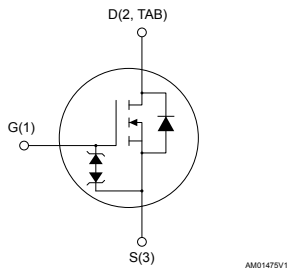
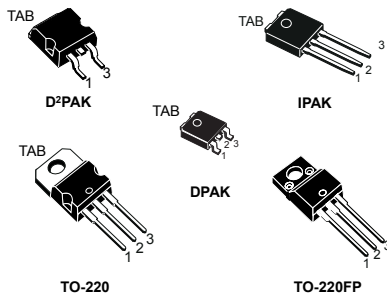


N-channel 600 V, 3.2 Ω typ., 2.4 A SuperMESH™ Power MOSFETs in D²PAK, IPAK, DPAK, TO-220 and TO-220FP packages



Features

Order codes	V _{DS}	R _{DS(on)} max.	I _D	Package
STB3NK60ZT4	600 V	3.6 Ω	2.4 A	D ² 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 ² PAK, TO-220	TO-220FP	DPAK, IPAK	
V _{DS}	Drain-source voltage	600			V
V _{GS}	Gate-source voltage	±30			V
I _D	Drain current (continuous) at T _C = 25 °C	2.4	2.4 ⁽¹⁾	2.4	A
I _D	Drain current (continuous) at T _C = 100 °C	1.51	1.51 ⁽¹⁾	1.51	A
I _{DM} ⁽²⁾	Drain current (pulsed)	9.6	9.6 ⁽¹⁾	9.6	A
P _{TOT}	Total dissipation at T _C = 25 °C	45	20	45	W
ESD	Gate-source human body model (R = 1.5 kΩ, C = 100 pF)	2.1			kV
V _{ISO}	Insulation withstand voltage (RMS) from all three leads to external heat-sink (t = 1 s, T _C = 25 °C)	2.5			kV
dv/dt ⁽³⁾	Peak diode recovery voltage slope	4.5			V/ns
T _j	Operating junction temperature range	-55 to 150			°C
T _{stg}	Storage temperature range				

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

Table 2. Thermal data

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

- When mounted on an 1-inch² FR-4, 2oz Cu board.

Table 3. Avalanche characteristics

Symbol	Parameter	Value	Unit
I _{AR}	Avalanche current, repetitive or not-repetitive (pulse width limited by T _j Max)	2.4	A
E _{AS}	Single pulse avalanche energy (starting T _j = 25 °C, I _D = I _{AR} , V _{DD} = 50 V)	150	mJ

2 Electrical characteristics

($T_{CASE} = 25\text{ °C}$ 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	μA
		$V_{GS} = 0\text{ V}$, $V_{DS} = 600\text{ V}$, $T_C = 125\text{ °C}$ ⁽¹⁾			50	μA
I_{GSS}	Gate body leakage current	$V_{DS} = 0\text{ V}$, $V_{GS} = \pm 20\text{ V}$			± 10	μA
$V_{GS(th)}$	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	Ω

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	-	μF
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	-	μF
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 Figure 17. Test circuit for inductive load switching and diode recovery times)		948		nC
I_{RRM}	Reverse recovery current			6.2		A

1. Pulse width limited by safe operating area.
2. Pulsed: pulse duration = 300 μs , 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	$I_{GS} = \pm 1 \text{ mA}, I_D = 0 \text{ A}$	± 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

