40		4.60
A1	0.03		0.23
b	0.70		0.93
b2	1.14		1.70
С	0.45		0.60
c2	1.23		1.36
D	8.95		9.35
D1	7.50	7.75	8.00
D2	1.10	1.30	1.50
E	10		10.40
E1	8.50	8.70	8.90
E2	6.85	7.05	7.25
е		2.54	
e1	4.88		5.28
Н	15		15.85
J1	2.49		2.69
L	2.29		2.79
L1	1.27		1.40
L2	1.30		1.75
R		0.4	
V2	0°		8°

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9.75

16.9

2.54

5.08

Figure 23. D<sup>2</sup>PAK footprint<sup>(a)</sup>

a. All dimension are in millimeters

## 4.2 TO-220, package information

øΡ H1 D1 L20 L30 <u>L</u>1 b1(X3) b (X3) \_e1\_\_

Figure 24. TO-220 type A outline

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0015988\_typeA\_Rev\_T

Table 10. TO-220 type A mechanical data

Dim		mm	
Dim.	Min.	Тур.	Max.
А	4.40		4.60
b	0.61		0.88
b1	1.14		1.70
С	0.48		0.70
D	15.25		15.75
D1		1.27	
E	10		10.40
е	2.40		2.70
e1	4.95		5.15
F	1.23		1.32
H1	6.20		6.60
J1	2.40		2.72
L	13		14
L1	3.50		3.93
L20		16.40	
L30		28.90	
ØP	3.75		3.85
Q	2.65		2.95

# 4.3 TO-247, package information

HEAT-SINK PLANE

BACK VIEW 0075325, H

Figure 25. TO-247 outline

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Table 11. TO-247 mechanical data

	Table 11. 10-247 mechanical data						
Dim.	mm.						
	Min.	Тур.	Max.				
Α	4.85		5.15				
A1	2.20		2.60				
b	1.0		1.40				
b1	2.0		2.40				
b2	3.0		3.40				
С	0.40		0.80				
D	19.85		20.15				
E	15.45		15.75				
е	5.30	5.45	5.60				
L	14.20		14.80				
L1	3.70		4.30				
L2		18.50					
ØP	3.55		3.65				
ØR	4.50		5.50				
S	5.30	5.50	5.70				

## 5 Packaging mechanical data

10 pitches cumulative tolerance on tape +/- 0.2 mm

Top cover tape

For machine ref. only including draft and radii concentric around B0

User direction of feed

Liser direction of feed

AM08852v1

Figure 26. Tape

REEL DIMENSIONS

T

40mm min.

Access hole

At sl ot location

Tape slot in core for tape start 25 mm min. width

AM08851v2

Figure 27. Reel

Table 12. D<sup>2</sup>PAK (TO-263) tape and reel mechanical data

Таре			Reel		
Dim.	m	m	Dim.	mm	
	Min.	Max.	] Dilli.	Min.	Max.
A0	10.5	10.7	Α		330
В0	15.7	15.9	В	1.5	
D	1.5	1.6	С	12.8	13.2
D1	1.59	1.61	D	20.2	
Е	1.65	1.85	G	24.4	26.4
F	11.4	11.6	N	100	
K0	4.8	5.0	Т		30.4
P0	3.9	4.1			
P1	11.9	12.1	Base qty 1000		
P2	1.9	2.1	Bulk qty 1000		
R	50				
Т	0.25	0.35			
W	23.7	24.3			

## 6 Revision history

Table 13. Document revision history

Date	Revision	Changes	
13-Sep-2013	1	First release.	
29-Jan-2014	2	<ul> <li>Modified: title, I<sub>D</sub> value and features in cover page</li> <li>Modified: I<sub>D</sub>, I<sub>DM</sub> and P<sub>TOT</sub> values in <i>Table 2</i></li> <li>Modified: note 2</li> <li>Modified: R<sub>thj-case</sub> value in <i>Table 3</i></li> <li>Modified: the entire typical values in <i>Table 4</i>, 6, 7 and 8</li> <li>Modified: R<sub>DS(on)</sub> typical value in <i>Table 5</i></li> <li>Modified: <i>Figure 9</i> and 10</li> <li>Added: <i>Section 4: Package information</i></li> <li>Minor text changes</li> </ul>	
09-Feb-2015	- Updated title and description - Updated Table 2.: Absolute maximum ratings and Table 4.:  Avalanche characteristics - Updated Figure 5.: Thermal impedance for TO-247 and Figure 6  Output characteristics - Updated 4: Package information - Minor text changes.		

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