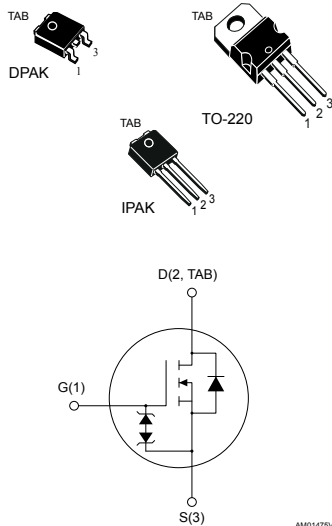


N-channel 600 V, 0.72 Ω typ., 5.5 A, MDmesh™ M2 Power MOSFETs in DPAK, TO-220 and IPAK packages



AM01475V1

Features

Order codes	$V_{DS} @ T_{Jmax}$	$R_{DS(on)}$ max.	I_D	P_{TOT}	Package
STD9N60M2	650 V	0.78 Ω	5.5 A	60 W	DPAK
STP9N60M2					TO-220
STU9N60M2					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

[STD9N60M2](#)
[STP9N60M2](#)
[STU9N60M2](#)

1 Electrical ratings

Table 1. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{GS}	Gate-source voltage	± 25	V
I_D	Drain current (continuous) at $T_{case} = 25\text{ }^\circ\text{C}$	5.5	A
	Drain current (continuous) at $T_{case} = 100\text{ }^\circ\text{C}$	3.6	
$I_{DM}^{(1)}$	Drain current (pulsed)	22	A
P_{TOT}	Total power dissipation at $T_{case} = 25\text{ }^\circ\text{C}$	60	W
$dv/dt^{(2)}$	Peak diode recovery voltage slope	15	V/ns
$dv/dt^{(3)}$	MOSFET dv/dt ruggedness	50	
T_{stg}	Storage temperature range	-55 to 150	$^\circ\text{C}$
T_j	Operating junction temperature range		

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

Table 2. Thermal data

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

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 non-repetitive (pulse width limited by T_{Jmax})	2	A
E_{AS}	Single pulse avalanche energy (starting $T_j = 25\text{ }^\circ\text{C}$, $I_D = I_{AR}$, $V_{DD} = 50\text{ V}$)	105	mJ

2 Electrical characteristics

($T_{\text{case}} = 25\text{ }^{\circ}\text{C}$ unless otherwise specified)

Table 4. On /off states

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(\text{BR})\text{DSS}}$	Drain-source breakdown voltage	$V_{\text{GS}} = 0\text{ V}$, $I_{\text{D}} = 1\text{ mA}$	600			V
I_{DSS}	Zero gate voltage drain current	$V_{\text{GS}} = 0\text{ V}$, $V_{\text{DS}} = 600\text{ V}$			1	μA
		$V_{\text{GS}} = 0\text{ V}$, $V_{\text{DS}} = 600\text{ V}$, $T_{\text{case}} = 125\text{ }^{\circ}\text{C}$ ⁽¹⁾			100	
I_{GSS}	Gate-body leakage current	$V_{\text{DS}} = 0\text{ V}$, $V_{\text{GS}} = \pm 25\text{ V}$			± 5	μA
$V_{\text{GS(th)}}$	Gate threshold voltage	$V_{\text{DS}} = V_{\text{GS}}$, $I_{\text{D}} = 250\text{ }\mu\text{A}$	2	3	4	V
$R_{\text{DS(on)}}$	Static drain-source on-resistance	$V_{\text{GS}} = 10\text{ V}$, $I_{\text{D}} = 3\text{ A}$		0.72	0.78	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	$V_{\text{DS}} = 100\text{ V}$, $f = 1\text{ MHz}$, $V_{\text{GS}} = 0\text{ V}$	-	320	-	μF
C_{oss}	Output capacitance		-	18	-	
C_{riss}	Reverse transfer capacitance		-	0.68	-	
$C_{\text{oss eq.}}^{(1)}$	Equivalent output capacitance	$V_{\text{DS}} = 0\text{ to }480\text{ V}$, $V_{\text{GS}} = 0\text{ V}$	-	88	-	μF
R_{G}	Intrinsic gate resistance	$f = 1\text{ MHz}$, $I_{\text{D}} = 0\text{ A}$	-	6.5	-	Ω
Q_{g}	Total gate charge	$V_{\text{DD}} = 480\text{ V}$, $I_{\text{D}} = 5.5\text{ A}$, $V_{\text{GS}} = 0\text{ to }10\text{ V}$ (see Figure 16. Test circuit for gate charge behavior)	-	10	-	nC
Q_{gs}	Gate-source charge		-	2	-	
Q_{gd}	Gate-drain charge		-	5.1	-	

1. $C_{\text{oss eq.}}$ 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 6. Switching times

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{\text{d(on)}}$	Turn-on delay time	$V_{\text{DD}} = 300\text{ V}$, $I_{\text{D}} = 3\text{ A}$, $R_{\text{G}} = 4.7\text{ }\Omega$, $V_{\text{GS}} = 10\text{ V}$ (see Figure 15. Test circuit for resistive load switching times and Figure 20. Switching time waveform)	-	8.8	-	ns
t_{r}	Rise time		-	7.5	-	
$t_{\text{d(off)}}$	Turn-off delay time		-	22	-	
t_{f}	Fall time		-	13.5	-	

Table 7. 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	$V_{GS} = 0\text{ V}$, $I_{SD} = 5.5\text{ A}$	-		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 17. Test circuit for inductive load switching and diode recovery times)	-	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 17. Test circuit for inductive load switching and diode recovery times)	-	377		ns
Q_{rr}	Reverse recovery charge		-	2.3		μC
I_{RRM}	Reverse recovery current		-	12.2		A

