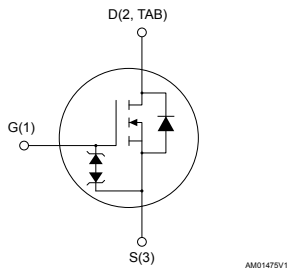
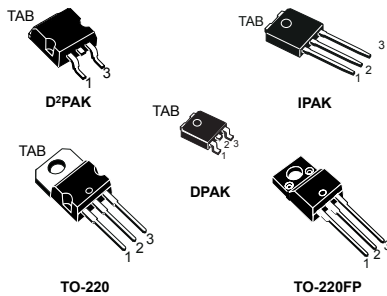




# THE DATASHEET OF P3NK60ZFP



N-channel 600 V, 3.2  $\Omega$  typ., 2.4 A SuperMESH™ Power MOSFETs in D<sup>2</sup>PAK, IPAK, DPAK, TO-220 and TO-220FP packages



## Features

Order codes	V <sub>DS</sub>	R <sub>DS(on)</sub> max.	I <sub>D</sub>	Package
STB3NK60ZT4	600 V	3.6 $\Omega$	2.4 A	D <sup>2</sup> PAK
STD3NK60Z-1				IPAK
STD3NK60ZT4				DPAK
STP3NK60Z				TO-220
STP3NK60ZFP				TO-220FP

- Extremely high dv/dt capability
- 100% avalanche tested
- Gate charge minimized
- Very low intrinsic capacitance
- 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 link

[STB3NK60ZT4](#)
[STD3NK60Z-1](#)
[STD3NK60ZT4](#)
[STP3NK60Z](#)
[STP3NK60ZFP](#)

# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

Symbol	Parameter	Value			Unit
		D <sup>2</sup> PAK, TO-220	TO-220FP	DPAK, IPAK	
V <sub>DS</sub>	Drain-source voltage	600			V
V <sub>GS</sub>	Gate-source voltage	±30			V
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 25 °C	2.4	2.4 <sup>(1)</sup>	2.4	A
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 100 °C	1.51	1.51 <sup>(1)</sup>	1.51	A
I <sub>DM</sub> <sup>(2)</sup>	Drain current (pulsed)	9.6	9.6 <sup>(1)</sup>	9.6	A
P <sub>TOT</sub>	Total dissipation at T <sub>C</sub> = 25 °C	45	20	45	W
ESD	Gate-source human body model (R = 1.5 kΩ, C = 100 pF)	2.1			kV
V <sub>ISO</sub>	Insulation withstand voltage (RMS) from all three leads to external heat-sink (t = 1 s, T <sub>C</sub> = 25 °C)	2.5			kV
dv/dt <sup>(3)</sup>	Peak diode recovery voltage slope	4.5			V/ns
T <sub>j</sub>	Operating junction temperature range	-55 to 150			°C
T <sub>stg</sub>	Storage temperature range				

- Limited by maximum junction temperature.
- Pulse width limited by safe operating area.
- $I_{SD} \leq 2.4 \text{ A}$ ,  $di/dt \leq 200 \text{ A}/\mu\text{s}$ ,  $V_{DSpeak} \leq V_{(BR)DSS}$ ,  $V_{DD} = 80\% V_{(BR)DSS}$ .

**Table 2. Thermal data**

Symbol	Parameter	Value					Unit
		D <sup>2</sup> PAK	TO-220	TO-220FP	DPAK	IPAK	
R <sub>thj-case</sub>	Thermal resistance junction-case	2.78		6.25	2.78		°C/W
R <sub>thj-amb</sub>	Thermal resistance junction-ambient	62.5			100		°C/W
R <sub>thj-pcb</sub> <sup>(1)</sup>	Thermal resistance junction-pcb	35			50		°C/W

- When mounted on an 1-inch<sup>2</sup> FR-4, 2oz Cu board.

**Table 3. Avalanche characteristics**

Symbol	Parameter	Value	Unit
I <sub>AR</sub>	Avalanche current, repetitive or not-repetitive (pulse width limited by T <sub>j</sub> Max)	2.4	A
E <sub>AS</sub>	Single pulse avalanche energy (starting T <sub>j</sub> = 25 °C, I <sub>D</sub> = I <sub>AR</sub> , V <sub>DD</sub> = 50 V)	150	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	$I_D = 1\text{ mA}, V_{GS} = 0\text{ V}$	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	$V_{GS} = 10\text{ V}, I_D = 1.2\text{ A}$		3.2	3.6	$\Omega$

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

**Table 5. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$C_{iss}$	Input capacitance	$V_{DS} = 25\text{ V}, f = 1\text{ MHz}, V_{GS} = 0\text{ V}$	-	311	-	$\mu\text{F}$
$C_{oss}$	Output capacitance			43		
$C_{rSS}$	Reverse transfer capacitance			8		
$C_{oss\text{ eq.}}^{(1)}$	Equivalent output capacitance	$V_{DS} = 0\text{ to }480\text{ V}, V_{GS} = 0\text{ V}$	-	26	-	$\mu\text{F}$
$Q_g$	Total gate charge	$V_{DD} = 480\text{ V}, I_D = 2.4\text{ A}, V_{GS} = 0\text{ to }10\text{ V}$ (see Figure 16. Test circuit for gate charge behavior)	-	11.8	-	nC
$Q_{gs}$	Gate-source charge			2.6		
$Q_{gd}$	Gate-drain charge			6.4		

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. Switching times**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 300\text{ V}, I_D = 1.5\text{ A},$ $R_G = 4.7\text{ }\Omega, V_{GS} = 10\text{ V}$ (see Figure 15. Test circuit for resistive load switching times and Figure 20. Switching time waveform)	-	9	-	ns
$t_r$	Rise time			14		
$t_{d(off)}$	Turn-off delay time			19		
$t_f$	Fall time			14		

**Table 7. Source drain diode**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{SD}$	Source-drain current		-		2.4	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)				9.6	
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 2.4 \text{ A}$ , $V_{GS} = 0 \text{ V}$	-		1.6	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 2.4 \text{ A}$ , $di/dt = 100 \text{ A}/\mu\text{s}$	-	306		ns
$Q_{rr}$	Reverse recovery charge	$V_{DD} = 48 \text{ V}$ , $T_j = 150^\circ\text{C}$ (see <a href="#">Figure 17. Test circuit for inductive load switching and diode recovery times</a> )		948		nC
$I_{RRM}$	Reverse recovery current			6.2		A

