

N-channel 600 V, 0.135 Ω typ., 22 A MDmesh™ M2
Power MOSFETs in D²PAK, I²PAK, TO-220 and TO-247

Datasheet - production data

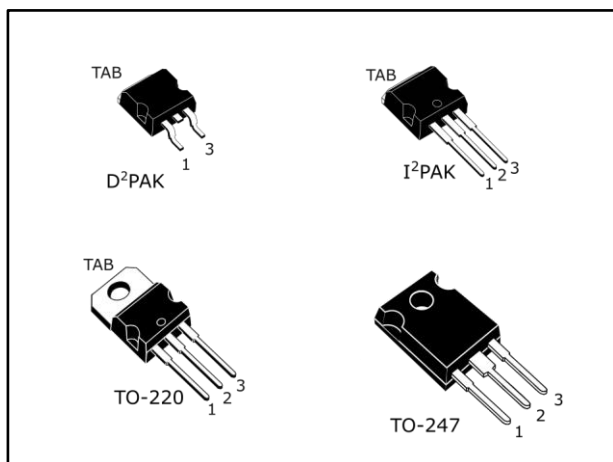
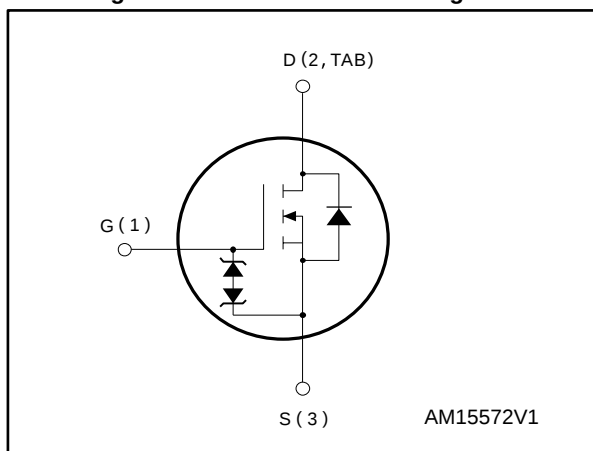


Figure 1: Internal schematic diagram



Features

Order code	V _{DS} @ T _{Jmax}	R _{DS(on)} max.	I _D
STB28N60M2	650 V	0.150 Ω	22 A
STI28N60M2			
STP28N60M2			
STW28N60M2			

- Extremely low gate charge
- Excellent output capacitance (C_{oss}) 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, these 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	Packing
STB28N60M2	28N60M2	D ² PAK	Tape and reel
STI28N60M2		I ² PAK	Tube
STP28N60M2		TO-220	
STW28N60M2		TO-247	

Contents

1	Electrical ratings	3
2	Electrical characteristics	4
	2.1 Electrical characteristics (curves)	6
3	Test circuits	9
4	Package information	10
	4.1 D ² PAK package information	10
	4.2 D ² PAK packing information	13
	4.3 I ² PAK package information	15
	4.4 TO-220 type A package information.....	16
	4.5 TO-247 package information.....	18
5	Revision history	20

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 $T_C = 25\text{ }^{\circ}\text{C}$	22	A
I_D	Drain current (continuous) at $T_C = 100\text{ }^{\circ}\text{C}$	14	A
$I_{DM}^{(1)}$	Drain current (pulsed)	88	A
P_{TOT}	Total dissipation at $T_C = 25\text{ }^{\circ}\text{C}$	170	W
$dv/dt^{(2)}$	Peak diode recovery voltage slope	15	V/ns
$dv/dt^{(3)}$	MOSFET dv/dt ruggedness	50	V/ns
T_{stg}	Storage temperature range	-55 to 150	$^{\circ}\text{C}$
T_j	Operating junction temperature range		

Notes:

(1)Pulse width limited by safe operating area.

(2) $I_{SD} \leq 22\text{ A}$, $di/dt \leq 400\text{ A}/\mu\text{s}$; $V_{DS(peak)} < V_{(BR)DSS}$, $V_{DD} = 400\text{ V}$.(3) $V_{DS} \leq 480\text{ V}$

Table 3: Thermal data

Symbol	Parameter	Value				Unit
		D ² PAK	I ² PAK	TO-220	TO-247	
$R_{thj-case}$	Thermal resistance junction-case max	0.74				$^{\circ}\text{C}/\text{W}$
$R_{thj-pcb}$	Thermal resistance junction-pcb max ⁽¹⁾	30				$^{\circ}\text{C}/\text{W}$
$R_{thj-amb}$	Thermal resistance junction-ambient max		62.5	62.5	50	$^{\circ}\text{C}/\text{W}$

Notes:(1)When mounted on 1 inch² FR-4, 2 Oz copper board.

Table 4: Avalanche characteristics

Symbol	Parameter	Value	Unit
I_{AR}	Avalanche current, repetetive or not repetetive (pulse width limited by T_{jmax})	3.6	A
E_{AS}	Single pulse avalanche energy (starting $T_j = 25\text{ }^{\circ}\text{C}$, $I_D = I_{AR}$, $V_{DD} = 50\text{ V}$)	350	mJ

2 Electrical characteristics

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

Table 5: On/off states

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source breakdown voltage	$V_{GS} = 0\text{ V}$, $I_D = 1\text{ mA}$	600			V
I_{DSS}	Zero gate voltage drain current	$V_{GS} = 0\text{ V}$, $V_{DS} = 600\text{ V}$			1	μA
		$V_{GS} = 0\text{ V}$, $V_{DS} = 600\text{ V}$, $T_C = 125\text{ }^{\circ}\text{C}$ ⁽¹⁾			100	μA
I_{GSS}	Gate-body leakage current	$V_{DS} = 0\text{ V}$, $V_{GS} = \pm 25\text{ V}$			± 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	$V_{GS} = 10\text{ V}$, $I_D = 11\text{ A}$		0.135	0.150	Ω

Notes:

