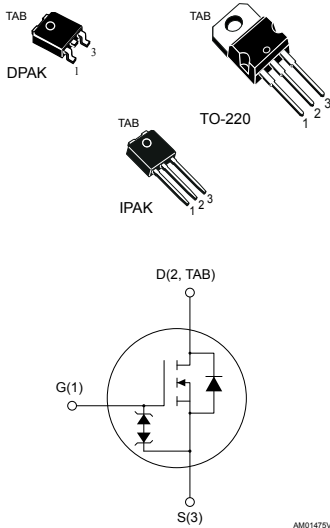




# THE DATASHEET OF STD9N60M2



## N-channel 600 V, 0.72 $\Omega$ 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 $\Omega$	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	$\pm 25$	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 inch<sup>2</sup> 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
$I_{\text{DSS}}$	Zero gate voltage drain current	$V_{\text{GS}} = 0\text{ V}$ , $V_{\text{DS}} = 600\text{ V}$			1	$\mu\text{A}$
		$V_{\text{GS}} = 0\text{ V}$ , $V_{\text{DS}} = 600\text{ V}$ , $T_{\text{case}} = 125\text{ }^{\circ}\text{C}$ <sup>(1)</sup>			100	
$I_{\text{GSS}}$	Gate-body leakage current	$V_{\text{DS}} = 0\text{ V}$ , $V_{\text{GS}} = \pm 25\text{ V}$			$\pm 5$	$\mu\text{A}$
$V_{\text{GS(th)}}$	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	$\Omega$

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

**Table 5. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$C_{\text{iss}}$	Input capacitance	$V_{\text{DS}} = 100\text{ V}$ , $f = 1\text{ MHz}$ , $V_{\text{GS}} = 0\text{ V}$	-	320	-	$\mu\text{F}$
$C_{\text{oss}}$	Output capacitance		-	18	-	
$C_{\text{riss}}$	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	-	$\mu\text{F}$
$R_{\text{G}}$	Intrinsic gate resistance	$f = 1\text{ MHz}$ , $I_{\text{D}} = 0\text{ A}$	-	6.5	-	$\Omega$
$Q_{\text{g}}$	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
$Q_{\text{gs}}$	Gate-source charge		-	2	-	
$Q_{\text{gd}}$	Gate-drain charge		-	5.1	-	

1.  $C_{\text{oss eq.}}$  is defined as a constant equivalent capacitance giving the same charging time as  $C_{\text{oss}}$  when  $V_{\text{DS}}$  increases from 0 to 80%  $V_{\text{DSS}}$ .

**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
$t_{\text{r}}$	Rise time		-	7.5	-	
$t_{\text{d(off)}}$	Turn-off delay time		-	22	-	
$t_{\text{f}}$	Fall time		-	13.5	-	

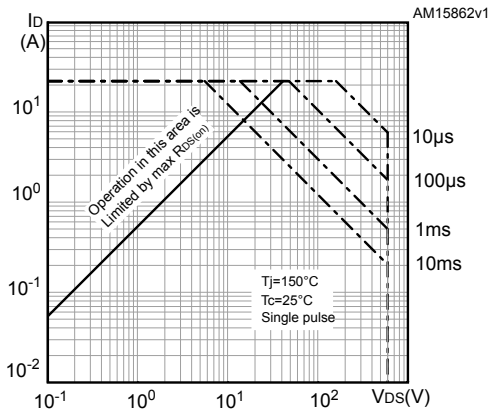
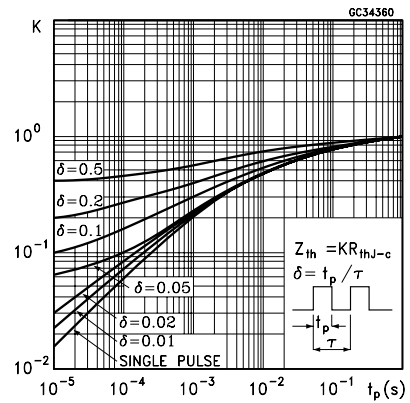
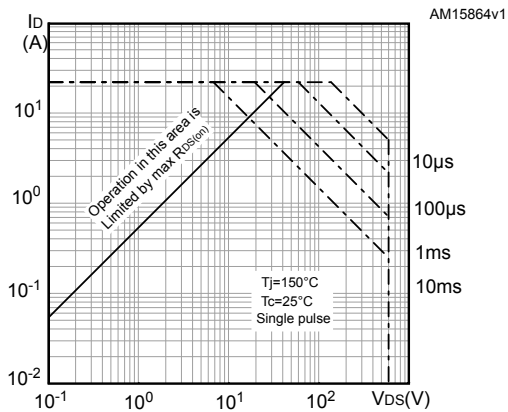
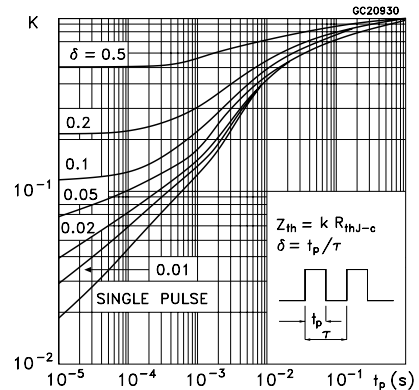
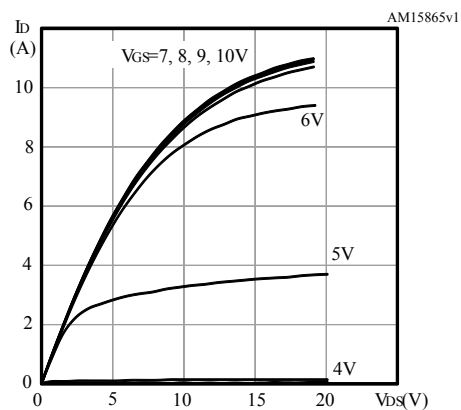
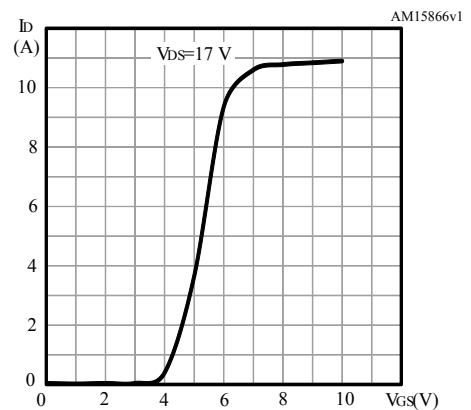
**Table 7. Source-drain diode**