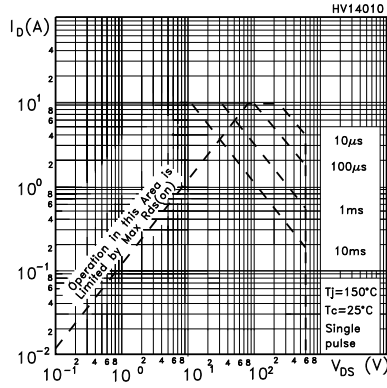


Figure 2. Thermal impedance

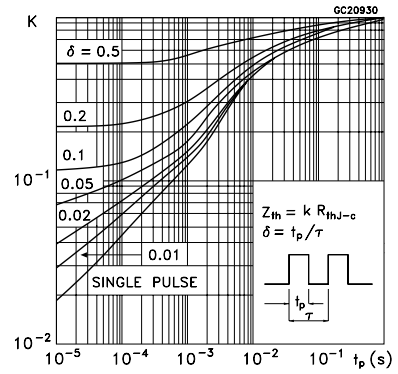


Figure 3. Safe operating area for TO-220FP

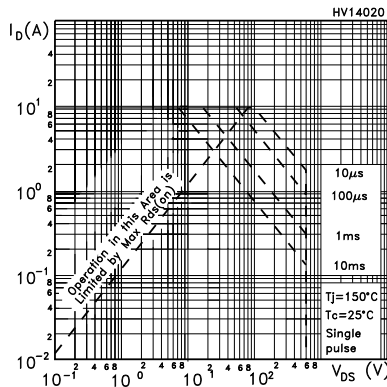


Figure 4. Thermal impedance for TO-220FP

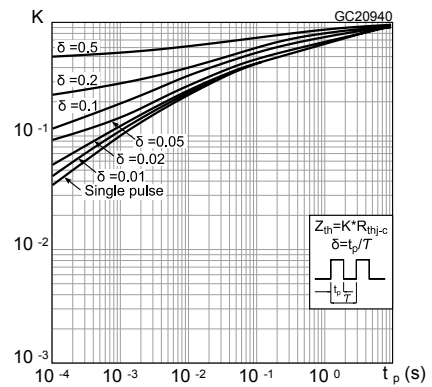


Figure 5. Output characteristics

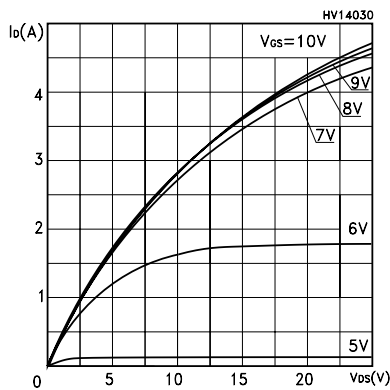


