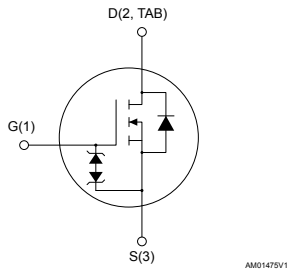
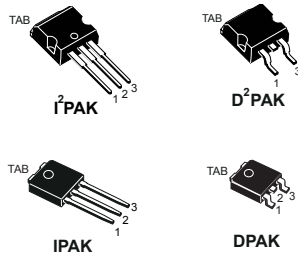


## N-channel 600 V, 1.7 $\Omega$ typ., 4 A SuperMESH™ Power MOSFETs in I<sup>2</sup>PAK, D<sup>2</sup>PAK, IPAK and DPAK packages



### Features

Order codes	V <sub>DS</sub>	R <sub>DS(on)</sub> max.	P <sub>TOT</sub>	I <sub>D</sub>
STB4NK60Z-1	600 V	2 $\Omega$	70 W	4 A
STB4NK60ZT4				
STD4NK60Z-1				
STD4NK60ZT4				

- Extremely high dv/dt capability
- 100% avalanche tested
- Gate charge minimized
- Zener-protected

### Applications

- Switching applications

### Description

These high-voltage devices are Zener-protected N-channel Power MOSFETs developed using the SuperMESH™ technology by STMicroelectronics, an optimization of the well-established PowerMESH™. In addition to a significant reduction in on-resistance, these devices are designed to ensure a high level of dv/dt capability for the most demanding applications.

Product status
STB4NK60Z-1
STB4NK60ZT4
STD4NK60Z-1
STD4NK60ZT4

# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

Symbol	Parameter	Value	Unit
$V_{DS}$	Drain-source voltage	600	V
$V_{GS}$	Gate-source voltage	±30	V
$I_D$	Drain current (continuous) at $T_C = 25\text{ °C}$	4	A
$I_D$	Drain current (continuous) at $T_C = 100\text{ °C}$	2.5	A
$I_{DM}^{(1)}$	Drain current (pulsed)	16	A
$P_{TOT}$	Total dissipation at $T_C = 25\text{ °C}$	70	W
ESD	Gate-source human body model (C=100 pF, R=1.5 kΩ)	3	kV
$dv/dt^{(2)}$	Peak diode recovery voltage slope	4.5	V/ns
$T_j$	Operating junction temperature range	-55 to 150	°C
$T_{stg}$	Storage temperature range		

1. Pulse width limited by safe operating area.

2.  $I_{SD} \leq 4\text{ A}$ ,  $di/dt \leq 200\text{ A}/\mu\text{s}$ ,  $V_{DD} \leq V_{(BR)DSS}$ .

**Table 2. Thermal data**

Symbol	Parameter	Value		Unit
		I <sup>2</sup> PAK, D <sup>2</sup> PAK	IPAK, DPAK	
$R_{thj-case}$	Thermal resistance junction- case	1.79		°C/W
$R_{thj-amb}$	Thermal resistance junction-ambient	62.5	100	°C/W

**Table 3. Avalanche characteristics**

Symbol	Parameter	Value	Unit
$I_{AR}$	Avalanche current, repetitive or not-repetitive (pulse width limited by $T_j$ max)	4	A
$E_{AS}$	Single pulse avalanche energy (starting $T_j = 25\text{ °C}$ , $I_D = I_{AR}$ , $V_{DD} = 50\text{ V}$ )	120	mJ

## 2 Electrical characteristics

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

**Table 4. On/off states**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source breakdown voltage	$V_{GS} = 0\text{ V}, I_D = 1\text{ mA}$	600			V
$I_{DSS}$	Zero gate voltage drain current	$V_{GS} = 0\text{ V}, V_{DS} = 600\text{ V}$			1	$\mu\text{A}$
		$V_{GS} = 0\text{ V}, V_{DS} = 600\text{ V}, T_C = 125\text{ }^{\circ}\text{C}$ <sup>(1)</sup>			50	$\mu\text{A}$
$I_{GSS}$	Gate-body leakage current	$V_{DS} = 0\text{ V}, V_{GS} = \pm 20\text{ V}$			$\pm 10$	$\mu\text{A}$
$V_{GS(th)}$	Gate threshold voltage	$V_{DS} = V_{GS}, I_D = 50\text{ }\mu\text{A}$	3	3.75	4.5	V
$R_{DS(on)}$	Static drain-source on resistance	$V_{GS} = 10\text{ V}, I_D = 2\text{ A}$		1.7	2	$\Omega$

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

**Table 5. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$C_{iss}$	Input capacitance	$V_{DS} = 25\text{ V}, f = 1\text{ MHz}, V_{GS} = 0\text{ V}$	-	510		pF
$C_{oss}$	Output capacitance			67		
$C_{riss}$	Reverse transfer capacitance			13		
$C_{oss\text{ eq.}}^{(1)}$	Equivalent output capacitance	$V_{GS} = 0\text{ V}, V_{DS} = 0\text{ V to } 480\text{ V}$	-	38.5		
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 300\text{ V}, I_D = 2\text{ A}, R_G = 4.7\text{ }\Omega, V_{GS} = 10\text{ V}$		12		ns
$t_r$	Rise time			9.5		
$t_{d(off)}$	Turn-off delay time	(see Figure 13. Test circuit for resistive load switching times)	-	29		ns
$t_f$	Fall time			16.5		
$t_{r(Voff)}$	Off-voltage rise time	$V_{DD} = 480\text{ V}, I_D = 4\text{ A}, R_G = 4.7\text{ }\Omega, V_{GS} = 10\text{ V}$		12		ns
$t_r$	Fall time			12		
$t_c$	Cross-over time	(see Figure 15. Test circuit for inductive load switching and diode recovery times)		19.5		
$Q_g$	Total gate charge	$V_{DD} = 480\text{ V}, I_D = 4\text{ A}, V_{GS} = 0\text{ to } 10\text{ V}$	-	18.8	26	nC
$Q_{gs}$	Gate-source charge			3.8		
$Q_{gd}$	Gate-drain charge			9.8		

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%  $V_{DSS}$ .

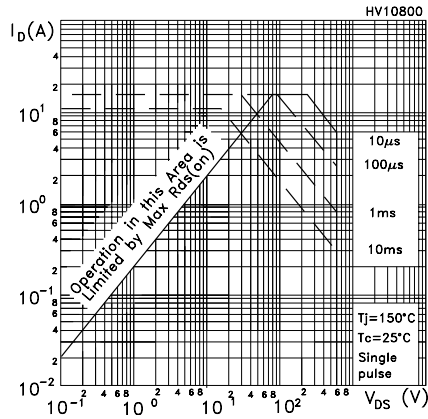
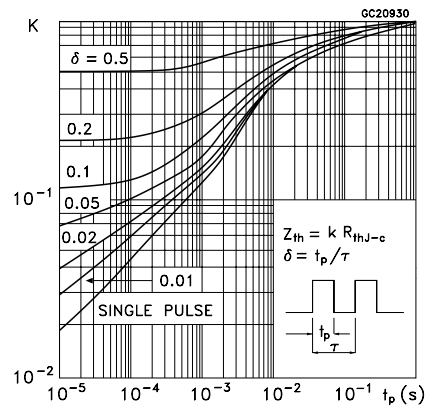
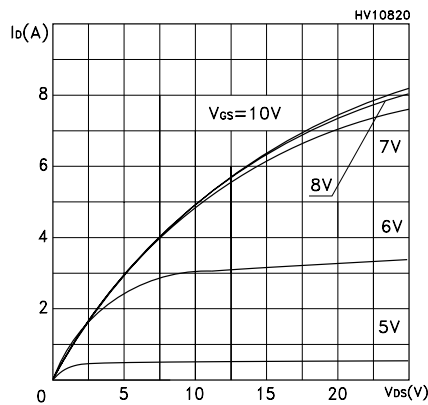
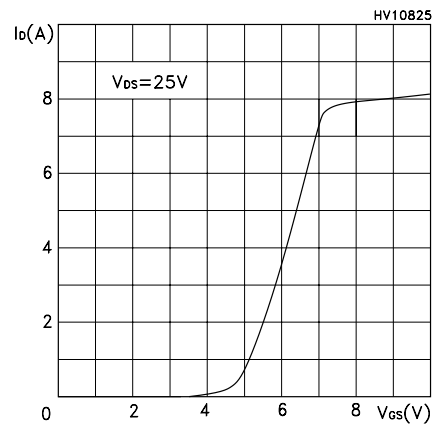
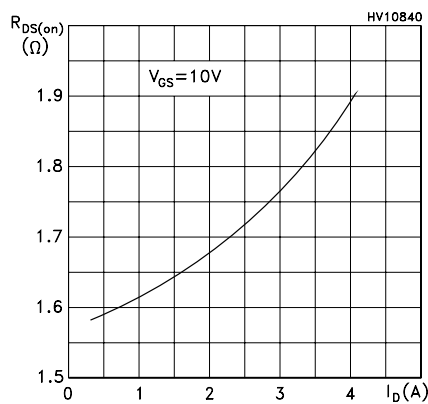
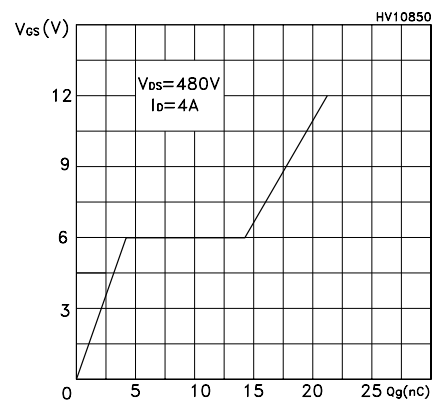
**Table 6. Source-drain diode**

