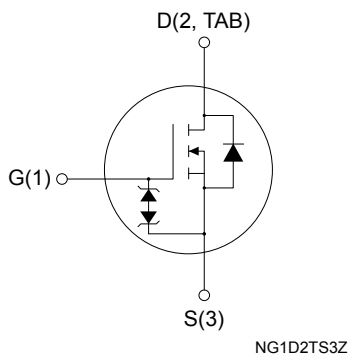
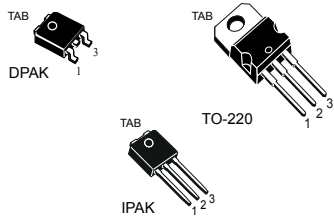


## N-channel 600 V, 1.3 $\Omega$ typ., 3.5 A, MDmesh™ M2 Power MOSFETs in DPAK, TO-220 and IPAK packages



### Features

Order code	$V_{DS@T_{Jmax}}$	$R_{DS(on) max.}$	$I_D$
STD5N60M2	650 V	1.4 $\Omega$	3.5 A
STP5N60M2			
STU5N60M2			

- 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 links

[STD5N60M2](#)
[STP5N60M2](#)
[STU5N60M2](#)

# 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 $T_C = 25\text{ }^\circ\text{C}$	3.5	A
	Drain current (continuous) at $T_C = 100\text{ }^\circ\text{C}$	2.2	
$I_{DM}^{(1)}$	Drain current (pulsed)	14	A
$P_{TOT}$	Total dissipation at $T_C = 25\text{ }^\circ\text{C}$	45	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.  $I_{SD} \leq 3.5\text{ A}$ ,  $di/dt \leq 400\text{ A}/\mu\text{s}$ ;  $V_{DS\text{ peak}} < V_{(BR)DSS}$ ,  $V_{DD} = 400\text{ V}$ .
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	2.8			$^\circ\text{C}/\text{W}$
$R_{thj-pcb}^{(1)}$	Thermal resistance junction-pcb	50			
$R_{thj-amb}$	Thermal resistance junction-ambient		62.5	100	

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 not repetitive <sup>(1)</sup>	0.5	A
$E_{AS}$	Single pulse avalanche energy <sup>(2)</sup>	80	mJ

1. Pulse width limited by  $T_{jmax}$
2. Starting  $T_j = 25\text{ }^\circ\text{C}$ ,  $I_D = I_{AR}$ ,  $V_{DD} = 50\text{ V}$

## 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	$\mu\text{A}$
		$V_{\text{GS}} = 0\text{ V}$ , $V_{\text{DS}} = 600\text{ V}$ , $T_{\text{C}} = 125\text{ }^{\circ}\text{C}$ <sup>(1)</sup>			100	
$I_{\text{GSS}}$	Gate-body leakage current	$V_{\text{DS}} = 0\text{ V}$ , $V_{\text{GS}} = \pm 25\text{ V}$			$\pm 10$	$\mu\text{A}$
$V_{\text{GS}(\text{th})}$	Gate threshold voltage	$V_{\text{DS}} = V_{\text{GS}}$ , $I_{\text{D}} = 250\text{ }\mu\text{A}$	2	3	4	V
$R_{\text{DS}(\text{on})}$	Static drain-source on-resistance	$V_{\text{GS}} = 10\text{ V}$ , $I_{\text{D}} = 1.7\text{ A}$		1.3	1.4	$\Omega$

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	$V_{\text{DS}} = 100\text{ V}$ , $f = 1\text{ MHz}$ , $V_{\text{GS}} = 0\text{ V}$	-	211	-	$\text{pF}$
$C_{\text{oss}}$	Output capacitance		-	13	-	
$C_{\text{riss}}$	Reverse transfer capacitance		-	0.75	-	
$C_{\text{oss eq.}}^{(1)}$	Equivalent output capacitance	$V_{\text{DS}} = 0\text{ to }480\text{ V}$ , $V_{\text{GS}} = 0\text{ V}$	-	19.5	-	$\text{pF}$
$R_{\text{G}}$	Intrinsic gate resistance	$f = 1\text{ MHz}$ open drain	-	6.2	-	$\Omega$
$Q_{\text{g}}$	Total gate charge	$V_{\text{DD}} = 480\text{ V}$ , $I_{\text{D}} = 3.5\text{ A}$ , $V_{\text{GS}} = 0\text{ to }10\text{ V}$ (see Figure 16. Test circuit for gate charge behavior)	-	8	-	$\text{nC}$
$Q_{\text{gs}}$	Gate-source charge		-	1.6	-	
$Q_{\text{gd}}$	Gate-drain charge		-	4.4	-	

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%  $V_{\text{DSS}}$ .