Figure 6. Transfer characteristics

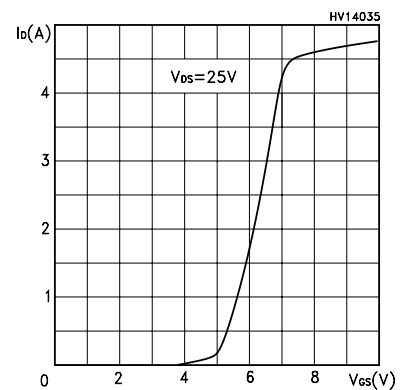


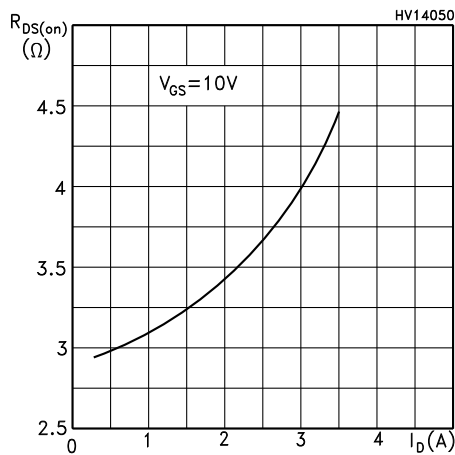
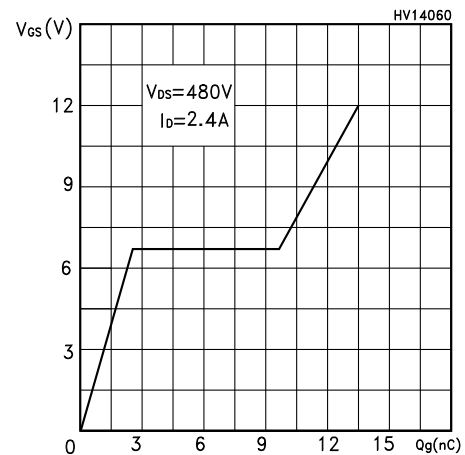
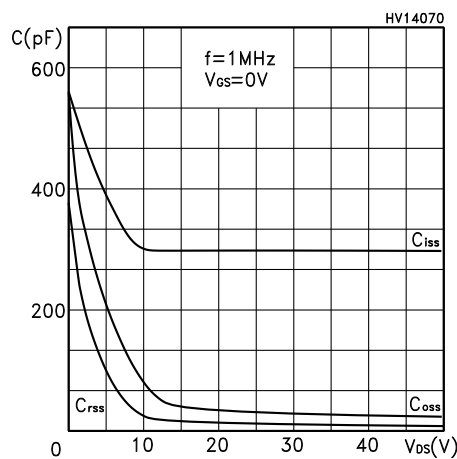
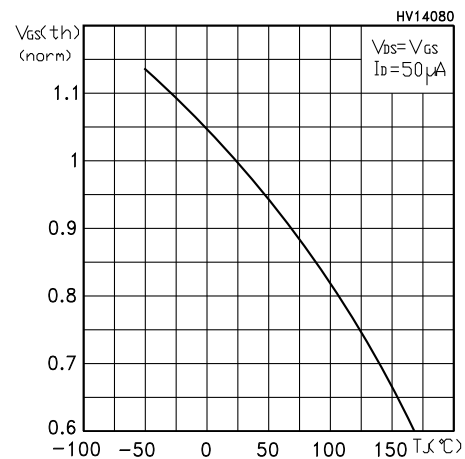
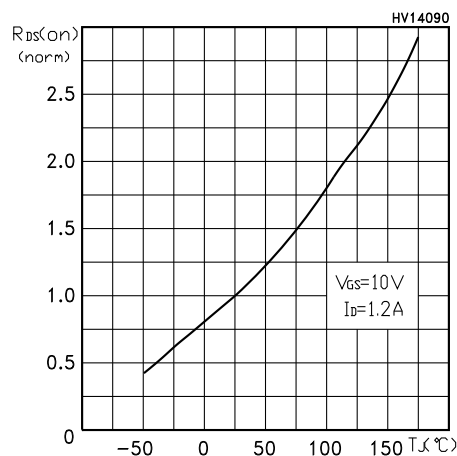
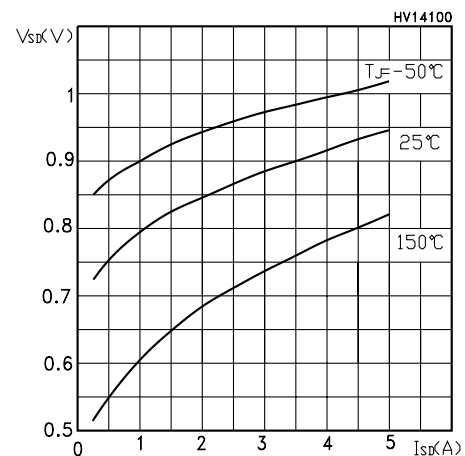
Figure 7. Static drain-source on resistance