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

Table 6: Dynamic

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
C_{iss}	Input capacitance	$V_{DS} = 100\text{ V}$, $f = 1\text{ MHz}$, $V_{GS} = 0\text{ V}$	-	1440	-	pF
C_{oss}	Output capacitance		-	70	-	pF
C_{rss}	Reverse transfer capacitance		-	2	-	pF
$C_{oss\text{ eq.}}^{(1)}$	Equivalent output capacitance	$V_{DS} = 0\text{ to }480\text{ V}$, $V_{GS} = 0\text{ V}$	-	104	-	pF
R_G	Intrinsic gate resistance	$f = 1\text{ MHz}$ open drain	-	5.5	-	Ω
Q_g	Total gate charge	$V_{DD} = 480\text{ V}$, $I_D = 22\text{ A}$,	-	36	-	nC
Q_{gs}	Gate-source charge	$V_{GS} = 0\text{ to }10\text{ V}$ (see Figure 17: "Test circuit for gate charge behavior")	-	7.2	-	nC
Q_{gd}	Gate-drain charge		-	16	-	nC

Notes:

⁽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	$V_{DD} = 300\text{ V}$, $I_D = 11\text{ A}$, $R_G = 4.7\text{ }\Omega$, $V_{GS} = 10\text{ V}$ (see Figure 16: "Test circuit for resistive load switching times" and Figure 21: "Switching time waveform")	-	14.5	-	ns
t_r	Rise time		-	7.2	-	ns
$t_{d(off)}$	Turn-off-delay time		-	100	-	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		-		22	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)		-		88	A
$V_{SD}^{(2)}$	Forward on voltage	$V_{GS} = 0\text{ V}$, $I_{SD} = 22\text{ A}$	-		1.6	V
t_{rr}	Reverse recovery time	$I_{SD} = 22\text{ A}$, $di/dt = 100\text{ A}/\mu\text{s}$, $V_{DD} = 60\text{ V}$ (see Figure 21: "Switching time waveform")	-	350		ns
Q_{rr}	Reverse recovery charge		-	4.7		μC
I_{RRM}	Reverse recovery current		-	27		A
t_{rr}	Reverse recovery time	$I_{SD} = 22\text{ A}$, $di/dt = 100\text{ A}/\mu\text{s}$, $V_{DD} = 60\text{ V}$, $T_j = 150\text{ }^\circ\text{C}$ (see Figure 21: "Switching time waveform")	-	451		ns
Q_{rr}	Reverse recovery charge		-	6.5		μC
I_{RRM}	Reverse recovery current		-	29		A

Notes:

⁽¹⁾Pulse width is 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 for D²PAK, TO-220 and I²PAK