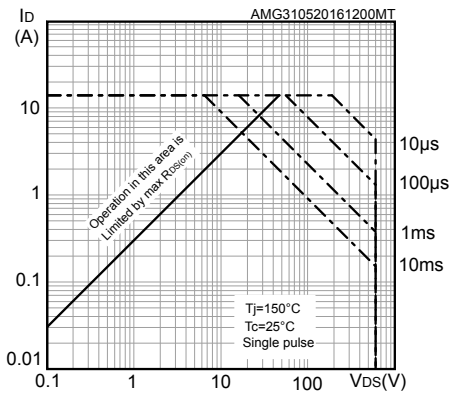
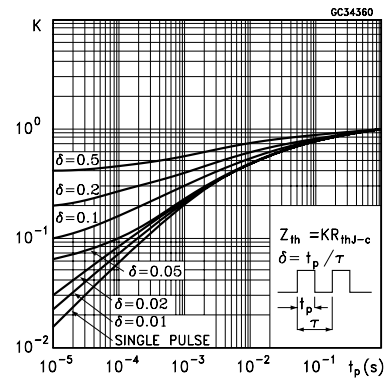
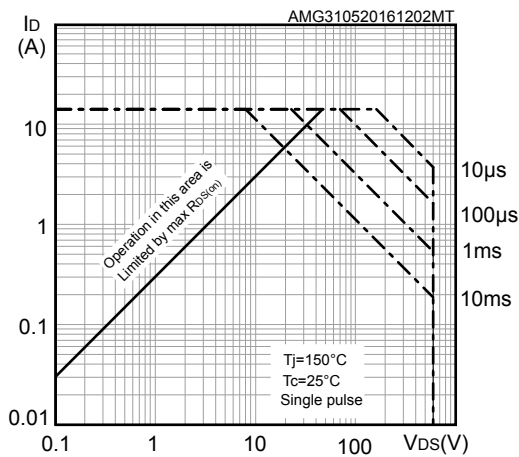
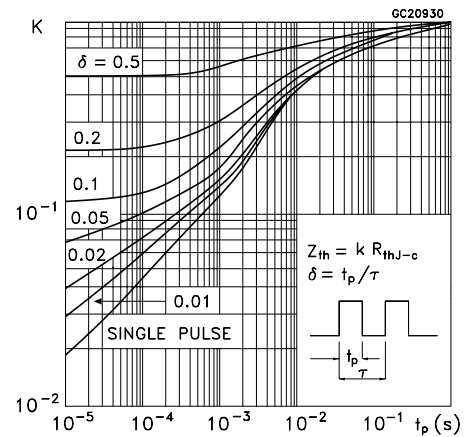
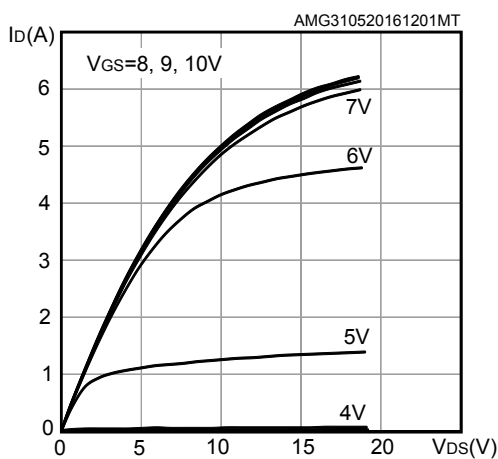
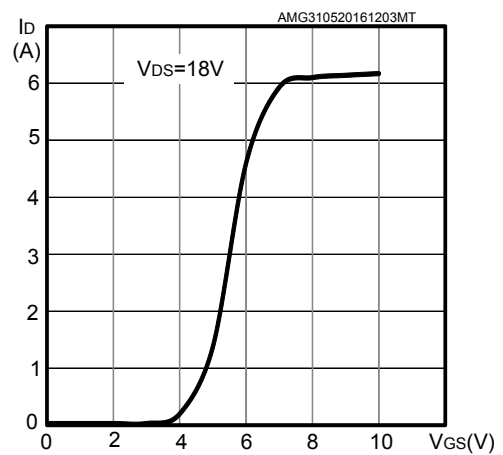
**Table 6. Switching times**

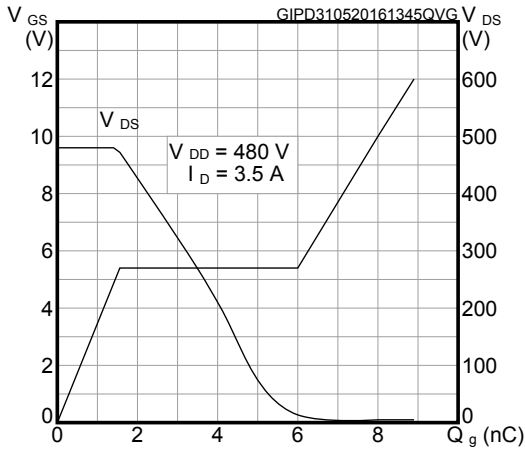
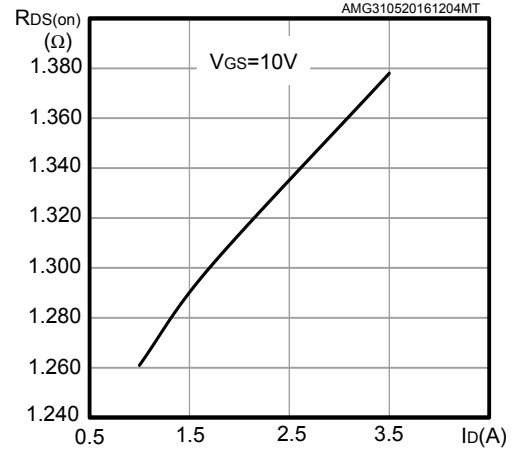
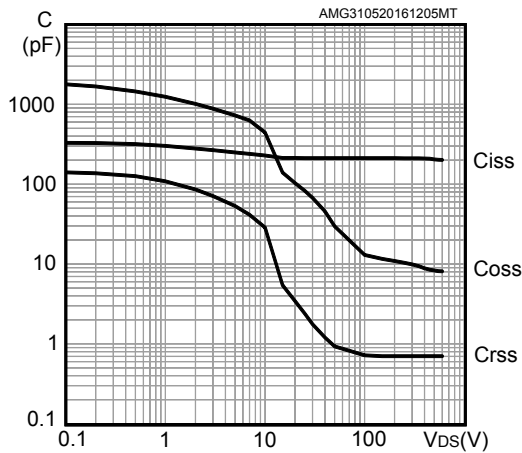
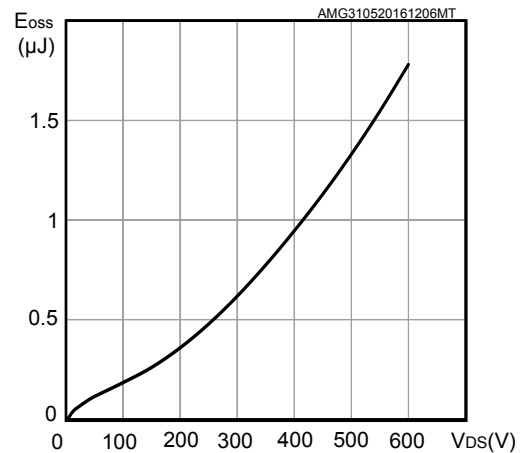
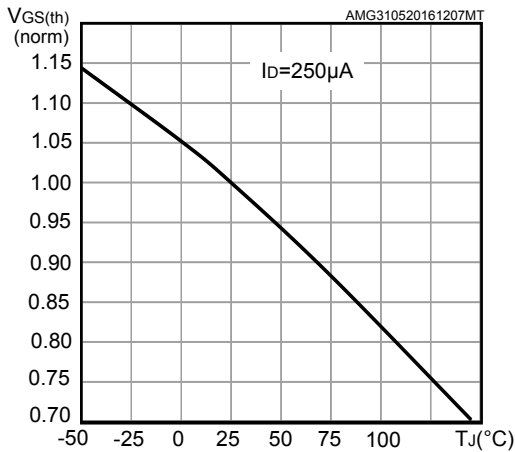
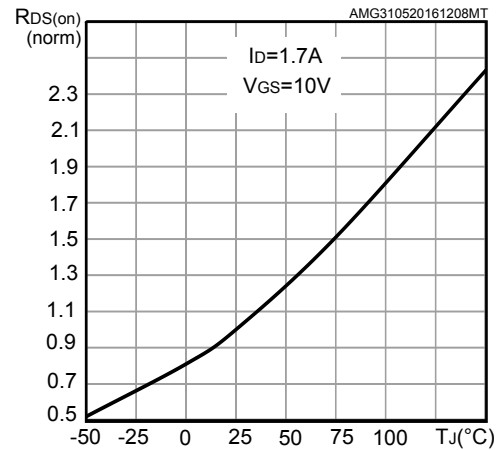
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{\text{d}(\text{on})}$	Turn-on delay time	$V_{\text{DD}} = 300\text{ V}$ , $I_{\text{D}} = 1.7\text{ A}$ , $R_{\text{G}} = 4.7\text{ }\Omega$ , $V_{\text{GS}} = 10\text{ V}$ (see Figure 15. Test circuit for resistive load switching times and Figure 20. Switching time waveform)	-	12	-	$\text{ns}$
$t_{\text{r}}$	Rise time		-	3	-	
$t_{\text{d}(\text{off})}$	Turn-off delay time		-	70	-	
$t_{\text{f}}$	Fall time		-	15	-	