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

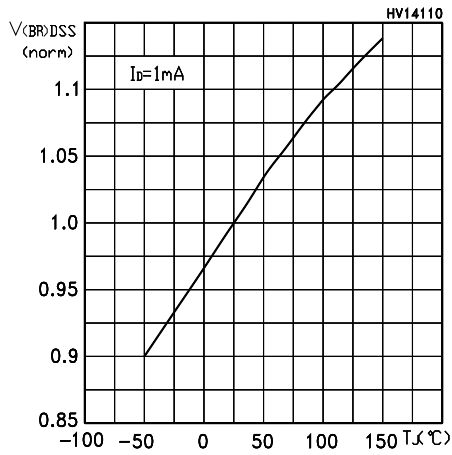
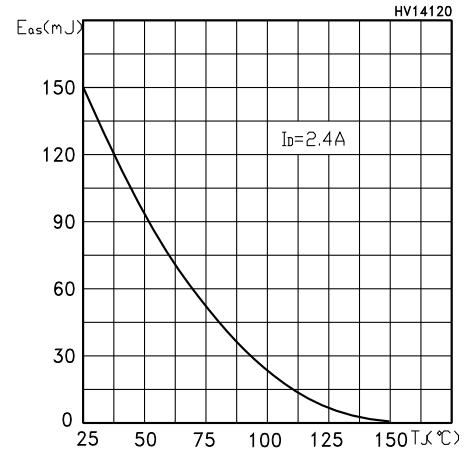
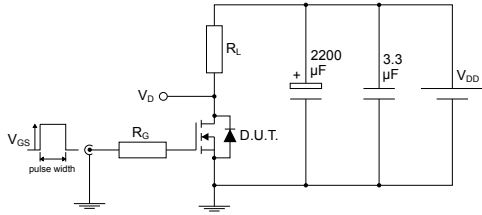


Figure 14. Maximum avalanche energy vs temperature



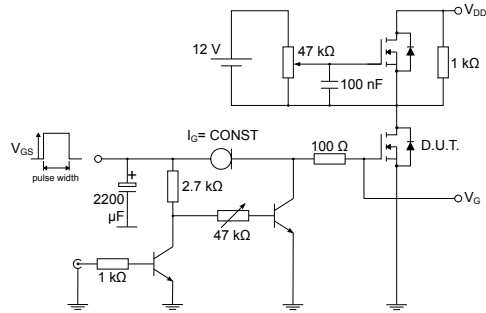
3 Test circuits

Figure 15. Test circuit for resistive load switching times



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Figure 16. Test circuit for gate charge behavior