1. Pulse width is limited by safe operating area.

2. Pulse test: pulse duration = 300 μs , duty cycle 1.5%.

2.1 Electrical characteristics (curves)

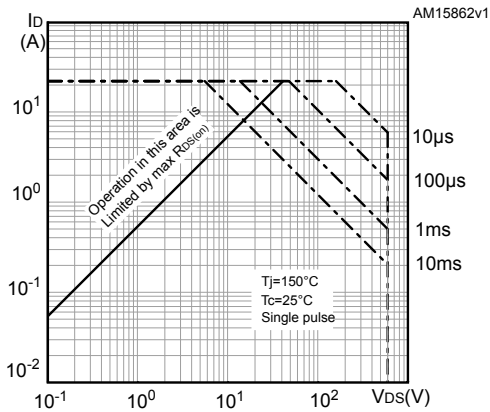
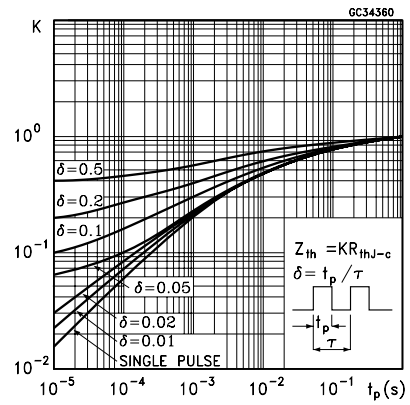
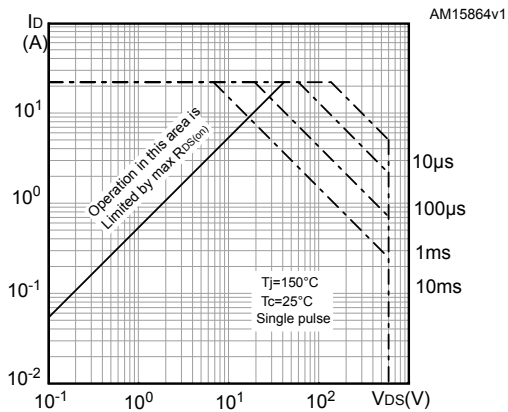
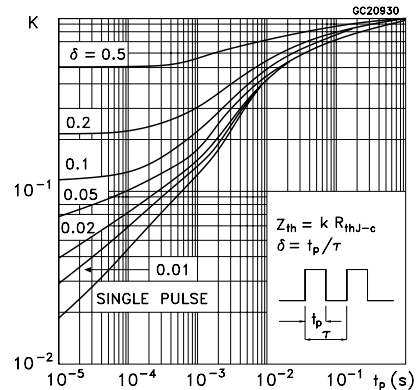
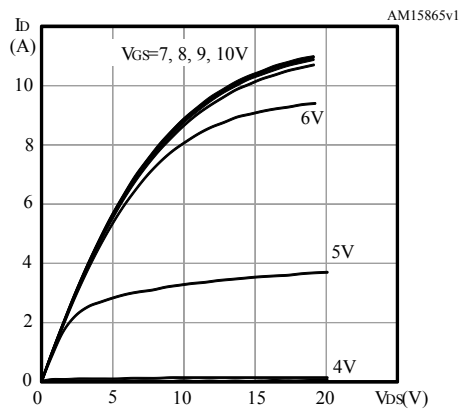
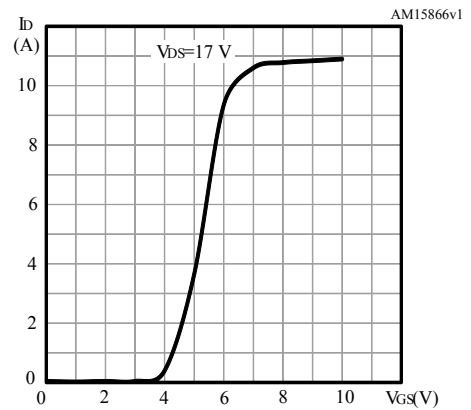
Figure 1. Safe operating area for DPAK and IPAK