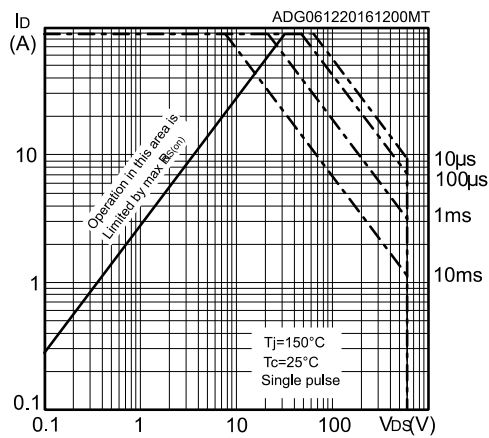


Figure 3: Thermal impedance for D²PAK, TO-220 and I²PAK

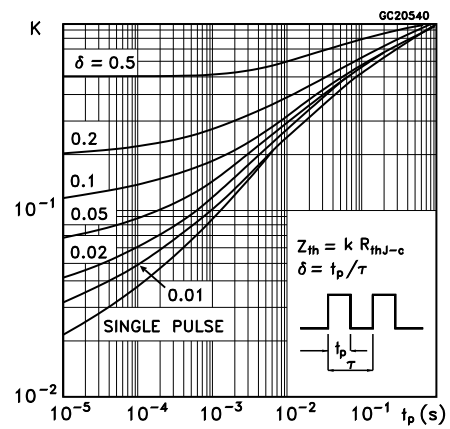


Figure 4: Safe operating area for TO-247

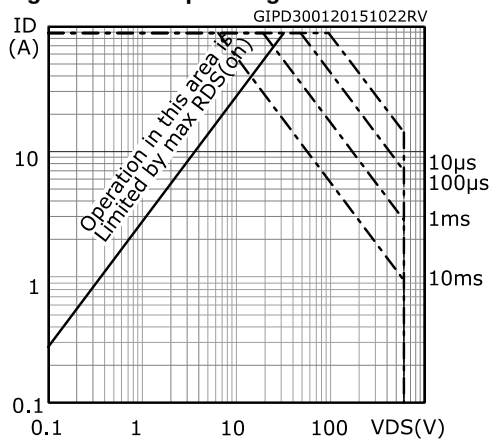


Figure 5: Thermal impedance for TO-247

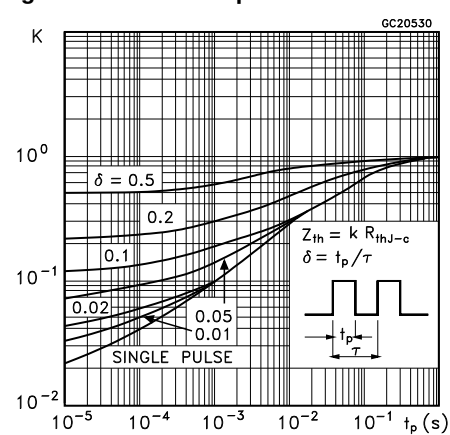


Figure 6: Output characteristics

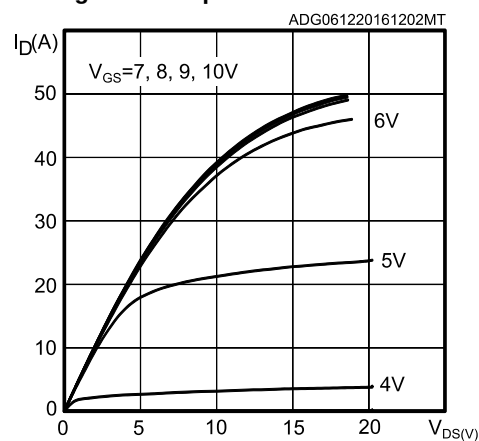


Figure 7: Transfer characteristics

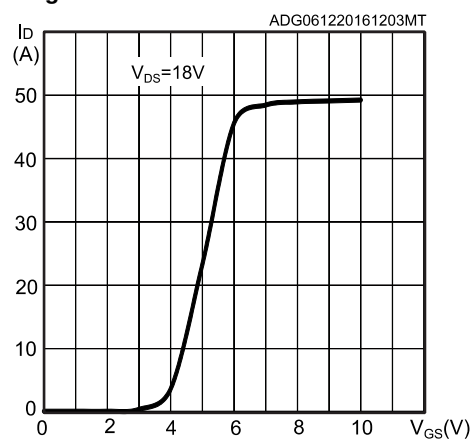


Figure 8: Gate charge vs gate-source voltage

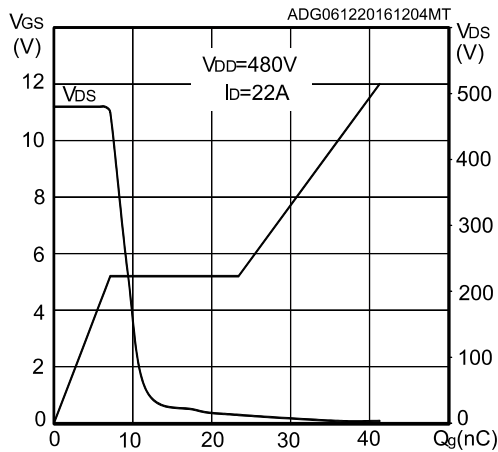


Figure 9: Static drain-source on-resistance