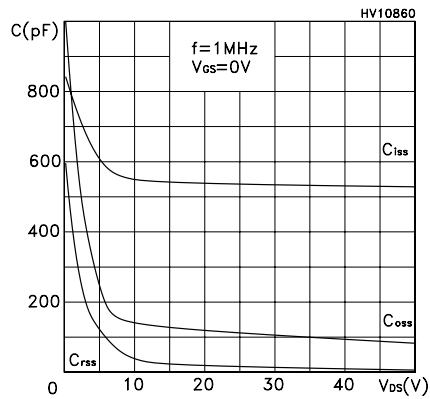
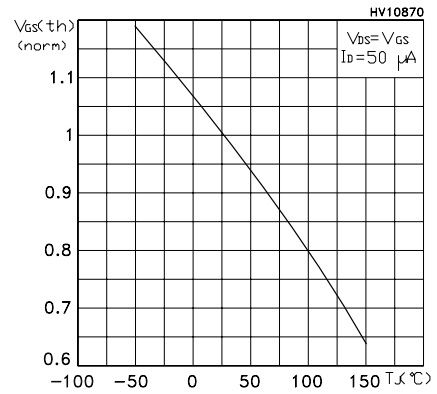
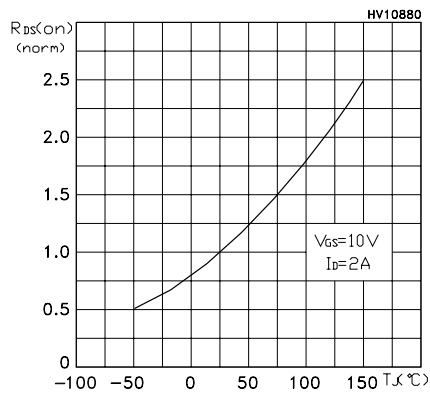
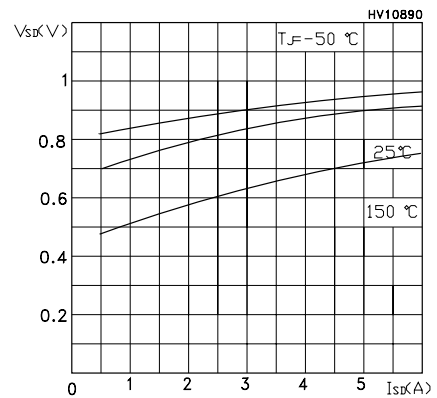
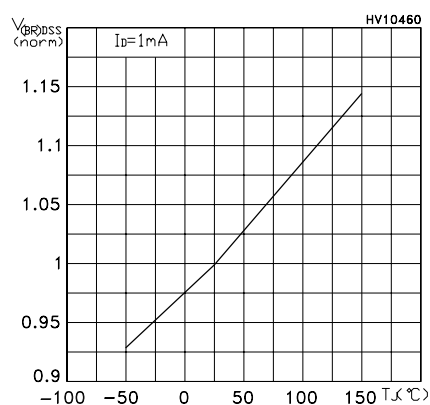
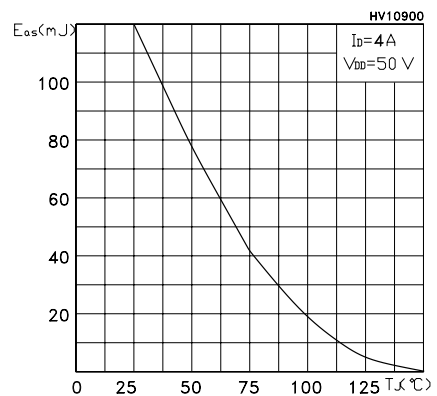
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{SD}$	Source-drain current		-		4	A
$I_{SDM}$	Source-drain current (pulsed)		-		16	
$V_{SD}$	Forward on voltage	$I_{SD} = 4\text{ A}$ , $V_{GS} = 0\text{ V}$	-		1.6	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 4\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$	-	400		ns
$Q_{rr}$	Reverse recovery charge	$V_{DD} = 24\text{ V}$ , $T_j = 150\text{ }^\circ\text{C}$	-	1.7		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current	(see Figure 15. Test circuit for inductive load switching and diode recovery times)	-	8.5		A

**Table 7. Gate-source Zener diode**

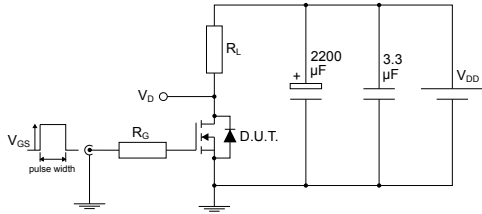
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)GSO}$	Gate-source breakdown voltage	$I_{GS} = \pm 1\text{ mA}$ , $I_D = 0\text{ A}$	$\pm 30$	-	-	V

The built-in back-to-back Zener diodes are specifically designed to enhance the ESD performance of the device. The Zener voltage facilitates efficient and cost-effective device integrity protection, thus eliminating the need for additional external componentry.

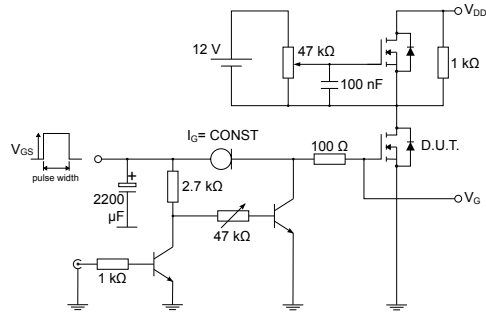
**2.1 Electrical characteristics (curves)**
**Figure 1. Safe operating area**