Figure 2. Thermal impedance for DPAK and IPAK

Figure 3. Safe operating area for TO-220

Figure 4. Thermal impedance for TO-220

Figure 5. Output characteristics

Figure 6. Transfer characteristics


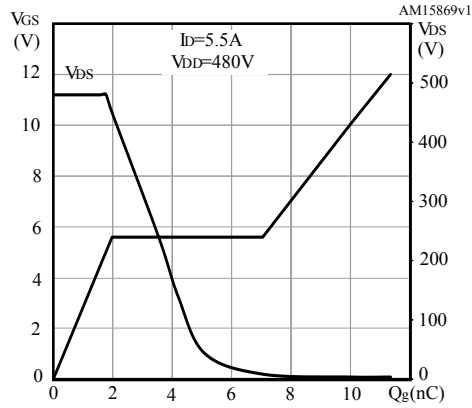
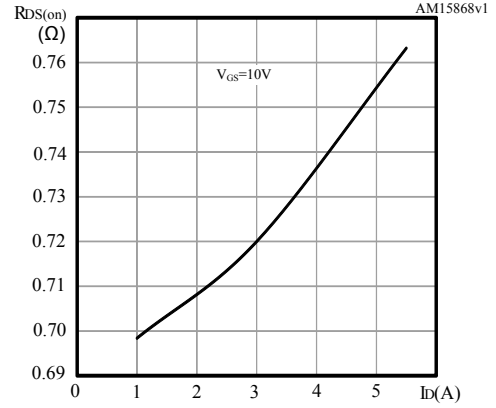
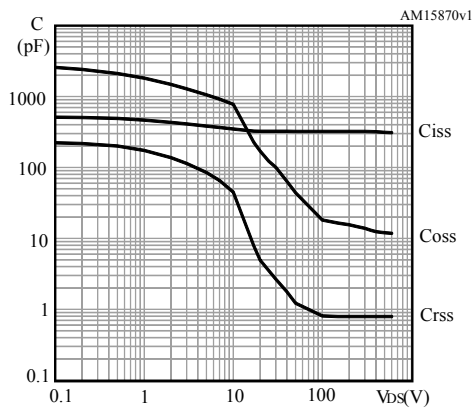
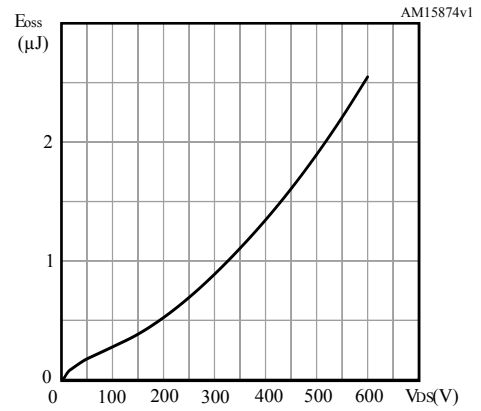
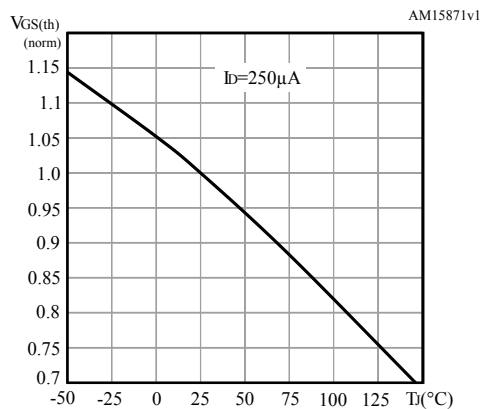
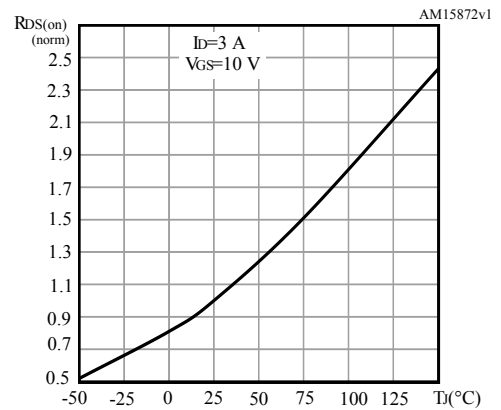
Figure 7. Gate charge vs gate-source voltage

Figure 8. Static drain-source on-resistance

Figure 9. Capacitance variations

Figure 10. Output capacitance stored energy

Figure 11. Normalized gate threshold voltage vs temperature

Figure 12. Normalized on-resistance vs temperature


Figure 13. Source-drain diode forward characteristics

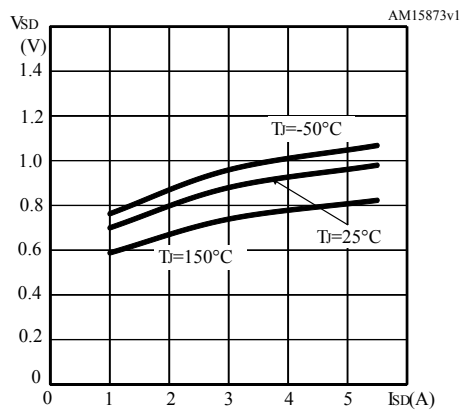
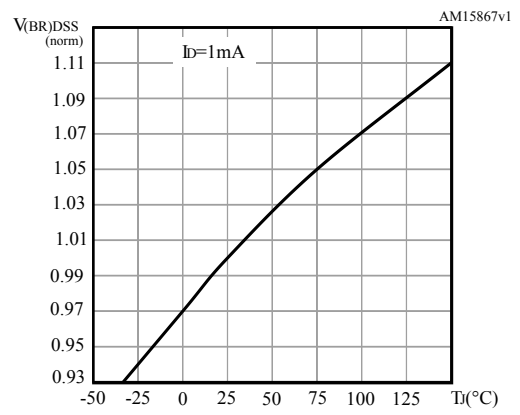


