

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

Datasheet - production data

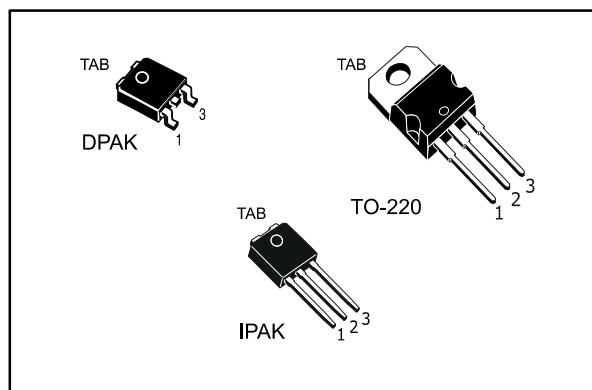
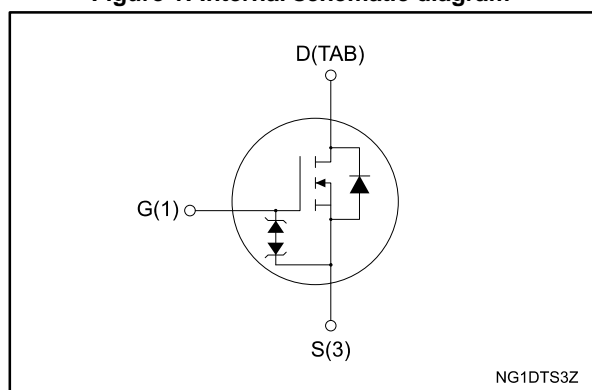


Figure 1: Internal schematic diagram



## Features

Order code	V <sub>DS</sub> @ T <sub>Jmax</sub>	R <sub>DS(on)</sub> max.	I <sub>D</sub>
STD5N60M2	650 V	1.4 $\Omega$	3.5 A
STP5N60M2			
STU5N60M2			

- Extremely low gate charge
- Excellent output capacitance (C<sub>oss</sub>) profile
- 100% avalanche tested
- Zener-protected

## Applications

- Switching applications

## 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
STD5N60M2	5N60M2	DPAK	Tape and reel
STP5N60M2		TO-220	Tube
STU5N60M2		IPAK	

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## Contents

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# 1 Electrical ratings

**Table 2: 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		

**Notes:**

(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 3: Thermal data**

Symbol	Parameter	Value			Unit
		DPAK	TO-220	IPAK	
$R_{thj-case}$	Thermal resistance junction-case max.	2.8			$^\circ\text{C}/\text{W}$
$R_{thj-pcb}$	Thermal resistance junction-pcb max. <sup>(1)</sup>	50			
$R_{thj-amb}$	Thermal resistance junction-ambient max.		62.5	100	

**Notes:**

(1) When mounted on 1 inch<sup>2</sup> FR-4, 2 Oz copper board.

**Table 4: Avalanche characteristics**

Symbol	Parameter	Value	Unit
$I_{AR}$	Avalanche current, repetitive or not repetitive (pulse width limited by $T_{jmax}$ )	0.5	A
$E_{AS}$	Single pulse avalanche energy (starting $T_j = 25\text{ }^\circ\text{C}$ , $I_D = I_{AR}$ ; $V_{DD} = 50\text{ V}$ )	80	mJ

## 2 Electrical characteristics

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

**Table 5: 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	$\mu\text{A}$
		$V_{\text{GS}} = 0\text{ V}$ , $V_{\text{DS}} = 600\text{ V}$ , $T_{\text{C}} = 125\text{ °C}$ <sup>(1)</sup>			100	
$I_{\text{GSS}}$	Gate-body leakage current	$V_{\text{DS}} = 0\text{ V}$ , $V_{\text{GS}} = \pm 25\text{ V}$			$\pm 10$	$\mu\text{A}$
$V_{\text{GS(th)}}$	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	$V_{\text{GS}} = 10\text{ V}$ , $I_{\text{D}} = 1.7\text{ A}$		1.3	1.4	$\Omega$

**Notes:**

<sup>(1)</sup> Defined by design, not subject to production test.

**Table 6: 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	-	
$C_{\text{rss}}$	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	$V_{\text{DD}} = 480\text{ V}$ , $I_{\text{D}} = 3.5\text{ A}$ , $V_{\text{GS}} = 10\text{ V}$ (see <a href="#">Figure 17</a> : "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	-	

**Notes:**

<sup>(1)</sup>  $C_{\text{oss eq.}}$  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 7: Switching times**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{\text{d(on)}}$	Turn-on delay time	$V_{\text{DD}} = 300\text{ V}$ , $I_{\text{D}} = 1.75\text{ A}$ $R_{\text{G}} = 4.7\text{ }\Omega$ , $V_{\text{GS}} = 10\text{ V}$ (see <a href="#">Figure 16</a> : "Test circuit for resistive load switching times" and <a href="#">Figure 21</a> : "Switching time waveform")	-	11.8	-	$\text{ns}$
$t_{\text{r}}$	Rise time		-	3	-	
$t_{\text{d(off)}}$	Turn-off delay time		-	70	-	
$t_{\text{f}}$	Fall time		-	15	-	