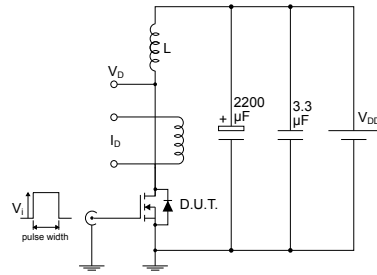
AM01469v1

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



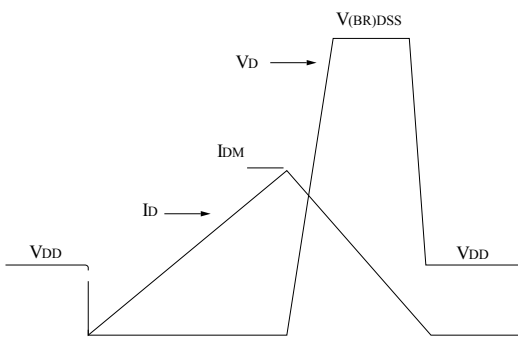
AM01470v1

Figure 18. Unclamped inductive load test circuit



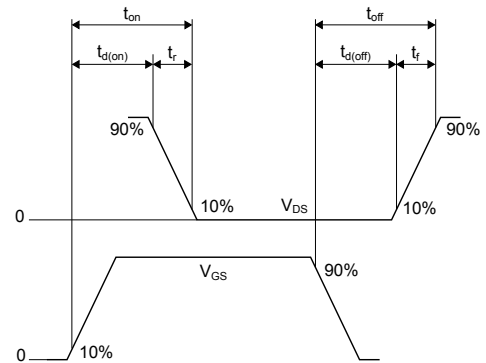
AM01471v1

Figure 19. Unclamped inductive waveform



AM01472v1

Figure 20. Switching time waveform



AM01473v1

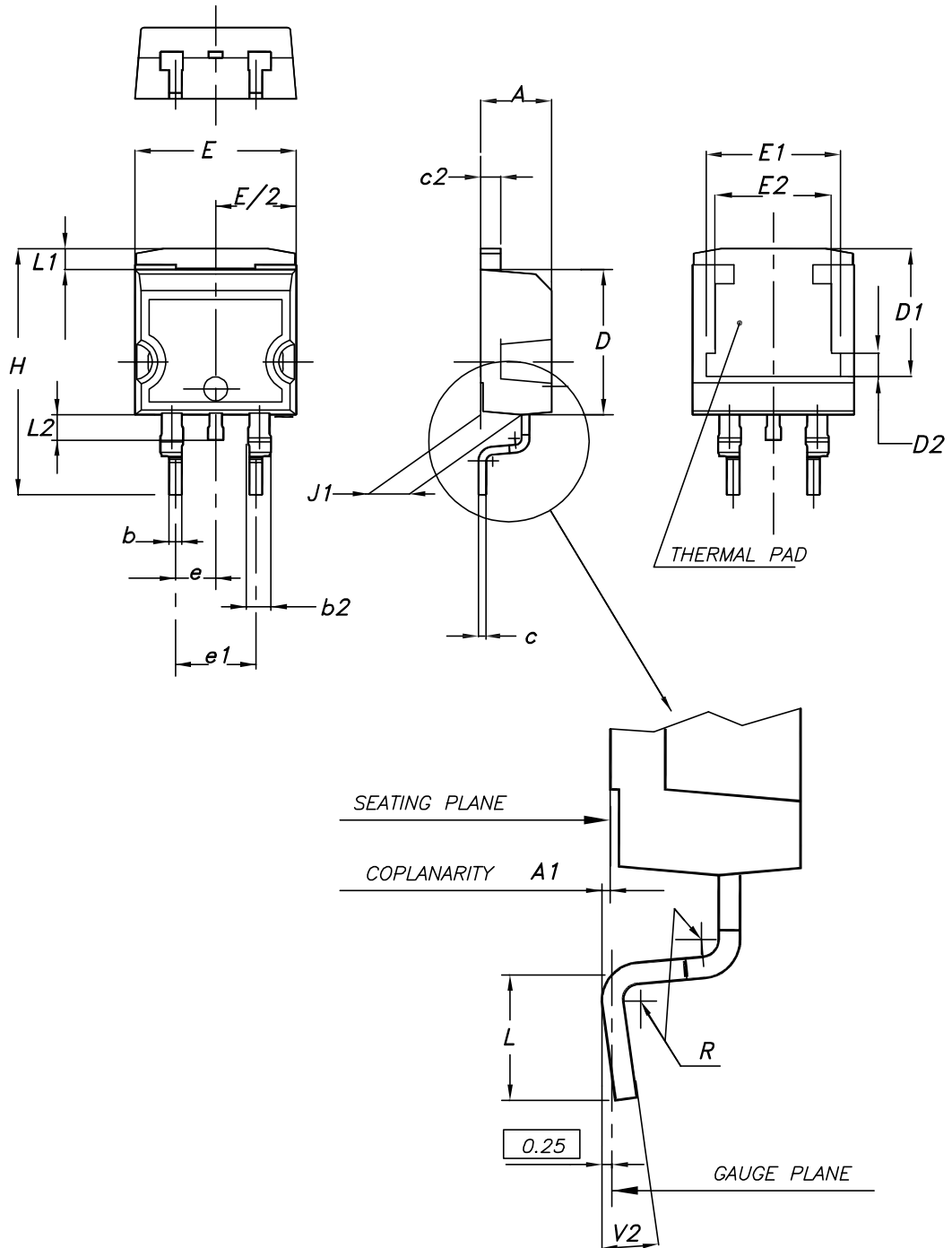


4 Package information

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. ECOPACK® is an ST trademark.