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		$\mu\text{C}$
$I_{RRM}$	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		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current		-	12.2		A

1. Pulse width is limited by safe operating area.

2. Pulse test: pulse duration = 300  $\mu\text{s}$ , 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**


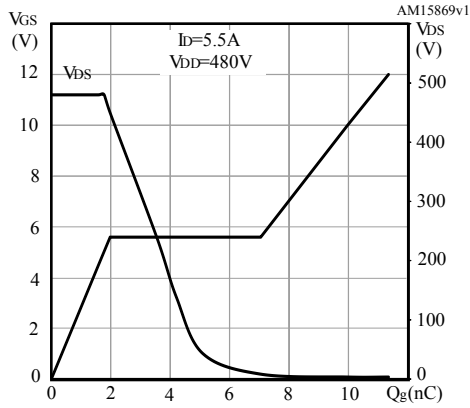
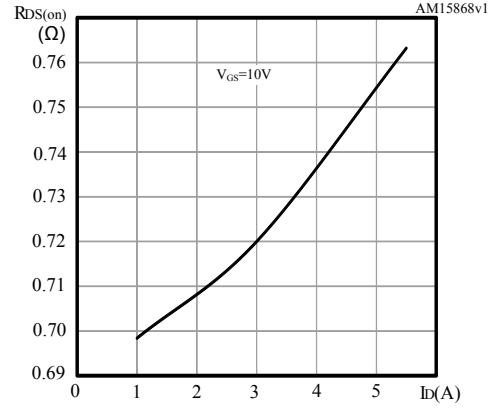
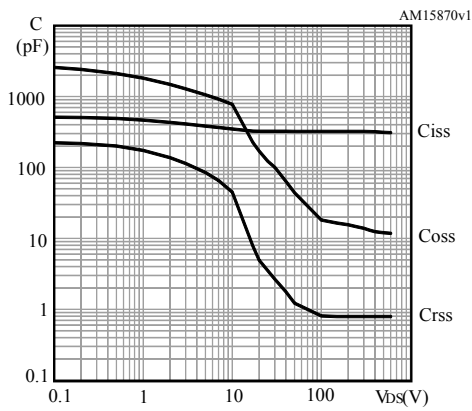
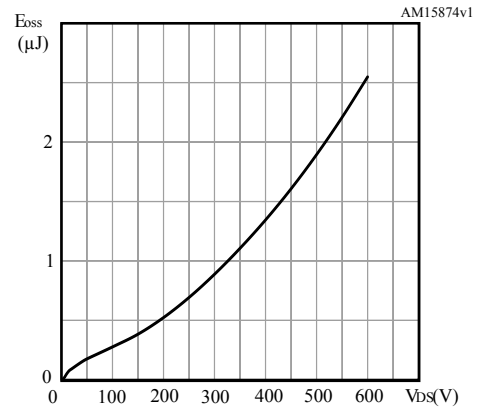
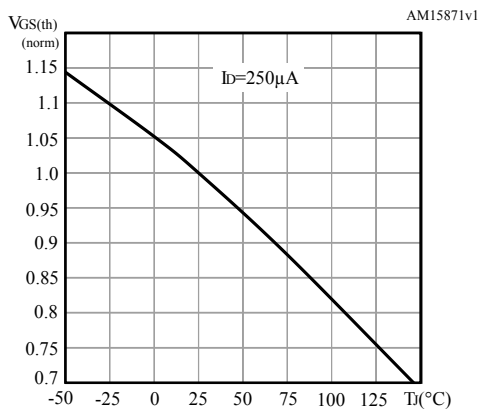
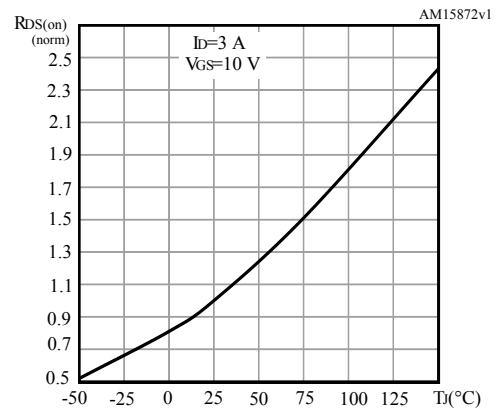
**Figure 7. Gate charge vs gate-source voltage**