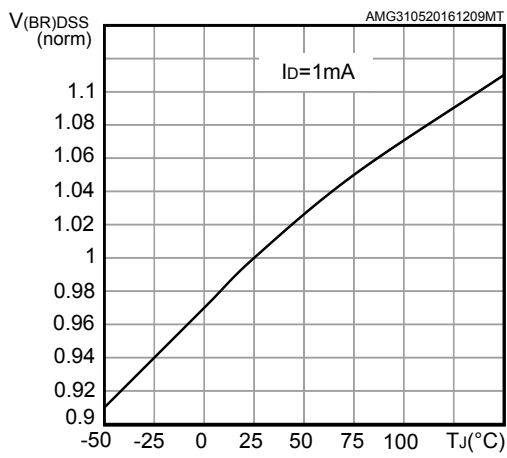
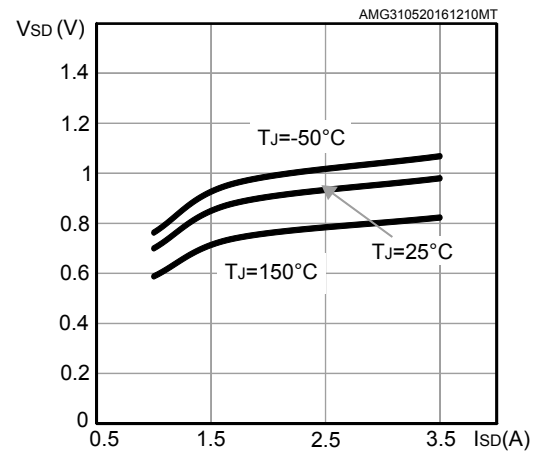
**Table 7. Source-drain diode**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{SD}$	Source-drain current		-		3.5	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)		-		14	A
$V_{SD}^{(2)}$	Forward on voltage	$V_{GS} = 0\text{ V}$ , $I_{SD} = 3.5\text{ A}$	-		1.6	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 3.5\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ , $V_{DD} = 60\text{ V}$	-	220		ns
$Q_{rr}$	Reverse recovery charge		-	1.05		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current	(see Figure 17. Test circuit for inductive load switching and diode recovery times)	-	9.5		A
$t_{rr}$	Reverse recovery time	$I_{SD} = 3.5\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ , $V_{DD} = 60\text{ V}$ , $T_j = 150\text{ }^\circ\text{C}$	-	314		ns
$Q_{rr}$	Reverse recovery charge		-	1.5		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current		(see Figure 17. Test circuit for inductive load switching and diode recovery times)	-	9.5	

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**


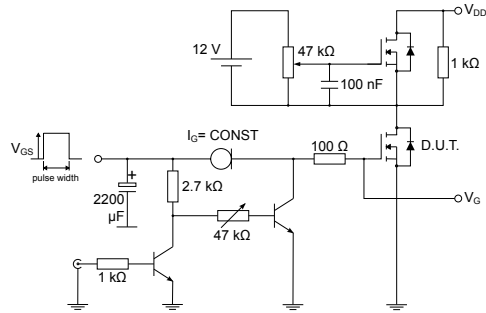
**Figure 7. Gate charge vs gate-source voltage**

