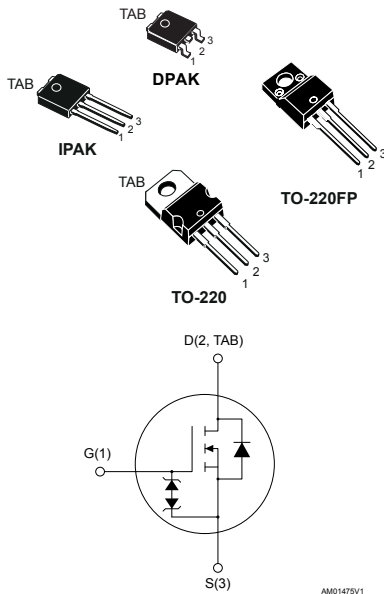


N-channel 650 V, 0.79 Ω typ., 5 A MDmesh M2 Power MOSFETs in DPAK, TO-220FP, TO-220 and IPAK packages



Features

Order codes	V_{DS}	$R_{DS(on)}$ max.	I_D	Package
STD9N65M2	650 V	0.90 Ω	5 A	DPAK
STF9N65M2				TO-220FP
STP9N65M2				TO-220
STU9N65M2				IPAK

- Extremely low gate charge
- Excellent output capacitance (C_{OSS}) profile
- 100% avalanche tested
- Zener-protected

Applications

- Switching applications

Description

These devices are N-channel Power MOSFETs developed using the 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.



Product status link

[STD9N65M2](#)

[STF9N65M2](#)

[STP9N65M2](#)

[STU9N65M2](#)

1 Electrical ratings

Table 1. Absolute maximum ratings

Symbol	Parameter	Value		Unit
		DPAK, TO-220, IPAK	TO-220FP	
V_{GS}	Gate-source voltage	±25		V
I_D	Drain current (continuous) at $T_C = 25\text{ °C}$	5	5 ⁽¹⁾	A
I_D	Drain current (continuous) at $T_C = 100\text{ °C}$	3.2	3.2 ⁽¹⁾	
I_{DM} ⁽²⁾	Drain current (pulsed)	20		A
P_{TOT}	Total power dissipation at $T_C = 25\text{ °C}$	60	20	W
V_{ISO}	Insulation withstand voltage (RMS) from all three leads to external heat sink ($t = 1\text{ s}$; $T_C = 25\text{ °C}$)	2.5		kV
dv/dt ⁽³⁾	Peak diode recovery voltage slope	15		V/ns
dv/dt ⁽⁴⁾	MOSFET dv/dt ruggedness	50		
T_{stg}	Storage temperature range	-55 to 150		°C
T_J	Operating junction temperature range			

1. Current limited by package.
2. Pulse width is limited by safe operating area.
3. $I_{SD} \leq 5\text{ A}$, $di/dt = 400\text{ A}/\mu\text{s}$; $V_{DS(peak)} < V_{(BR)DSS}$; $V_{DD} = 400\text{ V}$.
4. $V_{DS} \leq 520\text{ V}$.

Table 2. Thermal data

Symbol	Parameter	Value				Unit
		DPAK	TO-220FP	TO-220	IPAK	
$R_{thj-case}$	Thermal resistance junction-case	2.08	6.25	2.08		°C/W
$R_{thj-pcb}$	Thermal resistance junction-pcb	50				°C/W
$R_{thj-amb}$ ⁽¹⁾	Thermal resistance junction-ambient		62.5		100	°C/W

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

Table 3. Avalanche characteristics

Symbol	Parameter	Value	Unit
I_{AR}	Avalanche current, repetitive or not repetitive (pulse width limited by T_J max)	1	A
E_{AS}	Single pulse avalanche energy (starting $T_J = 25\text{ °C}$, $I_D = I_{AR}$; $V_{DD} = 50\text{ V}$)	105	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	$V_{GS} = 0\text{ V}$, $I_D = 1\text{ mA}$	650			V
I_{DSS}	Zero gate voltage drain current	$V_{GS} = 0\text{ V}$, $V_{DS} = 650\text{ V}$			1	μA
		$V_{GS} = 0\text{ V}$, $V_{DS} = 650\text{ V}$, $T_C = 125\text{ °C}$ ⁽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	$V_{GS} = 10\text{ V}$, $I_D = 2.5\text{ A}$		0.79	0.90	Ω

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

Table 5. Dynamic

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
C_{iss}	Input capacitance	$V_{DS} = 100\text{ V}$, $f = 1\text{ MHz}$, $V_{GS} = 0\text{ V}$	-	310	-	pF
C_{oss}	Output capacitance		-	18	-	pF
C_{riss}	Reverse transfer capacitance		-	0.9	-	pF
$C_{oss\text{ eq.}}$ ⁽¹⁾	Equivalent capacitance energy related	$V_{DS} = 0\text{ to }520\text{ V}$, $V_{GS} = 0\text{ V}$	-	109	-	pF
R_g	Intrinsic gate resistance	$f = 1\text{ MHz}$ open drain	-	6.6	-	Ω
Q_g	Total gate charge	$V_{DD} = 520\text{ V}$, $I_D = 5\text{ A}$	-	10.3	-	nC
Q_{gs}	Gate-source charge	$V_{GS} = 0\text{ to }10\text{ V}$	-	2.4	-	nC
Q_{gd}	Gate-drain charge	(see Figure 18. Test circuit for gate charge behavior)	-	4.8	-	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 6. Switching times

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 325\text{ V}$, $I_D = 2.5\text{ A}$,	-	7.5	-	ns
t_r	Rise time	$R_G = 4.7\text{ }\Omega$, $V_{GS} = 10\text{ V}$	-	6.6	-	ns
$t_{d(off)}$	Turn-off delay time	(see Figure 17. Test circuit for resistive load switching times and	-	22.5	-	ns
t_f	Fall time	Figure 22. Switching time waveform)	-	18	-	ns

Table 7. Source-drain diode

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{SD}	Source-drain current		-		5	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)		-		20	A
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 5\text{ A}$, $V_{GS} = 0\text{ V}$	-		1.6	V
t_{rr}	Reverse recovery time	$I_{SD} = 5\text{ A}$, $di/dt = 100\text{ A}/\mu\text{s}$, $V_{DD} = 60\text{ V}$ (see Figure 19. Test circuit for inductive load switching and diode recovery times)	-	276		ns
Q_{rr}	Reverse recovery charge		-	1.7		μC
I_{RRM}	Reverse recovery current	$I_{SD} = 5\text{ A}$, $di/dt = 100\text{ A}/\mu\text{s}$, $V_{DD} = 60\text{ V}$, $T_J = 150\text{ }^\circ\text{C}$ (see Figure 19. Test circuit for inductive load switching and diode recovery times)	-	12.5		A
t_{rr}	Reverse recovery time		-	312		ns
Q_{rr}	Reverse recovery charge		-	1.9		μC
I_{RRM}	Reverse recovery current		-	12.4		A