Figure 14. Normalized $V_{(BR)DSS}$ vs temperature



3 Test circuits

Figure 15. Test circuit for resistive load switching times


AM01468v1

Figure 16. Test circuit for gate charge behavior


AM01469v1

Figure 17. Test circuit for inductive load switching and diode recovery times


AM01470v1

Figure 18. Unclamped inductive load test circuit


AM01471v1

Figure 19. Unclamped inductive waveform


AM01472v1

Figure 20. Switching time waveform

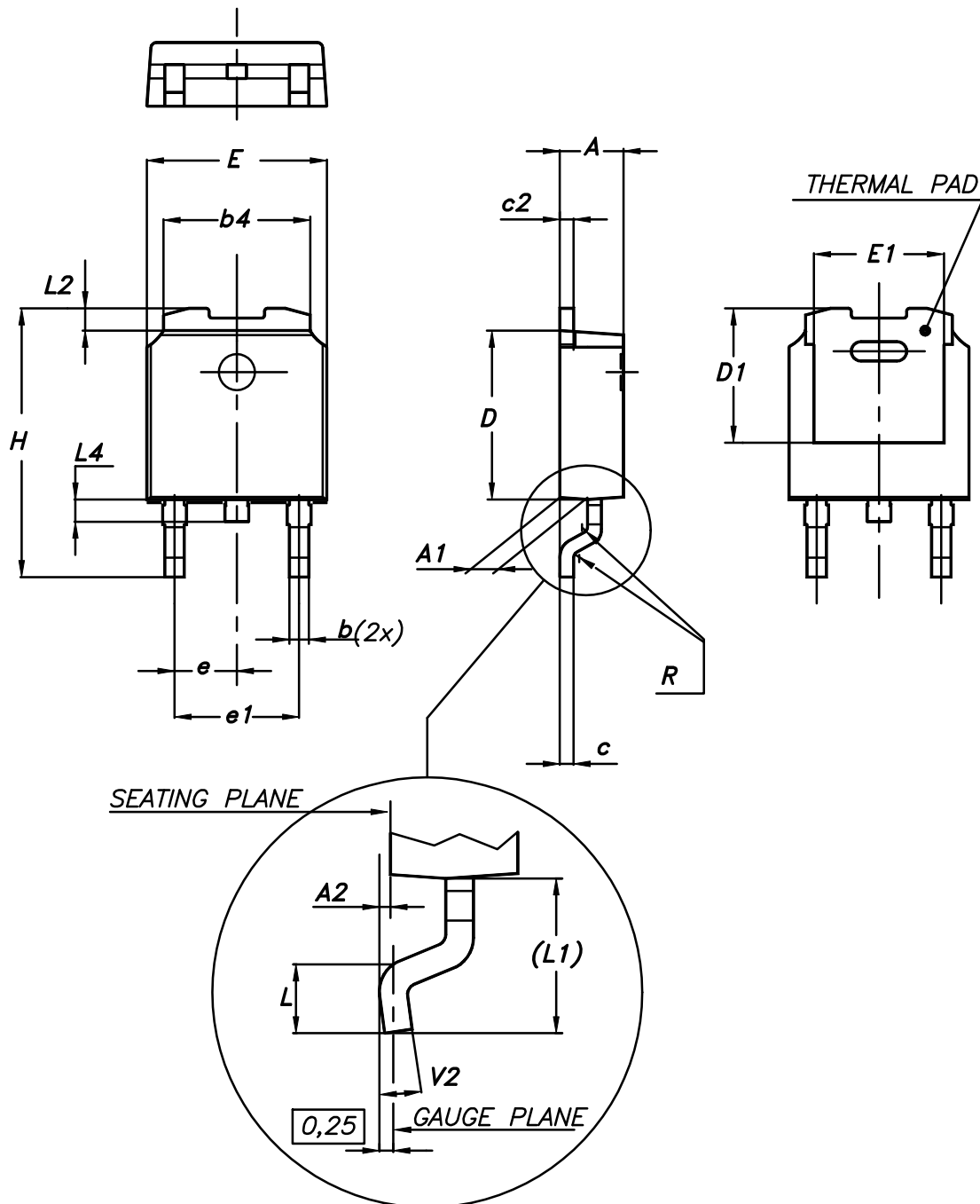

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4 Package information

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 21. DPAK (TO-252) type A package outline



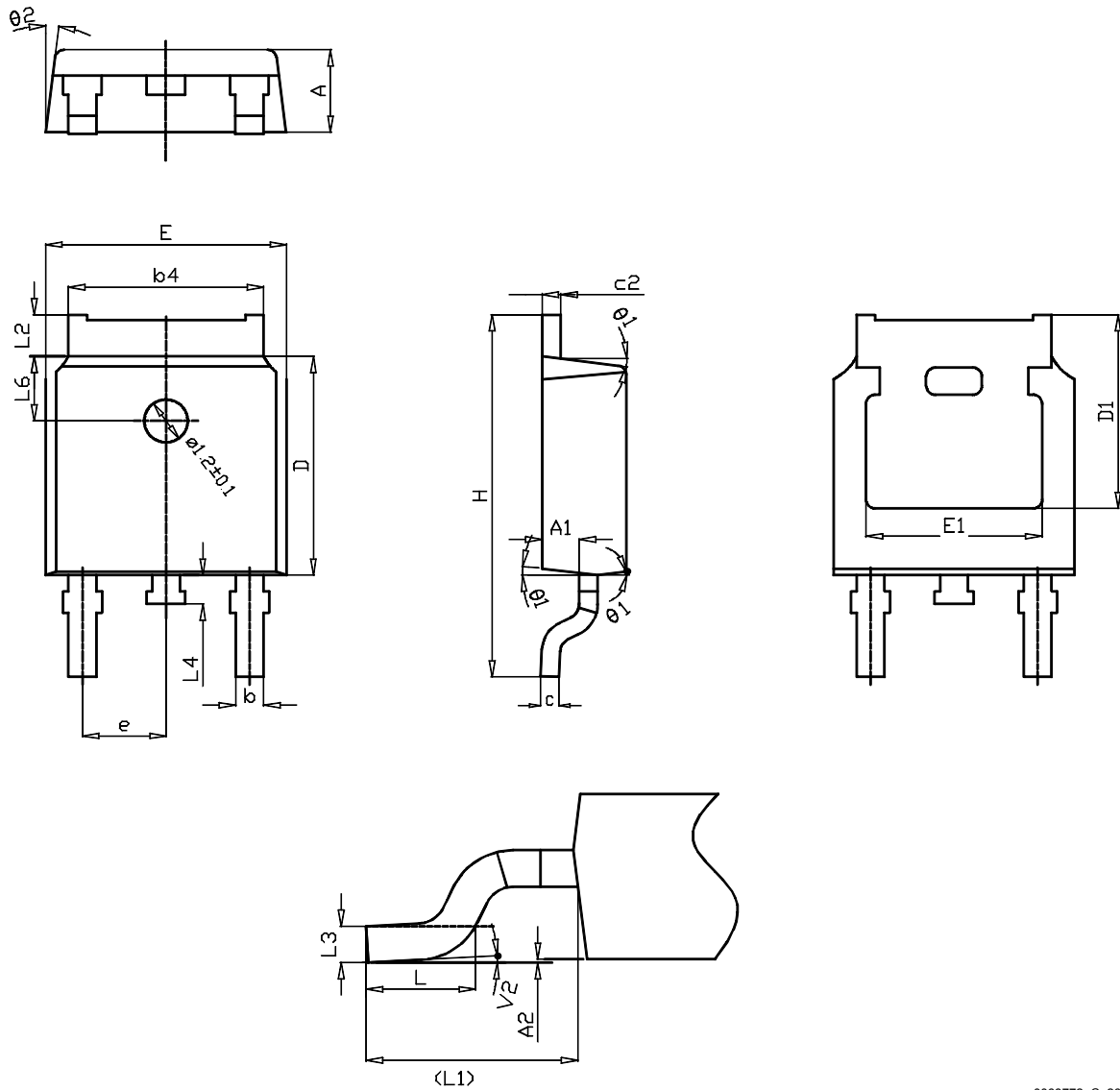
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Table 8. DPAK (TO-252) type A mechanical data