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

**Figure 14. Source-drain diode forward characteristics**


### 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**

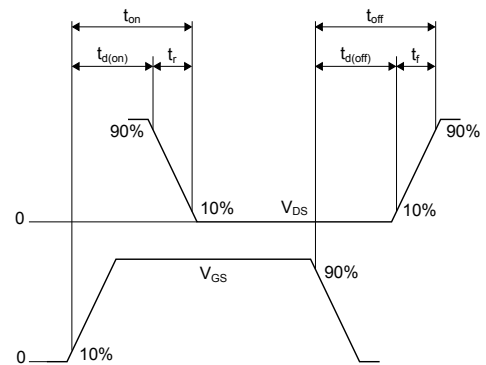

AM01470v1

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


AM01471v1

**Figure 19. Unclamped inductive waveform**


AM01472v1

**Figure 20. Switching time waveform**


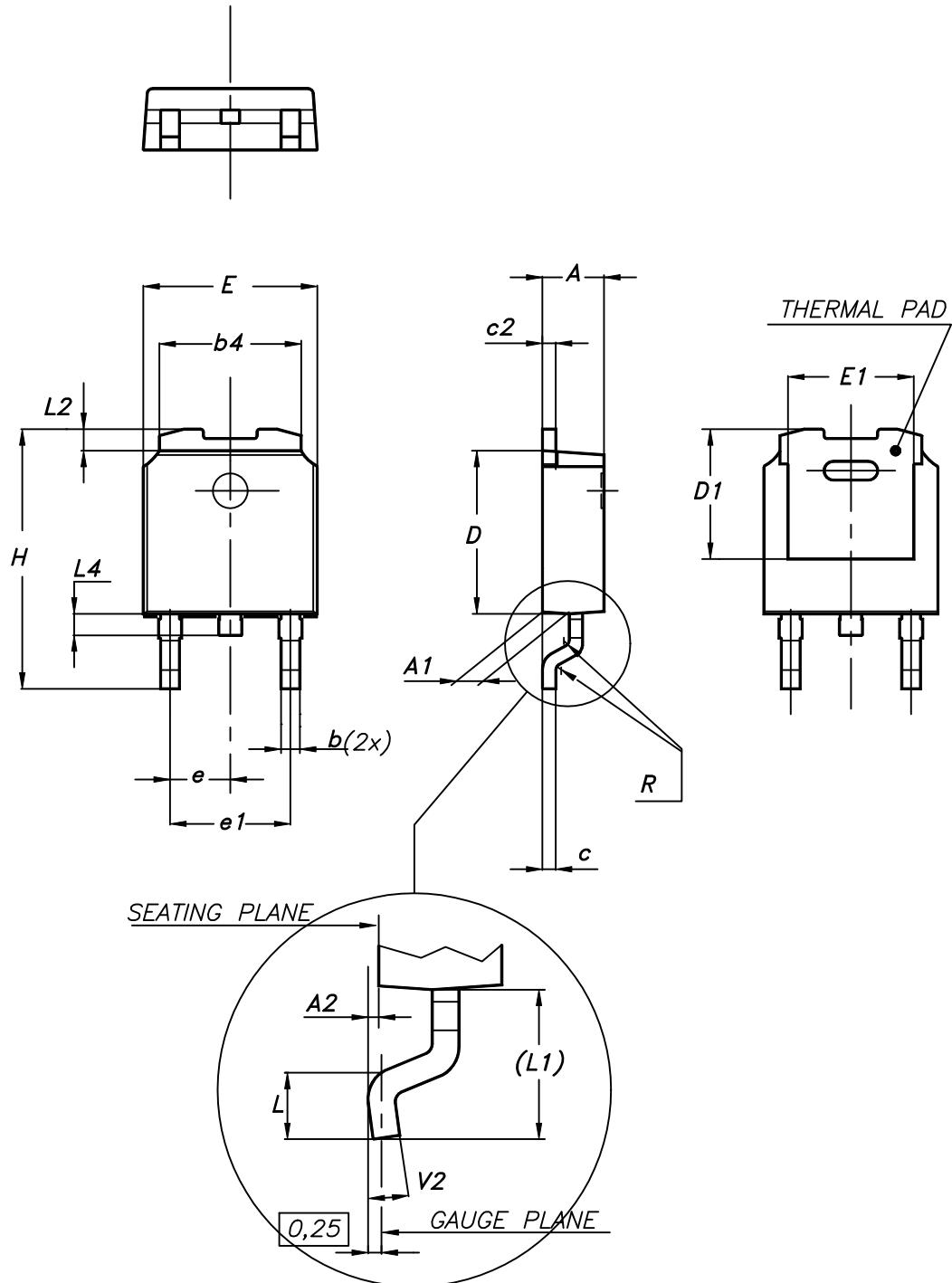
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## 4 Package information