**Figure 2. Thermal impedance**

**Figure 3. Output characteristics**

**Figure 4. Transfer characteristics**

**Figure 5. Static drain-source on-resistance**

**Figure 6. Gate charge vs gate-source voltage**


**Figure 7. Capacitance variations**

**Figure 8. Normalized gate threshold voltage vs temperature**

**Figure 9. Normalized on-resistance vs temperature**

**Figure 10. Source-drain diode forward characteristic**

**Figure 11. Normalized V<sub>(BR)DSS</sub> vs temperature**

**Figure 12. Maximum avalanche energy vs temperature**


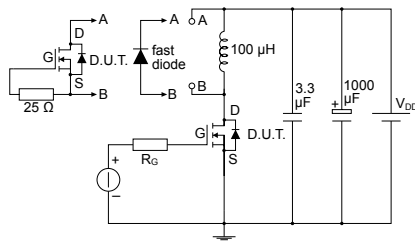
### 3 Test circuits

**Figure 13. Test circuit for resistive load switching times**


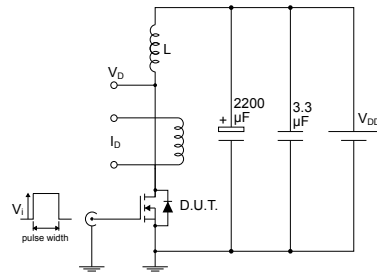
AM01468v1

**Figure 14. Test circuit for gate charge behavior**


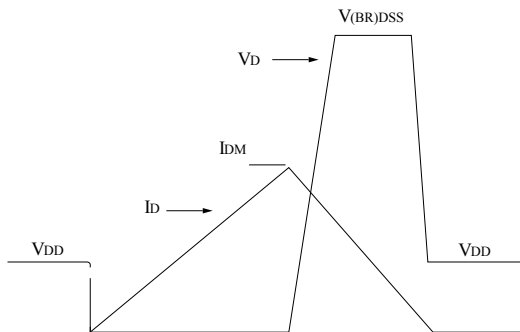
AM01469v1

**Figure 15. Test circuit for inductive load switching and diode recovery times**


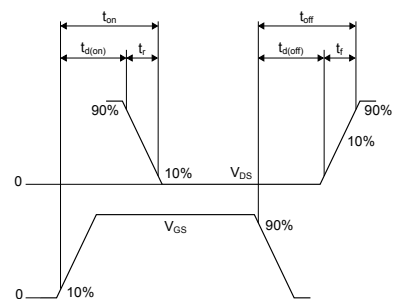
AM01470v1

**Figure 16. Unclamped inductive load test circuit**


AM01471v1

**Figure 17. Unclamped inductive waveform**


AM01472v1

**Figure 18. Switching time waveform**


AM01473v1

## 4 Package information

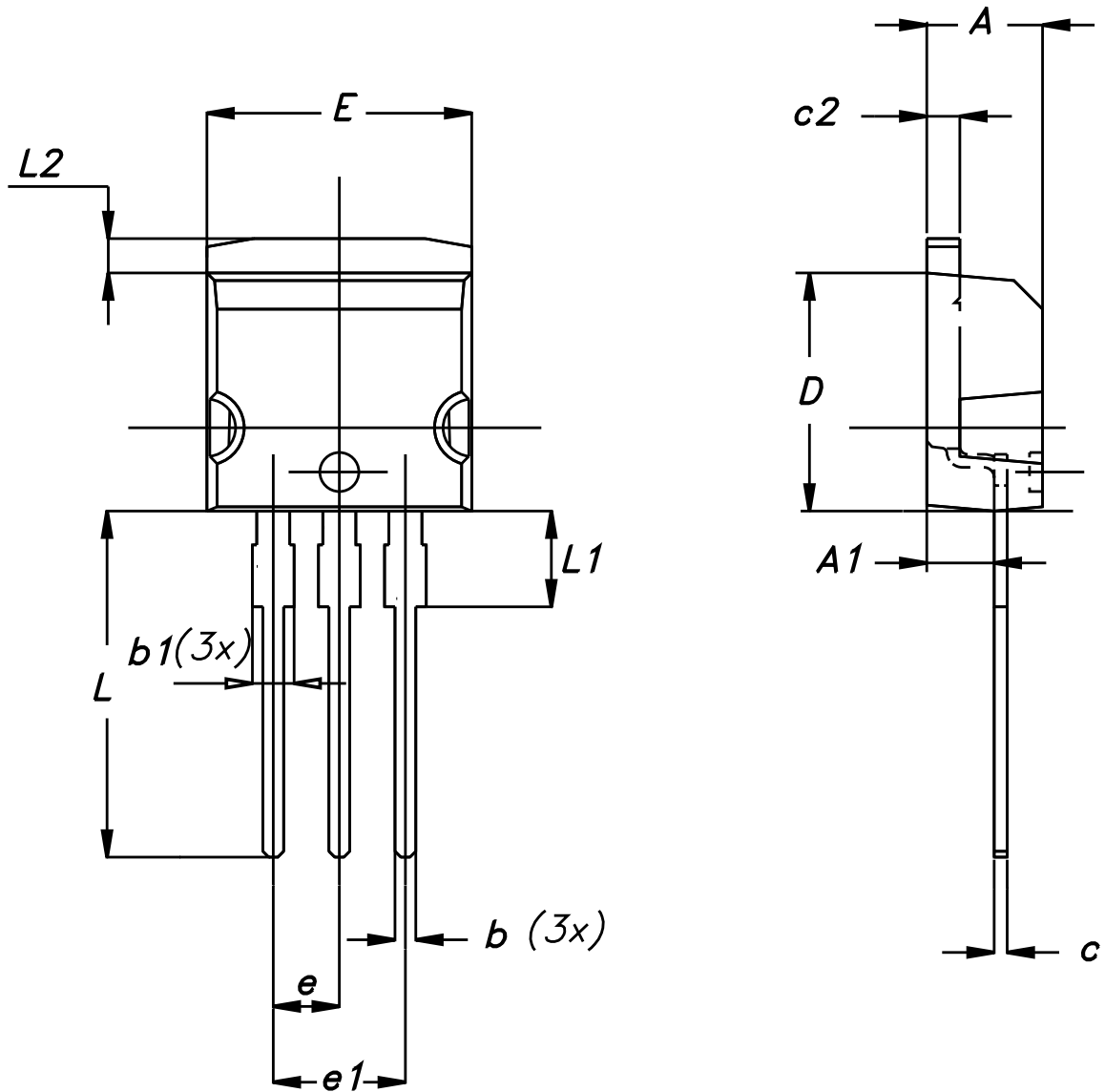
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In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK® is an ST trademark.