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 22. DPAK (TO-252) type C package outline



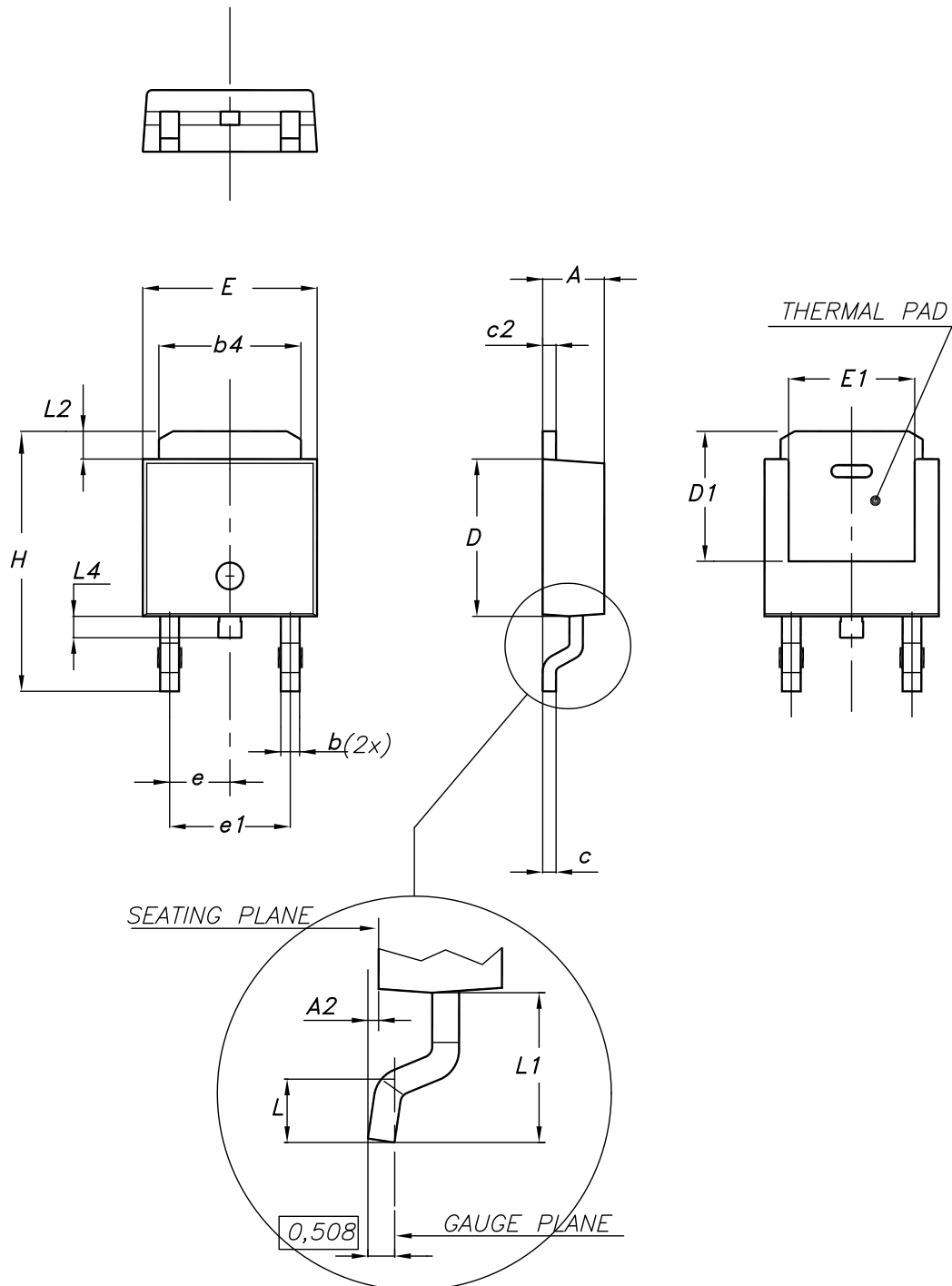
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Table 9. DPAK (TO-252) type C mechanical data