Table 8: Source-drain diode

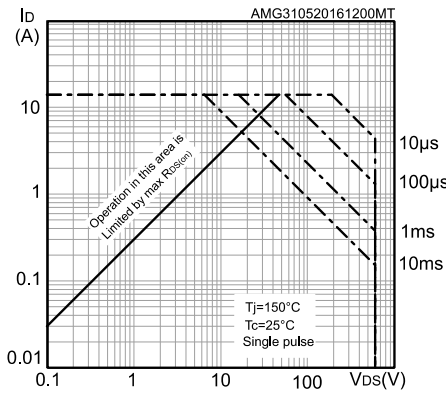
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{SD}$	Source-drain current		-		3.5	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)		-		14	A
$V_{SD}^{(2)}$	Forward on voltage	$V_{GS} = 0\text{ V}$ , $I_{SD} = 3.5\text{ A}$	-		1.6	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 3.5\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ , $V_{DD} = 60\text{ V}$ (see <a href="#">Figure 18: "Test circuit for inductive load switching and diode recovery times"</a> )	-	221		ns
$Q_{rr}$	Reverse recovery charge		-	1.05		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current		-	9.5		A
$t_{rr}$	Reverse recovery time	$I_{SD} = 3.5\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ , $V_{DD} = 60\text{ V}$ , $T_j = 150\text{ }^\circ\text{C}$ (see <a href="#">Figure 18: "Test circuit for inductive load switching and diode recovery times"</a> )	-	314		ns
$Q_{rr}$	Reverse recovery charge		-	1.5		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current		-	9.5		A

**Notes:**

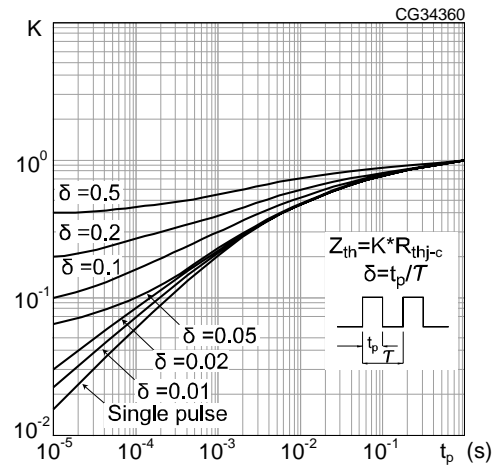
- (1) Pulse width is limited by safe operating area.  
(2) Pulse test: pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5 %.

## 2.1 Electrical characteristics (curves)

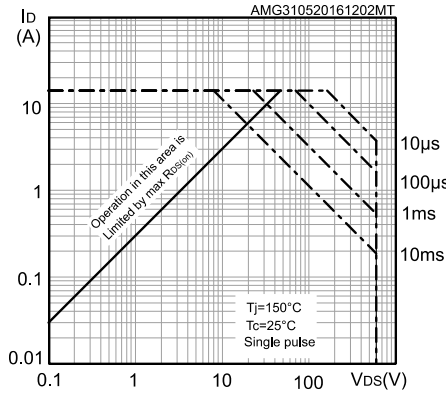
**Figure 2: Safe operating area for DPAK and IPAK**



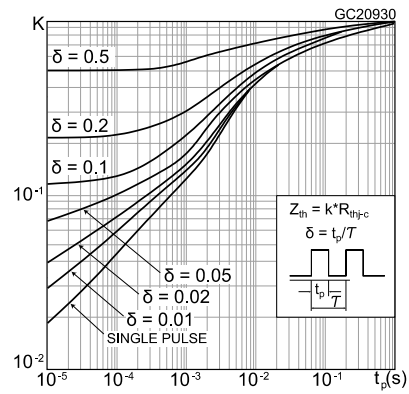
**Figure 3: Thermal impedance for DPAK and IPAK**



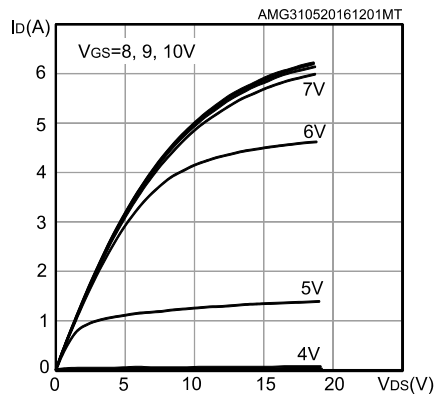
**Figure 4: Safe operating area for TO-220**