**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

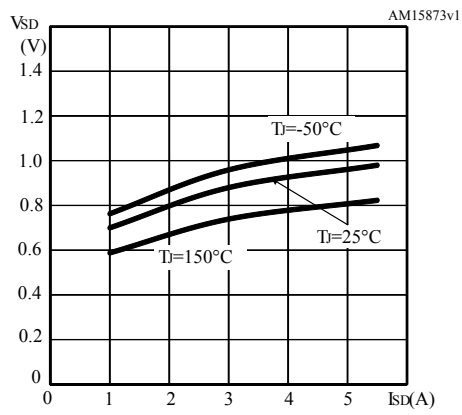
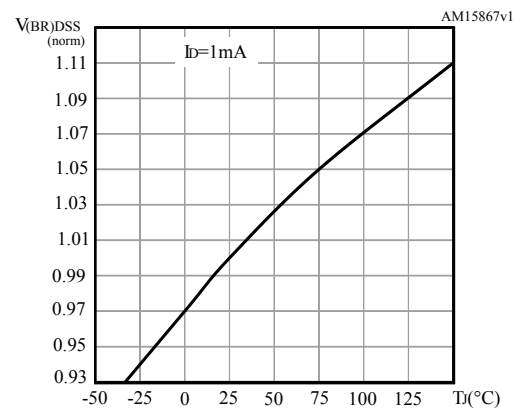
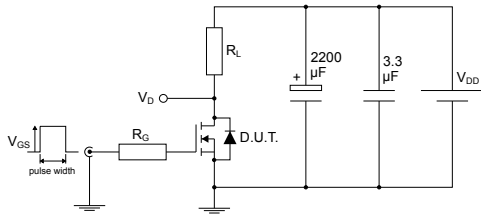


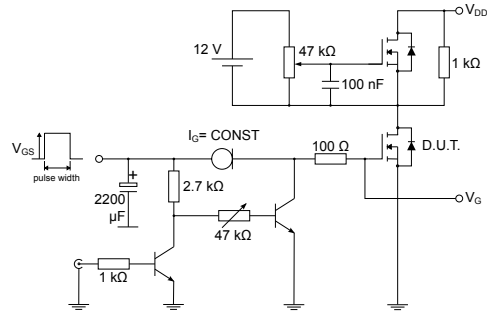
Figure 14. Normalized  $V_{(BR)DSS}$  vs temperature



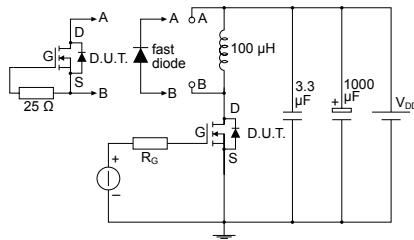
### 3 Test circuits

**Figure 15. Test circuit for resistive load switching times**


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**Figure 16. Test circuit for gate charge behavior**


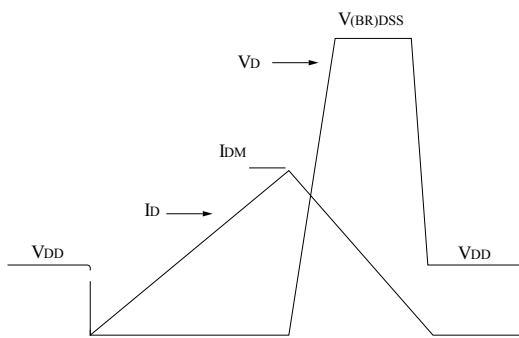
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**Figure 17. Test circuit for inductive load switching and diode recovery times**


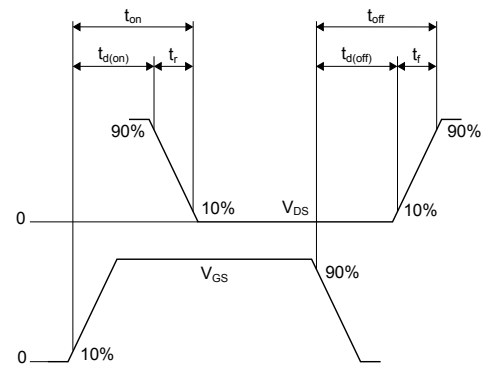
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**Figure 18. Unclamped inductive load test circuit**


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**Figure 19. Unclamped inductive waveform**