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°

4.3 DPAK (TO-252) type E package information

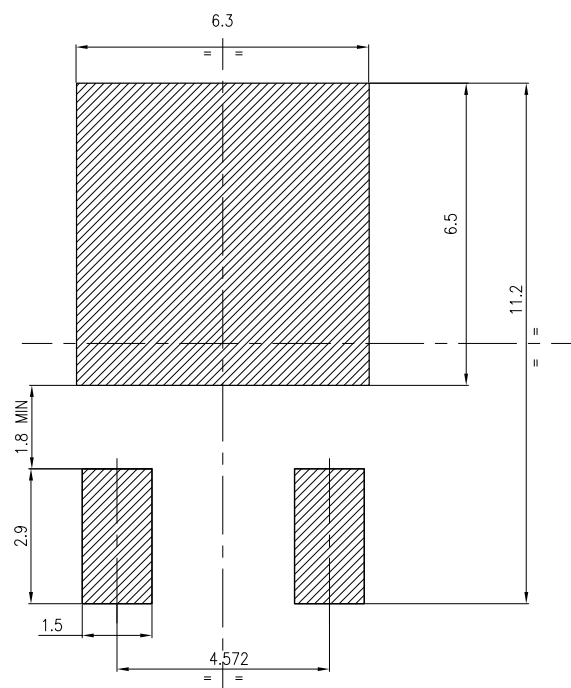
Figure 23. DPAK (TO-252) type E package outline



0068772_type-E_rev.26

Table 10. DPAK (TO-252) type E mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	2.18		2.39
A2			0.13
b	0.65		0.884
b4	4.95		5.46
c	0.46		0.61
c2	0.46		0.60
D	5.97		6.22
D1	5.21		
E	6.35		6.73
E1	4.32		
e		2.286	
e1		4.572	
H	9.94		10.34
L	1.50		1.78
L1		2.74	
L2	0.89		1.27
L4			1.02

Figure 24. DPAK (TO-252) recommended footprint (dimensions are in mm)


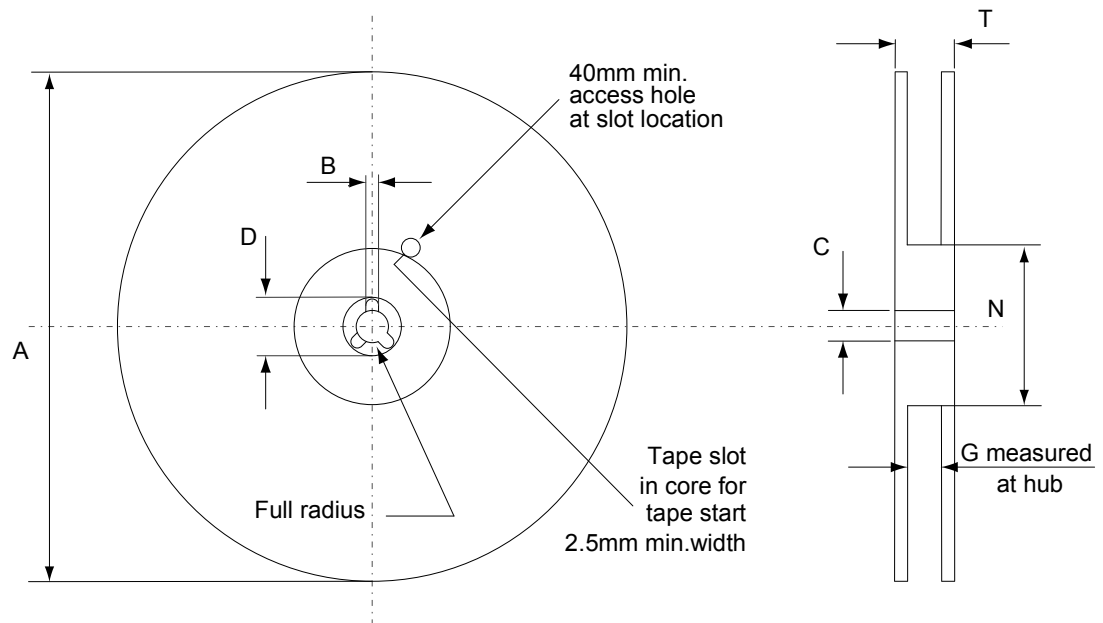
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4.4 DPAK (TO-252) packing information