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

**Table 8. 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

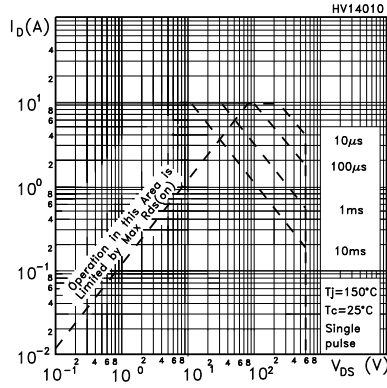


Figure 2. Thermal impedance

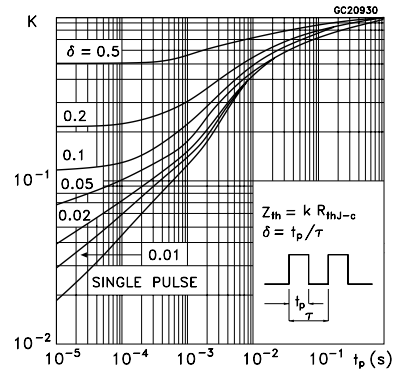


Figure 3. Safe operating area for TO-220FP

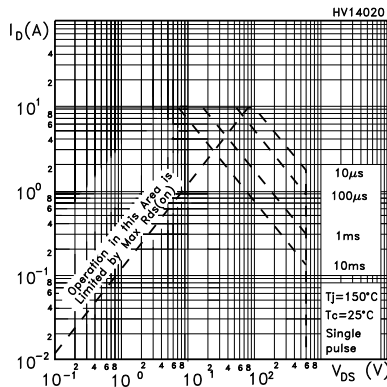


Figure 4. Thermal impedance for TO-220FP

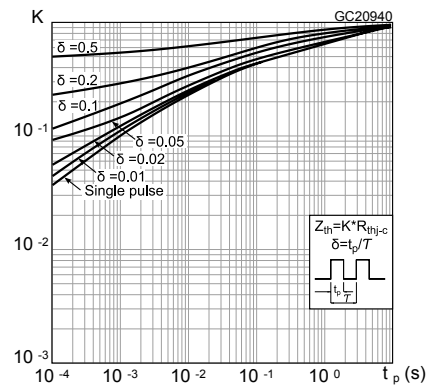


Figure 5. Output characteristics

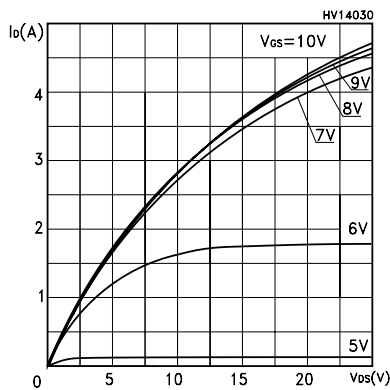


Figure 6. Transfer characteristics

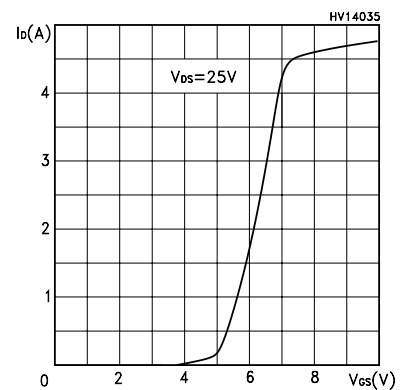


Figure 7. Static drain-source on resistance

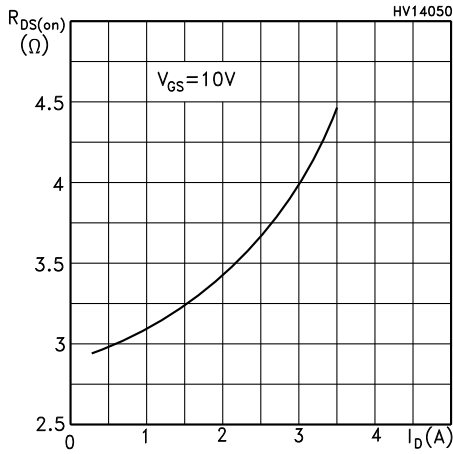


Figure 8. Gate charge vs gate-source voltage

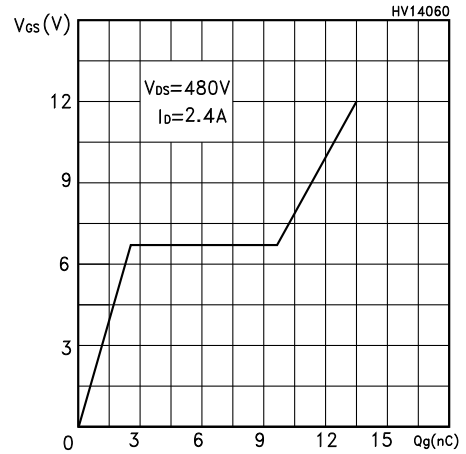


Figure 9. Capacitance variations

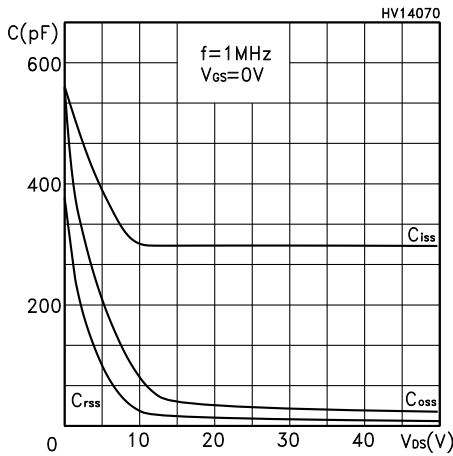


Figure 10. Normalized gate threshold voltage vs temperature

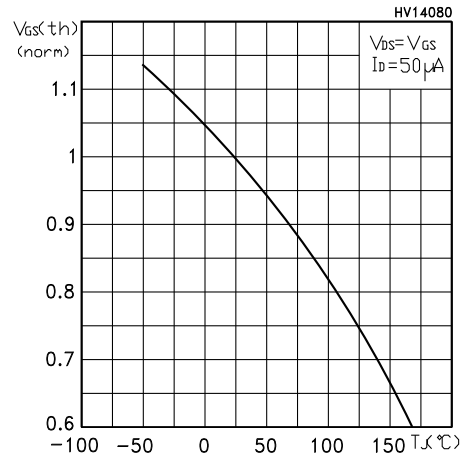


Figure 11. Normalized on resistance vs temperature

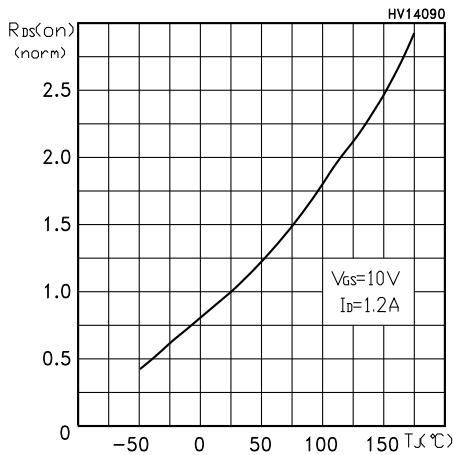


Figure 12. Source-drain diode forward characteristic

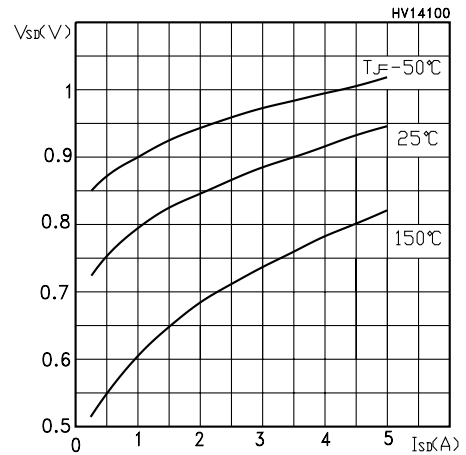


Figure 13. Normalized  $V_{(BR)DSS}$  vs temperature

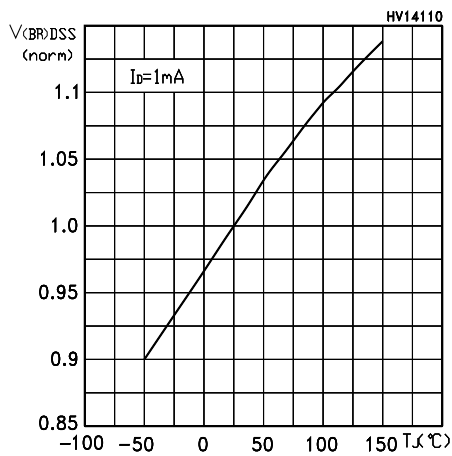
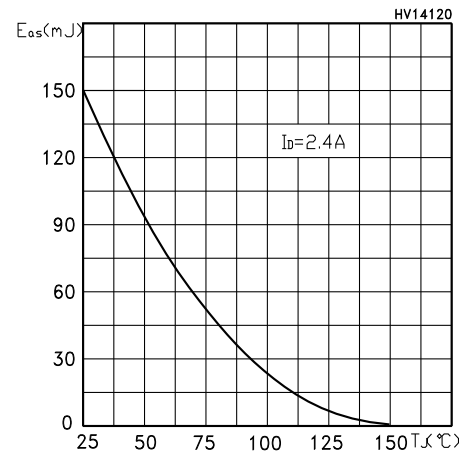
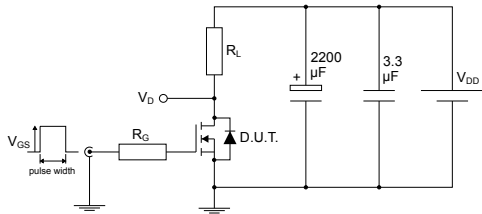