AM01472v1

**Figure 20. Switching time waveform**


AM01473v1

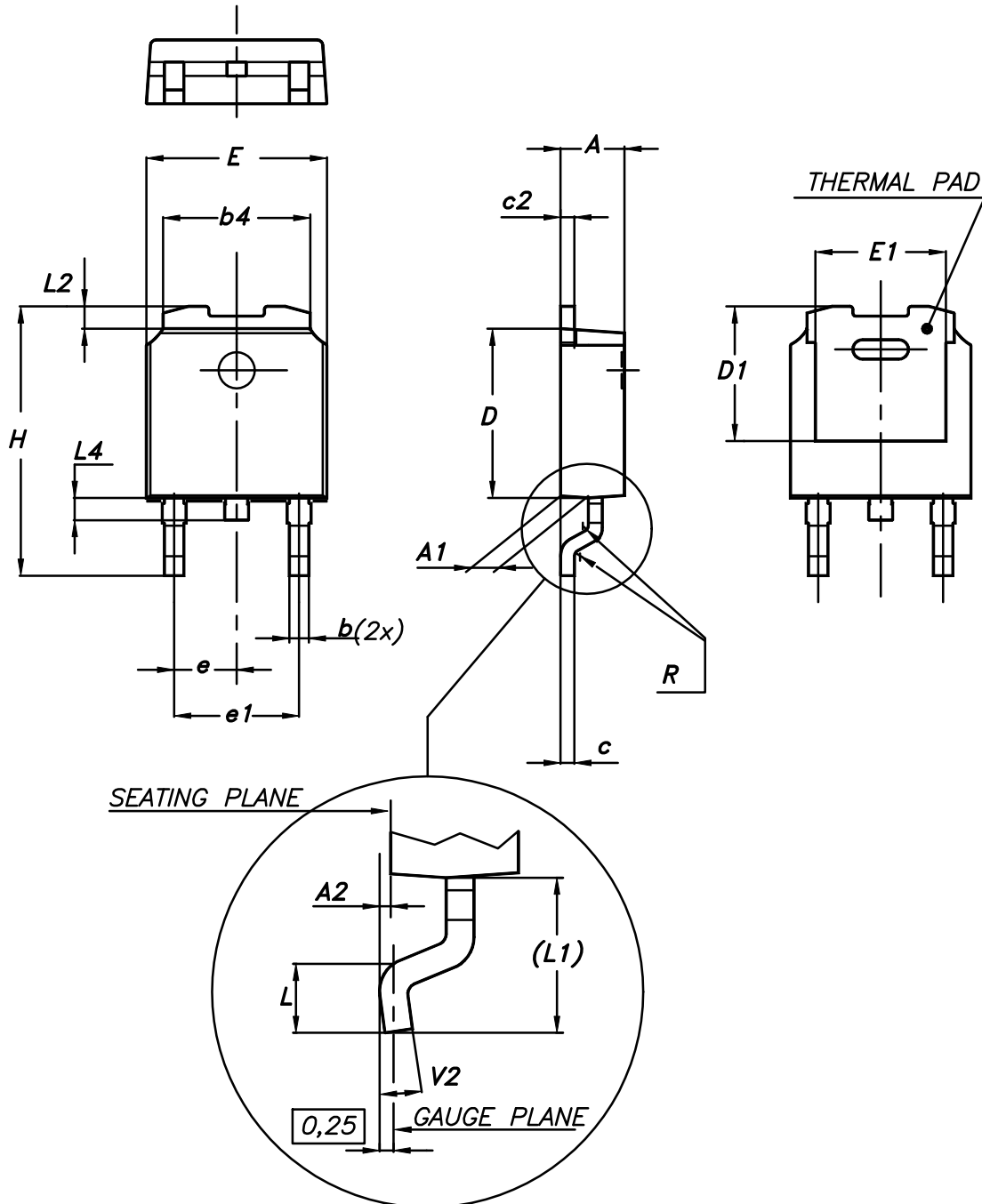
## 4 Package information

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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: [www.st.com](http://www.st.com). ECOPACK<sup>®</sup> is an ST trademark.