1. Pulse width is limited by safe operating area.
2. Pulsed: pulse duration = 300 μs , duty cycle 1.5%.

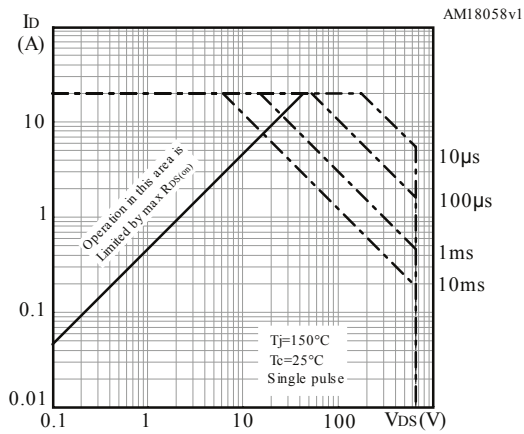
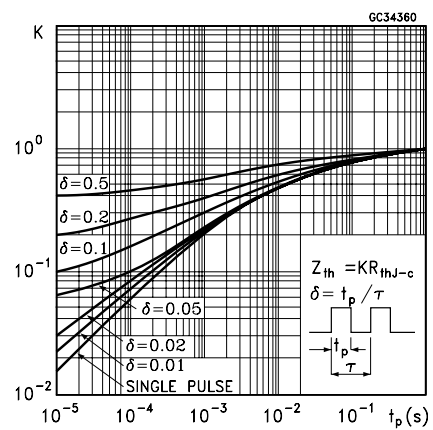
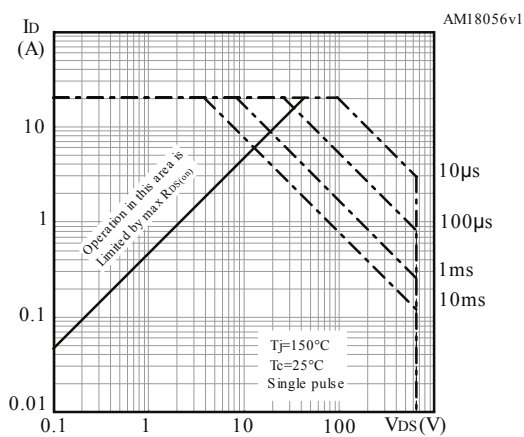
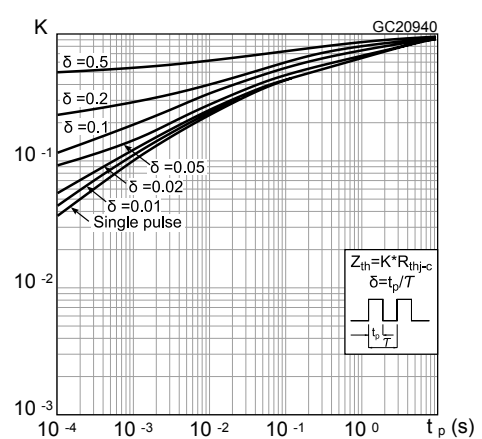
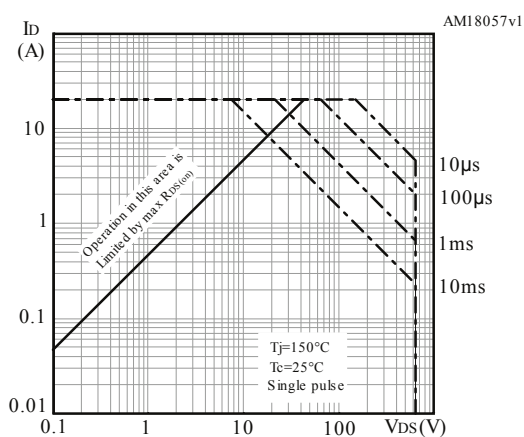
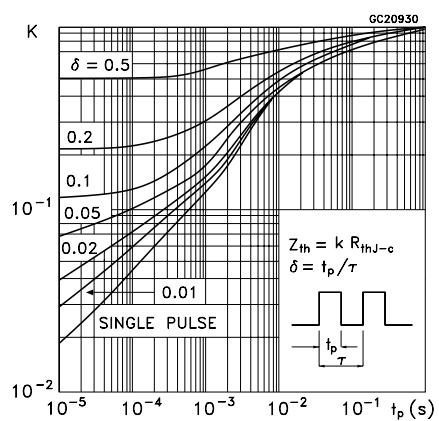
2.1 Electrical characteristics (curves)
Figure 1. Safe operating area for DPAK and IPAK