**Figure 5: Thermal impedance for TO-220**



**Figure 6: Output characteristics**



**Figure 7: Transfer characteristics**

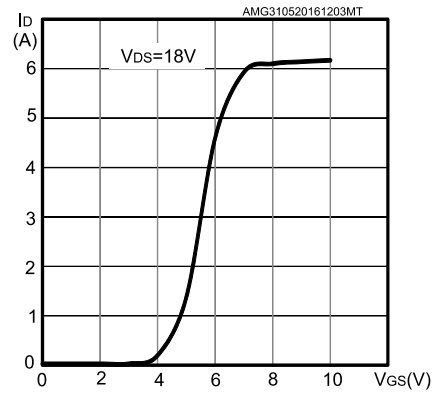


Figure 8: Gate charge vs gate-source voltage

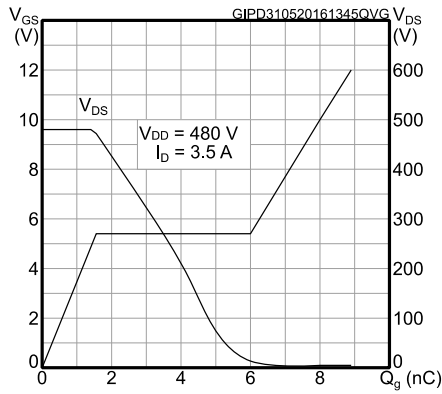


Figure 9: Static drain-source on-resistance

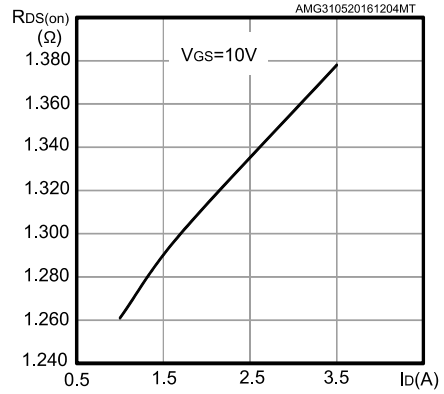


Figure 10: Capacitance variations

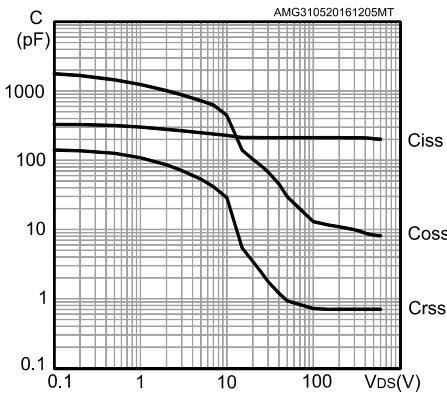


Figure 11: Output capacitance stored energy

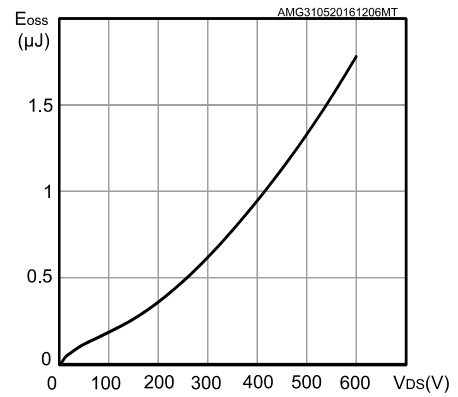


Figure 12: Normalized gate threshold voltage vs temperature

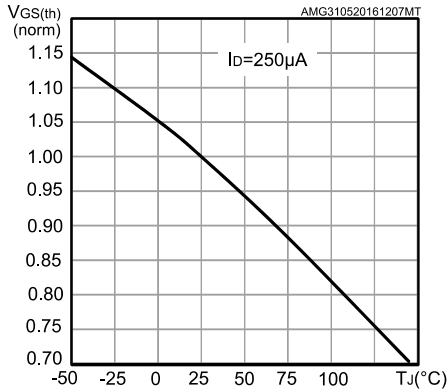


Figure 13: Normalized on-resistance vs temperature

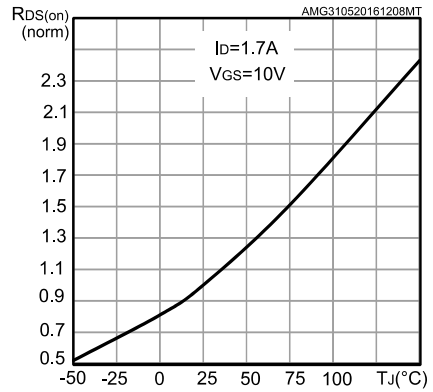


Figure 14: Normalized  $V_{(BR)DSS}$  vs temperature

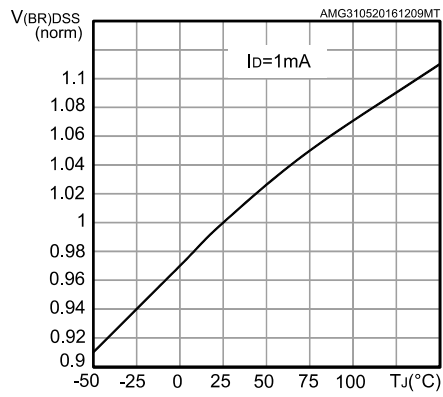
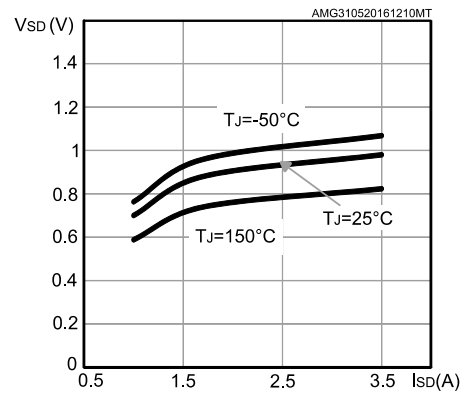
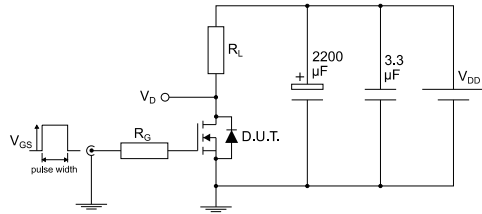