### 4.1 DPAK (TO-252) type A package information

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



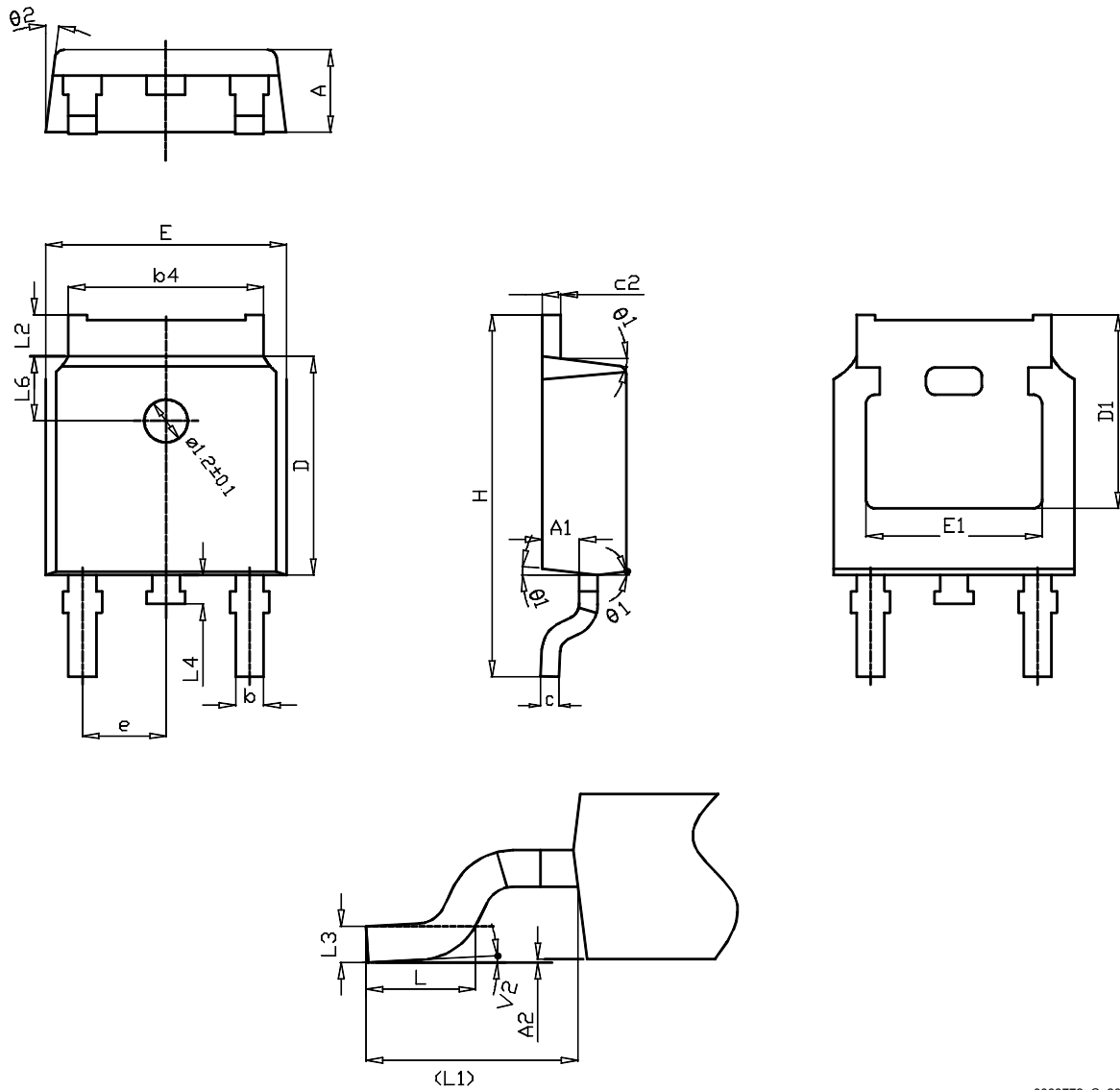
0068772\_A\_26

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



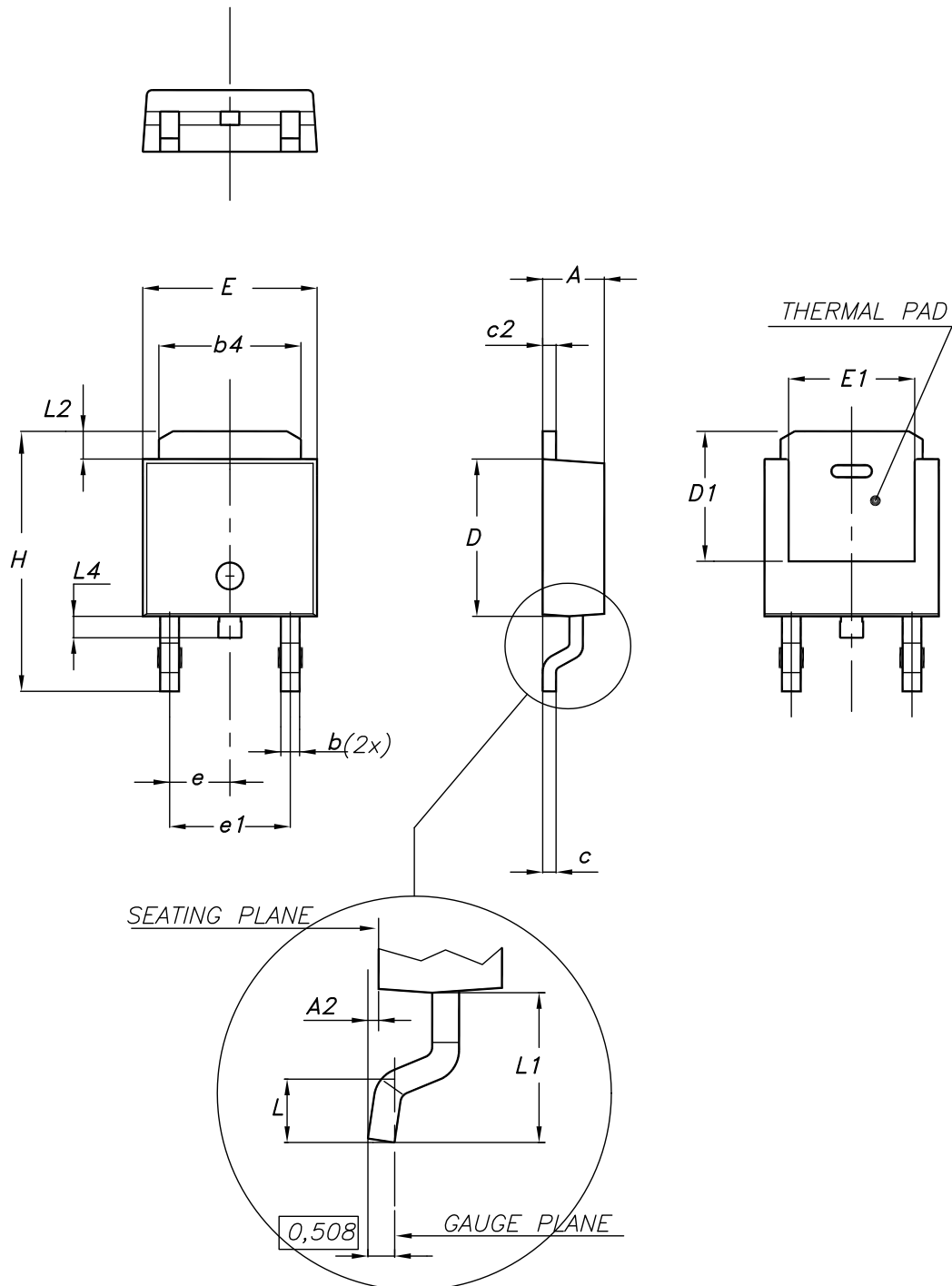
0068772\_C\_26

**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°

### 4.3 DPAK (TO-252) type E package information

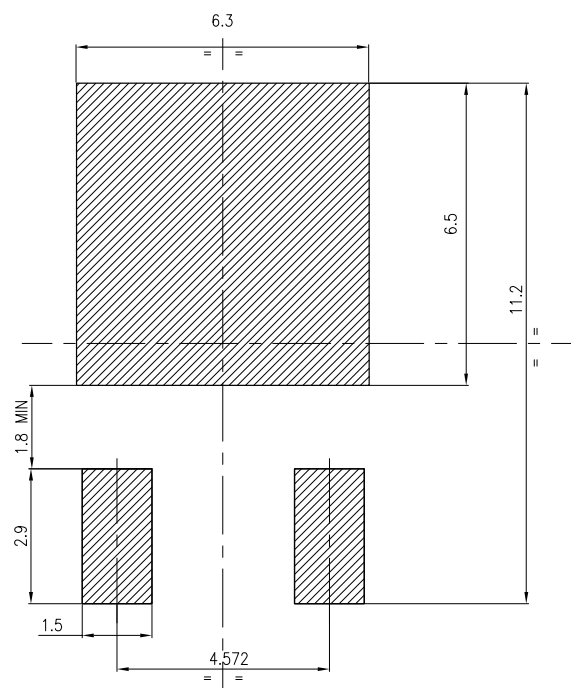
Figure 23. DPAK (TO-252) type E package outline