Figure 2. Thermal impedance for DPAK and IPAK

Figure 3. Safe operating area for TO-220FP

Figure 4. Thermal impedance for TO-220FP

Figure 5. Safe operating area for TO-220

Figure 6. Thermal impedance for TO-220


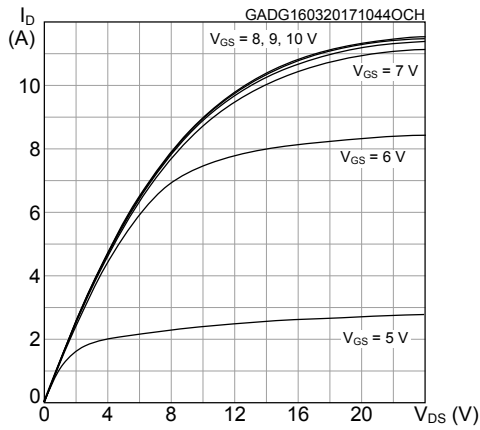
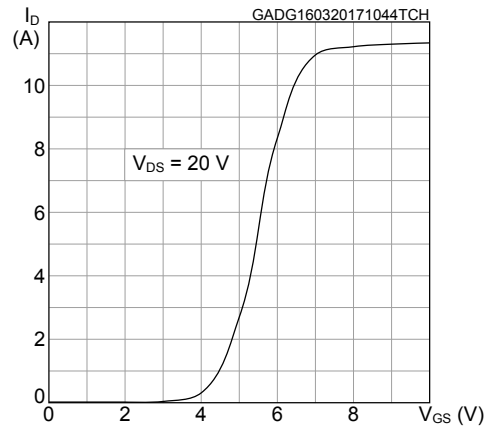
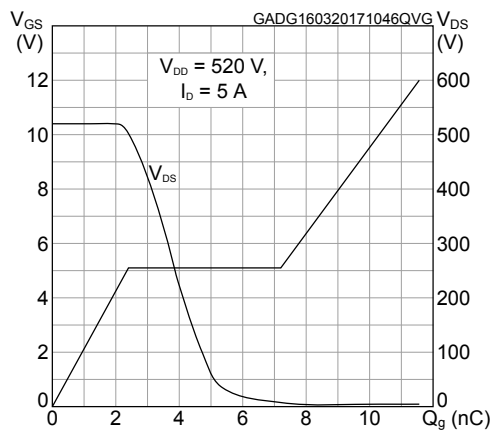
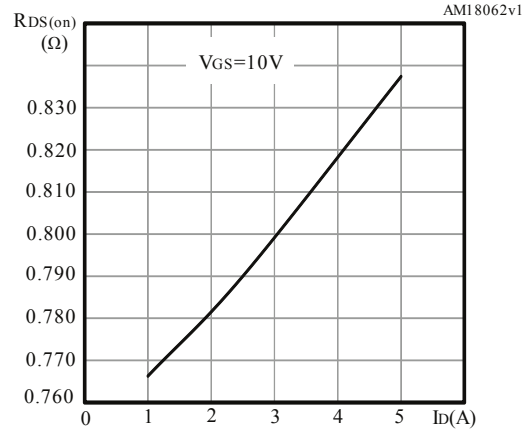
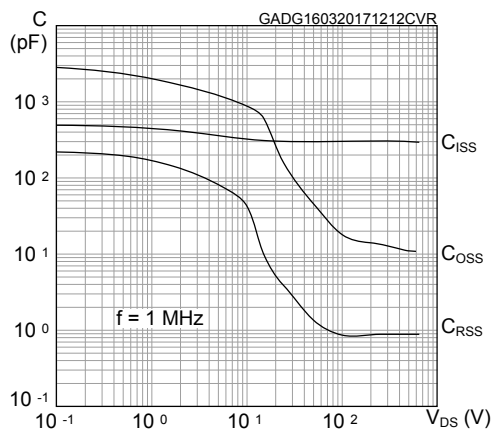
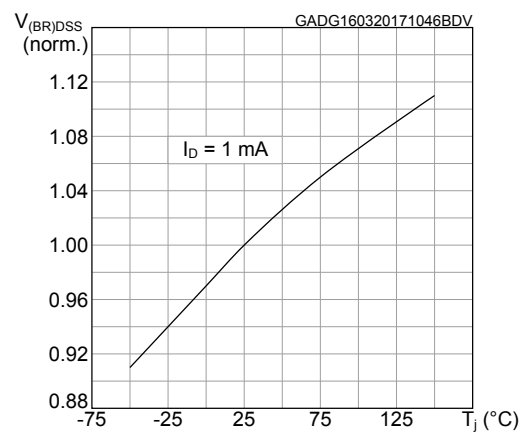
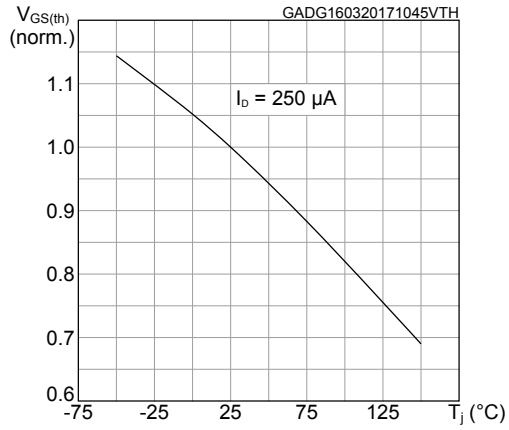
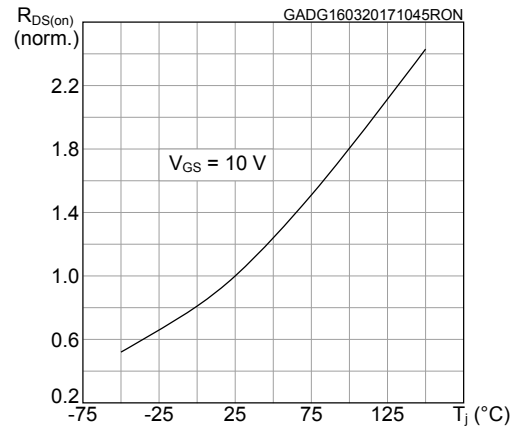
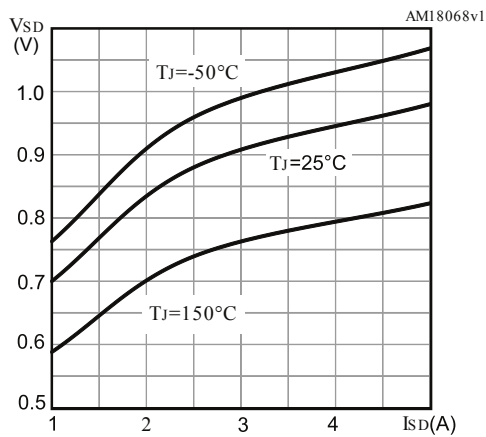
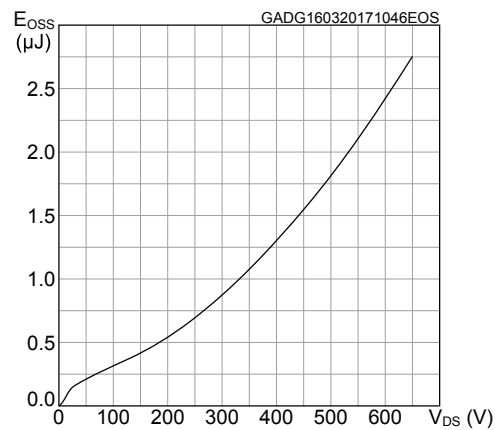
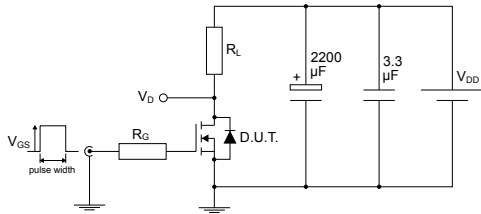
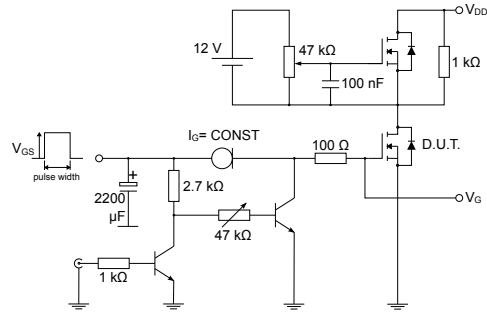
Figure 7. Output characteristics