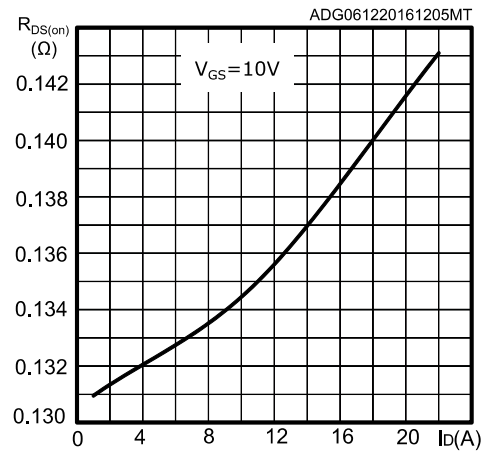


Figure 10: Capacitance variations

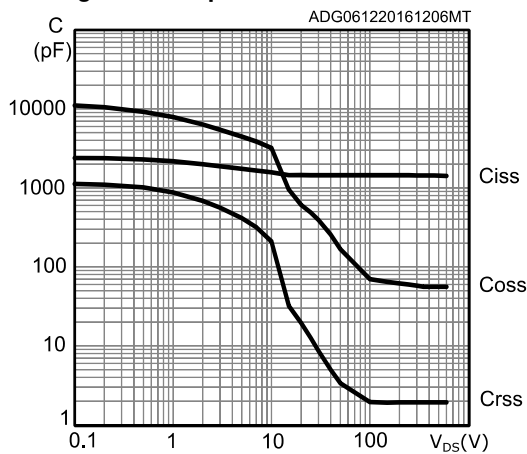


Figure 11: Output capacitance stored energy

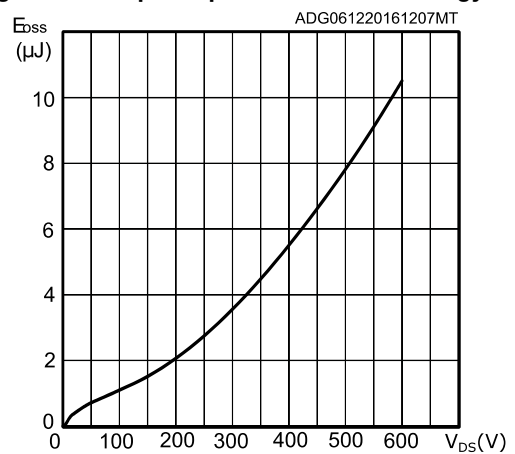


Figure 12: Normalized gate threshold voltage vs temperature

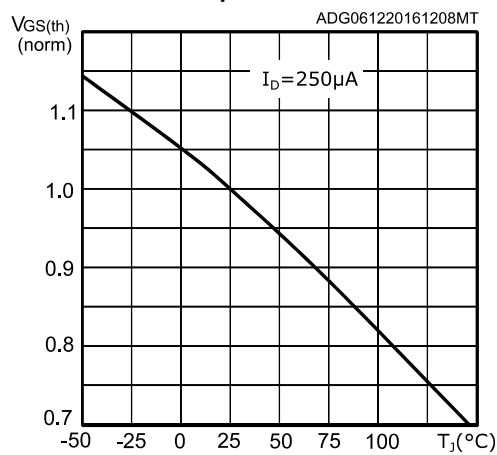


Figure 13: Normalized on-resistance vs temperature

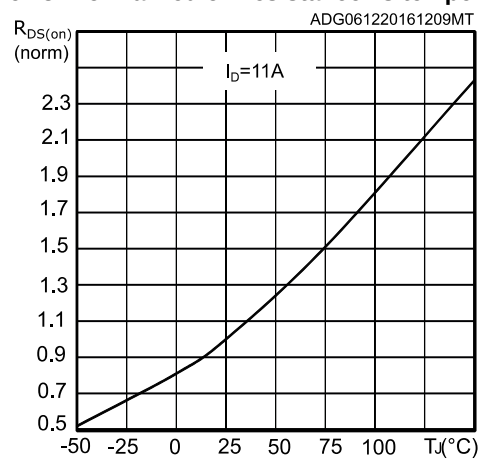


Figure 14: Normalized VDS vs temperature

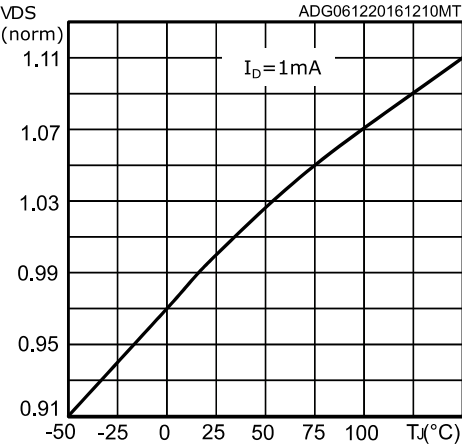
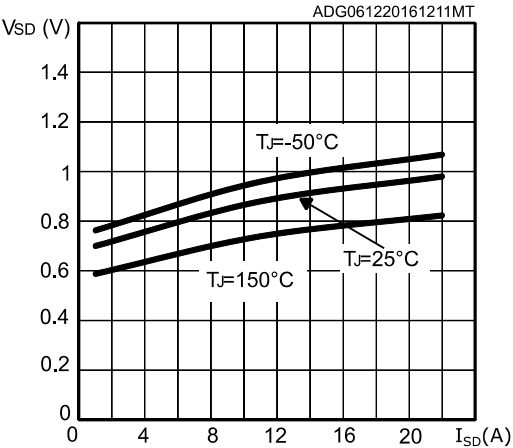
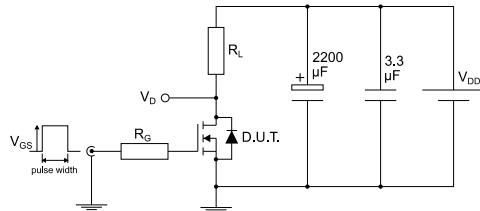