0068772\_type-E\_rev.26

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

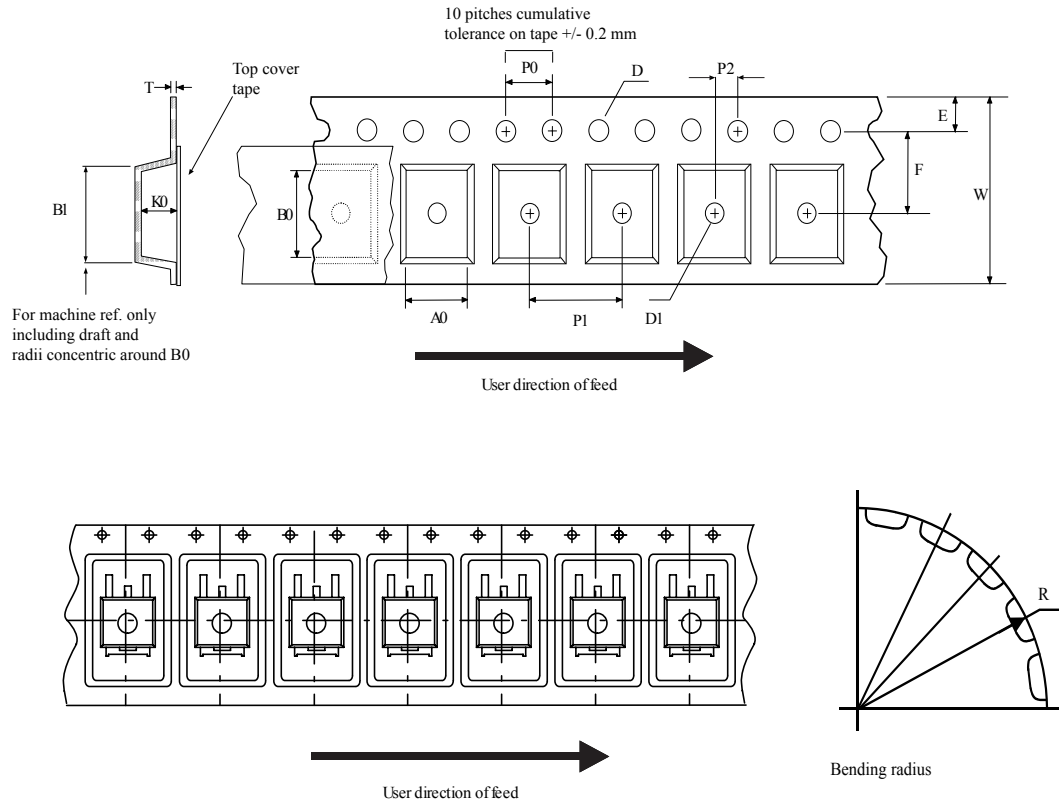
Dim.	mm		
	Min.	Typ.	Max.
A	2.18		2.39
A2			0.13
b	0.65		0.884
b4	4.95		5.46
c	0.46		0.61
c2	0.46		0.60
D	5.97		6.22
D1	5.21		
E	6.35		6.73
E1	4.32		
e		2.286	
e1		4.572	
H	9.94		10.34
L	1.50		1.78
L1		2.74	
L2	0.89		1.27
L4			1.02

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


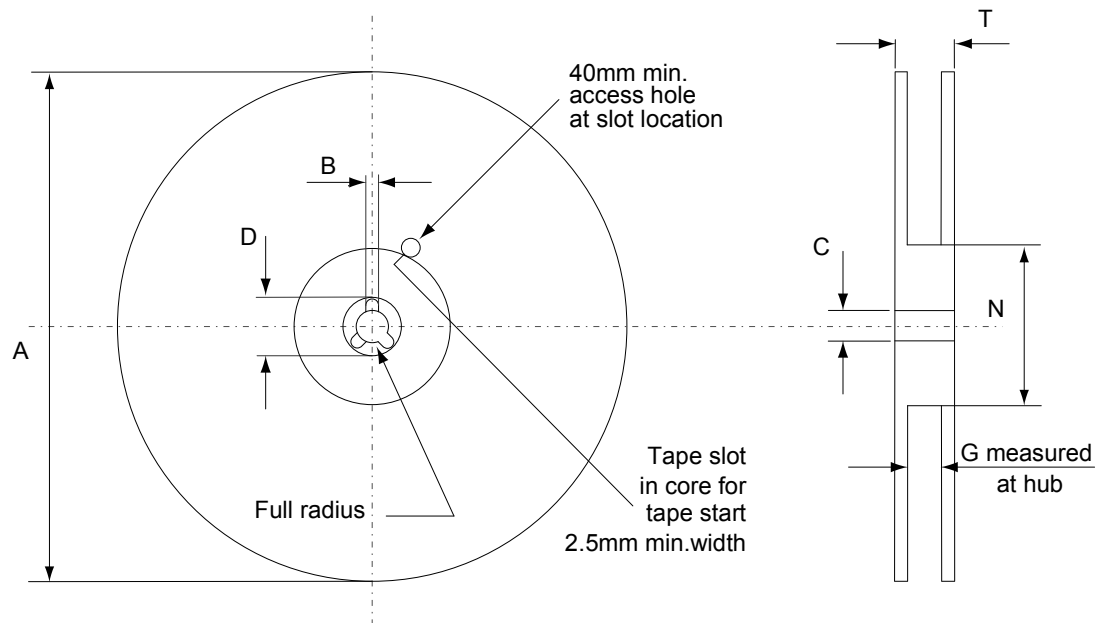
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#### 4.4 DPAK (TO-252) packing information