Figure 8. Transfer characteristics

Figure 9. Gate charge vs gate-source voltage

Figure 10. Static drain-source on-resistance

Figure 11. Capacitance variations

Figure 12. Normalized $V_{(BR)DSS}$ vs temperature


Figure 13. Normalized gate threshold voltage vs temperature

Figure 14. Normalized on-resistance vs temperature

Figure 15. Source-drain diode forward characteristics

Figure 16. Output capacitance stored energy


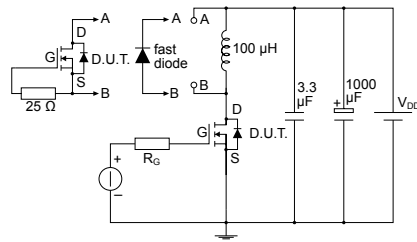
3 Test circuits

Figure 17. Test circuit for resistive load switching times


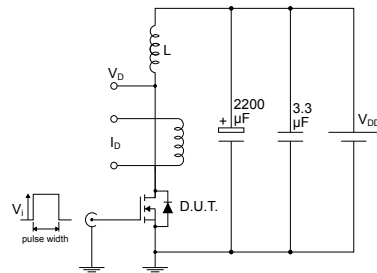
AM01468v1

Figure 18. Test circuit for gate charge behavior


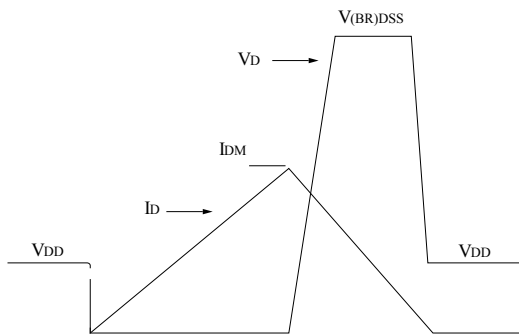
AM01469v1

Figure 19. Test circuit for inductive load switching and diode recovery times


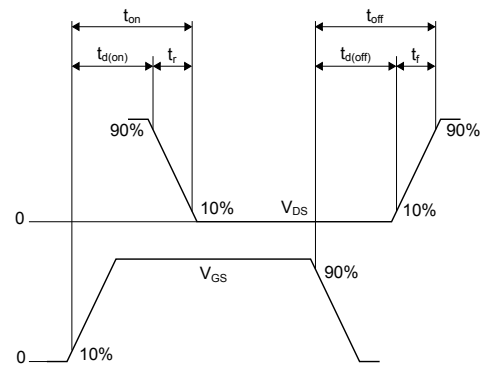
AM01470v1

Figure 20. Unclamped inductive load test circuit


AM01471v1

Figure 21. Unclamped inductive waveform


AM01472v1

Figure 22. Switching time waveform


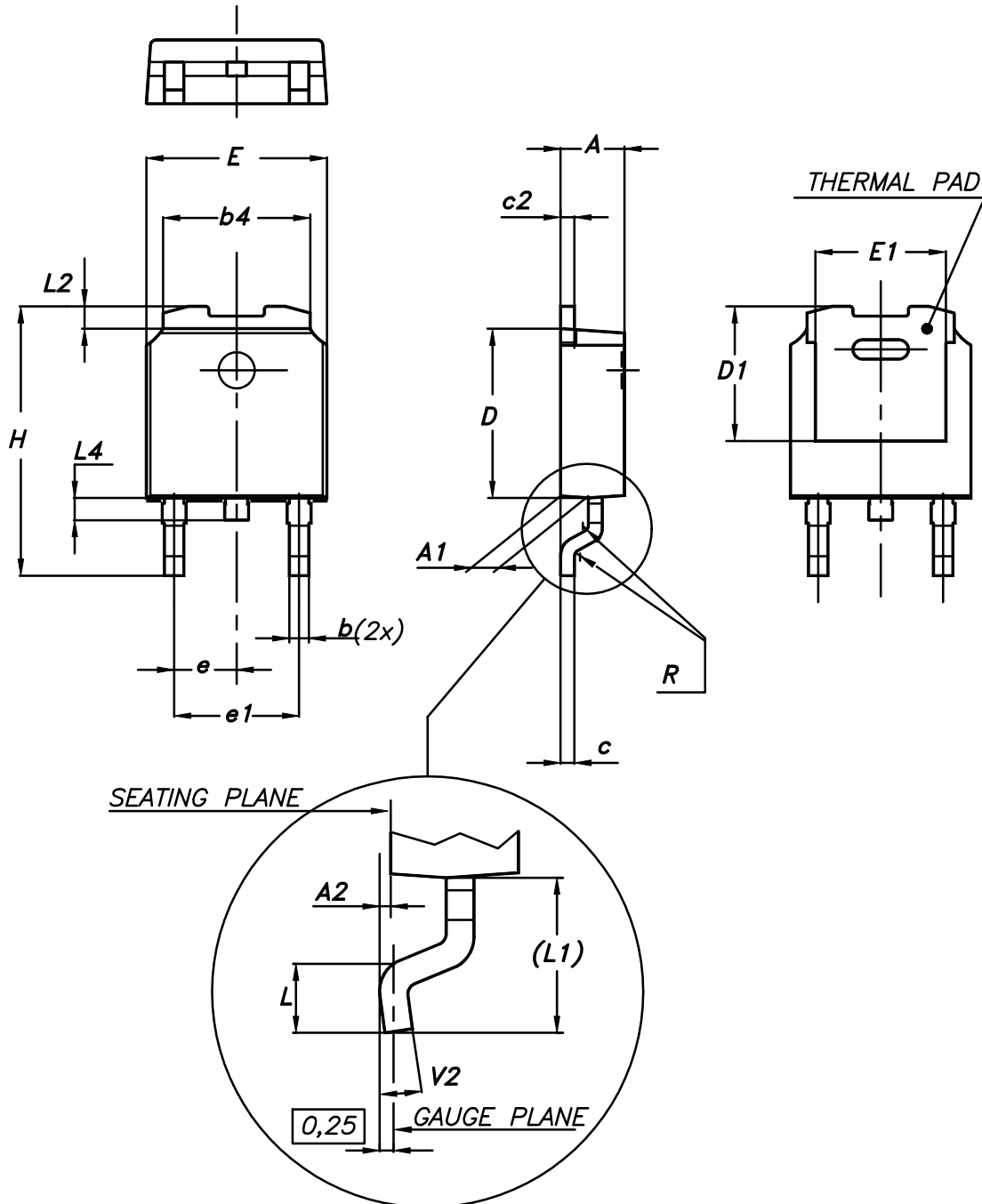
AM01473v1

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 DPAK (TO-252) type A package information