Figure 25. DPAK (TO-252) tape outline



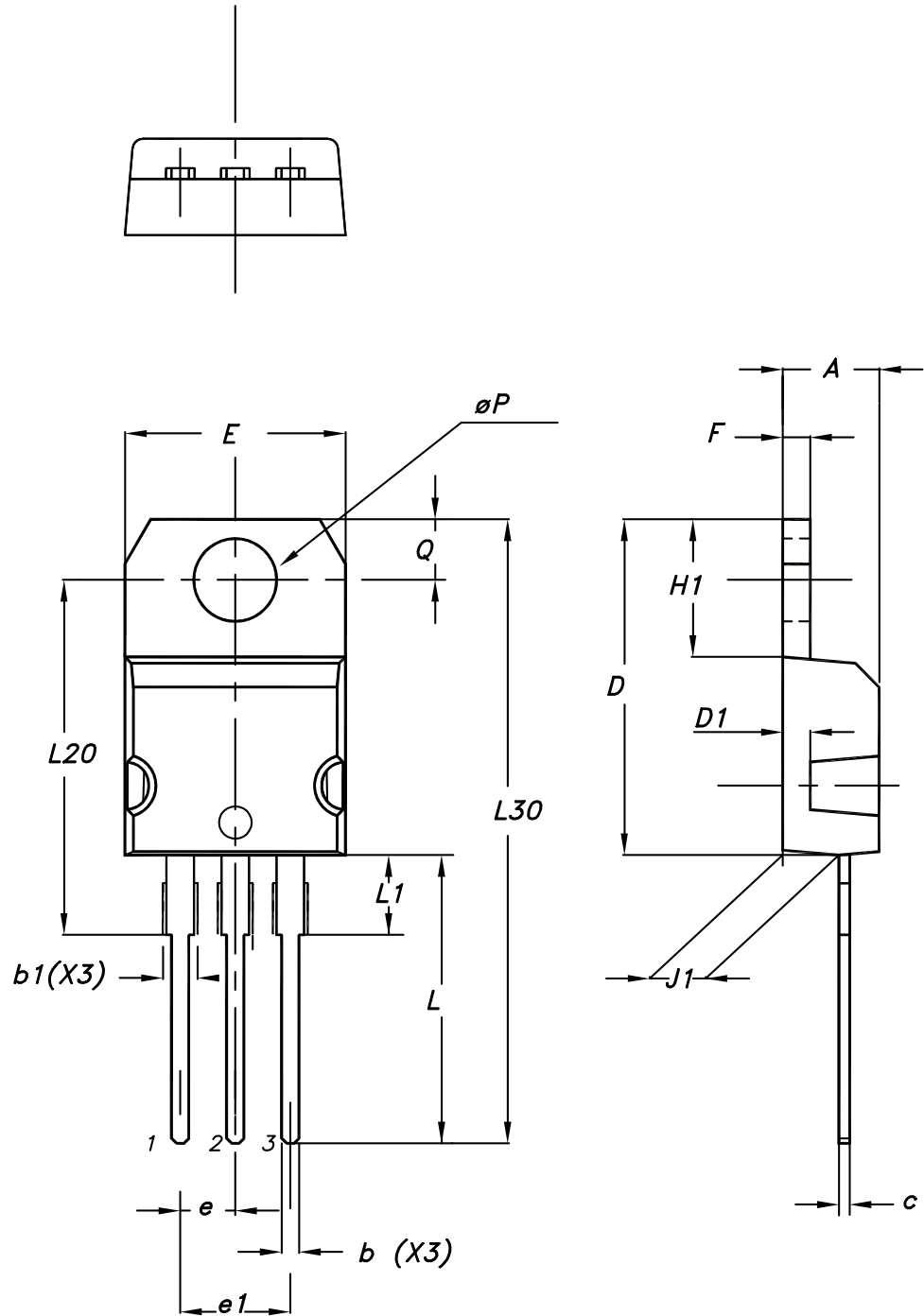
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Figure 26. DPAK (TO-252) reel outline