Figure 14. Maximum avalanche energy vs temperature



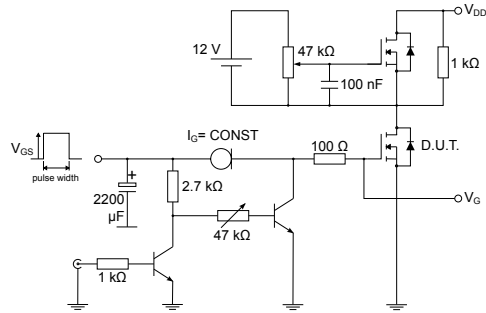
### 3 Test circuits

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



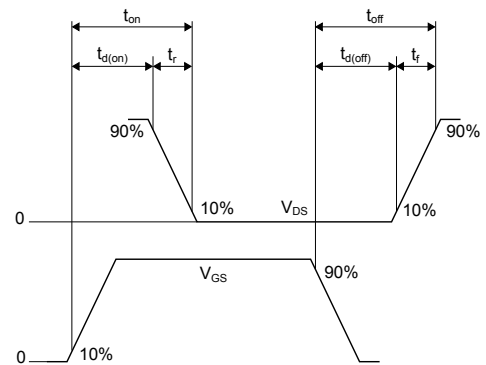
AM01471v1

Figure 19. Unclamped inductive waveform



AM01472v1

Figure 20. Switching time waveform



AM01473v1



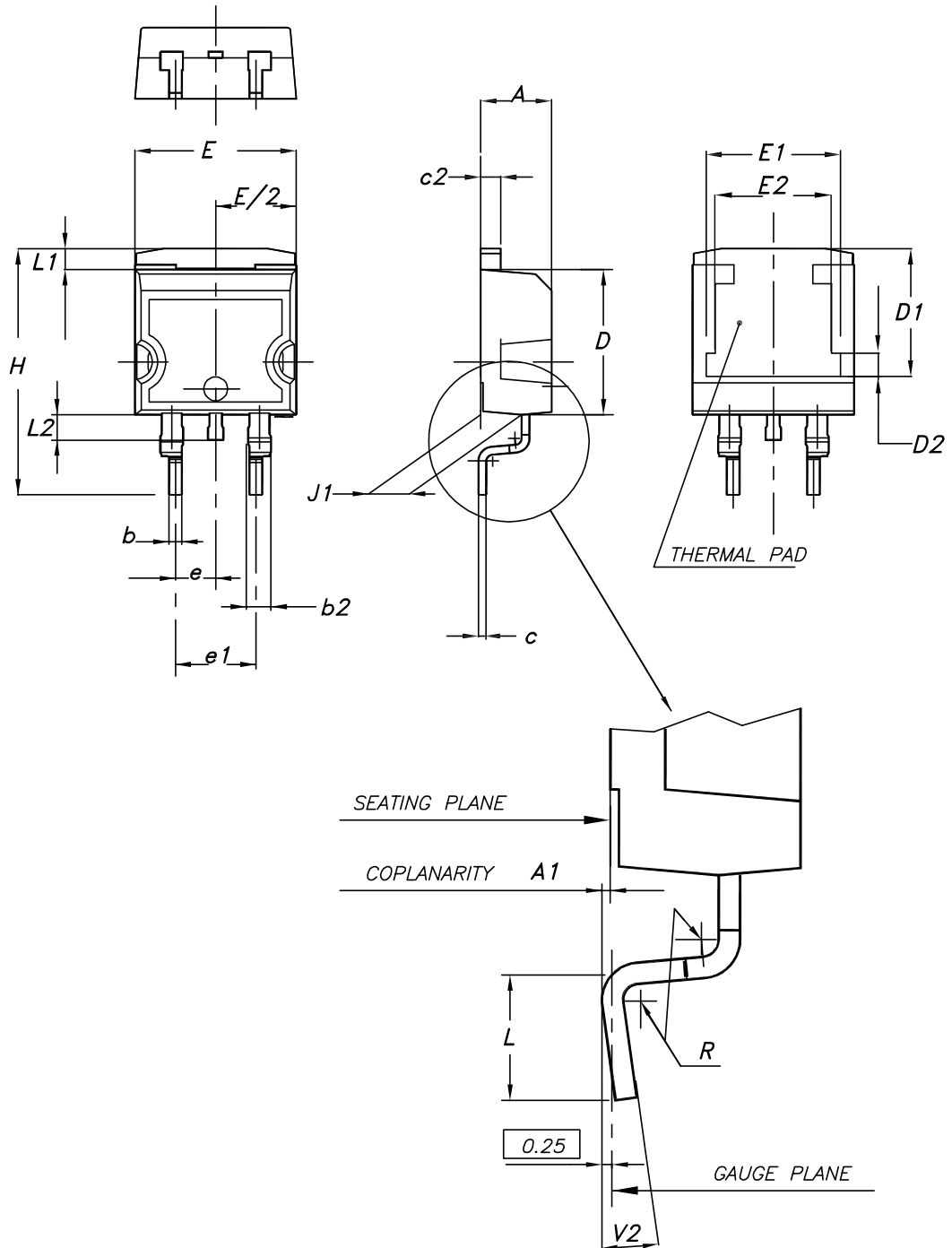
## 4 Package information

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

Figure 21. D<sup>2</sup>PAK (TO-263) type A package outline

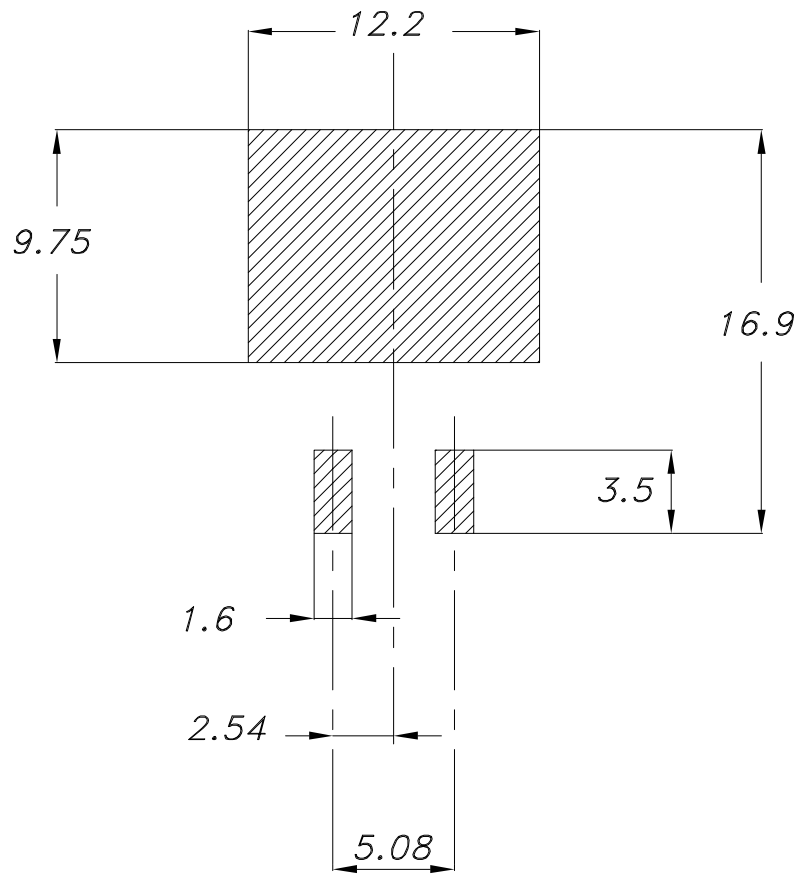


0079457\_25

**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	8.30	8.50	8.70
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°