Figure 23. DPAK (TO-252) type A package outline



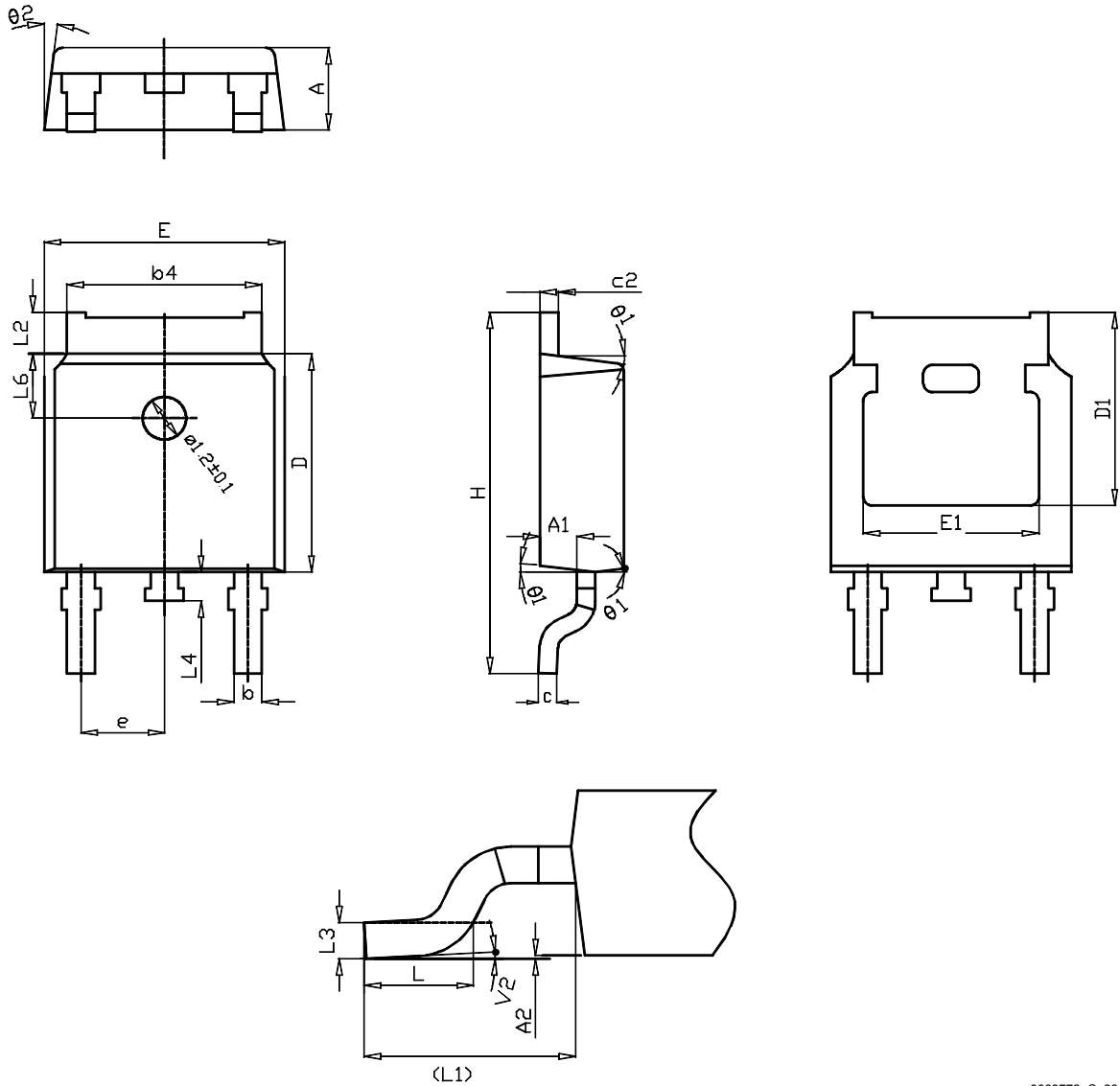
0068772_A_26

Table 8. DPAK (TO-252) type A mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	2.20		2.40
A1	0.90		1.10
A2	0.03		0.23
b	0.64		0.90
b4	5.20		5.40
c	0.45		0.60
c2	0.48		0.60
D	6.00		6.20
D1	4.95	5.10	5.25
E	6.40		6.60
E1	4.60	4.70	4.80
e	2.159	2.286	2.413
e1	4.445	4.572	4.699
H	9.35		10.10
L	1.00		1.50
(L1)	2.60	2.80	3.00
L2	0.65	0.80	0.95
L4	0.60		1.00
R		0.20	
V2	0°		8°

4.2 DPAK (TO-252) type C package information

Figure 24. DPAK (TO-252) type C package outline

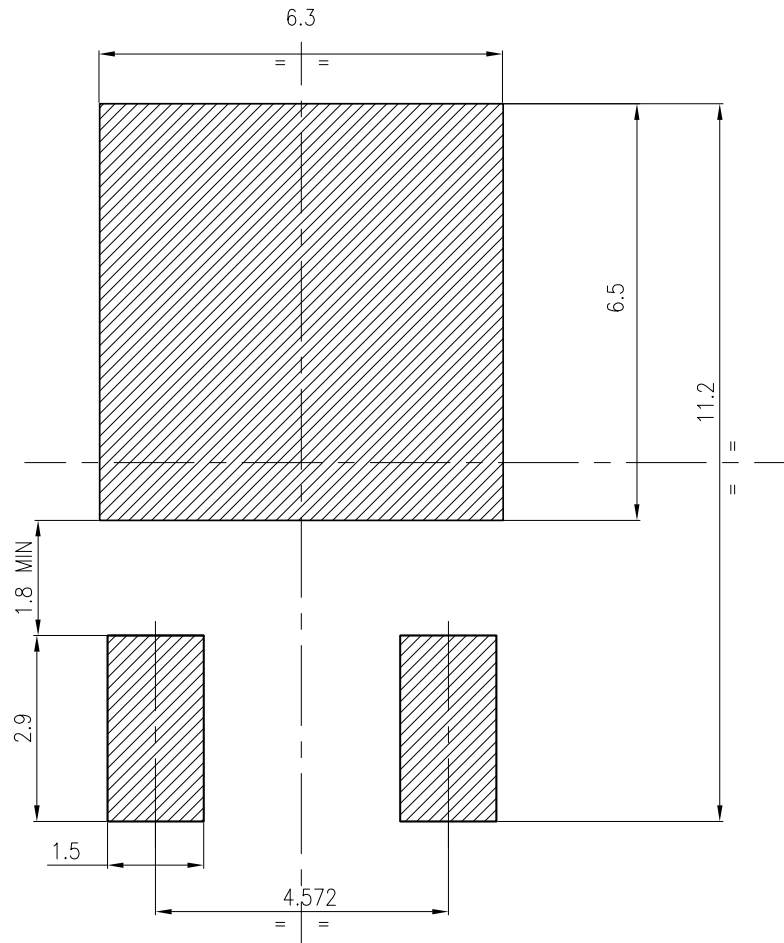


0068772_C_26

Table 9. DPAK (TO-252) type C mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	2.20	2.30	2.38
A1	0.90	1.01	1.10
A2	0.00		0.10
b	0.72		0.85
b4	5.13	5.33	5.46
c	0.47		0.60
c2	0.47		0.60
D	6.00	6.10	6.20
D1	5.25		
E	6.50	6.60	6.70
E1	4.70		
e	2.186	2.286	2.386
H	9.80	10.10	10.40
L	1.40	1.50	1.70
L1	2.90 REF		
L2	0.90		1.25
L3	0.51 BSC		
L4	0.60	0.80	1.00
L6	1.80 BSC		
θ1	5°	7°	9°
θ2	5°	7°	9°
V2	0°		8°

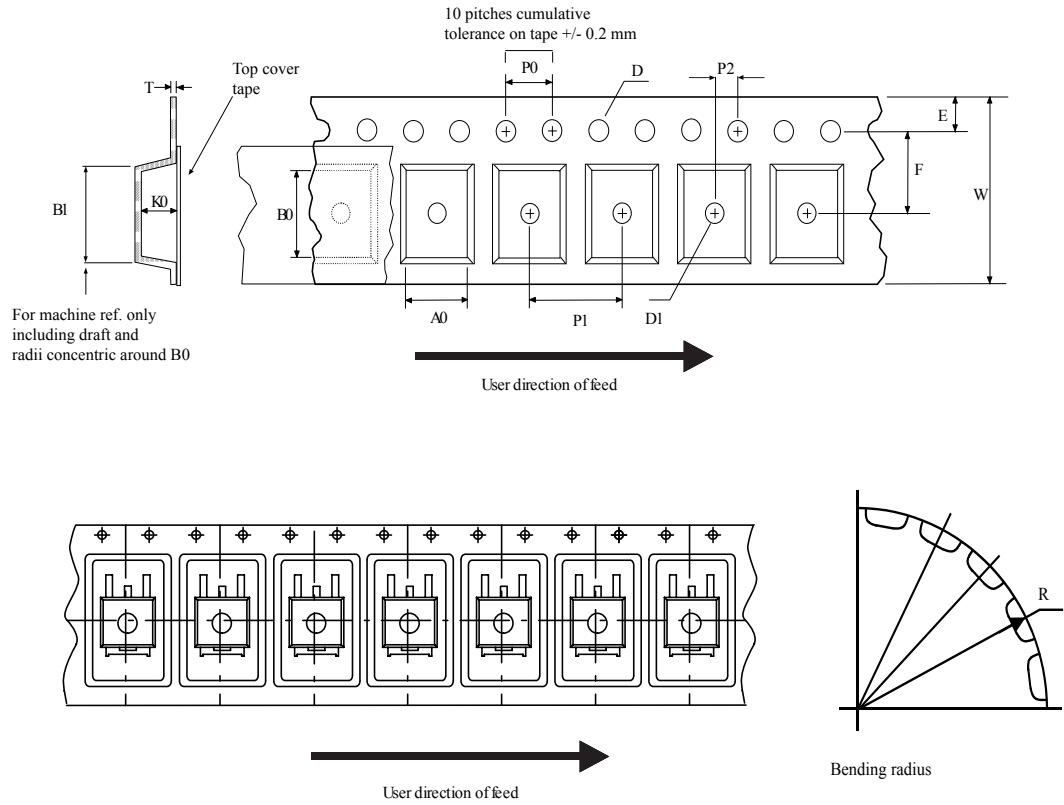
Figure 25. DPAK (TO-252) recommended footprint (dimensions are in mm)