4.1 I<sup>2</sup>PAK package information

Figure 19. I<sup>2</sup>PAK package outline



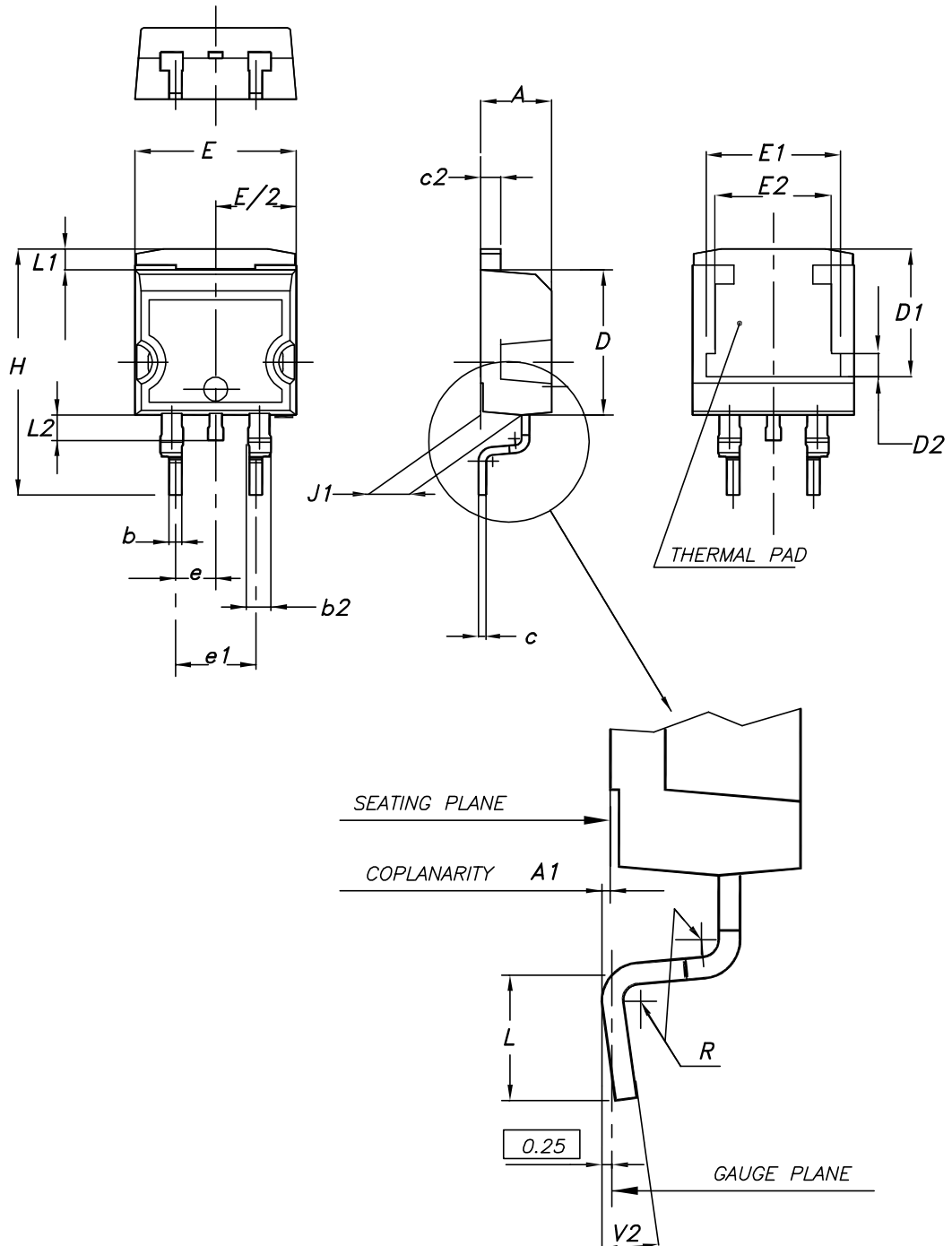
0004982\_Rev\_H

**Table 8. I<sup>2</sup>PAK package mechanical data**

Dim.	mm		
	Min.	Typ.	Max.
A	4.40	-	4.60
A1	2.40	-	2.72
b	0.61	-	0.88
b1	1.14	-	1.70
c	0.49	-	0.70
c2	1.23	-	1.32
D	8.95	-	9.35
e	2.40	-	2.70
e1	4.95	-	5.15
E	10	-	10.40
L	13	-	14
L1	3.50	-	3.93
L2	1.27	-	1.40

## 4.2 D<sup>2</sup>PAK (TO-263) type A package information

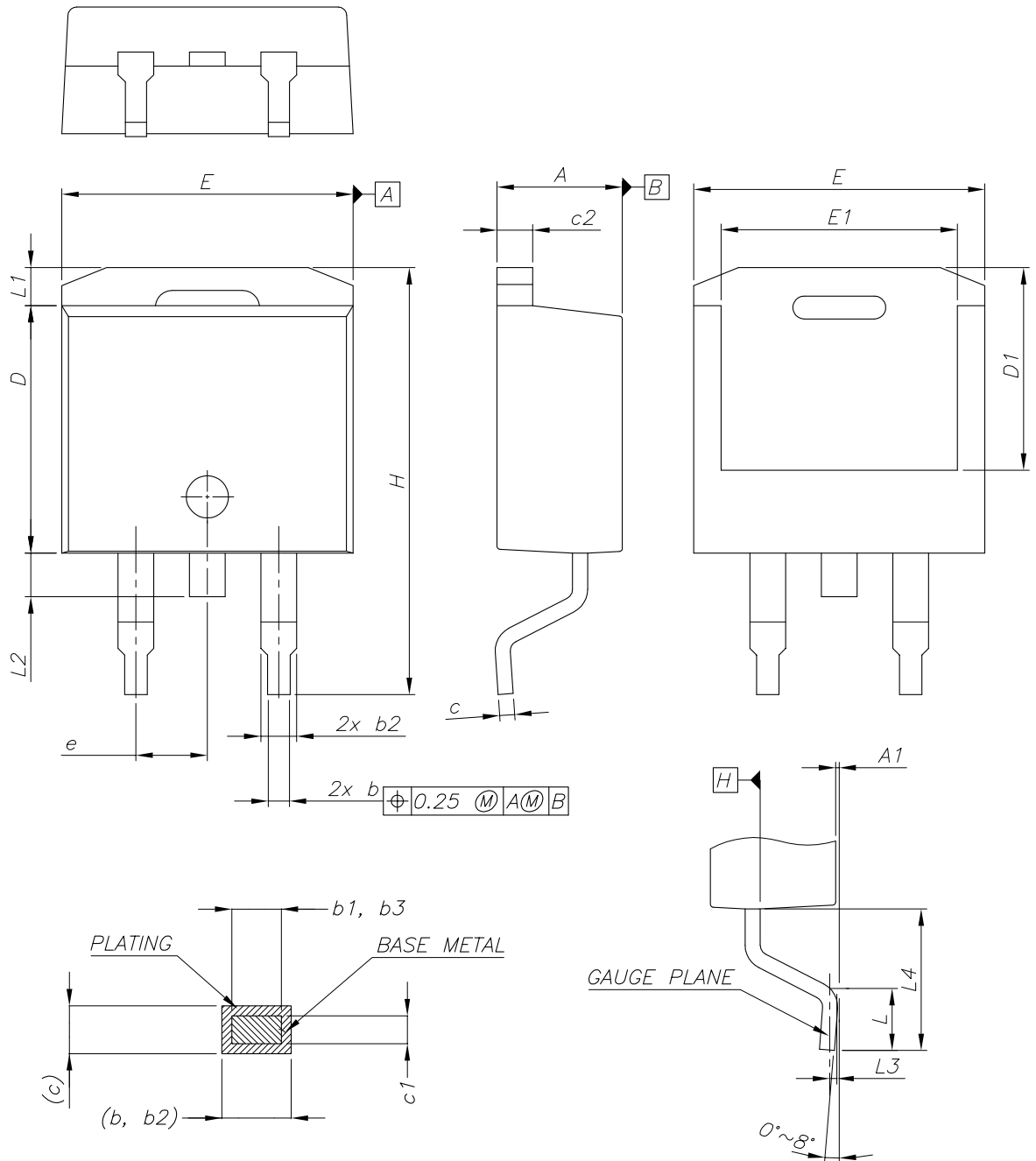
Figure 20. D<sup>2</sup>PAK (TO-263) type A package outline



0079457\_24

**Table 9. D<sup>2</sup>PAK (TO-263) type A package mechanical data**

Dim.	mm		
	Min.	Typ.	Max.
A	4.40		4.60
A1	0.03		0.23
b	0.70		0.93
b2	1.14		1.70
c	0.45		0.60
c2	1.23		1.36
D	8.95		9.35
D1	7.50	7.75	8.00
D2	1.10	1.30	1.50
E	10.00		10.40
E1	8.50	8.70	8.90
E2	6.85	7.05	7.25
e		2.54	
e1	4.88		5.28
H	15.00		15.85
J1	2.49		2.69
L	2.29		2.79
L1	1.27		1.40
L2	1.30		1.75
R		0.40	
V2	0°		8°