AM06038v1

Table 11. 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			

4.5 TO-220 type A package information
Figure 27. TO-220 type A package outline


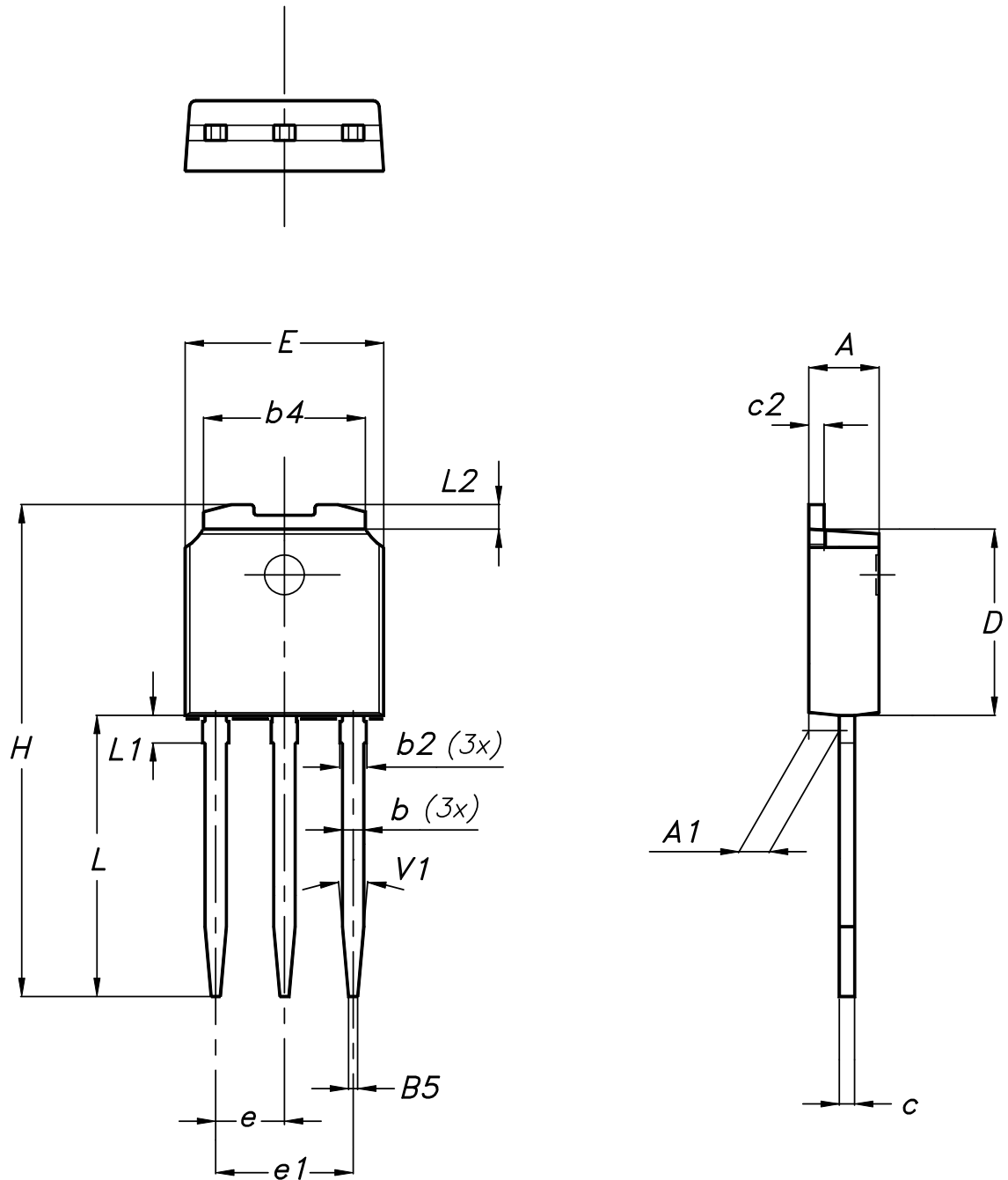
0015988_typeA_Rev_22

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 28. IPAK (TO-251) type A package outline



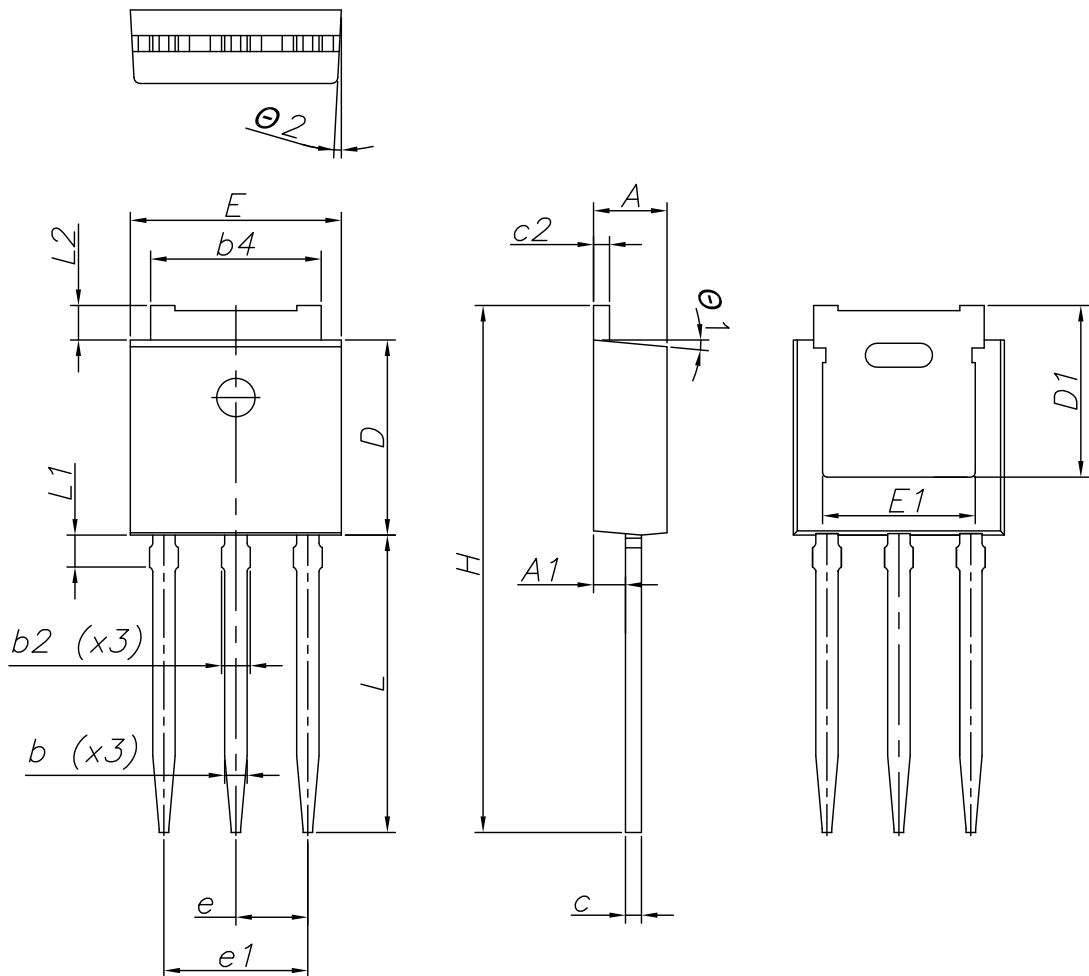
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Table 13. IPAK (TO-251) type A package mechanical data

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 29. 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
STD9N60M2	9N60M2	DPAK	Tape and reel
STP9N60M2		TO-220	Tube
STU9N60M2		IPAK	

Revision history

Table 16. Document revision history

Date	Revision	Changes
19-Mar-2013	1	First release.
30-May-2013	2	<ul style="list-style-type: none"> – The part number STF9N60M2 has been moved to a separate datasheet. – Modified: I_{AR} and I_{AS} values, the entire typical values in <i>Table 4, 6, 7 and 8</i> – Updated: <i>Section 4: Package mechanical data</i> only for TO-220 package
12-Dec-2018	3	<p>Removed maturity status indication from cover page. The document status is production data.</p> <p>Updated features and description on cover page.</p> <p>Modified Table 2. Thermal data.</p> <p>Added Section 4.2 DPAK (TO-252) type C package information, Section 4.3 DPAK (TO-252) type E package information and Section 4.6 IPAK (TO-251) type A package information.</p> <p>Minor text changes.</p>

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