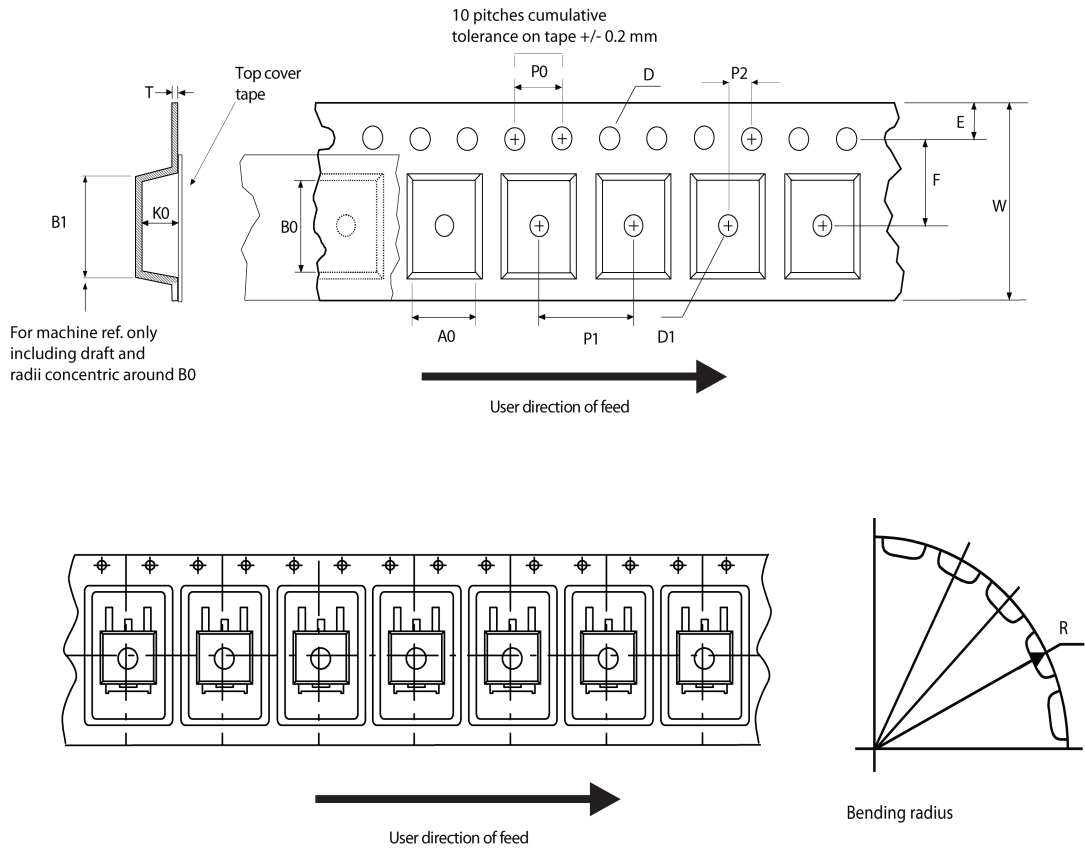
Figure 22. D<sup>2</sup>PAK (TO-263) recommended footprint (dimensions are in mm)



Footprint

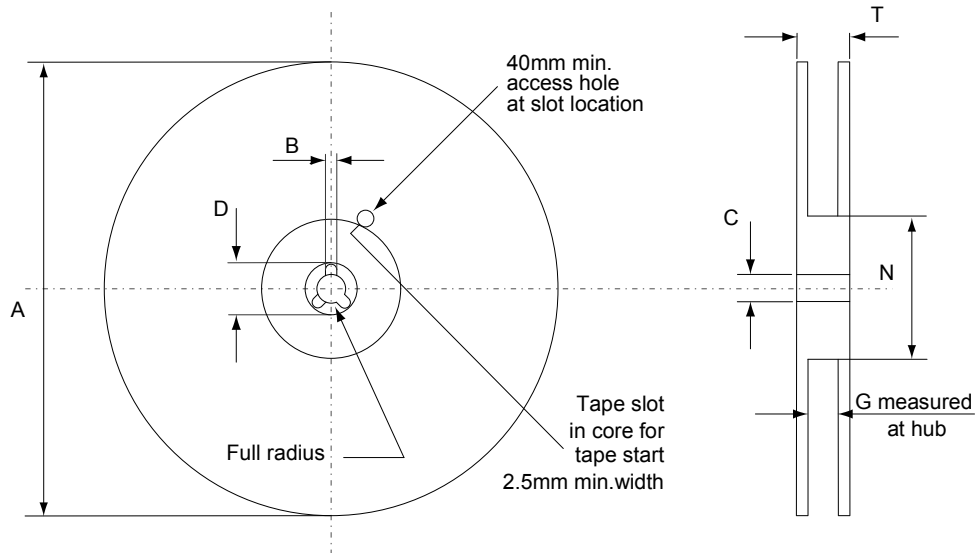
## 4.2 D<sup>2</sup>PAK packing information