Figure 15: Source-drain diode forward characteristics



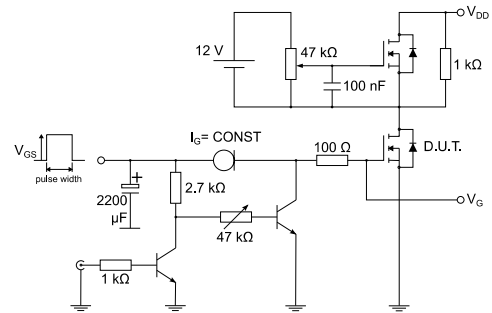
3 Test circuits

Figure 16: Test circuit for resistive load switching times



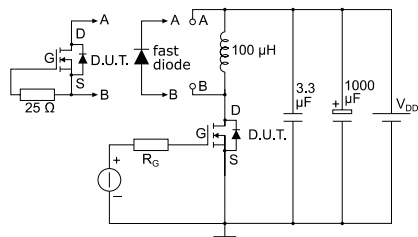
AM01468v1

Figure 17: Test circuit for gate charge behavior



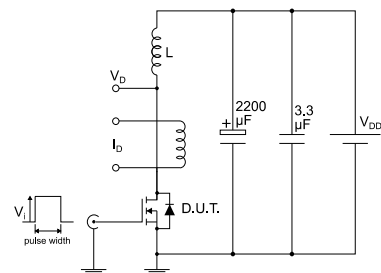
AM01469v1

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



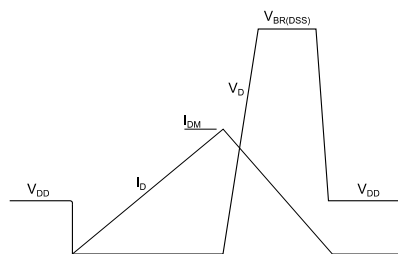
AM01470v1

Figure 19: Unclamped inductive load test circuit



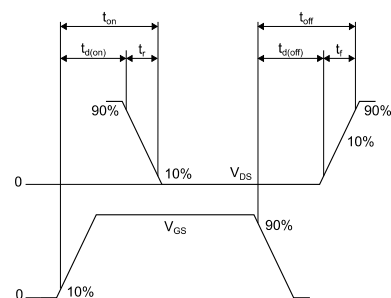
AM01471v1

Figure 20: Unclamped inductive waveform



AM01472v1

Figure 21: Switching time waveform



AM01473v1

4 Package information

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 D²PAK package information

Figure 22: D²PAK (TO-263) type A package outline

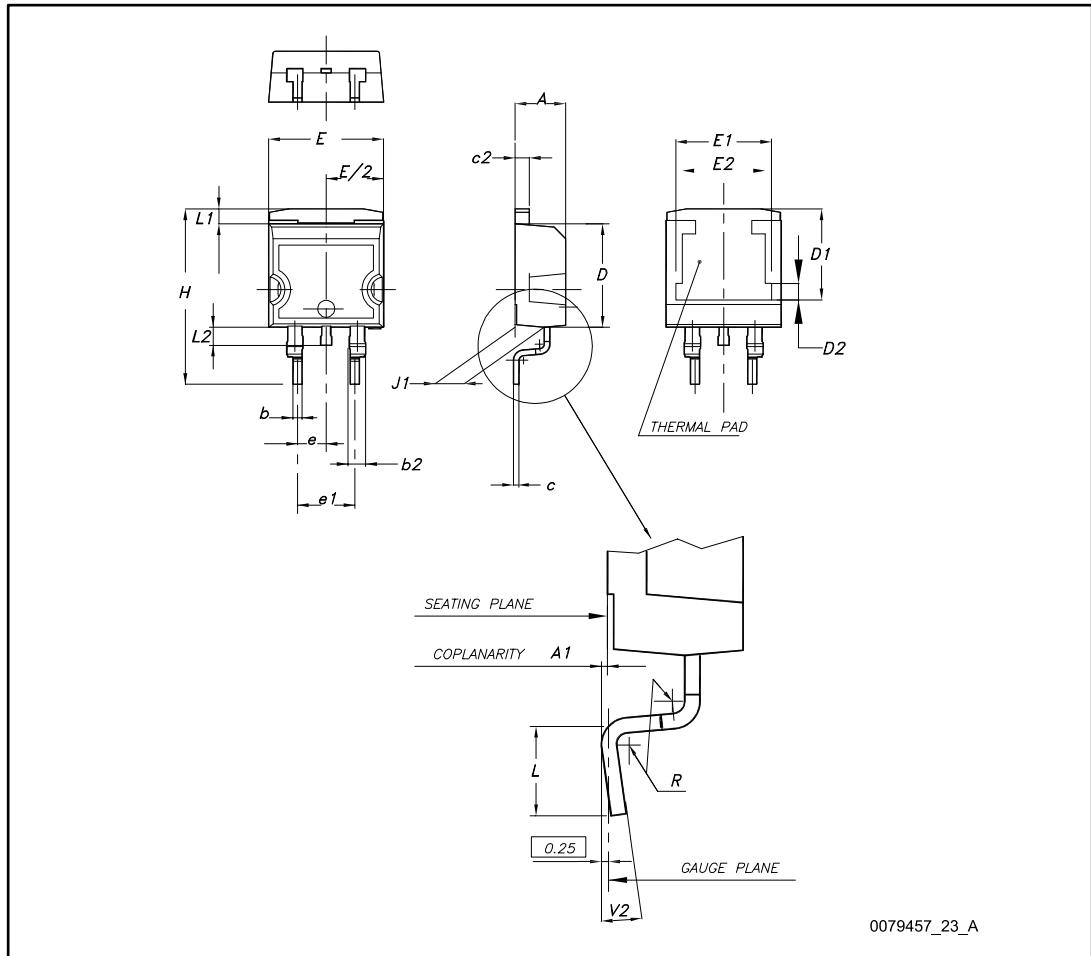
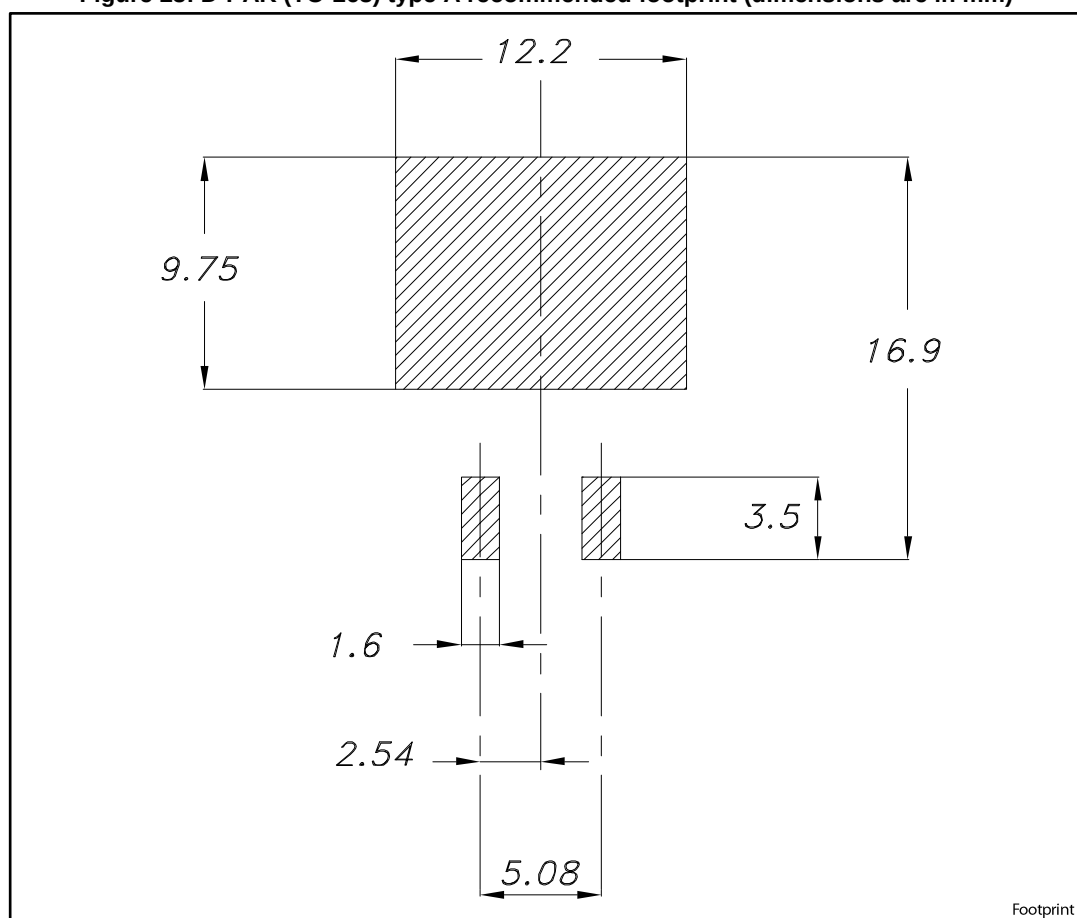


Table 9: D²PAK (TO-263) type A package mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	4.40		4.60
A1	0.03		0.23
b	0.70		0.93
b2	1.14		1.70
c	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	10.00		10.40
E1	8.50	8.70	8.90
E2	6.85	7.05	7.25
e		2.54	
e1	4.88		5.28
H	15.00		15.85
J1	2.49		2.69
L	2.29		2.79
L1	1.27		1.40
L2	1.30		1.75
R		0.40	
V2	0°		8°

Figure 23: D²PAK (TO-263) type A recommended footprint (dimensions are in mm)