4.1 D²PAK (TO-263) type A package information

Figure 21. D²PAK (TO-263) type A package outline

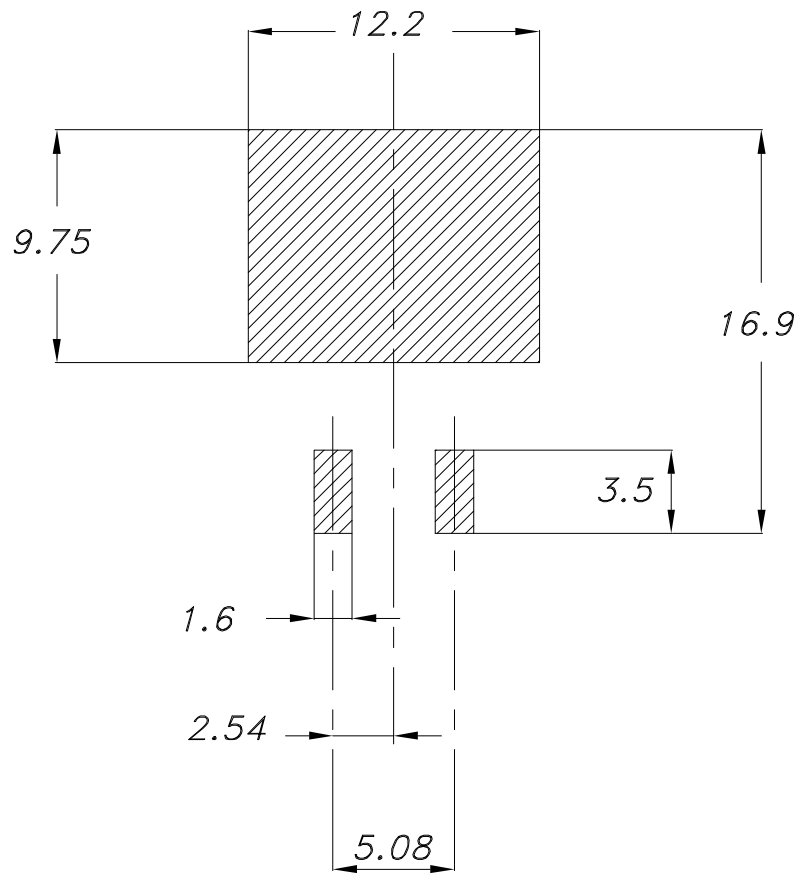


0079457_25

Table 9. D²PAK (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°

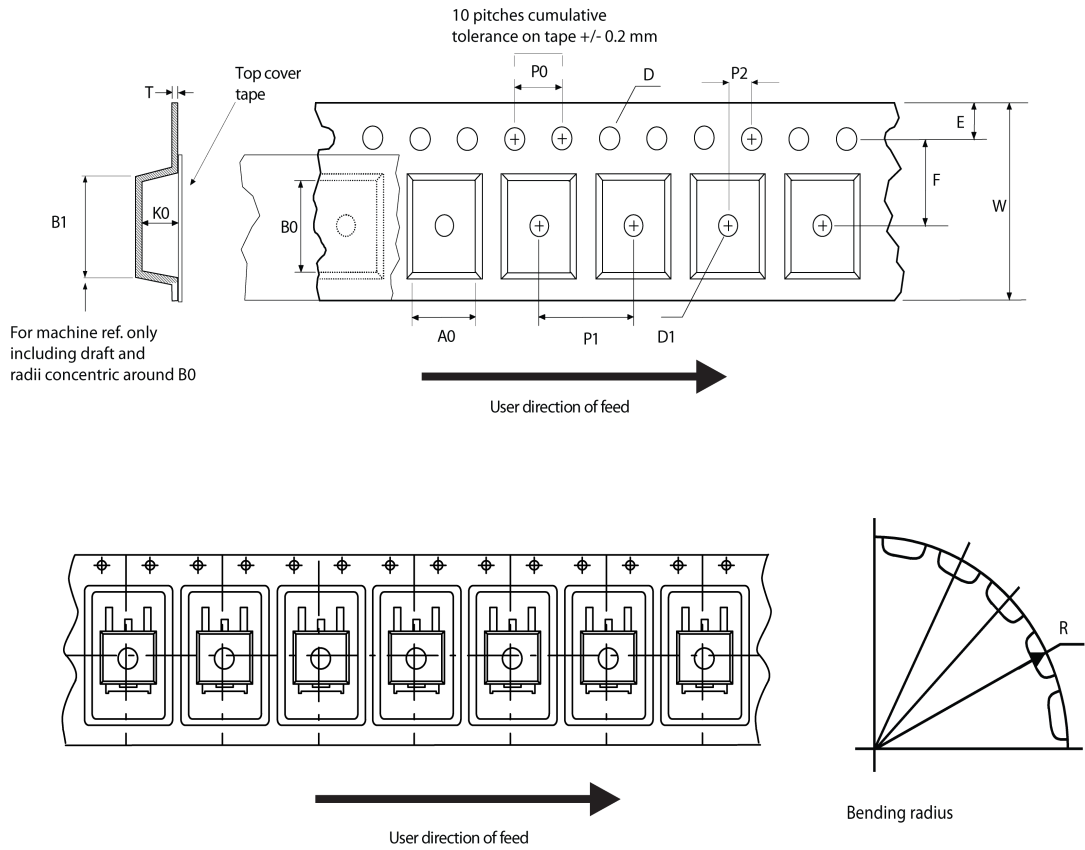
Figure 22. D²PAK (TO-263) recommended footprint (dimensions are in mm)