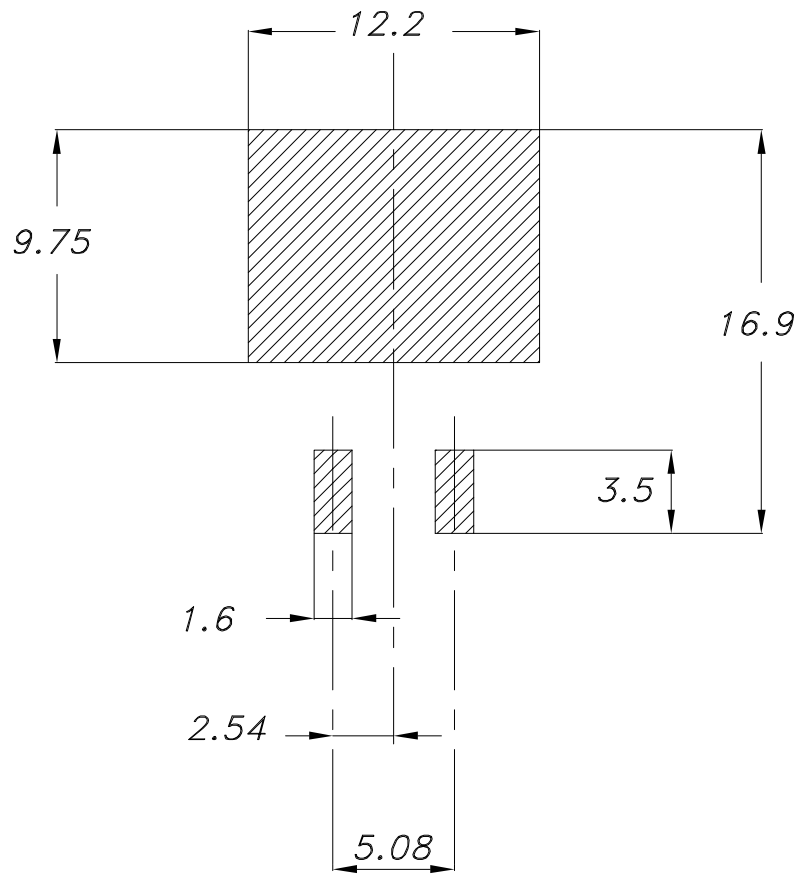
**4.3 D<sup>2</sup>PAK (TO-263) type B package information**
**Figure 21. D<sup>2</sup>PAK (TO-263) type B package outline**


0079457\_24\_B

**Table 10. D<sup>2</sup>PAK (TO-263) type B mechanical data**

Dim.	mm		
	Min.	Typ.	Max.
A	4.36		4.56
A1	0		0.25
b	0.70		0.90
b1	0.51		0.89
b2	1.17		1.37
b3	1.36		1.46
c	0.38		0.694
c1	0.38		0.534
c2	1.19		1.34
D	8.60		9.00
D1	6.90		7.50
E	10.15		10.55
E1	8.10		8.70
e	2.54 BSC		
H	15.00		15.60
L	1.90		2.50
L1			1.65
L2			1.78
L3		0.25	
L4	4.78		5.28

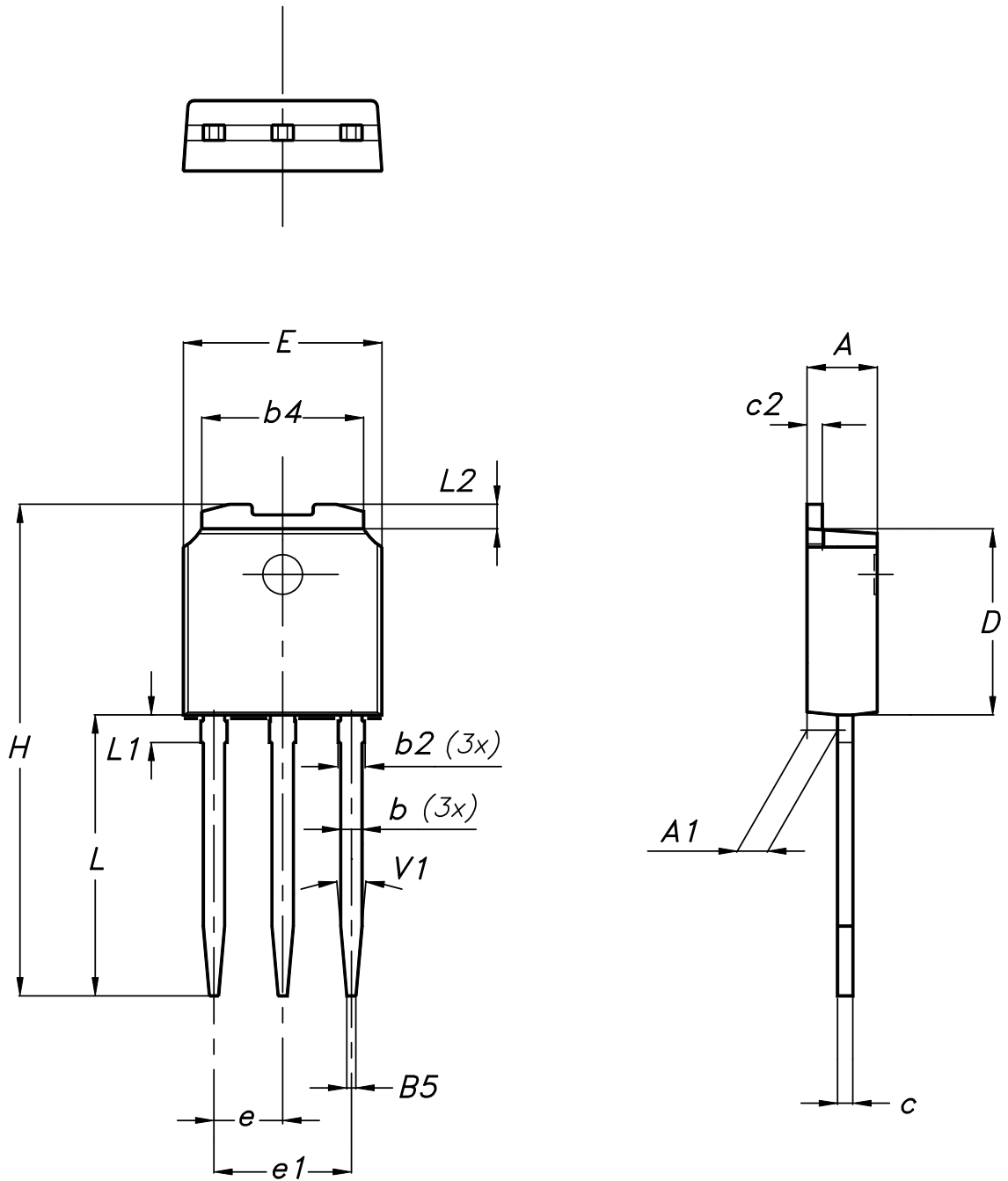
Figure 22. D<sup>2</sup>PAK (TO-263) recommended footprint (dimensions are in mm)