4.2 D²PAK packing information

Figure 24: D2PAK type A tape outline

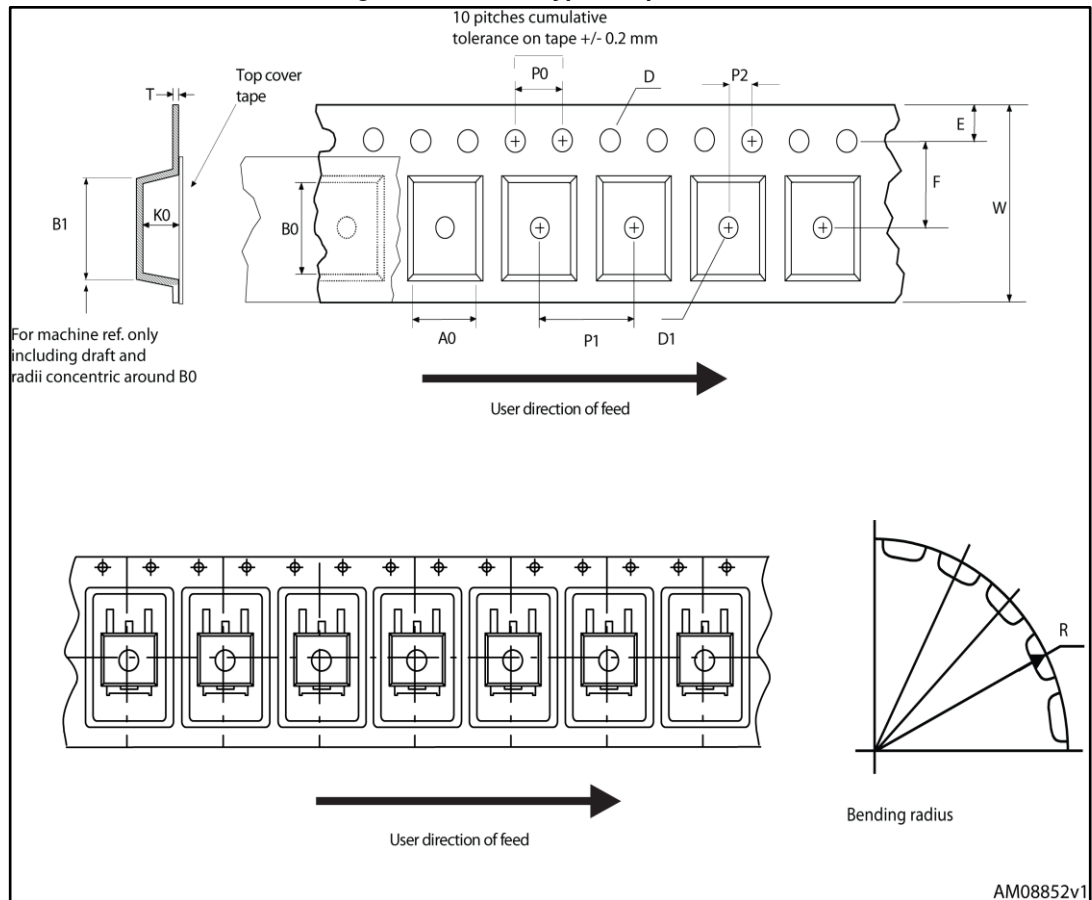


Figure 25: D2PAK type A reel outline

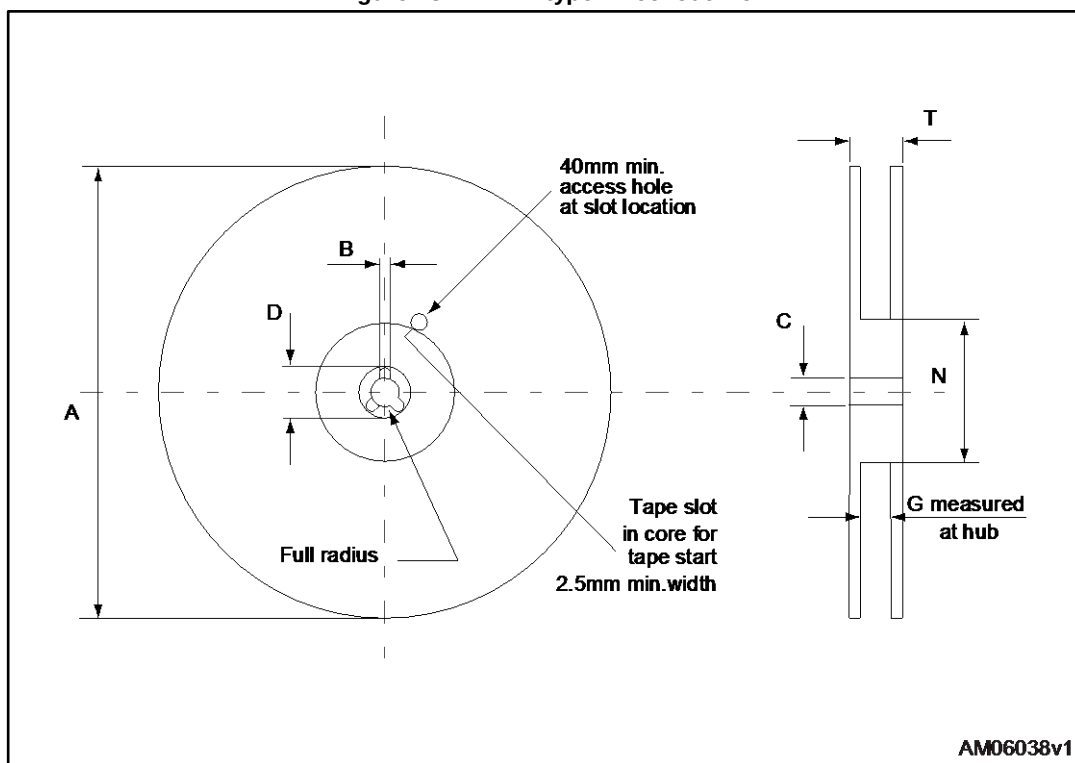
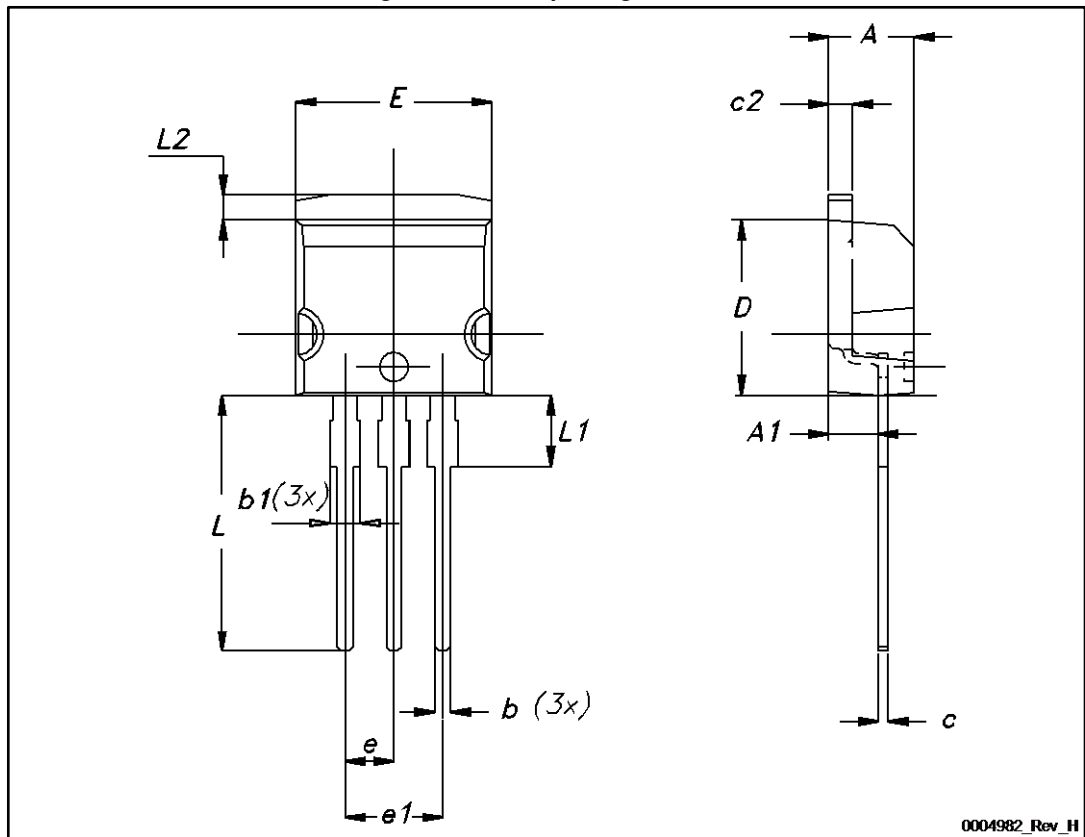