Figure 15: Source- drain diode forward characteristics



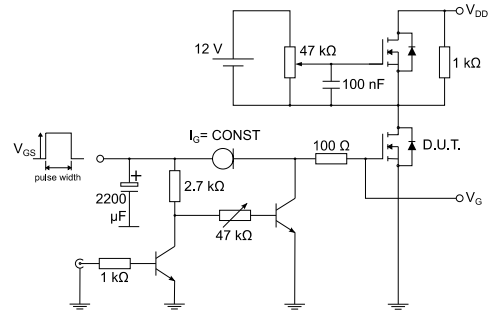
### 3 Test circuits

**Figure 16: Test circuit for resistive load switching times**



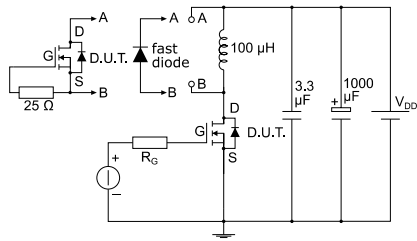
AM01468v1

**Figure 17: Test circuit for gate charge behavior**



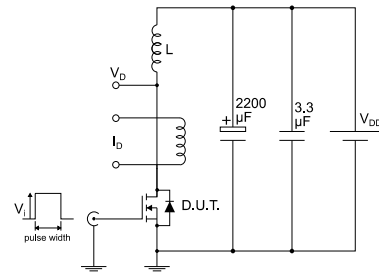
AM01469v1

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



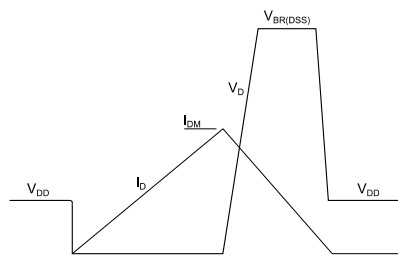
AM01470v1

**Figure 19: Unclamped inductive load test circuit**



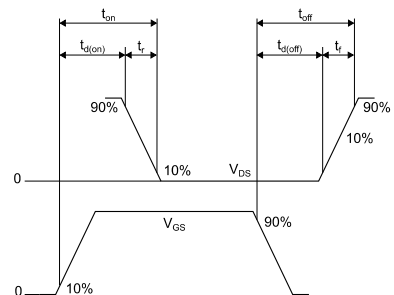