Figure 23. D<sup>2</sup>PAK tape outline



AM08852v1

Figure 24. D<sup>2</sup>PAK reel outline



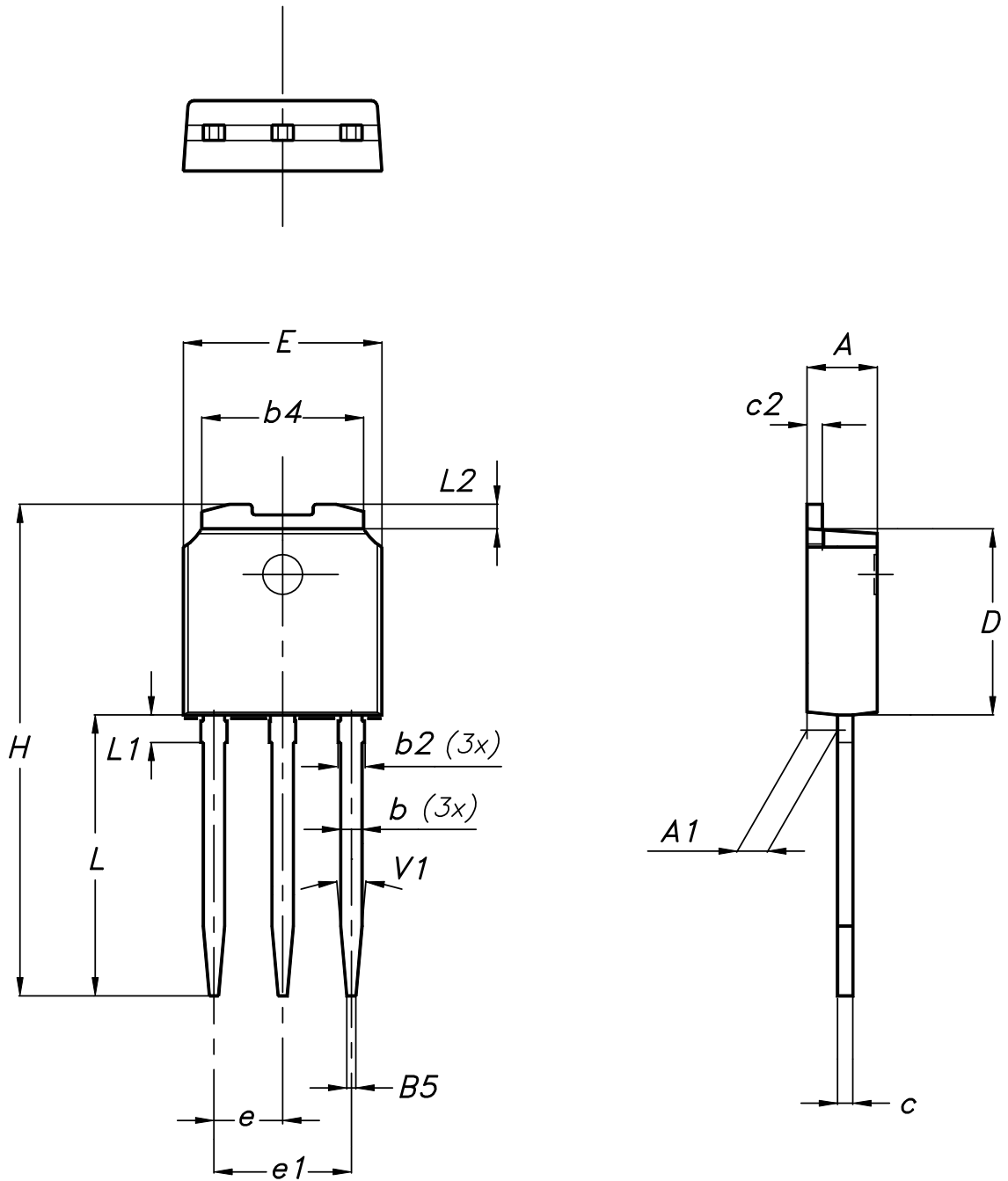
AM06038v1

Table 10. 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				

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

Figure 25. IPAk (TO-251) type A package outline



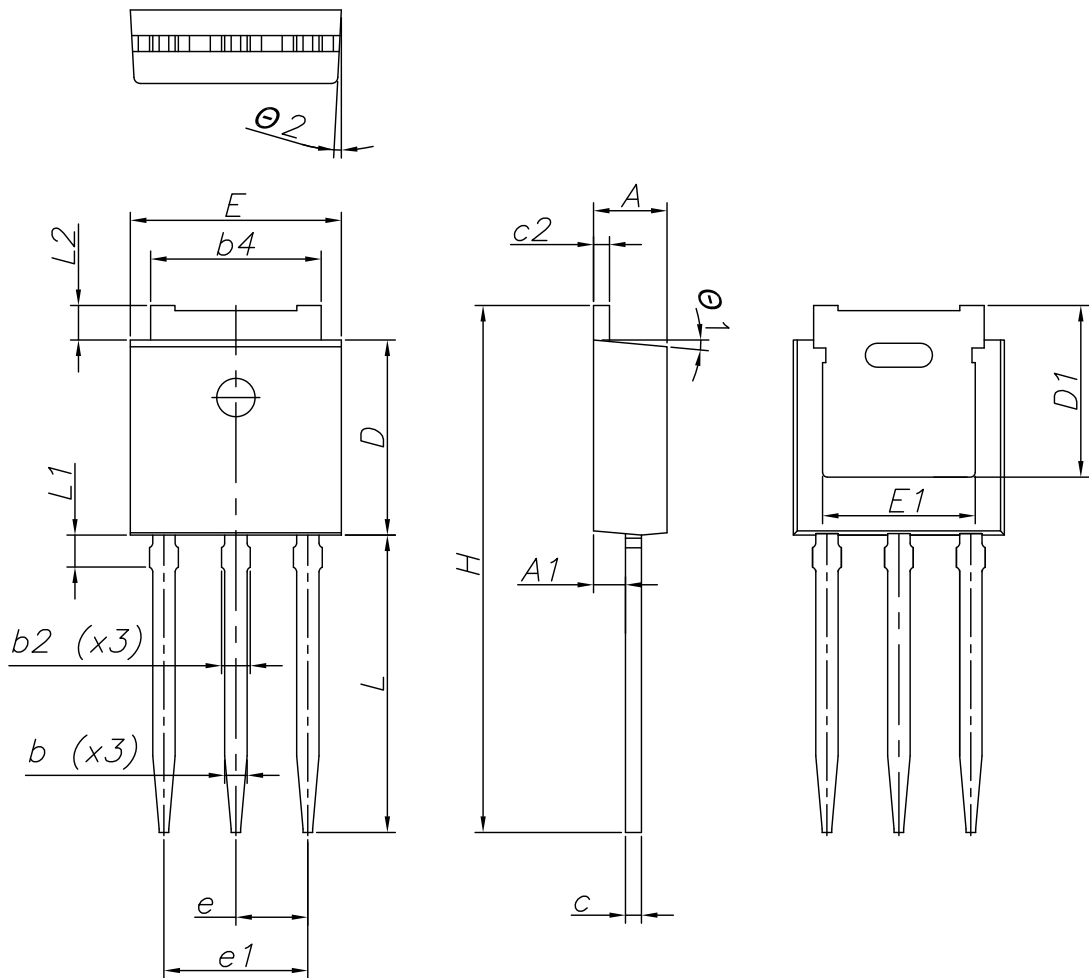
0068771\_IK\_typeA\_rev14

**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°	

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

Figure 26. IPAK (TO-251) type C package outline