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

**4.1 DPAK (TO-252) type A2 package information**
**Figure 21. DPAK (TO-252) type A2 package outline**


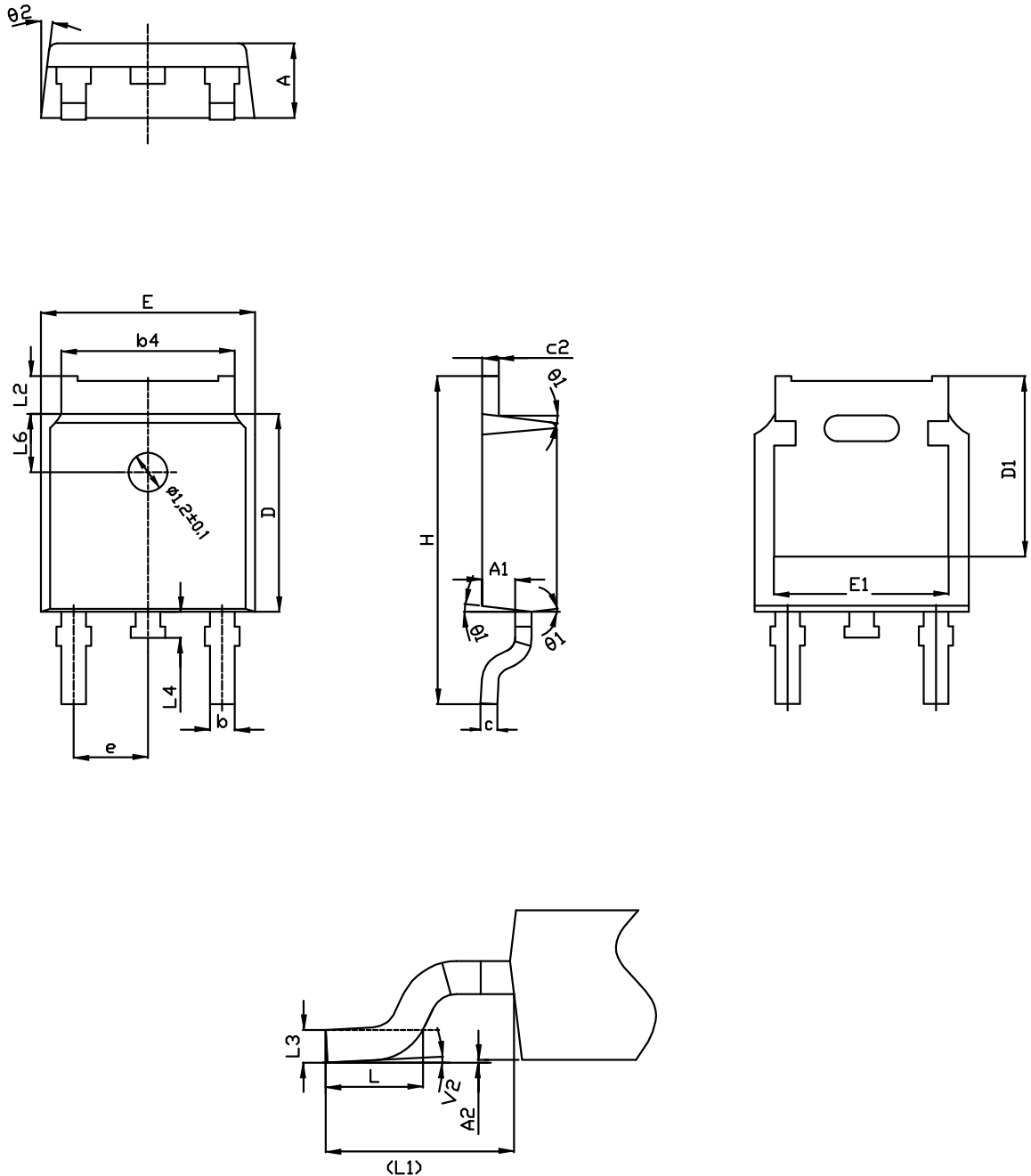
0068772\_type-A2\_rev25

**Table 8. DPAK (TO-252) type A2 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	5.10	5.20	5.30
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 C2 package information

Figure 22. DPAK (TO-252) type C2 package outline



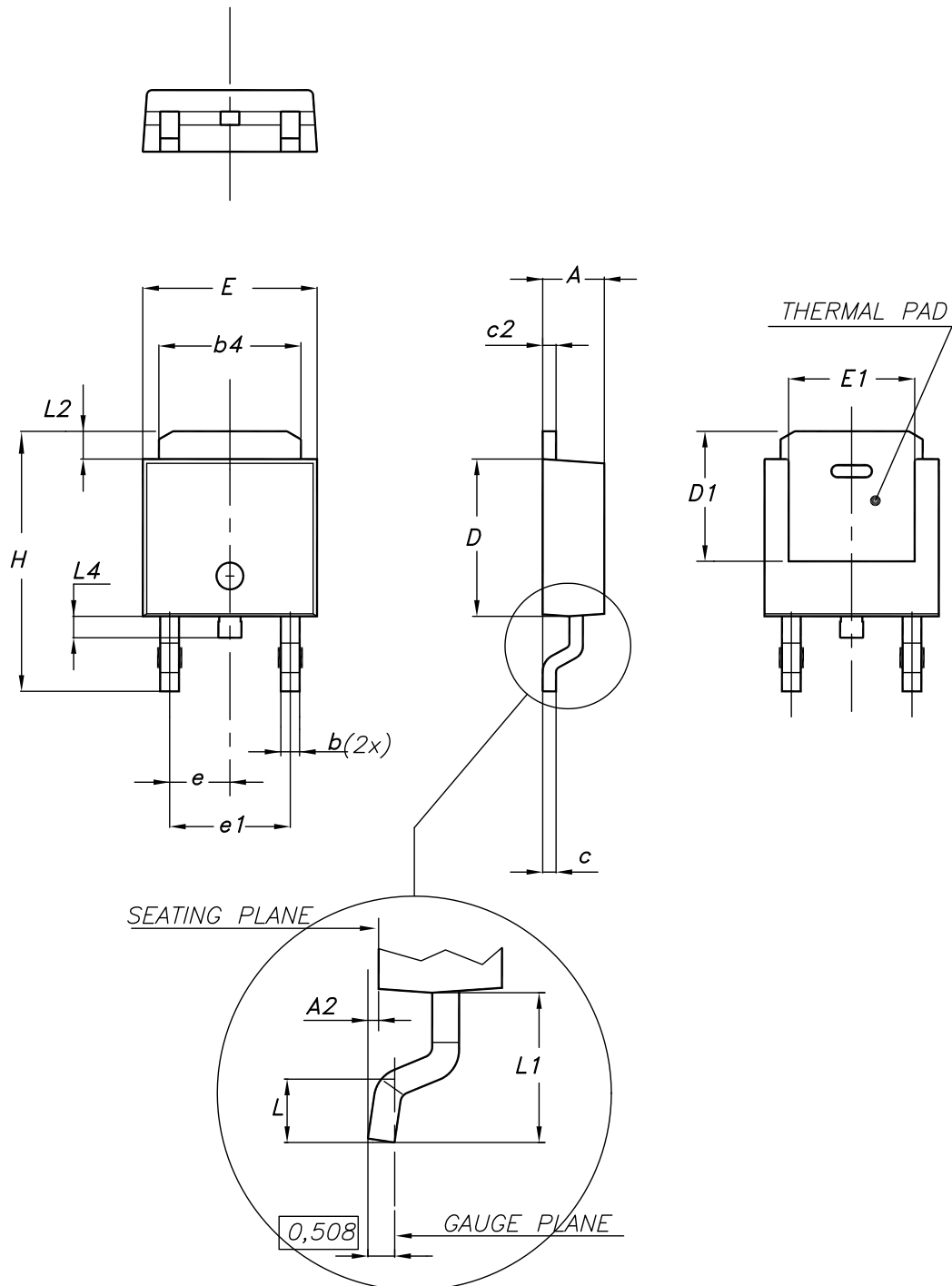
0068772\_C2\_25

**Table 9. DPAK (TO-252) type C2 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	5.10		5.60
E	6.50	6.60	6.70
E1	5.20		5.50
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