Footprint

#### 4.4 IPAk (TO-251) type A package information

Figure 23. IPAk (TO-251) type A package outline



0068771\_IK\_typeA\_rev14

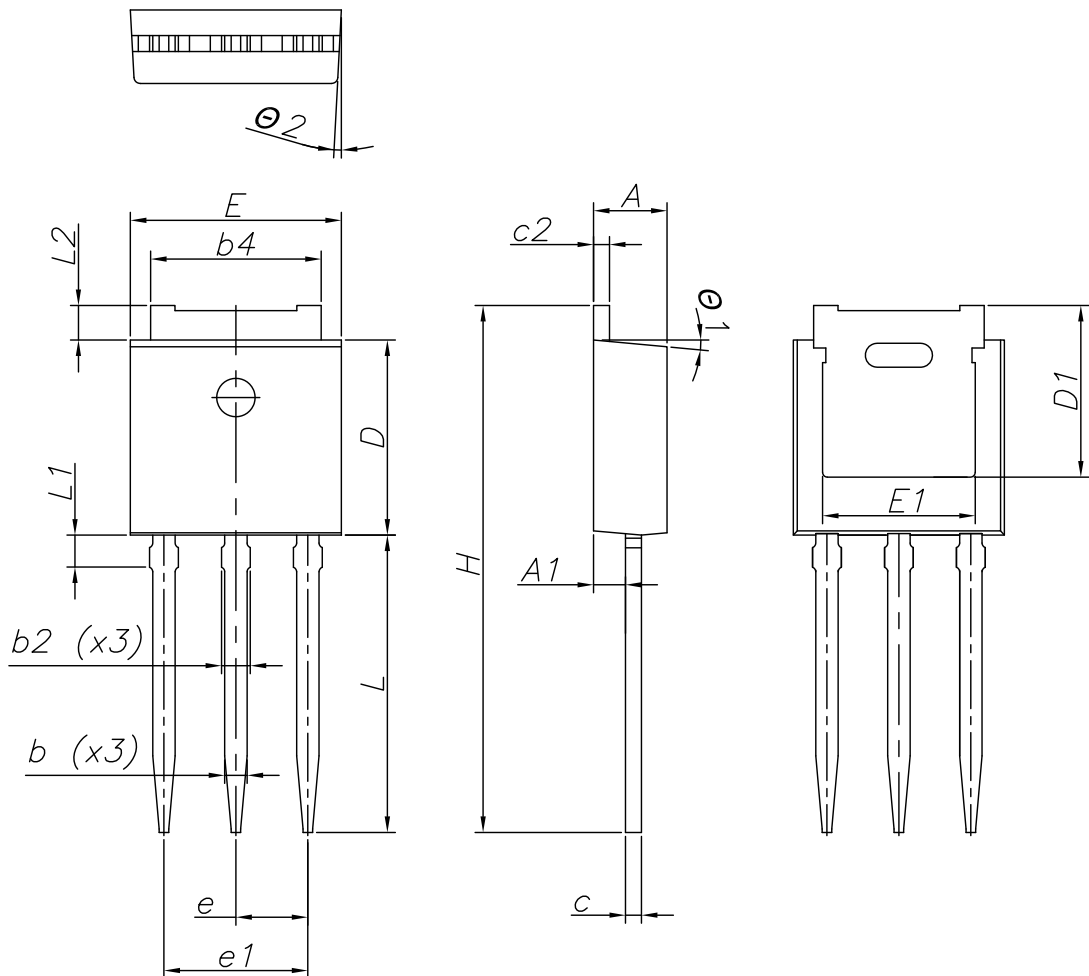


**Table 11. IPAK (TO-251) type A package mechanical data**

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°	

### 4.5 IPAK (TO-251) type C package information

Figure 24. IPAK (TO-251) type C package outline



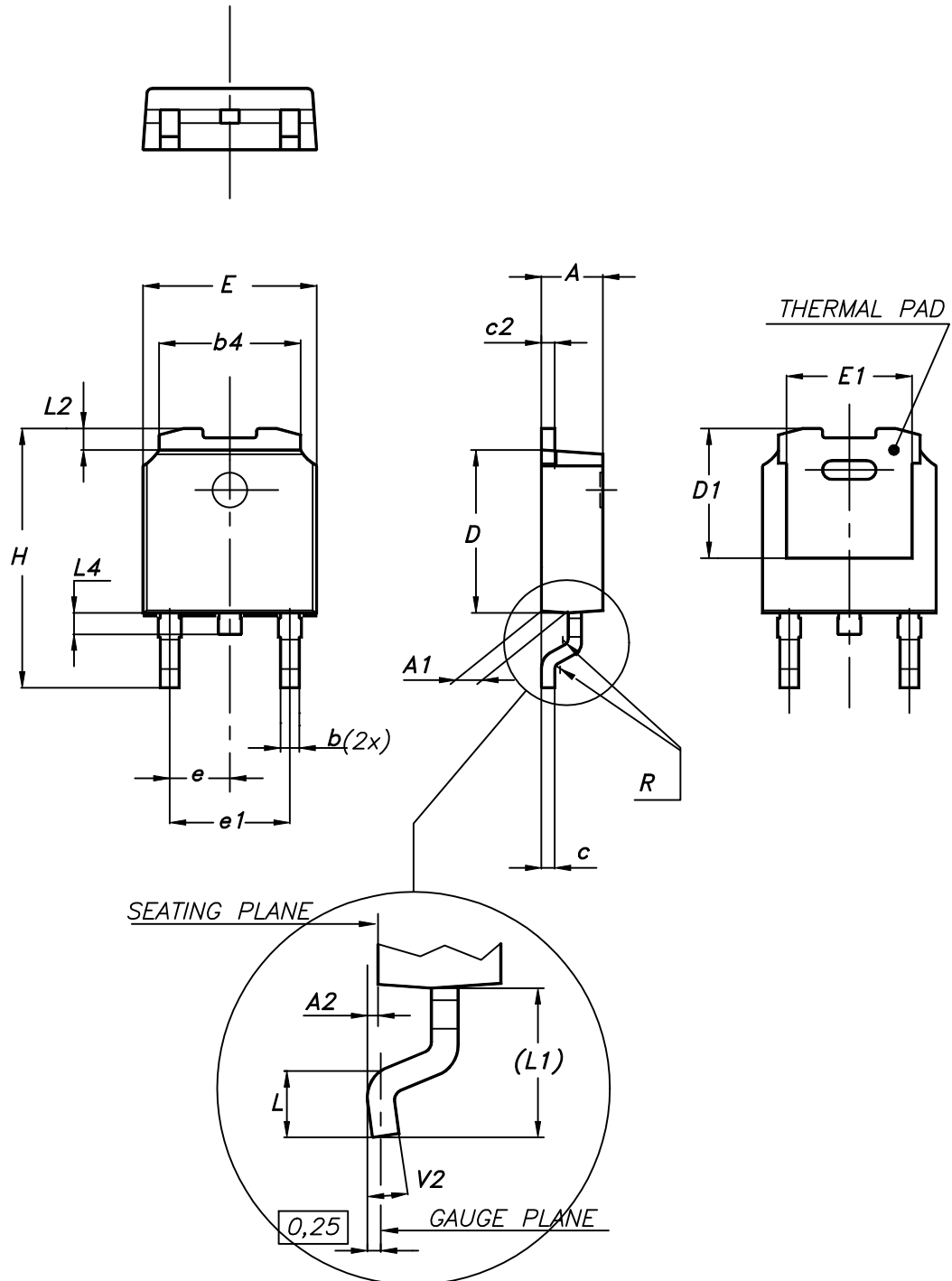
0068771\_IK\_typeC\_rev14

**Table 12. 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°

#### 4.6 DPAK (TO-252) type A2 package information

Figure 25. DPAK (TO-252) type A2 package outline



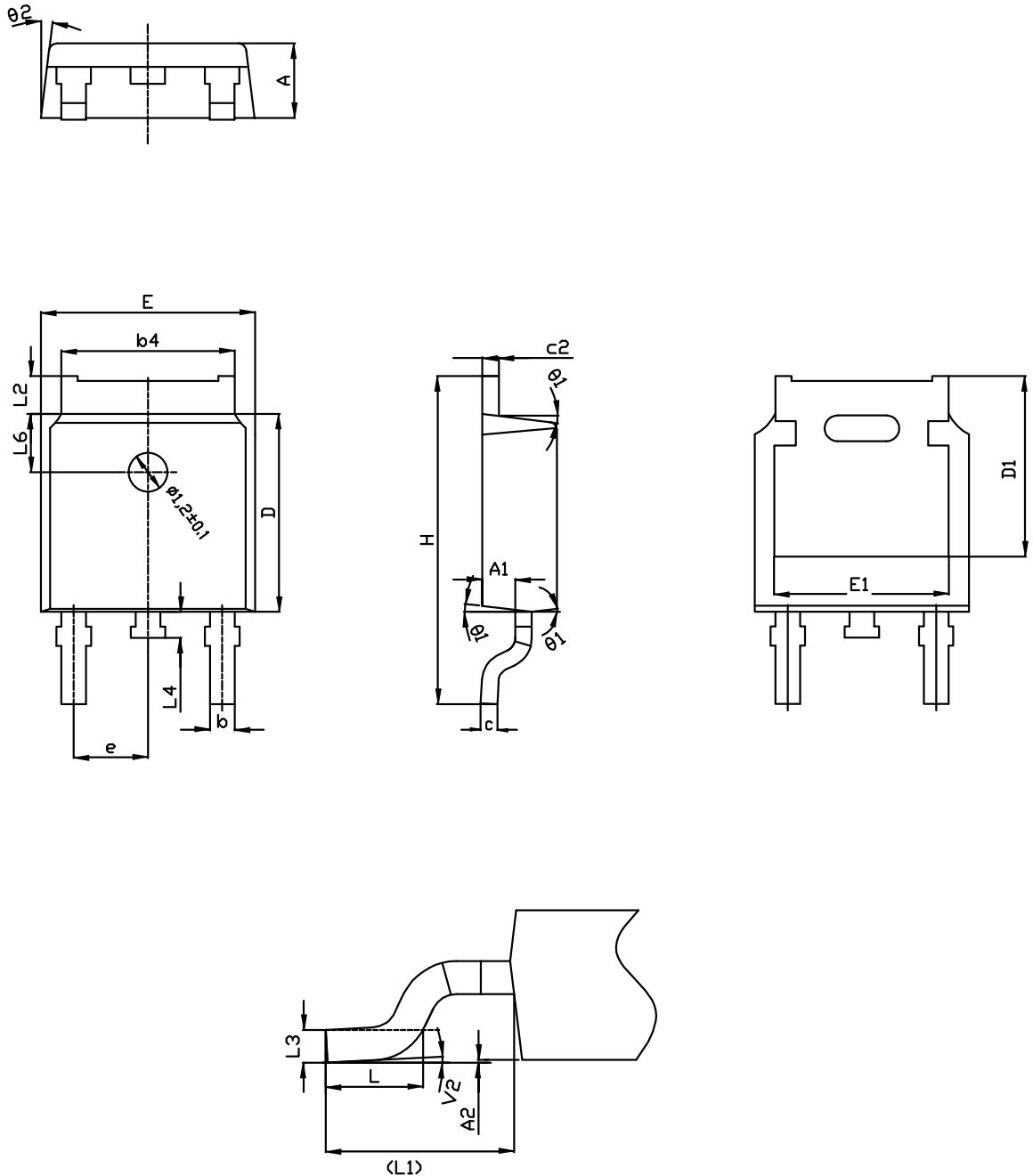
0068772\_type-A2\_rev24

**Table 13. 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	2.16	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°