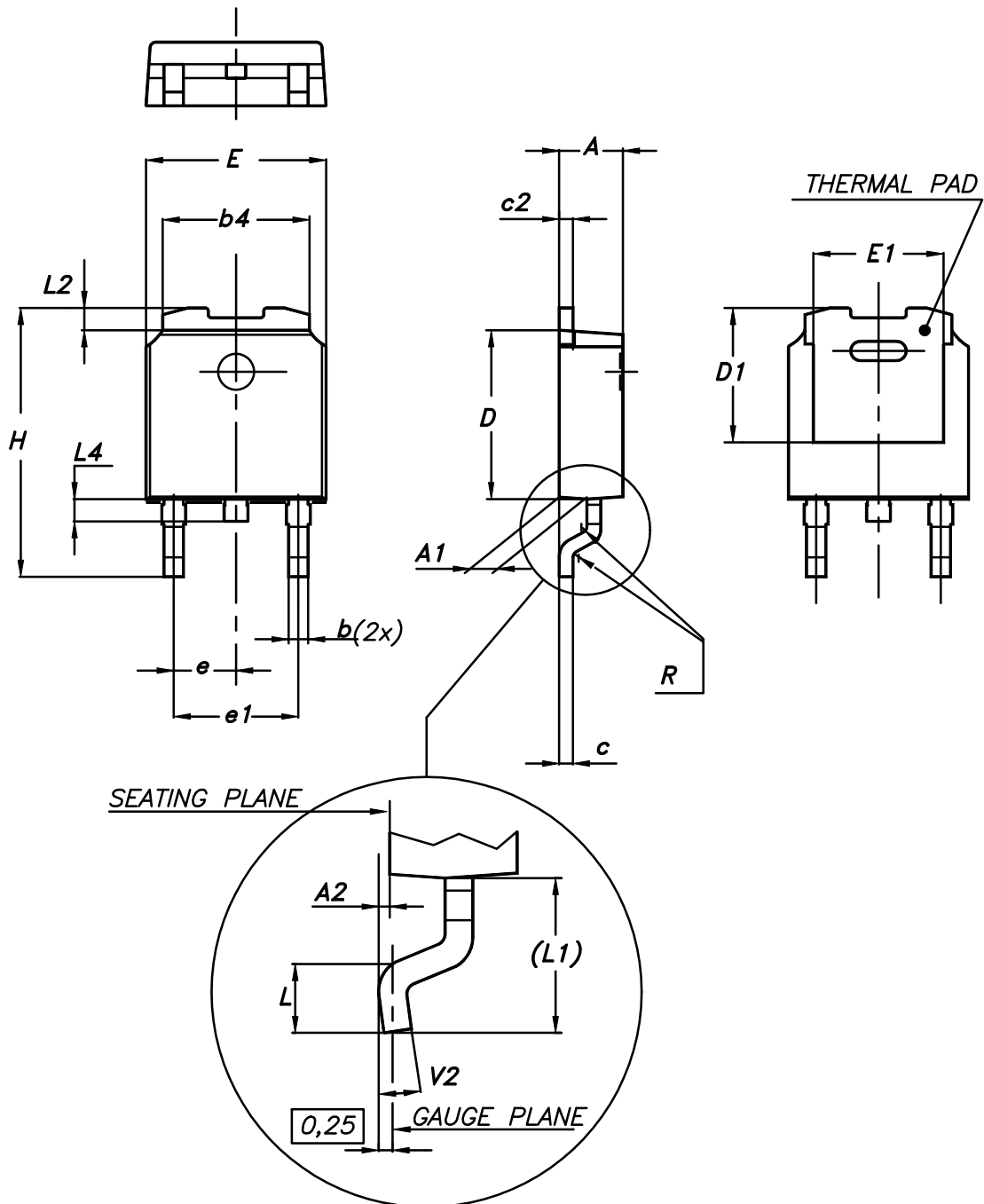
0068771\_IK\_typeC\_rev14

**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°

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

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



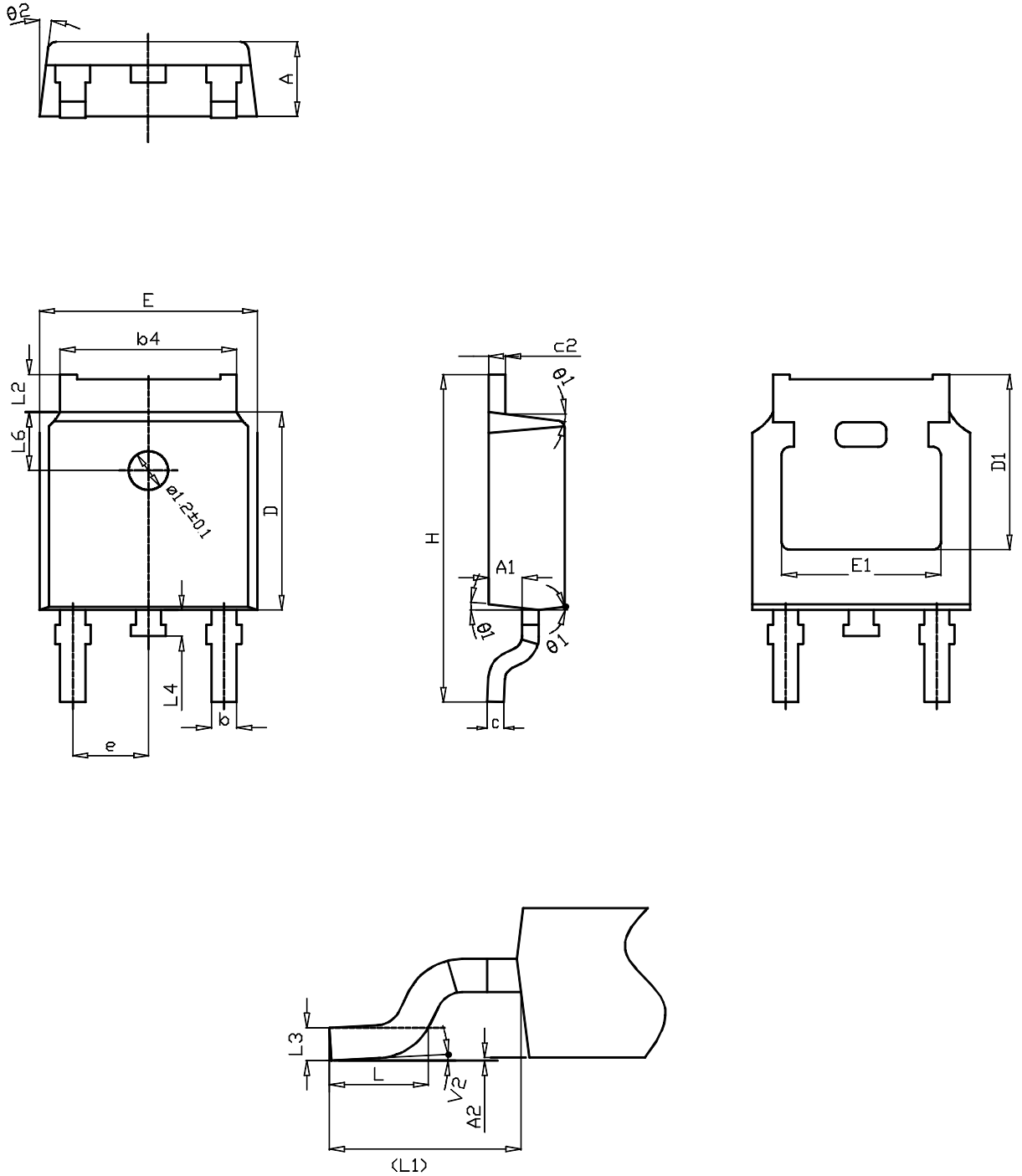
0068772\_A\_25

**Table 13. 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°

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

Figure 28. DPAK (TO-252) type C package outline



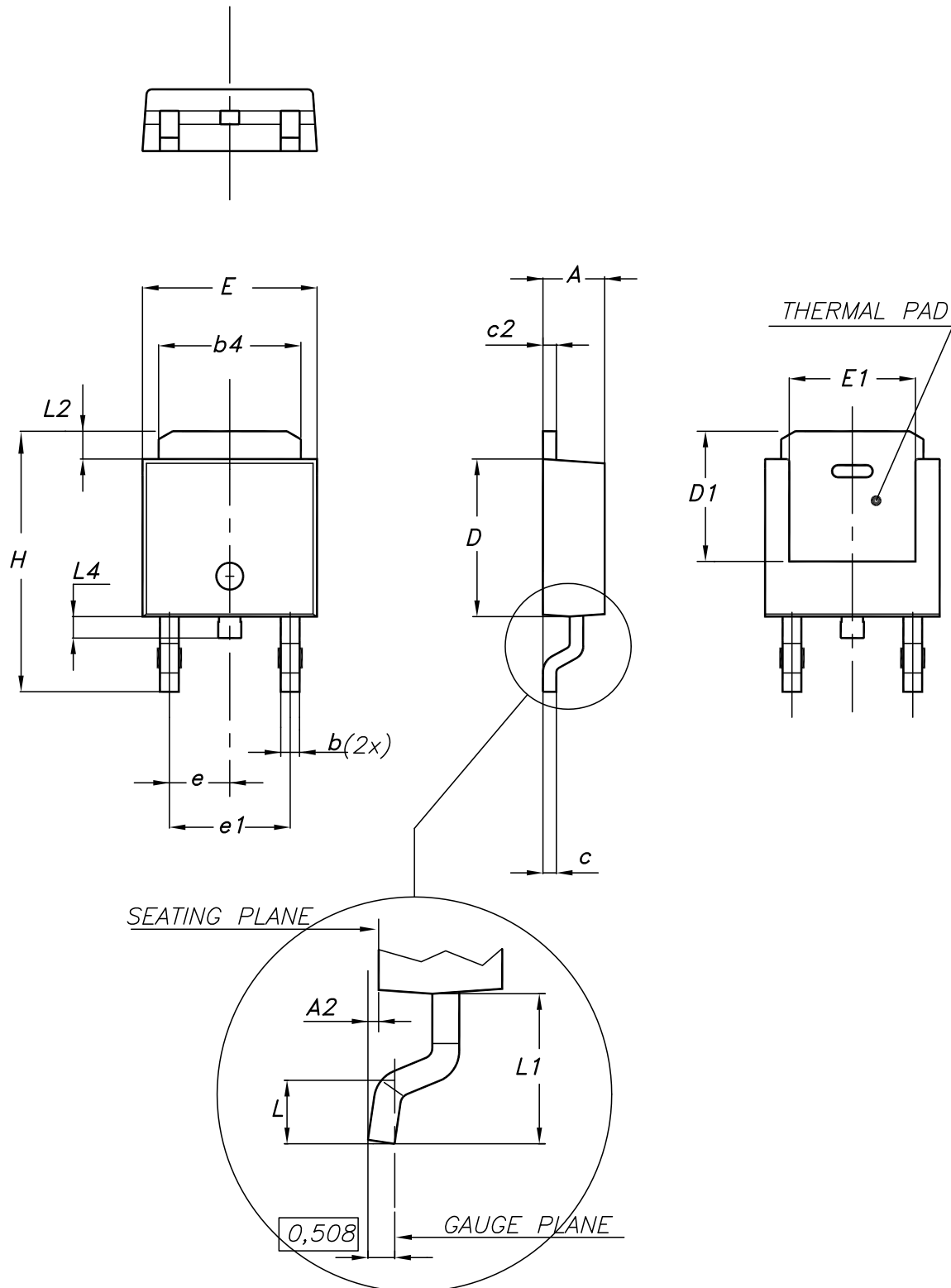
0068772\_C\_25