Figure 25. DPAK (TO-252) tape outline



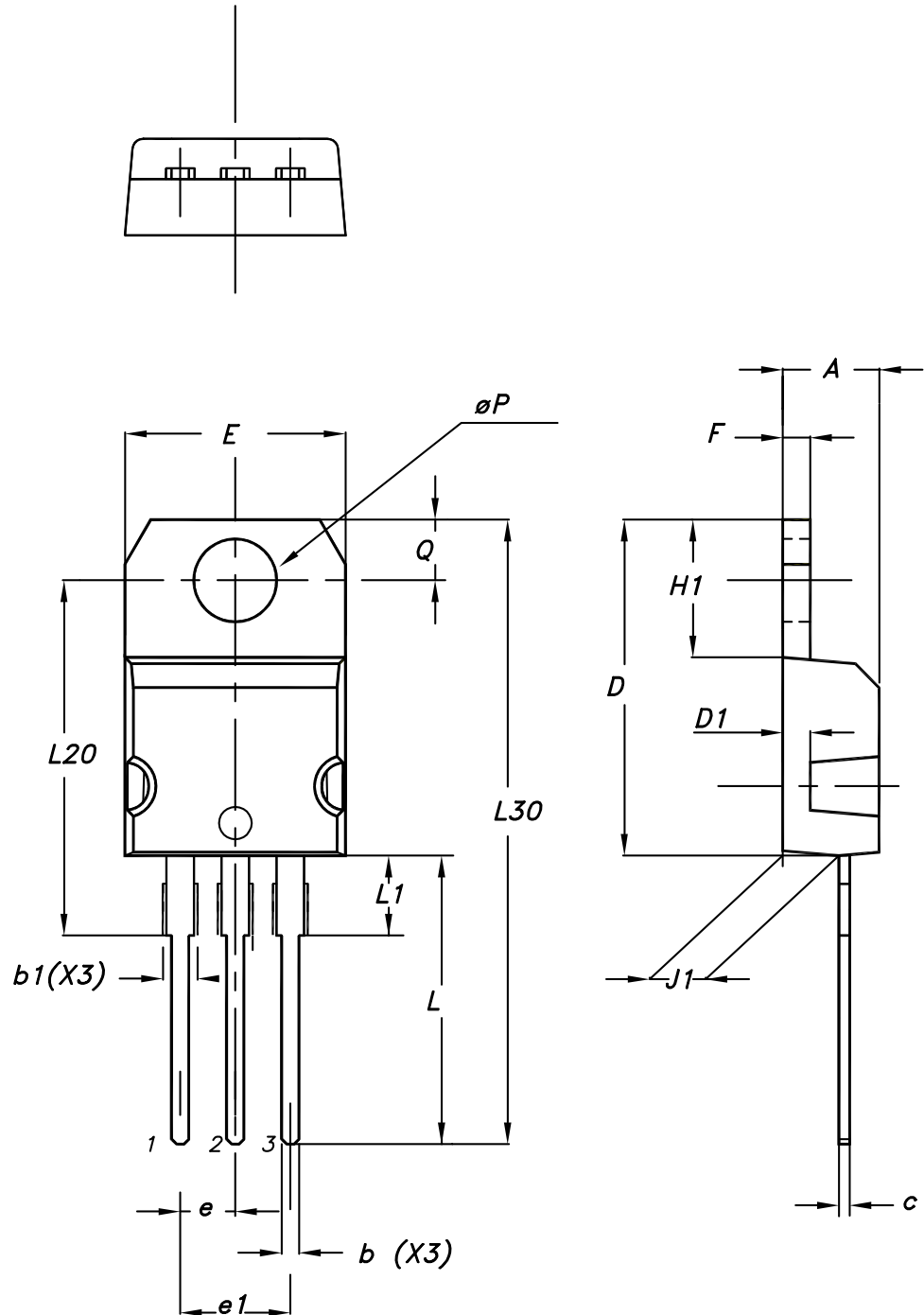
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**Figure 26. DPAK (TO-252) reel outline**