#### 4.7 DPAK (TO-252) type C2 package information

Figure 26. DPAK (TO-252) type C2 package outline



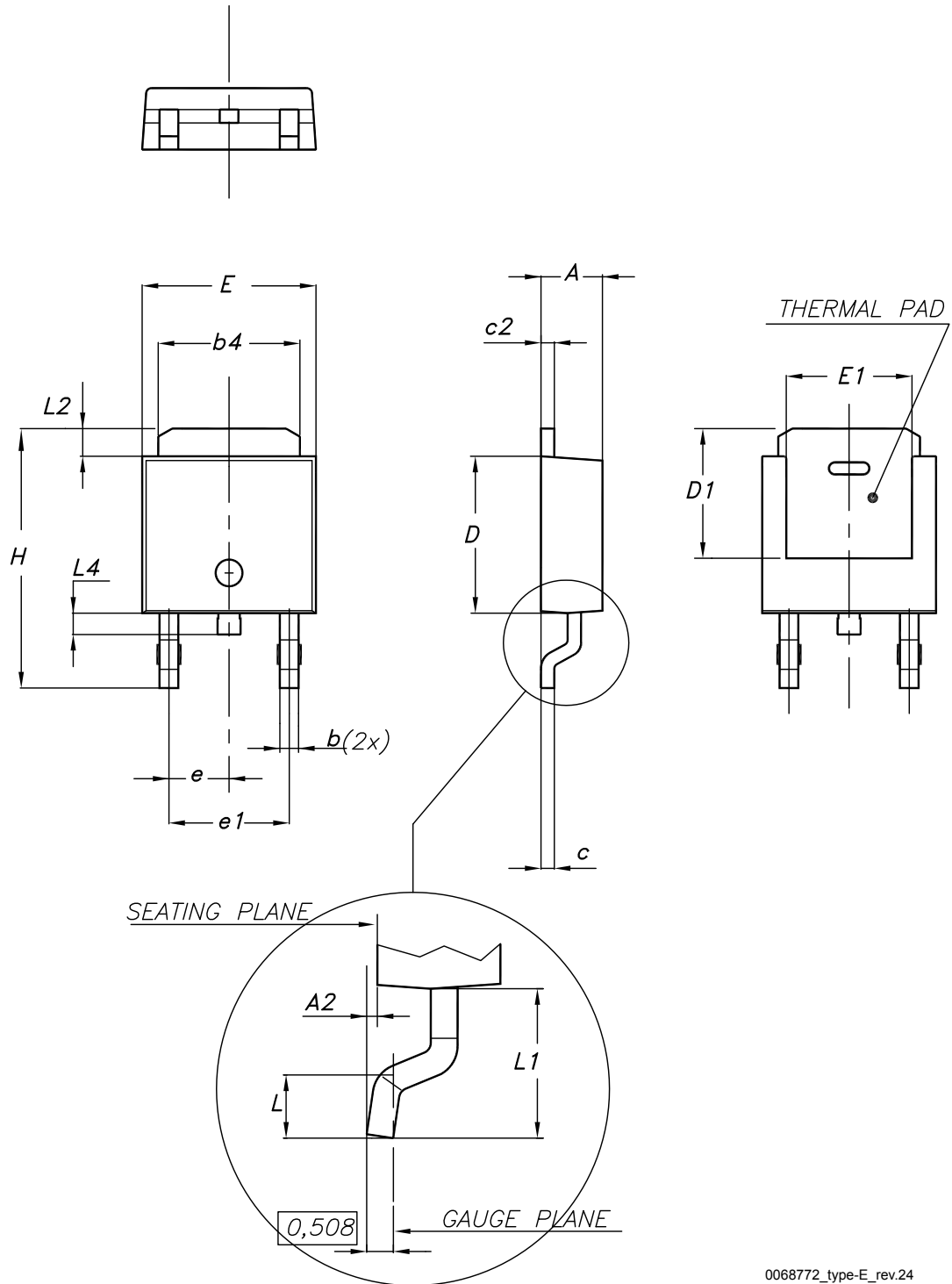
0068772\_C2\_24

**Table 14. 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°

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

Figure 27. DPAK (TO-252) type E package outline

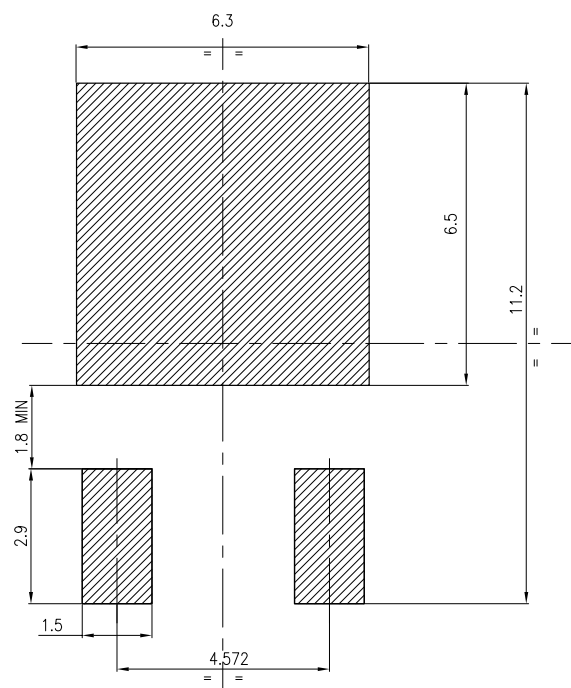


0068772\_type-E\_rev.24



**Table 15. DPAK (TO-252) type E mechanical data**

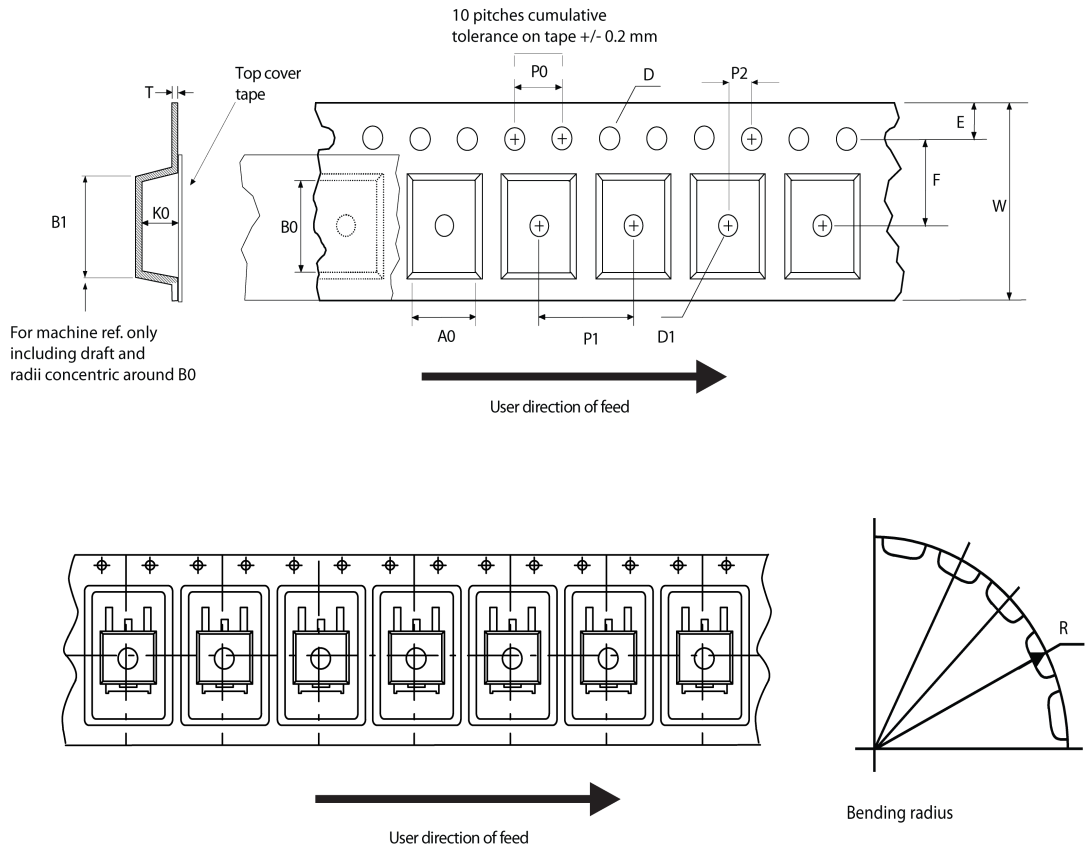
Dim.	mm		
	Min.	Typ.	Max.
A	2.18		2.39
A2			0.13
b	0.65		0.884
b4	4.95		5.46
c	0.46		0.61
c2	0.46		0.60
D	5.97		6.22
D1	5.21		
E	6.35		6.73
E1	4.32		
e		2.286	
e1		4.572	
H	9.94		10.34
L	1.50		1.78
L1		2.74	
L2	0.89		1.27
L4			1.02

**Figure 28. DPAK (TO-252) recommended footprint (dimensions are in mm)**


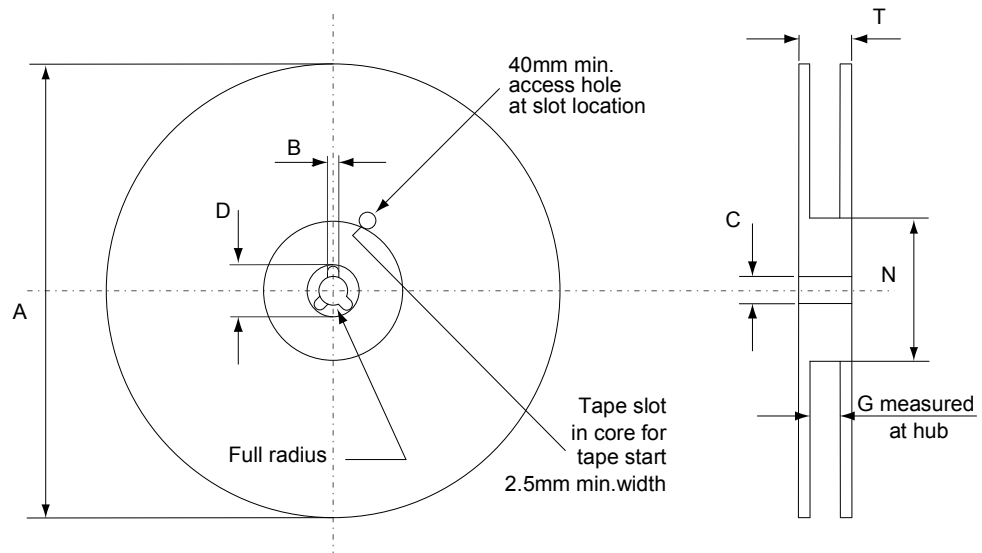
FP\_0068772\_24

## 4.9 D<sup>2</sup>PAK and DPAK packing information

Figure 29. Tape outline



AM08852v1

**Figure 30. Reel outline**


AM06038v1

**Table 16. D<sup>2</sup>PAK tape and reel mechanical data**

Tape			Reel			
Dim.	mm		Dim.	mm		
	Min.	Max.		Min.	Max.	
A0	10.5	10.7	A		330	
B0	15.7	15.9	B	1.5		
D	1.5	1.6	C	12.8	13.2	
D1	1.59	1.61	D	20.2		
E	1.65	1.85	G	24.4	26.4	
F	11.4	11.6	N	100		
K0	4.8	5.0	T		30.4	
P0	3.9	4.1	Base quantity Bulk quantity			
P1	11.9	12.1				1000
P2	1.9	2.1				1000
R	50					
T	0.25	0.35				
W	23.7	24.3				

**Table 17. DPAK 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			

## 5 Ordering information

Table 18. Order codes

Order code	Marking	Package	Packing
STB4NK60Z-1	B4NK60Z	I <sup>2</sup> PAK	Tube
STB4NK60ZT4		D <sup>2</sup> PAK	Tape and reel
STD4NK60Z-1	D4NK60Z	IPAK	Tube
STD4NK60ZT4		DPAK	Tape and reel

## Revision history

**Table 19. Document revision history**

Date	Version	Changes
25-Oct-2006	4	Document reformatted no content change.
04-Mar-2008	5	Modified TO-220 and TO-220FP mechanical data.
16-Apr-2008	6	Minor text changes to improve readability.