**Table 14. 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°

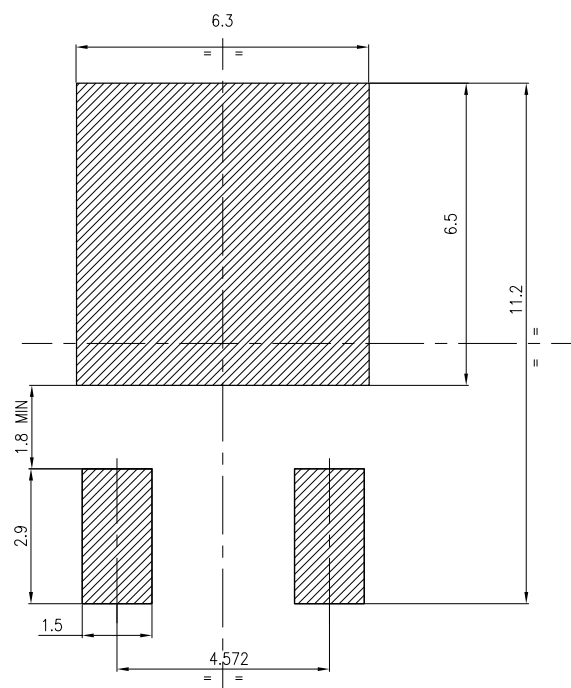
#### 4.7 DPAK (TO-252) type E package information

Figure 29. DPAK (TO-252) type E package outline



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

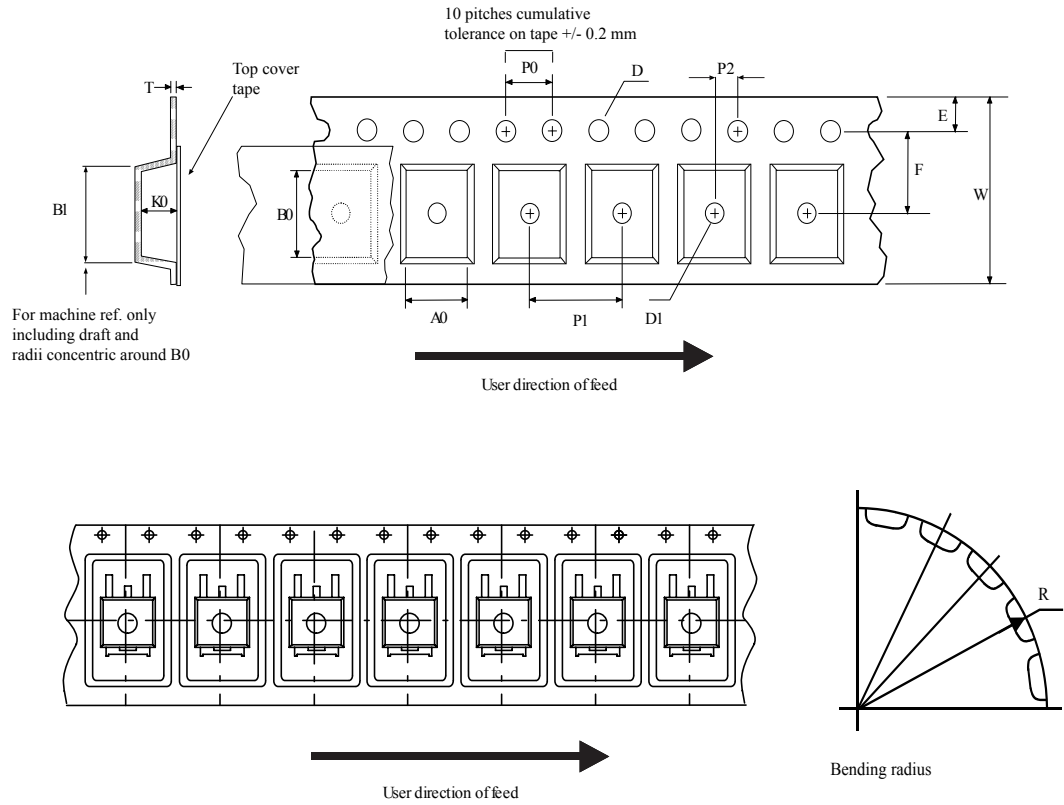
Dim.	mm		
	Min.	Typ.	Max.
A	2.18		2.39
A2			0.13
b	0.65		0.884
b4	4.95		5.46
c	0.46		0.61
c2	0.46		0.60
D	5.97		6.22
D1	5.21		
E	6.35		6.73
E1	4.32		
e		2.286	
e1		4.572	
H	9.94		10.34
L	1.50		1.78
L1		2.74	
L2	0.89		1.27
L4			1.02