Table 10: D²PAK type A tape and reel mechanical data

Tape			Reel		
Dim.	mm		Dim.	mm	
	Min.	Max.		Min.	Max.
A0	10.5	10.7	A		330
B0	15.7	15.9	B	1.5	
D	1.5	1.6	C	12.8	13.2
D1	1.59	1.61	D	20.2	
E	1.65	1.85	G	24.4	26.4
F	11.4	11.6	N	100	
K0	4.8	5.0	T		30.4
P0	3.9	4.1			
P1	11.9	12.1	Base quantity		1000
P2	1.9	2.1	Bulk quantity		1000
R	50				
T	0.25	0.35			
W	23.7	24.3			

4.3 I²PAK package information

Figure 26: I²PAK package outline

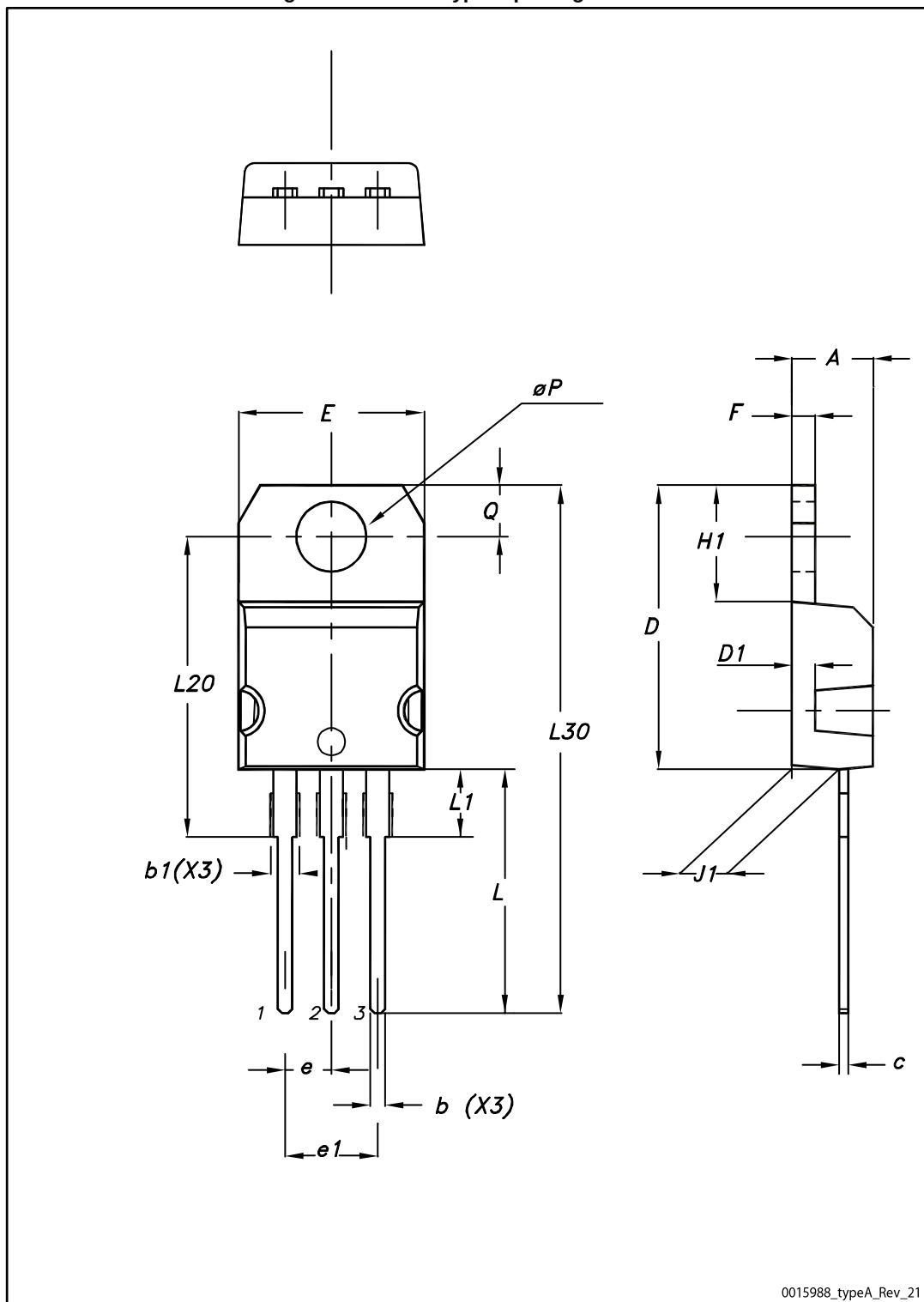
0004982_Rev_H

Table 11: I²PAK package mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	4.40	-	4.60
A1	2.40	-	2.72
b	0.61	-	0.88
b1	1.14	-	1.70
c	0.49	-	0.70
c2	1.23	-	1.32
D	8.95	-	9.35
e	2.40	-	2.70
e1	4.95	-	5.15
E	10	-	10.40
L	13	-	14
L1	3.50	-	3.93
L2	1.27	-	1.40