11-Jul-2011	7	Updated package mechanical data <i>Section 4</i> and packaging mechanical data <i>Section 4</i> .
18-Jul-2013	8	<ul style="list-style-type: none"> <li>– Minor text changes</li> <li>– The part numbers STP4NK60Z and STP4NK60ZFP have been moved to a separate datasheet</li> <li>– Updated: <i>Section 4: Package mechanical data</i> and <i>Section 4: Package mechanical data</i></li> </ul>
05-Apr-2018	9	<p>Removed maturity status indication from cover page. The document status is production data.</p> <p>Updated part numbers.</p> <p>Updated <a href="#">Table 1. Absolute maximum ratings</a>, <a href="#">Table 4. On/off states</a>, <a href="#">Table 5. Dynamic</a>, <a href="#">Table 6. Source-drain diode</a> and <a href="#">Table 7. Gate-source Zener diode</a>.</p> <p>Updated <a href="#">Section 2.1 Electrical characteristics (curves)</a> and <a href="#">Section 4 Package information</a>.</p> <p>Minor text changes.</p>

## Contents

<b>1</b>	<b>Electrical ratings</b> .....	<b>2</b>
<b>2</b>	<b>Electrical characteristics</b> .....	<b>3</b>
<b>2.1</b>	Electrical characteristics (curves) .....	5
<b>3</b>	<b>Test circuits</b> .....	<b>7</b>
<b>4</b>	<b>Package information</b> .....	<b>8</b>
<b>4.1</b>	I <sup>2</sup> PAK package information .....	8
<b>4.2</b>	D <sup>2</sup> PAK (TO-263) type A package information .....	10
<b>4.3</b>	D <sup>2</sup> PAK (TO-263) type B package information .....	12
<b>4.4</b>	IPAK (TO-251) type A package information .....	15
<b>4.5</b>	IPAK (TO-251) type C package information .....	17
<b>4.6</b>	DPAK (TO-252) type A2 package information .....	19
<b>4.7</b>	DPAK (TO-252) type C2 package information .....	21
<b>4.8</b>	DPAK (TO-252) type E package information .....	23
<b>4.9</b>	D <sup>2</sup> PAK and DPAK packing information .....	25
<b>5</b>	<b>Ordering information</b> .....	<b>29</b>
	<b>Revision history</b> .....	<b>30</b>



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