**Figure 30. DPAK (TO-252) recommended footprint (dimensions are in mm)**


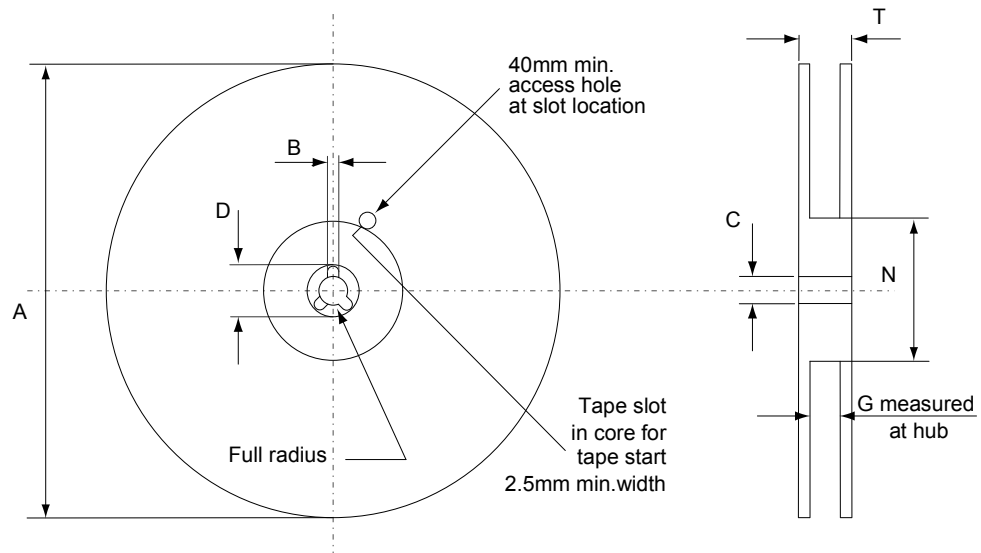
FP\_0068772\_25

## 4.8 DPAK (TO-252) packing information

Figure 31. DPAK (TO-252) tape outline



AM08852v1

**Figure 32. DPAK (TO-252) reel outline**


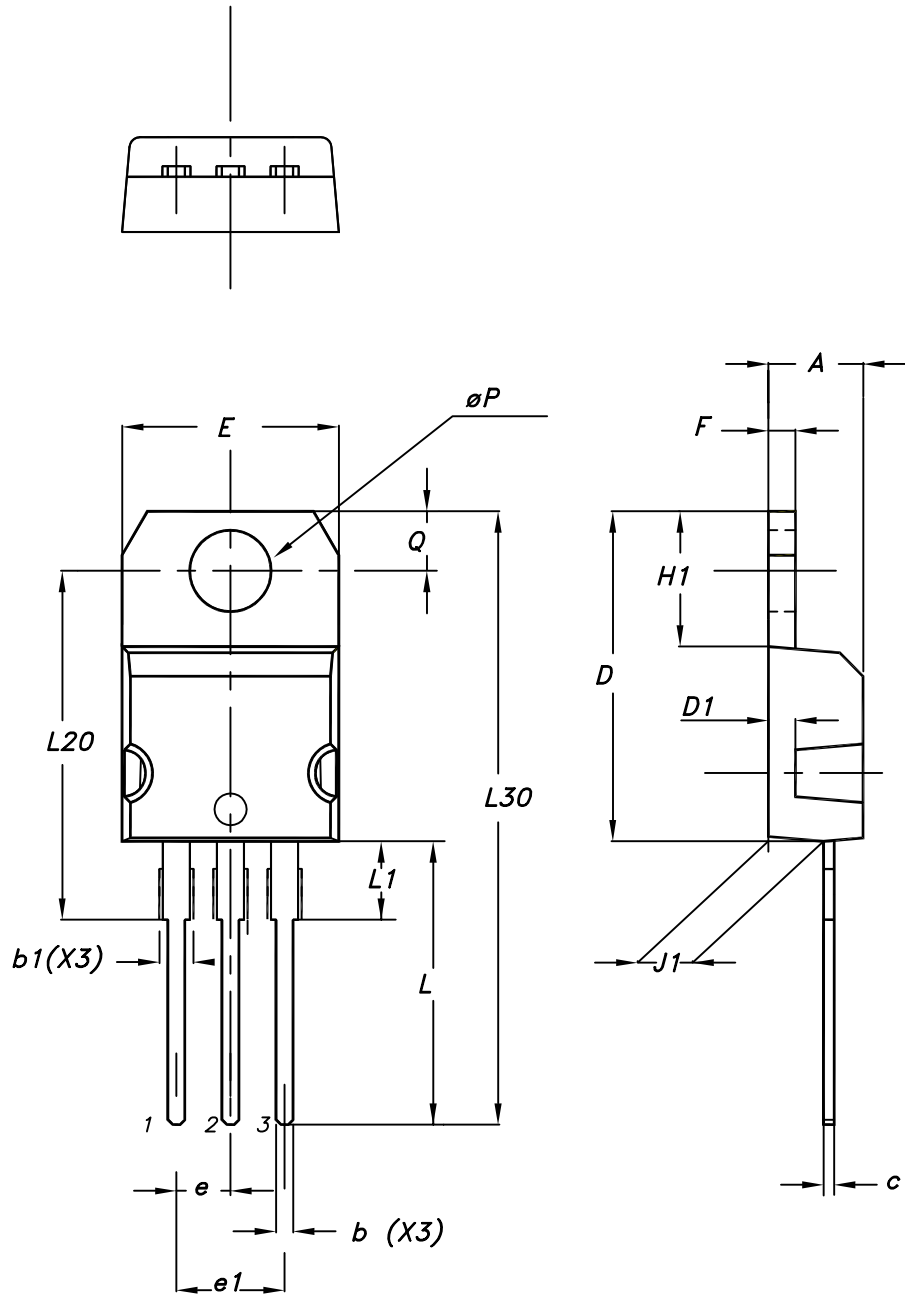
AM06038v1

**Table 16. 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			

### 4.9 TO-220 type A package information

Figure 33. TO-220 type A package outline



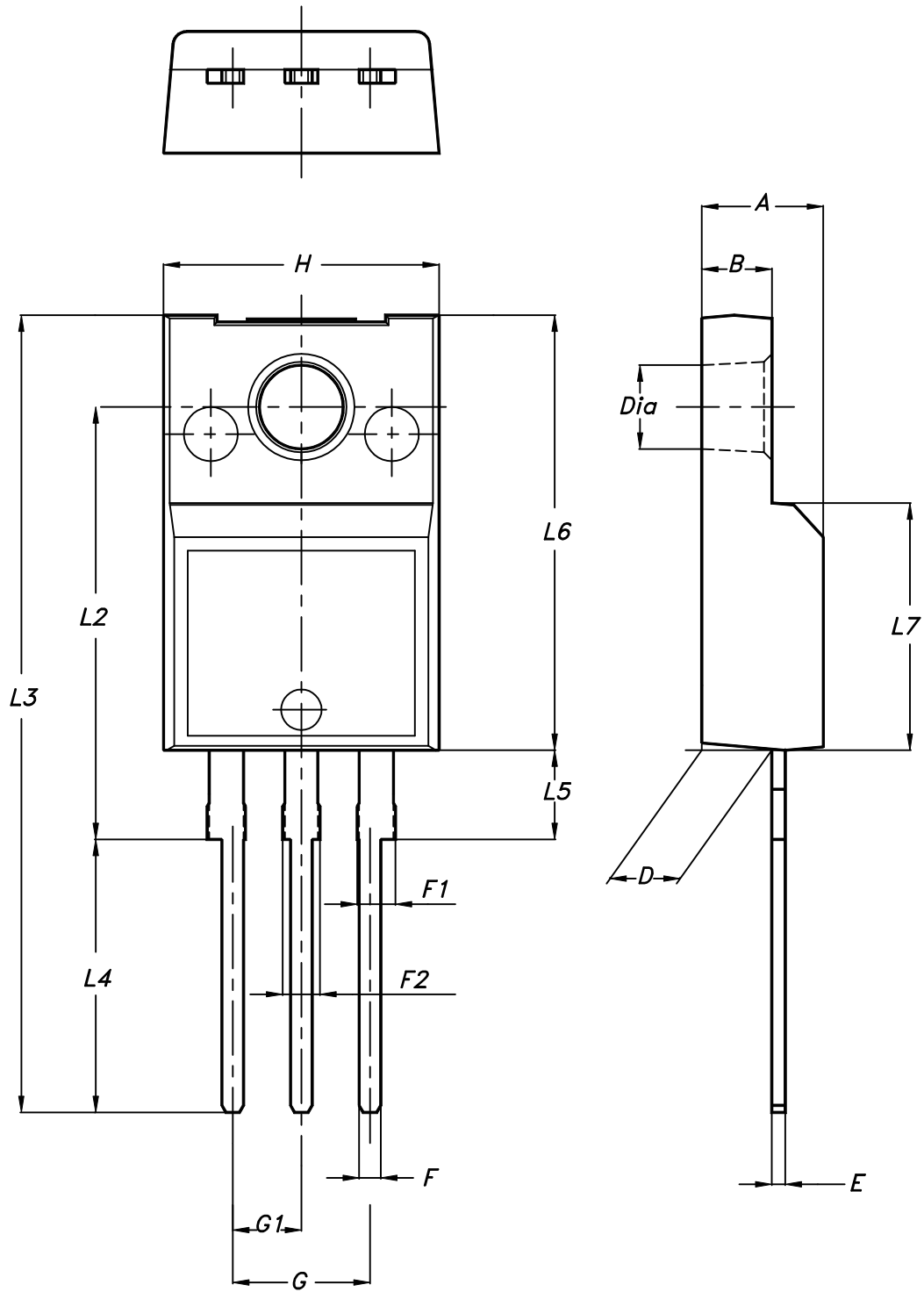
0015988\_typeA\_Rev\_21

**Table 17. 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

#### 4.10 TO-220FP package information

Figure 34. TO-220FP package outline



7012510\_Rev\_12\_B

**Table 18. TO-220FP package mechanical data**

Dim.	mm		
	Min.	Typ.	Max.
A	4.4		4.6
B	2.5		2.7
D	2.5		2.75
E	0.45		0.7
F	0.75		1
F1	1.15		1.70
F2	1.15		1.70
G	4.95		5.2
G1	2.4		2.7
H	10		10.4
L2		16	
L3	28.6		30.6
L4	9.8		10.6
L5	2.9		3.6
L6	15.9		16.4
L7	9		9.3
Dia	3		3.2

## 5 Ordering information

**Table 19. Order codes**

Order code	Marking	Package	Packing
STB3NK60ZT4	B3NK60Z	D <sup>2</sup> PAK	Tape and reel
STD3NK60Z-1	D3NK60Z	IPAK	Tube
STD3NK60ZT4		DPAK	Tape and reel
STP3NK60Z	P3NK60Z	TO-220	Tube
STP3NK60ZFP	P3NK60ZFP	TO-220FP	Tube

## Revision history

**Table 20. Document revision history**

Date	Version	Changes
07-Jul-2003	5	Updated document.
20-Aug-2018	6	Updated <a href="#">Section 1 Electrical ratings</a> , <a href="#">Section 2 Electrical characteristics</a> and <a href="#">Section 4 Package information</a> . Minor text changes.

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