Footprint

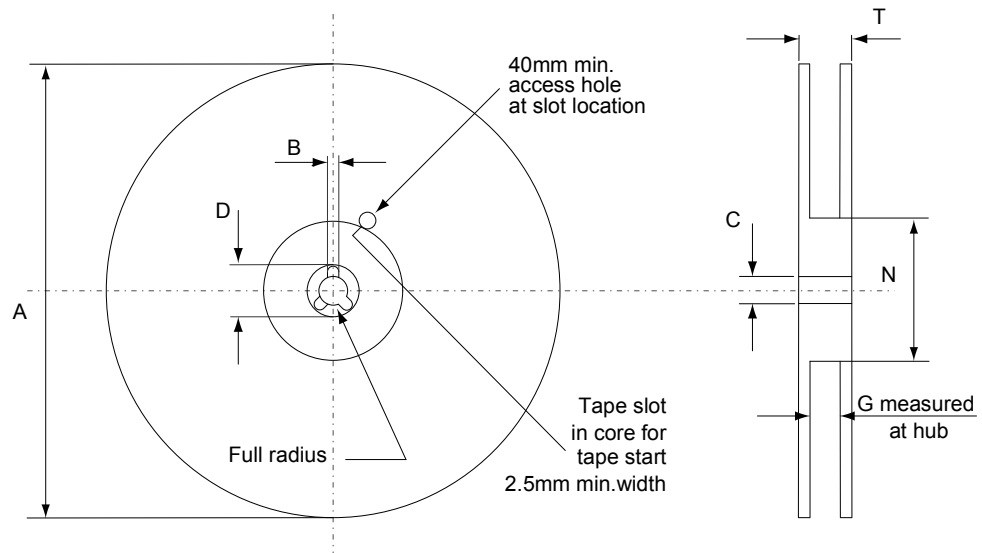
4.2 D²PAK packing information

Figure 23. D²PAK tape outline



AM08852v1

Figure 24. D²PAK reel outline



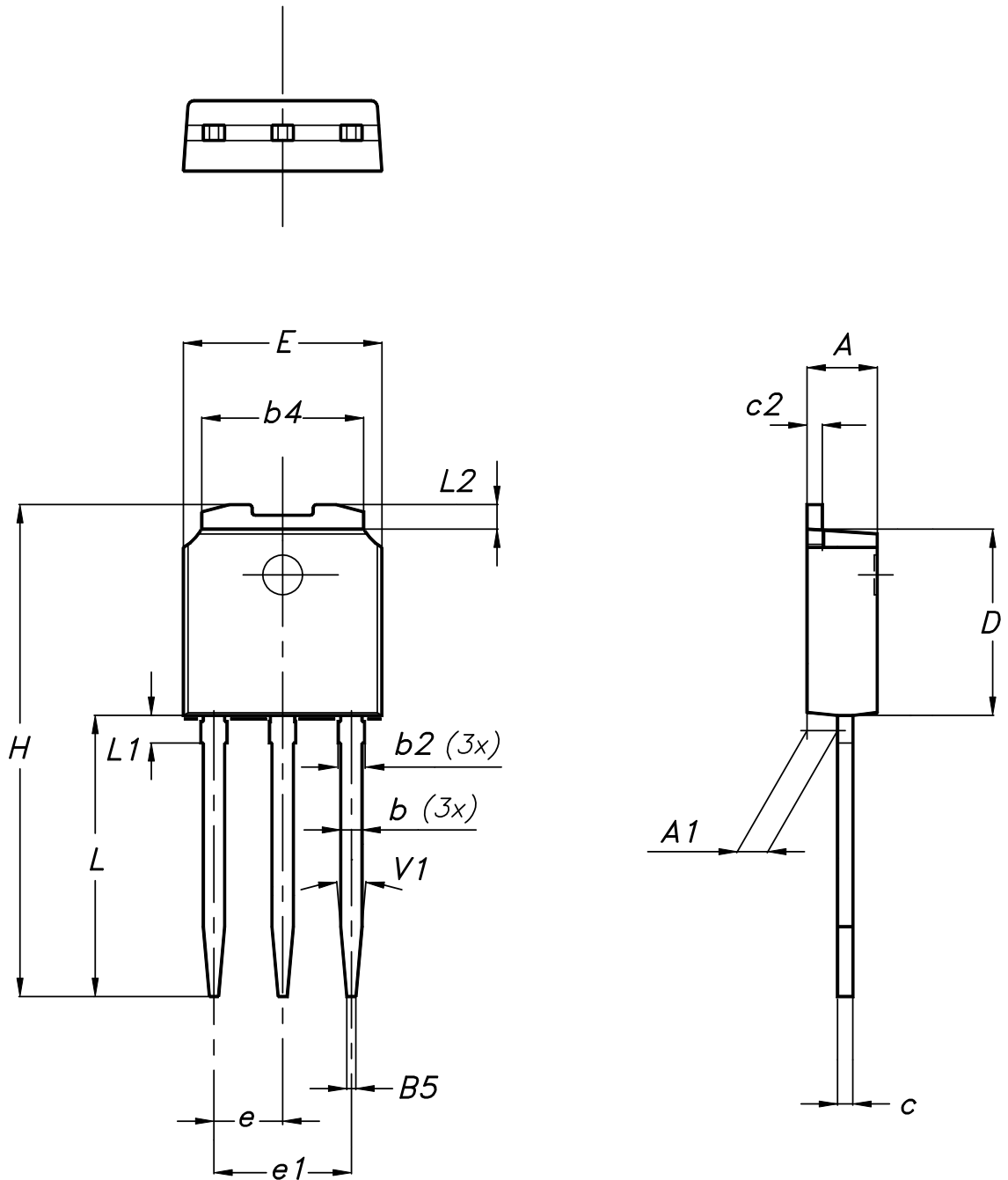
AM06038v1

Table 10. D²PAK 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		
P1	11.9	12.1			
P2	1.9	2.1	Bulk quantity		
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