AM01471v1

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

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

Figure 22: DPAK (TO-252) type A package outline

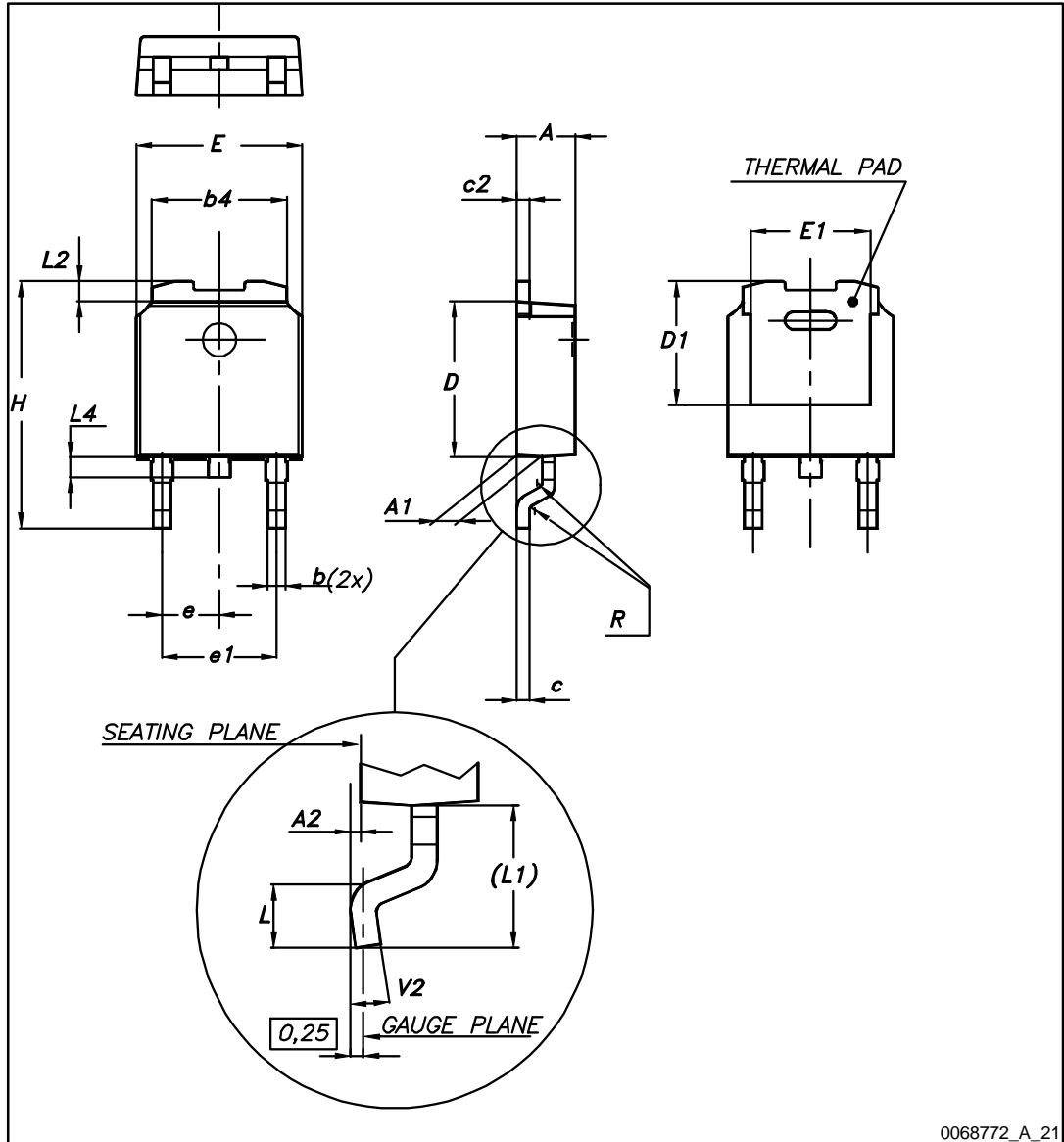


Table 9: DPAK (TO-252) type A mechanical data

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	2.16	2.28	2.40
e1	4.40		4.60
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 23: DPAK (TO-252) type C package outline

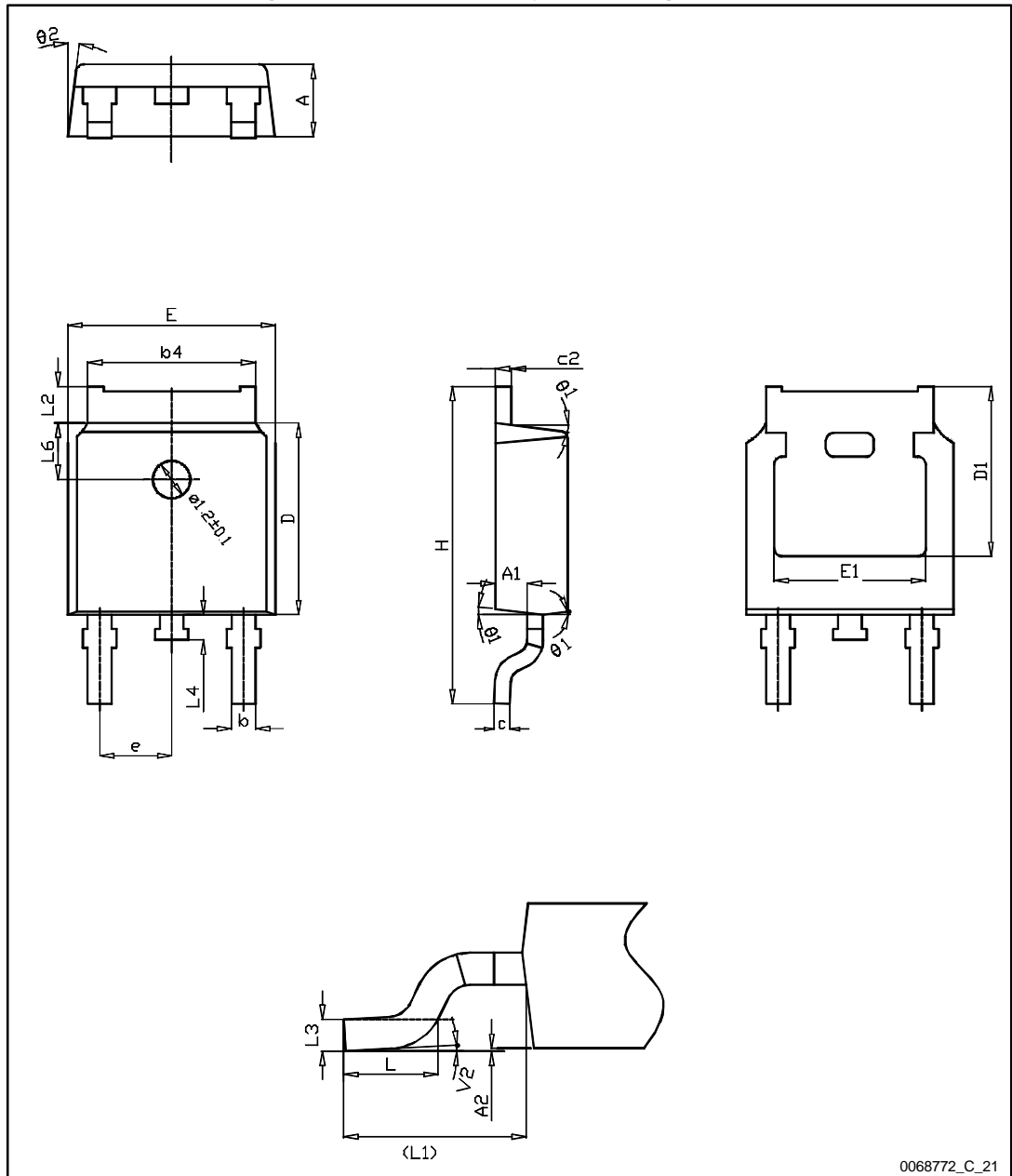
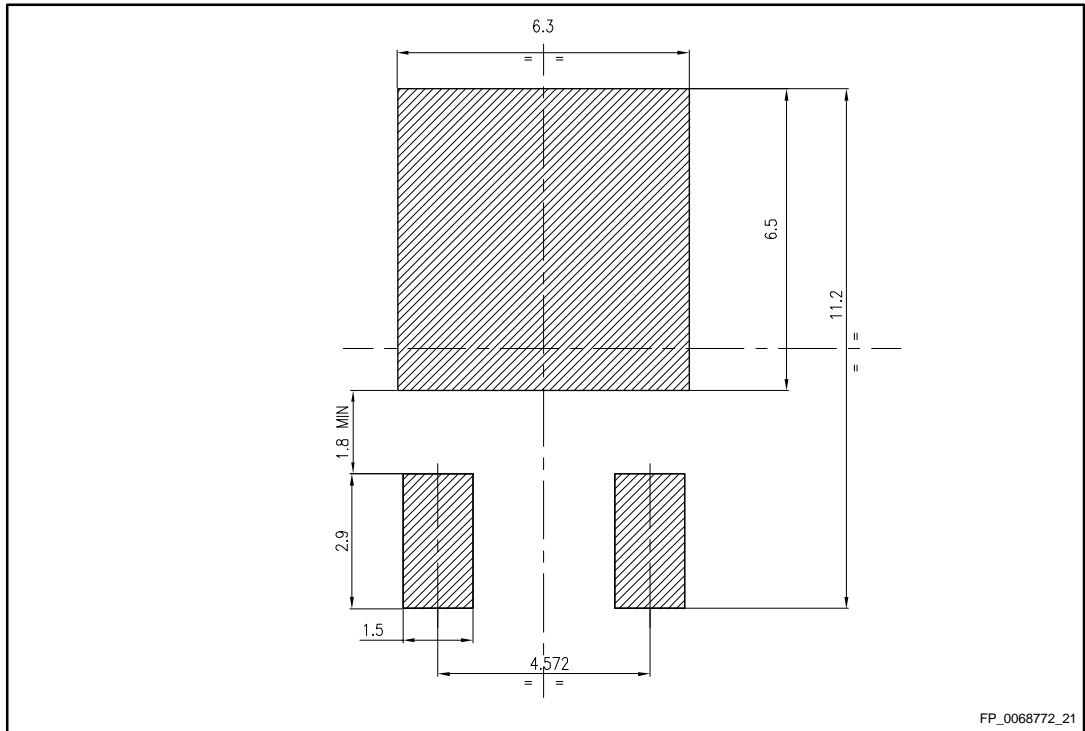