4.4 TO-220 type A package information

Figure 27: TO-220 type A package outline



0015988_typeA_Rev_21

Table 12: TO-220 type A mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	4.40		4.60
b	0.61		0.88
b1	1.14		1.55
c	0.48		0.70
D	15.25		15.75
D1		1.27	
E	10.00		10.40
e	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	13.00		14.00
L1	3.50		3.93
L20		16.40	
L30		28.90	
øP	3.75		3.85
Q	2.65		2.95

4.5 TO-247 package information

Figure 28: TO-247 package outline

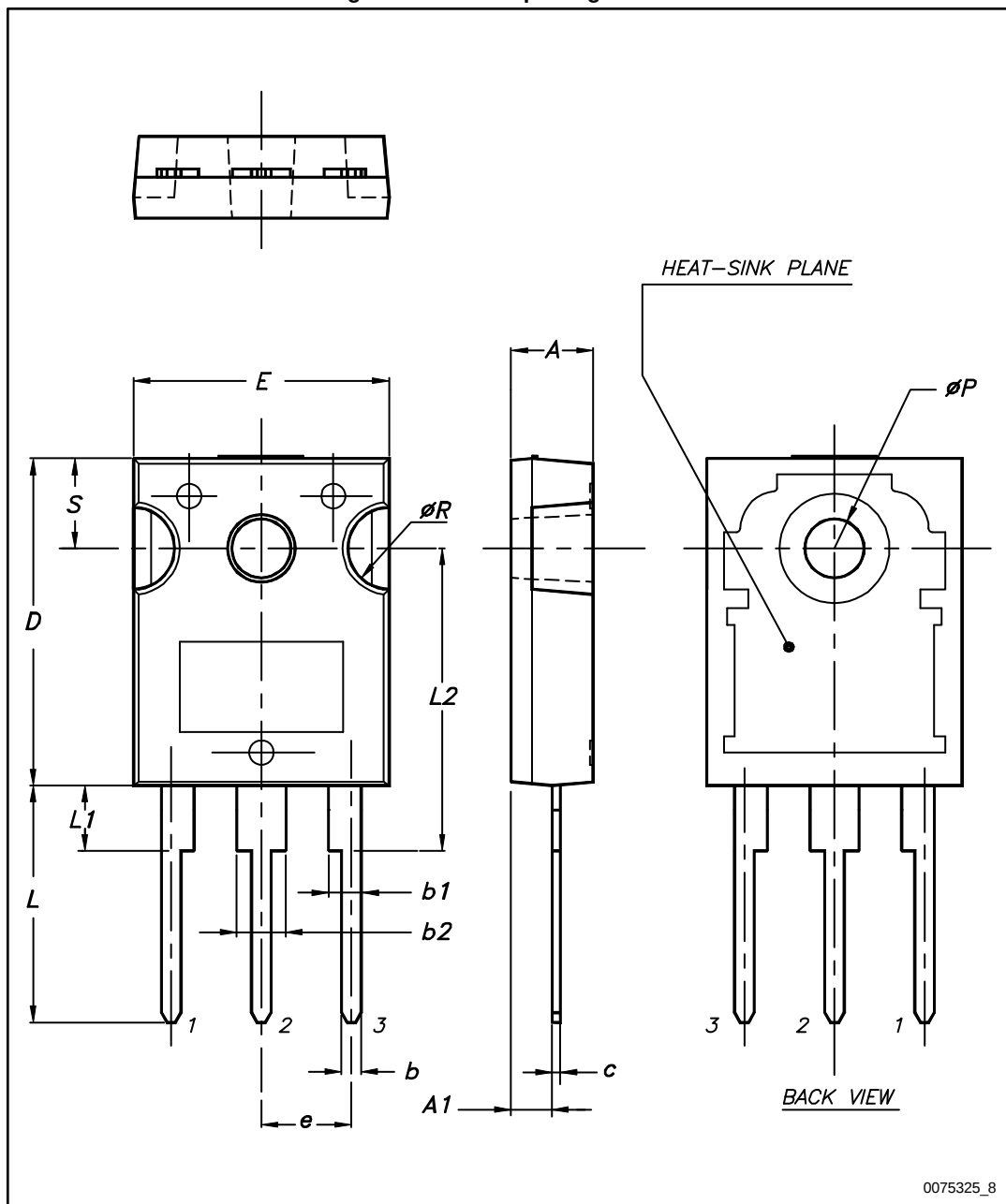


Table 13: TO-247 package mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	4.85		5.15
A1	2.20		2.60
b	1.0		1.40
b1	2.0		2.40
b2	3.0		3.40
c	0.40		0.80
D	19.85		20.15
E	15.45		15.75
e	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 Revision history

Table 14: Document revision history

Date	Revision	Changes
13-Sep-2013	1	First release.
29-Jan-2014	2	– Modified: title, ID value and features in cover page – Modified: ID, IDM and PTOT values in Table 2 – Modified: note 2 – Modified: Rthj-case value in Table 3 – Modified: the entire typical values in Table 4, 6, 7 and 8 – Modified: RDS(on) typical value in Table 5 – Modified: Figure 9 and 10 – Added: Section 4: Package information – Minor text changes
09-Feb-2015	3	– 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.
14-Mar-2017	4	Added part number STI28N60M2. Updated title, silhouette, features and Table 1: "Device summary" in cover page. Updated Table 3: "Thermal data" and Section 4: "Package information". Minor text changes.

IMPORTANT NOTICE – PLEASE READ CAREFULLY

STMicroelectronics NV and its subsidiaries ("ST") reserve the right to make changes, corrections, enhancements, modifications, and improvements to ST products and/or to this document at any time without notice. Purchasers should obtain the latest relevant information on ST products before placing orders. ST products are sold pursuant to ST's terms and conditions of sale in place at the time of order acknowledgement.

Purchasers are solely responsible for the choice, selection, and use of ST products and ST assumes no liability for application assistance or the design of Purchasers' products.

No license, express or implied, to any intellectual property right is granted by ST herein.

Resale of ST products with provisions different from the information set forth herein shall void any warranty granted by ST for such product.

ST and the ST logo are trademarks of ST. All other product or service names are the property of their respective owners.

Information in this document supersedes and replaces information previously supplied in any prior versions of this document.

© 2017 STMicroelectronics – All rights reserved