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**


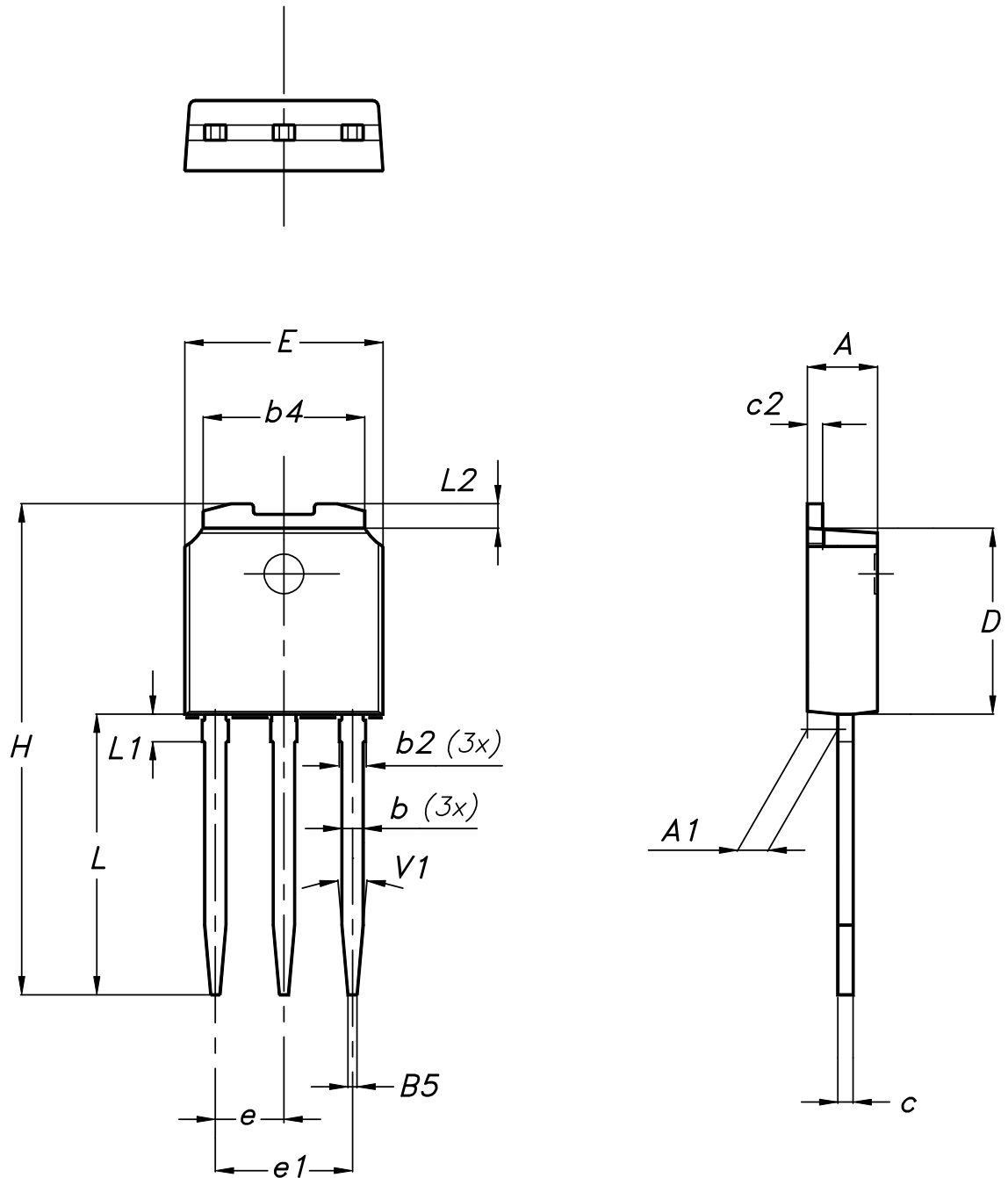
0015988\_typeA\_Rev\_22

**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



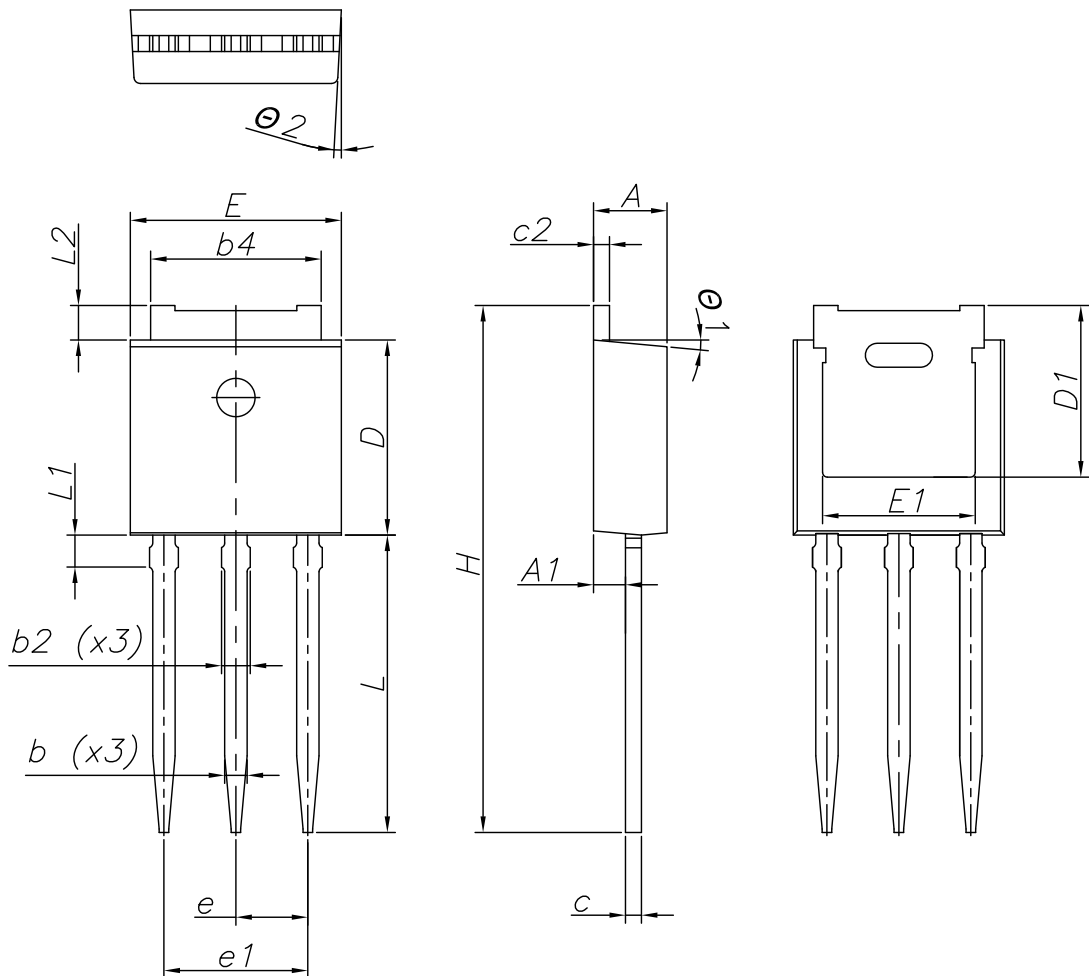
0068771\_IK\_typeA\_rev14

**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 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"> <li>– The part number STF9N60M2 has been moved to a separate datasheet.</li> <li>– Modified: <math>I_{AR}</math> and <math>I_{AS}</math> values, the entire typical values in <i>Table 4, 6, 7 and 8</i></li> <li>– Updated: <i>Section 4: Package mechanical data</i> only for TO-220 package</li> </ul>
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 <a href="#">Table 2. Thermal data.</a></p> <p>Added <a href="#">Section 4.2 DPAK (TO-252) type C package information</a>, <a href="#">Section 4.3 DPAK (TO-252) type E package information</a> and <a href="#">Section 4.6 IPAK (TO-251) type A package information</a>.</p> <p>Minor text changes.</p>

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