FP_0068772_26

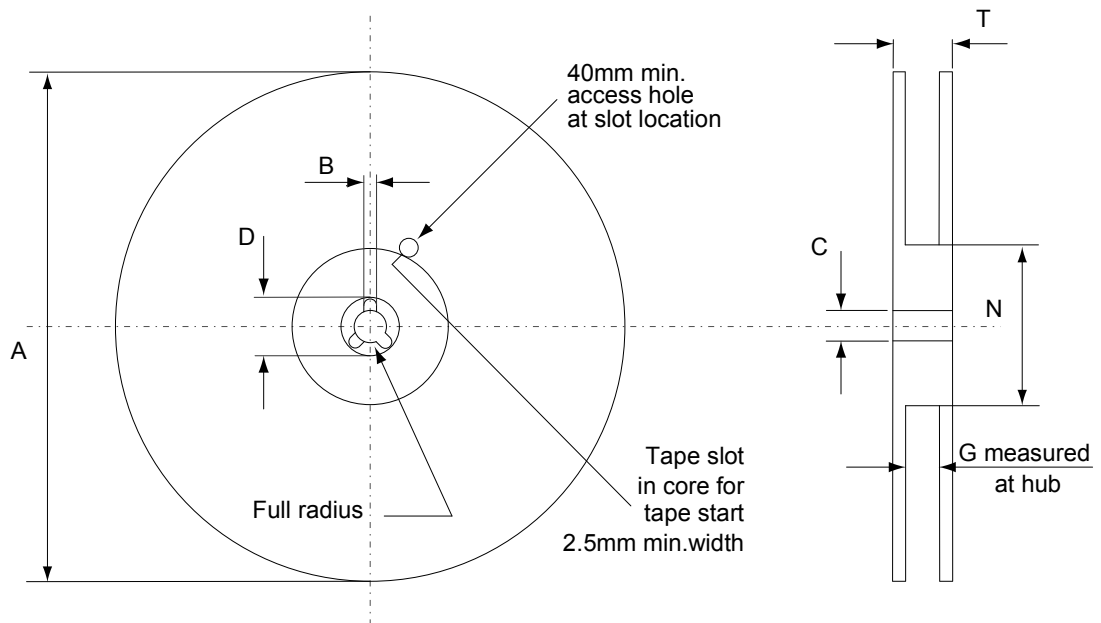
4.3 DPAK (TO-252) packing information

Figure 26. DPAK (TO-252) tape outline



AM08852v1

Figure 27. DPAK (TO-252) reel outline



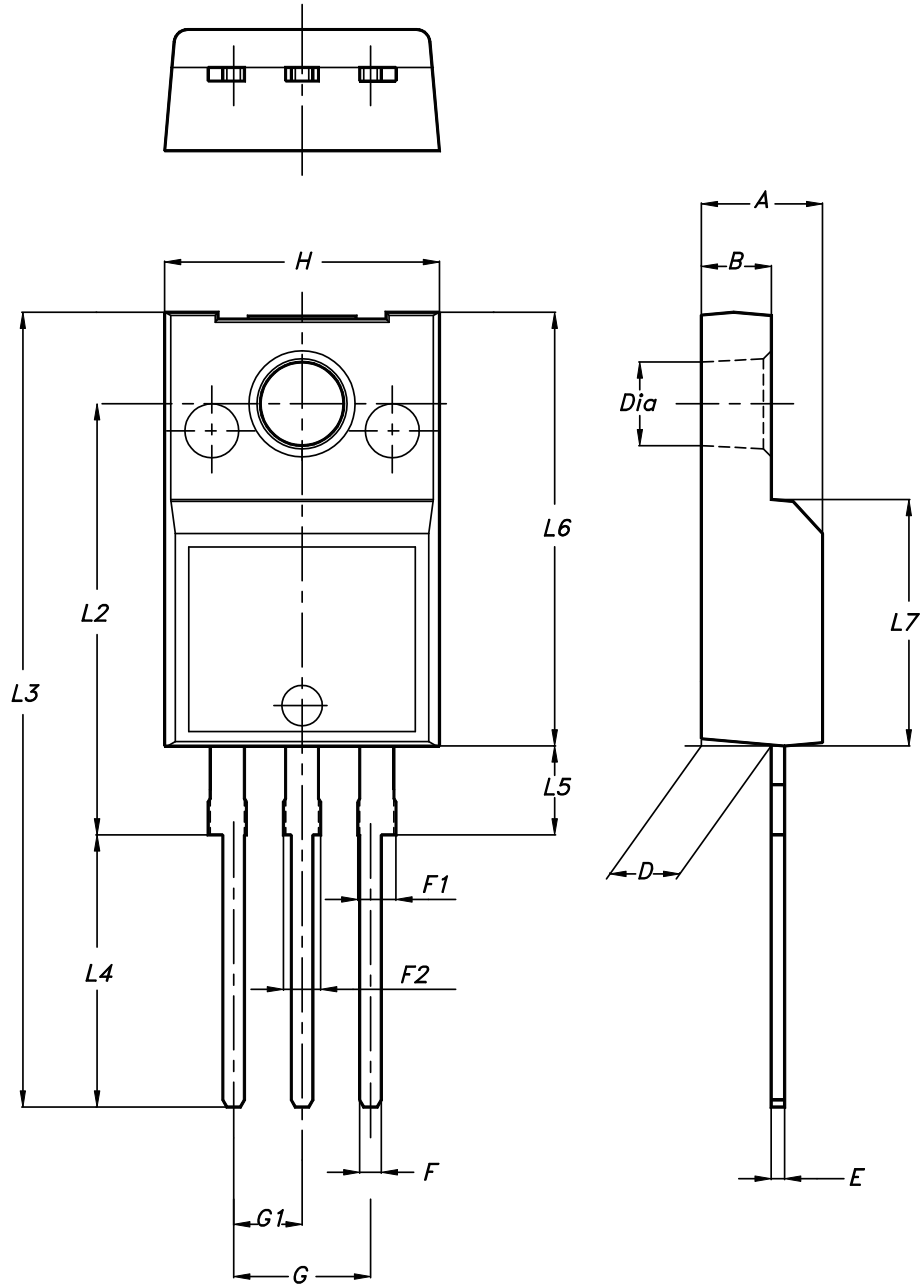
AM06038v1

Table 10. DPAK (TO-252) tape and reel mechanical data

Tape			Reel		
Dim.	mm		Dim.	mm	
	Min.	Max.		Min.	Max.
A0	6.8	7	A		330
B0	10.4	10.6	B	1.5	
B1		12.1	C	12.8	13.2
D	1.5	1.6	D	20.2	
D1	1.5		G	16.4	18.4
E	1.65	1.85	N	50	
F	7.4	7.6	T		22.4
K0	2.55	2.75			
P0	3.9	4.1		Base qty.	2500
P1	7.9	8.1		Bulk qty.	2500
P2	1.9	2.1			
R	40				
T	0.25	0.35			
W	15.7	16.3			