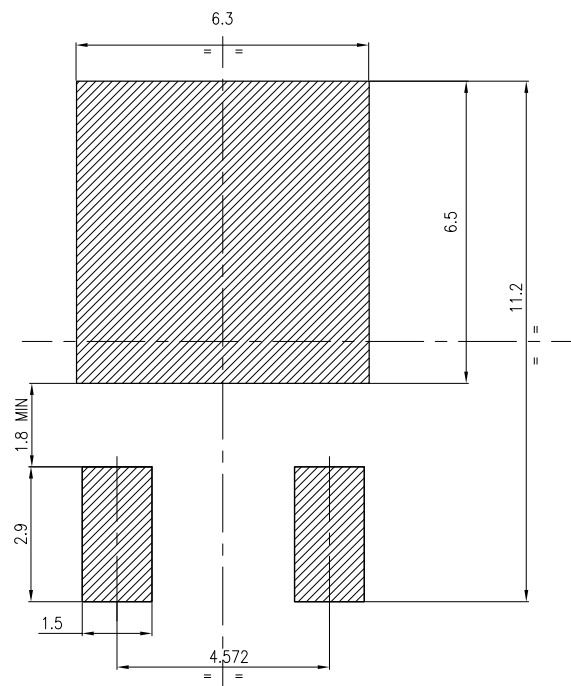
Figure 23. DPAK (TO-252) type E package outline



0068772\_type-E\_rev.25

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

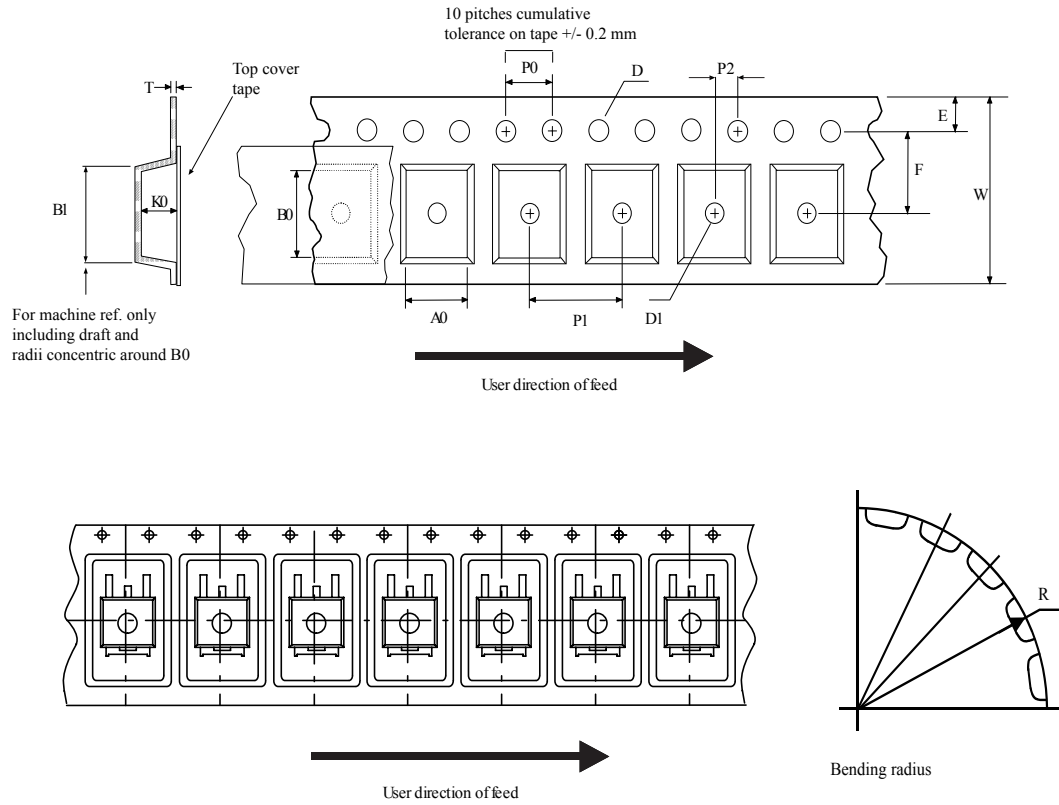
Dim.	mm		
	Min.	Typ.	Max.
A	2.18		2.39
A2			0.13
b	0.65		0.884
b4	4.95		5.46
c	0.46		0.61
c2	0.46		0.60
D	5.97		6.22
D1	5.21		
E	6.35		6.73
E1	4.32		
e		2.286	
e1		4.572	
H	9.94		10.34
L	1.50		1.78
L1		2.74	
L2	0.89		1.27
L4			1.02

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


FP\_0068772\_25

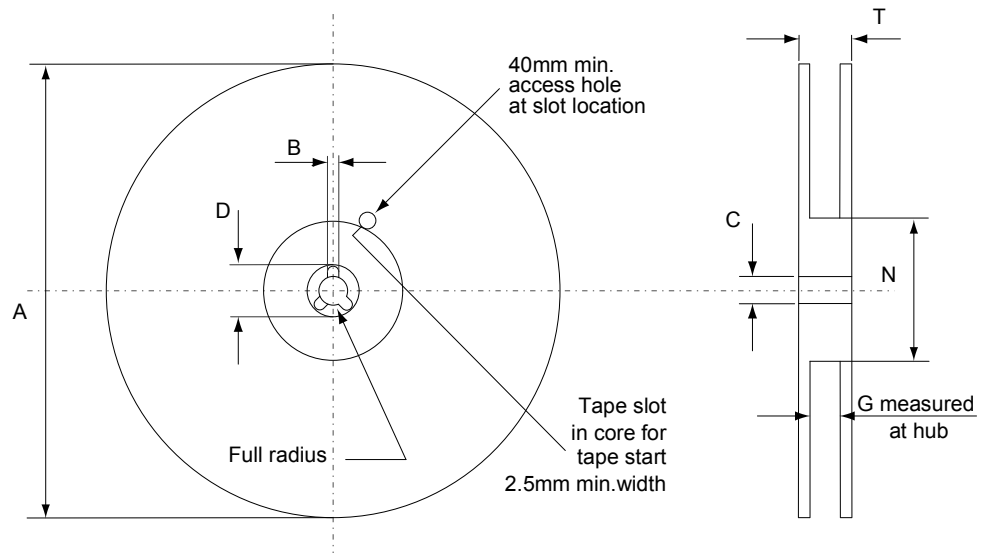
#### 4.4 DPAK (TO-252) packing information