Table 10: DPAK (TO-252) type C mechanical data

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



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

Figure 25: DPAK (TO-252) tape outline

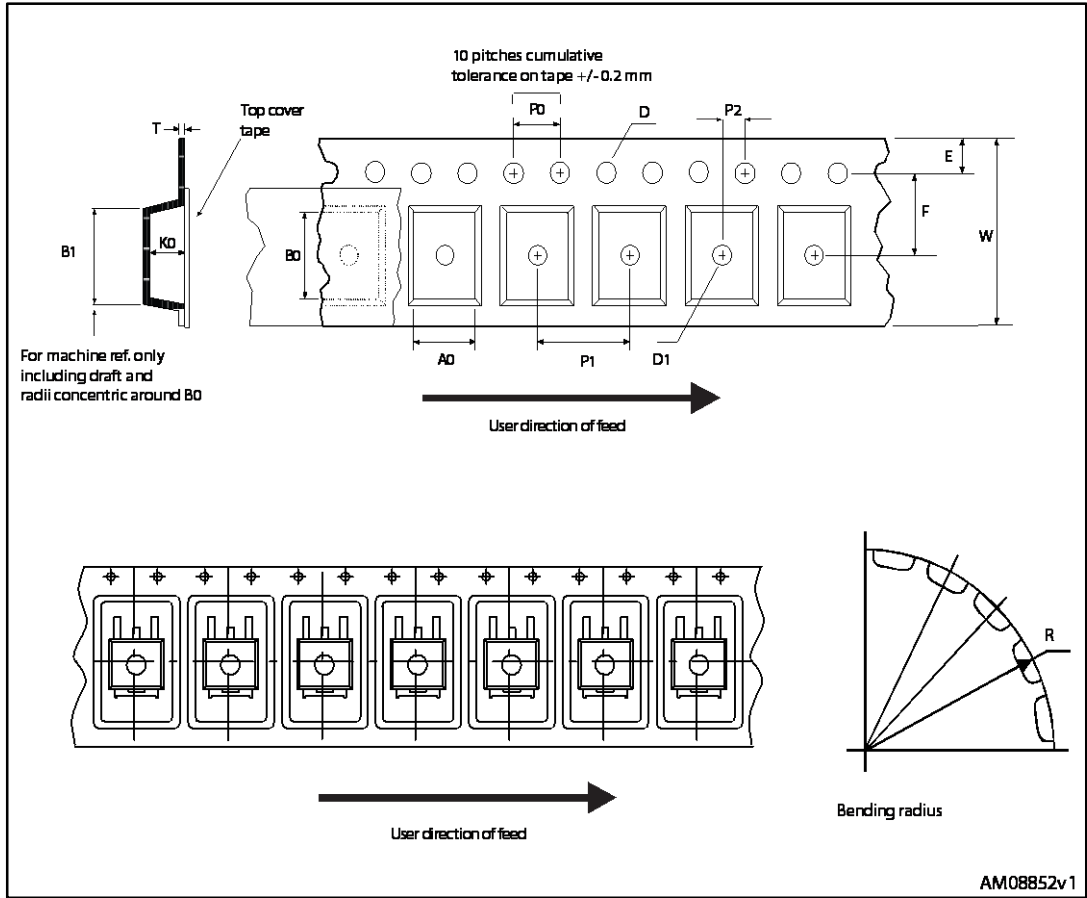


Figure 26: DPAK (TO-252) reel outline

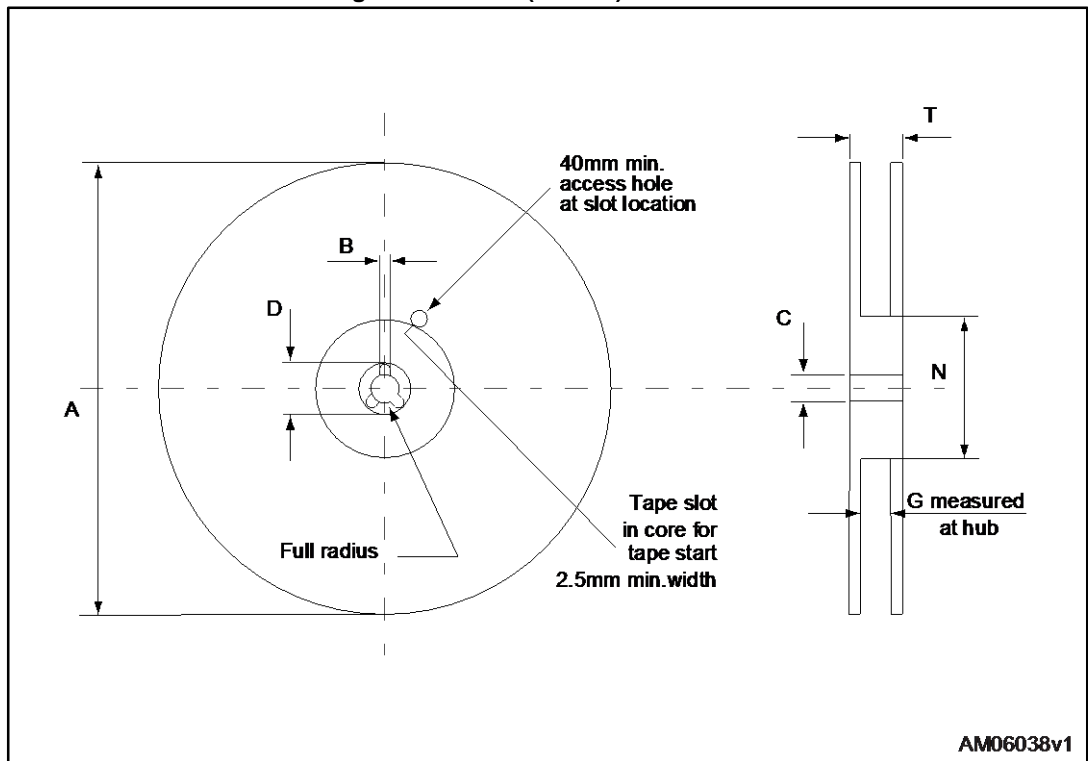


Table 11: DPAK (TO-252) tape and reel mechanical data

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			