4.4 TO-220FP package information

Figure 28. TO-220FP package outline



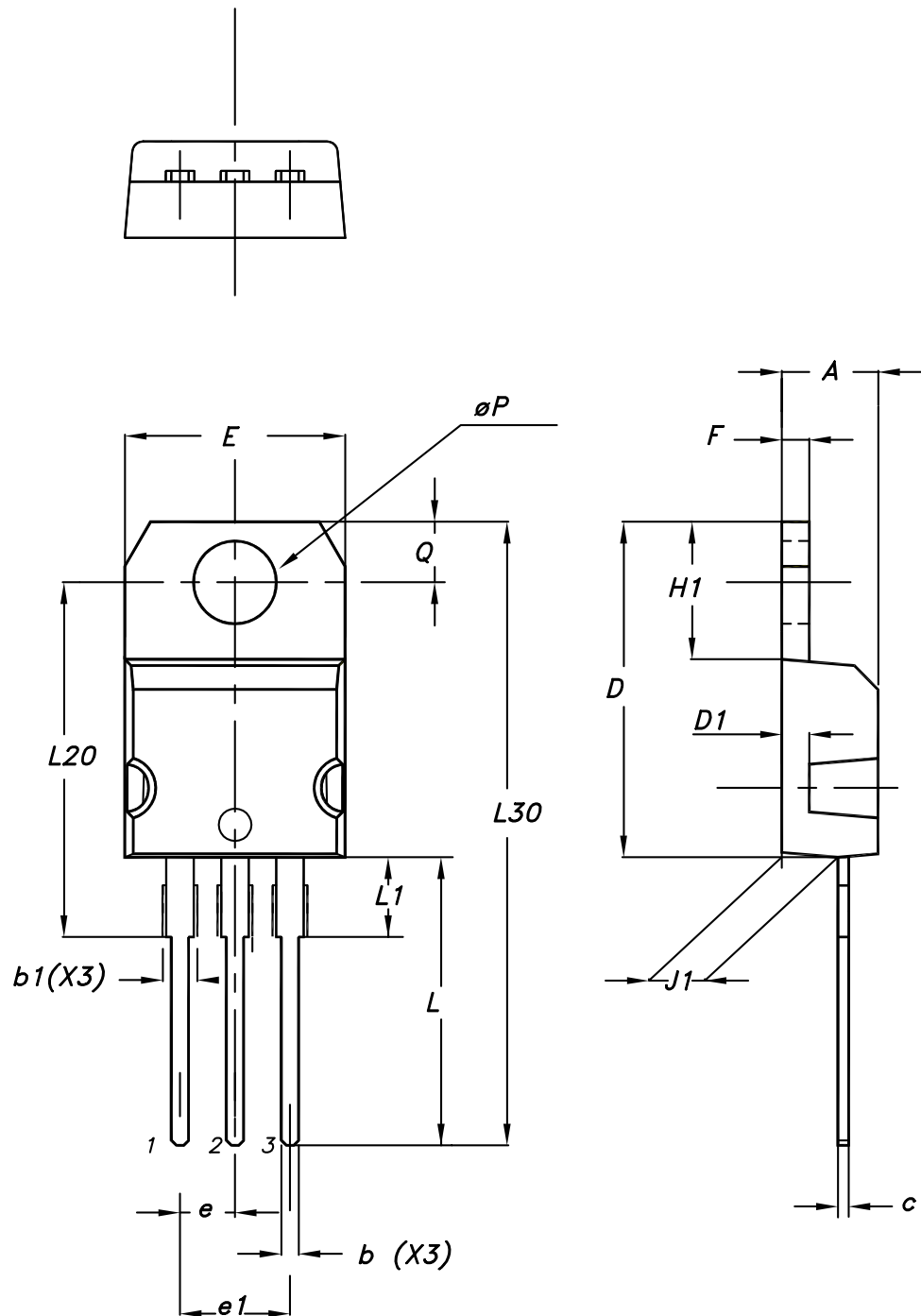
7012510_Rev_13_B

Table 11. TO-220FP package mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	4.40		4.60
B	2.50		2.70
D	2.50		2.75
E	0.45		0.70
F	0.75		1.00
F1	1.15		1.70
F2	1.15		1.70
G	4.95		5.20
G1	2.40		2.70
H	10.00		10.40
L2		16.00	
L3	28.60		30.60
L4	9.80		10.60
L5	2.90		3.60
L6	15.90		16.40
L7	9.00		9.30
Dia	3.00		3.20

4.5 TO-220 type A package information

Figure 29. TO-220 type A package outline



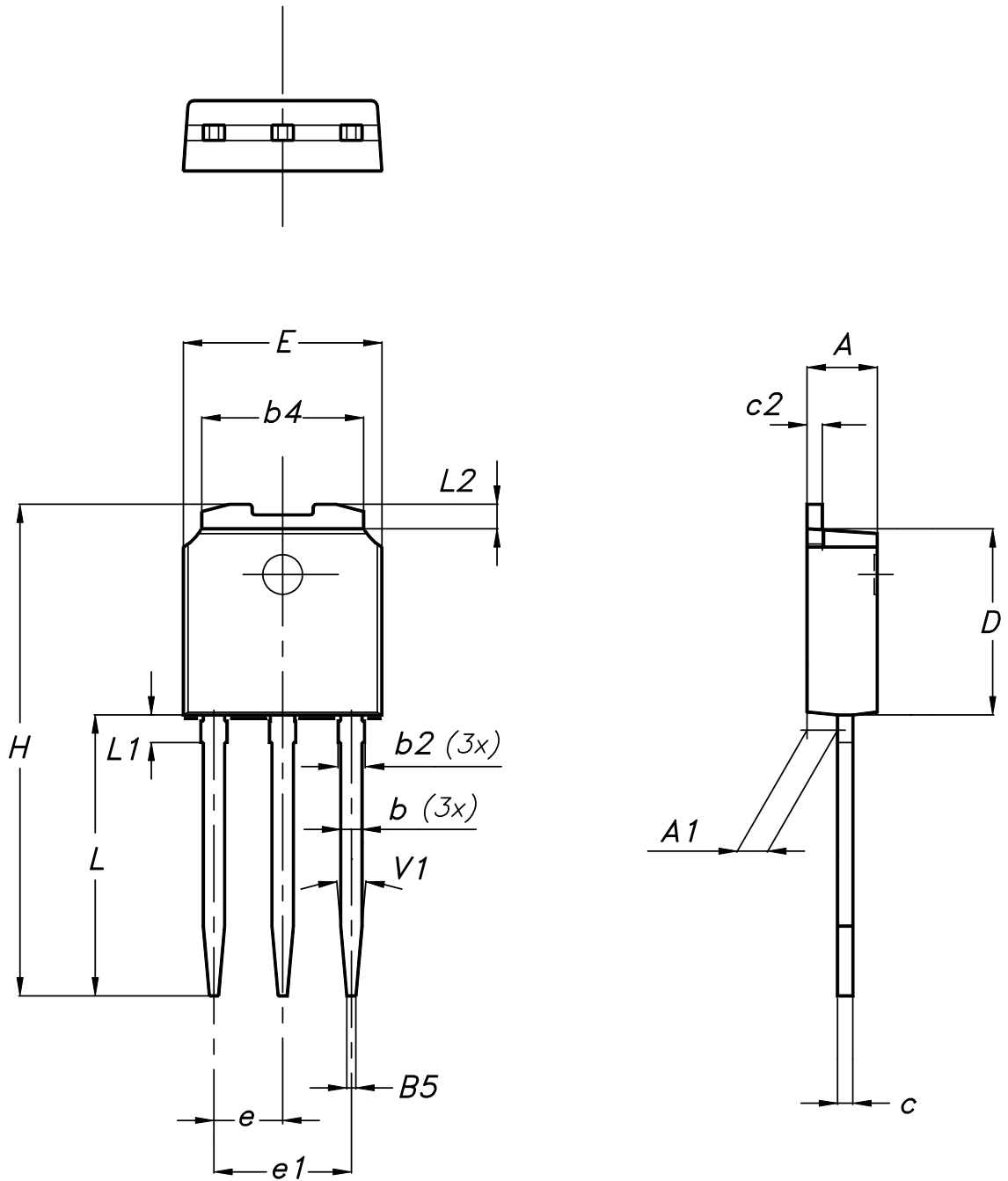
0015988_typeA_Rev_22

Table 12. TO-220 type A package 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