Figure 25. DPAK (TO-252) tape outline



AM08852v1

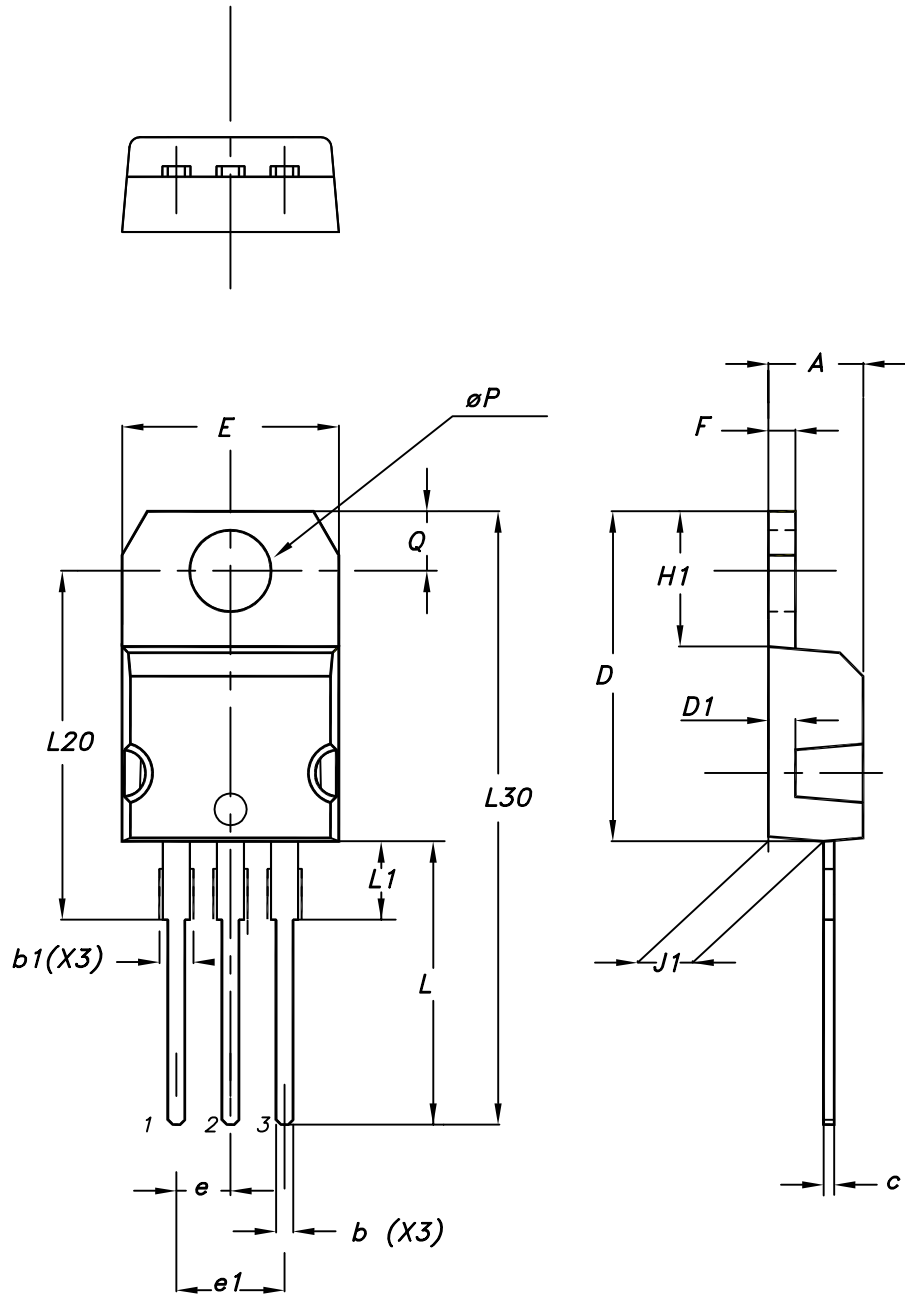


**Figure 26. DPAK (TO-252) reel outline**


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**


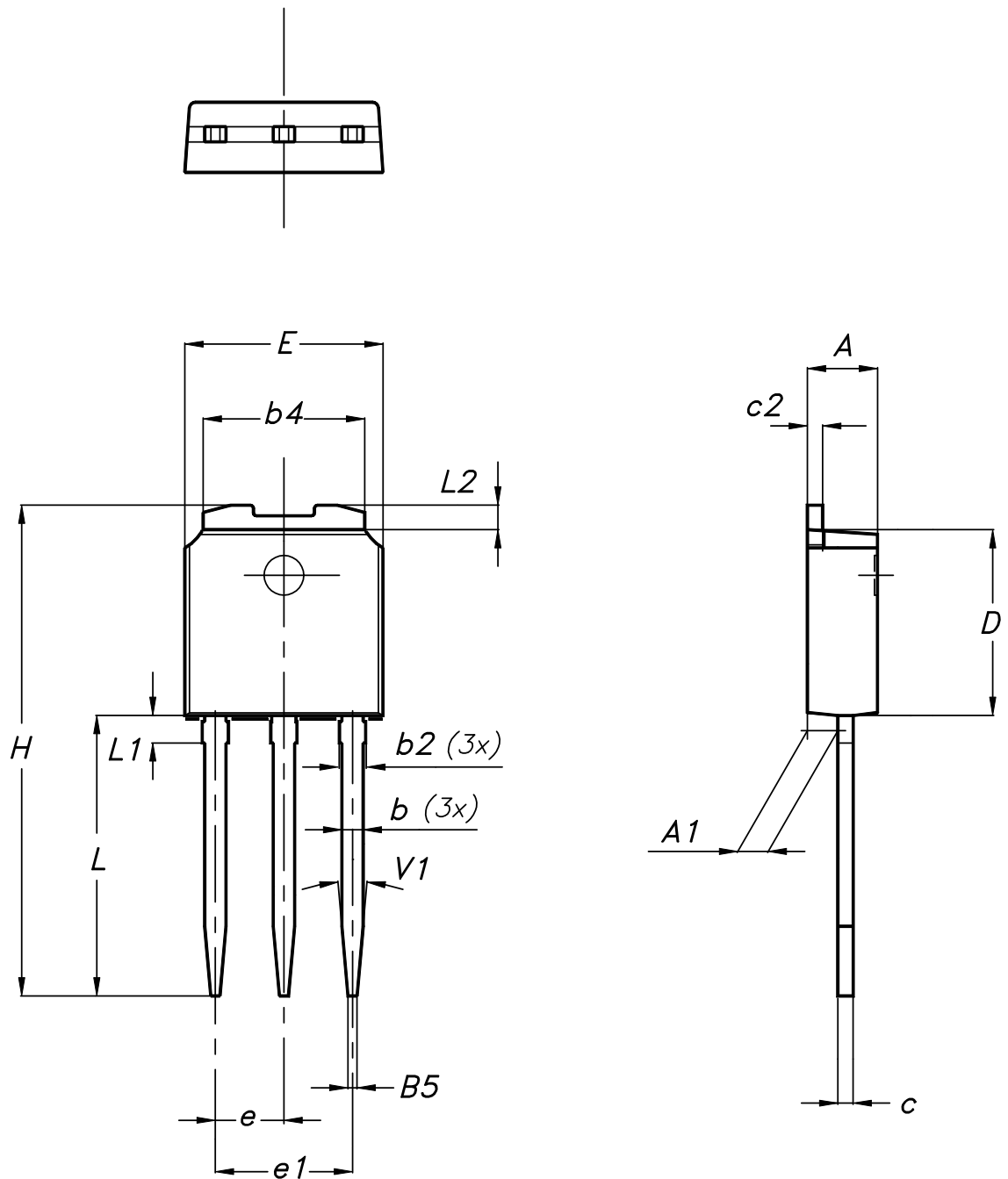
0015988\_typeA\_Rev\_21

**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



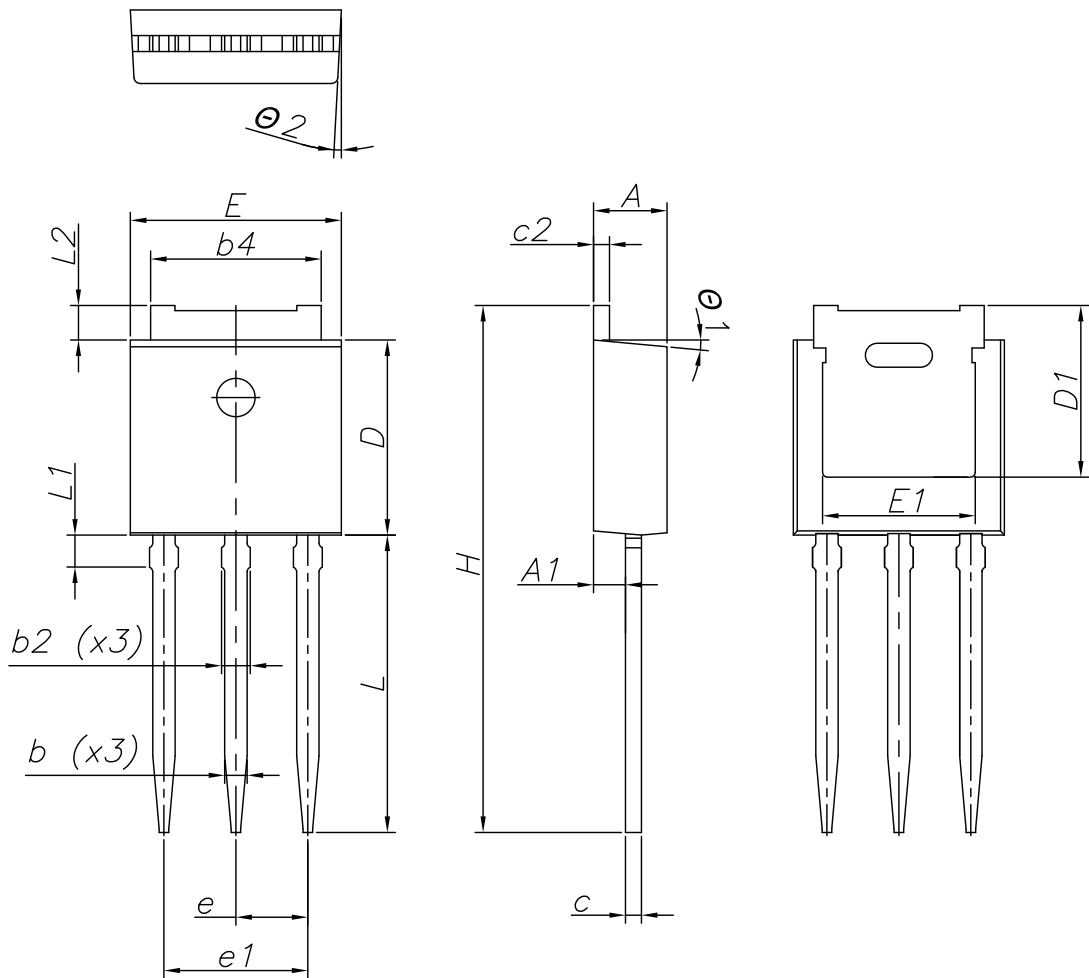
0068771\_IK\_typeA\_rev14

**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. Ordering information

Order code	Marking	Package	Packing
STD5N60M2	5N60M2	DPAK	Tape and reel
STP5N60M2		TO-220	Tube
STU5N60M2		IPAK	



## Revision history

**Table 16. Document revision history**

Date	Revision	Changes
30-Sep-2013	1	First release.
20-Mar-2014	2	<ul style="list-style-type: none"> <li>– Modified: ID, IDM and note 2 values in Table 2</li> <li>– Modified: the entire values in Table 4</li> <li>– Modified: RDS(on) typical and ID values in Table 5</li> <li>– Modified: the entire typical values, ISD and ISDM in Table 6, 7 and 8</li> <li>– Updated: Section 4.1: DPAK, STD5N60M2</li> <li>– Minor text changes</li> </ul>
08-Jun-2016	3	<p>Updated title, features, applications and description in cover page. Updated <i>Section 1: "Electrical ratings"</i>, <i>Table 6: "Dynamic"</i> and <i>Section 2.1: "Electrical characteristics (curves)"</i>.</p> <p>Updated IPAK C</p> <p>Minor text changes</p>
16-Jun-2016	4	<p>Updated <i>Figure 1: "Internal schematic diagram"</i>.</p> <p>Updated <i>Table 7: "Switching times"</i> and <i>Table 8: "Source-drain diode"</i>.</p> <p>Minor text changes.</p>
01-Oct-2018	5	<p>Updated <a href="#">Section 4 Package information</a>.</p> <p>Minor text changes</p>

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