### 4.4 TO-220 type A package information

Figure 27: TO-220 type A package outline

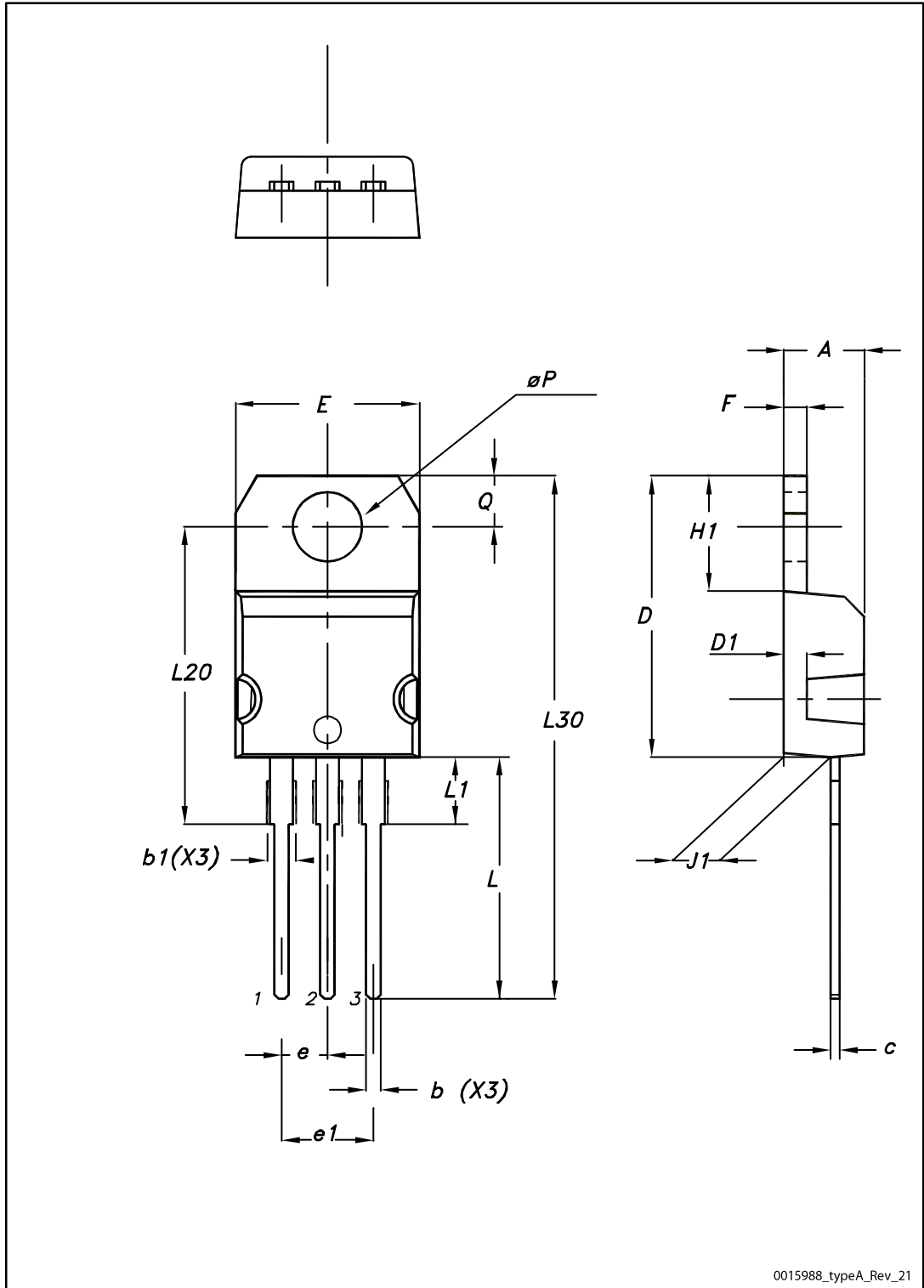
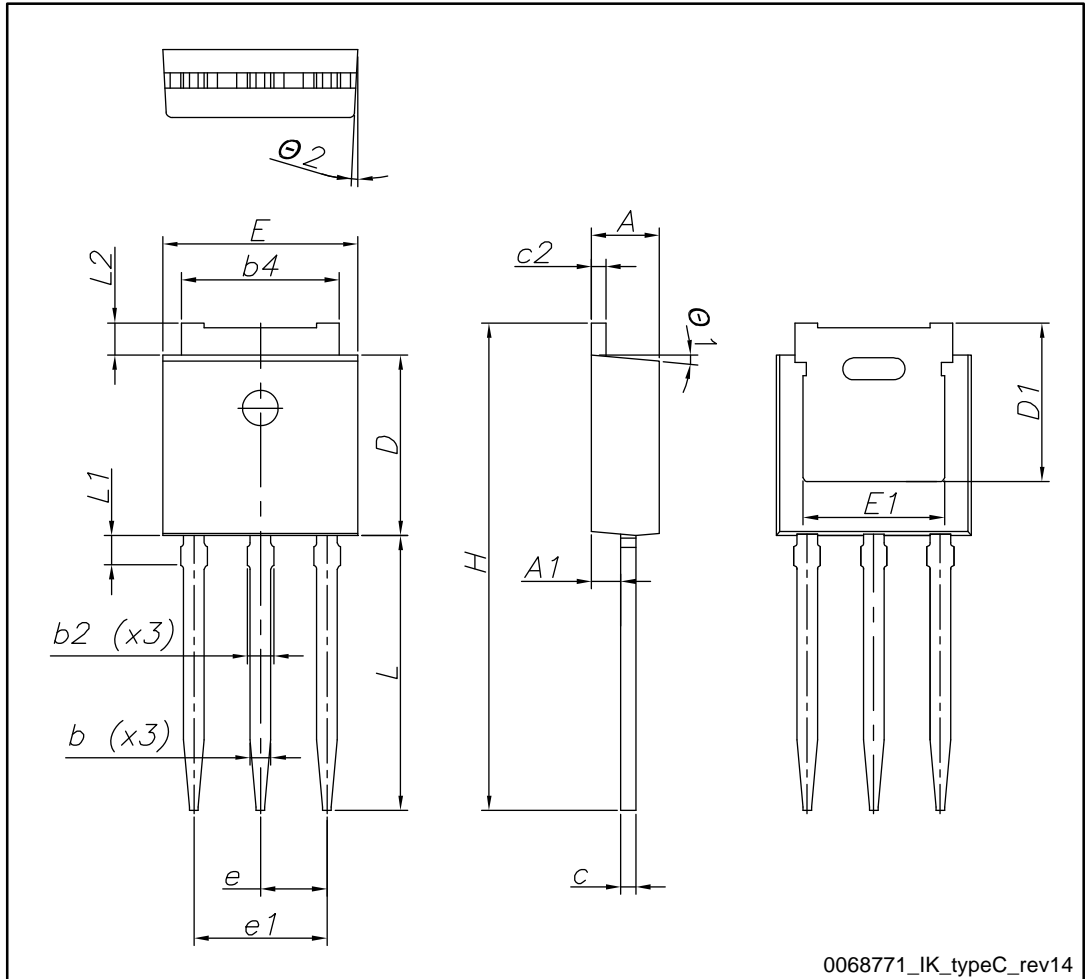


Table 12: TO-220 type A mechanical data

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 IPAK (TO-251) Type C package information

Figure 28: IPAK (TO-251) type C package outline



0068771\_IK\_typeC\_rev14

Table 13: 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	0.90	1.00	1.20
L2	0.90	1.08	1.25
$\theta 1$	3°	5°	7°
$\theta 2$	1°	3°	5°

## 5 Revision history

Table 14: 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.</p> <p>Updated <a href="#">Section 1: "Electrical ratings"</a>, <a href="#">Table 6: "Dynamic"</a> and <a href="#">Section 2.1: "Electrical characteristics (curves)"</a>.</p> <p>Updated IPAK C</p> <p>Minor text changes</p>

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