4.6 IPAK (TO-251) type A package information

Figure 30. IPAK (TO-251) type A package outline



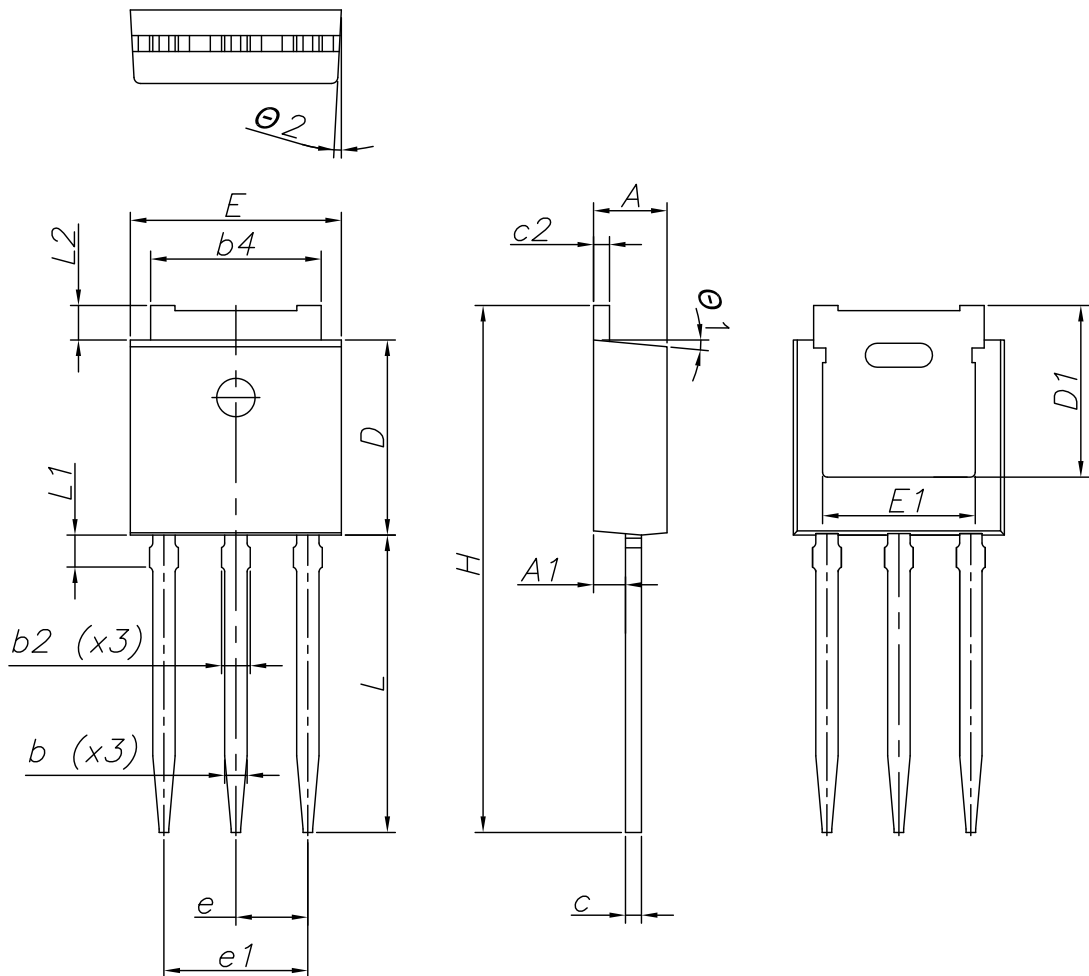
0068771_IK_typeA_rev14

Table 13. IPAK (TO-251) type A package mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	2.20		2.40
A1	0.90		1.10
b	0.64		0.90
b2			0.95
b4	5.20		5.40
B5		0.30	
c	0.45		0.60
c2	0.48		0.60
D	6.00		6.20
E	6.40		6.60
e		2.28	
e1	4.40		4.60
H		16.10	
L	9.00		9.40
L1	0.80		1.20
L2		0.80	1.00
V1		10°	

4.7 IPAK (TO-251) type C package information

Figure 31. IPAK (TO-251) type C package outline



0068771_IK_typeC_rev14

Table 14. IPAK (TO-251) type C package mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	2.20	2.30	2.35
A1	0.90	1.00	1.10
b	0.66		0.79
b2			0.90
b4	5.23	5.33	5.43
c	0.46		0.59
c2	0.46		0.59
D	6.00	6.10	6.20
D1	5.20	5.37	5.55
E	6.50	6.60	6.70
E1	4.60	4.78	4.95
e	2.20	2.25	2.30
e1	4.40	4.50	4.60
H	16.18	16.48	16.78
L	9.00	9.30	9.60
L1	0.80	1.00	1.20
L2	0.90	1.08	1.25
θ1	3°	5°	7°
θ2	1°	3°	5°

5 Ordering information

Table 15. Order codes

Order code	Marking	Package	Packing
STD9N65M2	9N65M2	DPAK	Tape and reel
STF9N65M2		TO-220FP	Tube
STP9N65M2		TO-220	
STU9N65M2		IPAK	

Revision history

Table 16. Document revision history

Date	Version	Changes
24-Feb-2014	1	First release.
15-Jul-2014	2	<ul style="list-style-type: none"> – Modified: title, <i>Features</i> and <i>Description</i> – Modified: <i>Figure 5</i> and <i>15</i> – Updated: <i>Figure 28</i> and <i>Table 12</i> – Minor text changes.
19-Jun-2019	3	<p>Removed maturity status indication from cover page. The document status is production data.</p> <p>Updated Section 1 Electrical ratings, Section 2 Electrical characteristics and Section 2.1 Electrical characteristics (curves)</p> <p>Minor text changes.</p>

Contents

1	Electrical ratings	2
2	Electrical characteristics	3
2.1	Electrical characteristics (curves)	5
3	Test circuits	8
4	Package information	9
4.1	DPAK (TO-252) type A package information	9
4.2	DPAK (TO-252) type C package information	11
4.3	DPAK (TO-252) packing information	14
4.4	TO-220FP package information	16
4.5	TO-220 type A package information	18
4.6	IPAK (TO-251) type A package information	20
4.7	IPAK (TO-251) type C package information	22
5	Ordering information	25
	Revision history	26



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. For additional information about ST trademarks, please refer to www.st.com/trademarks. 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.

© 2019 STMicroelectronics – All rights reserved