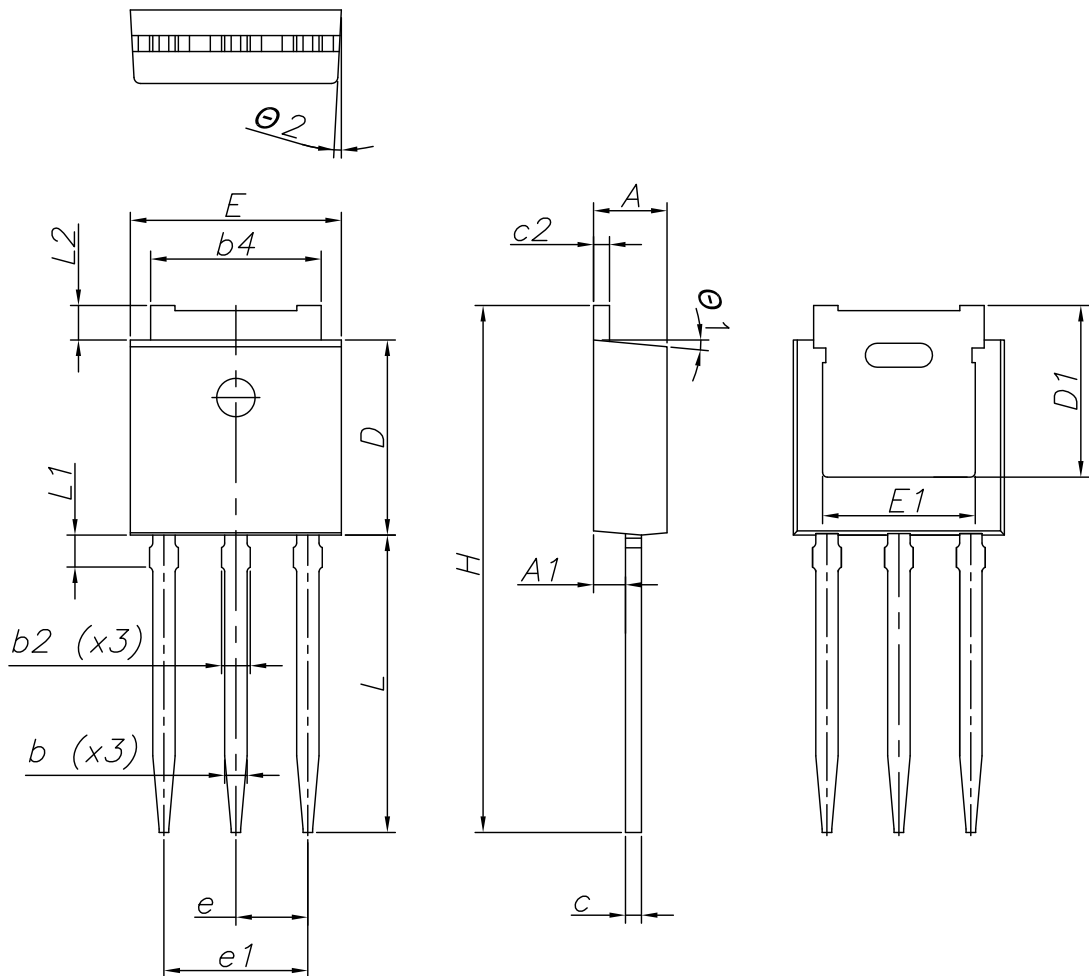
0068771_IK_typeA_rev14

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



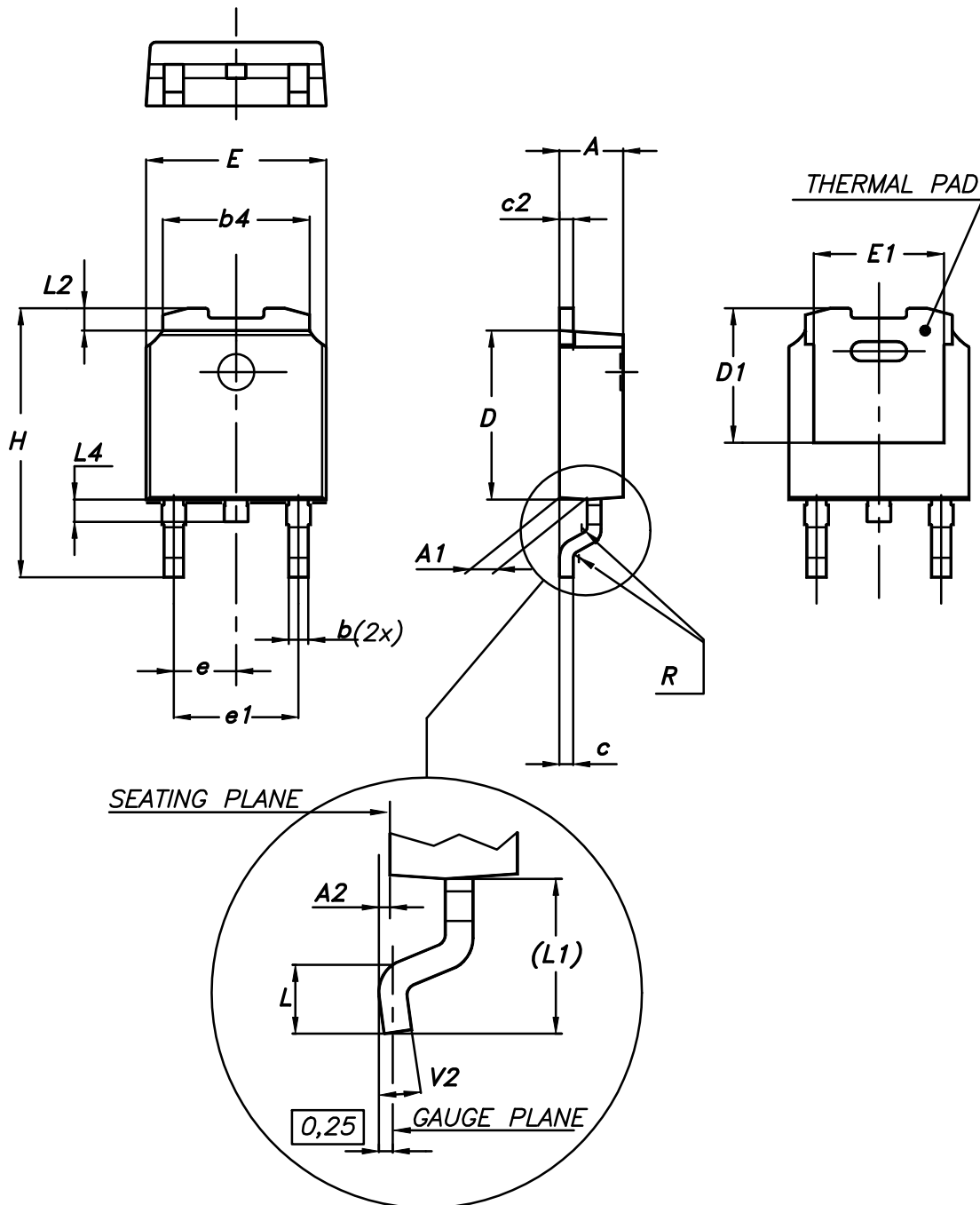
0068771_IK_typeC_rev14

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



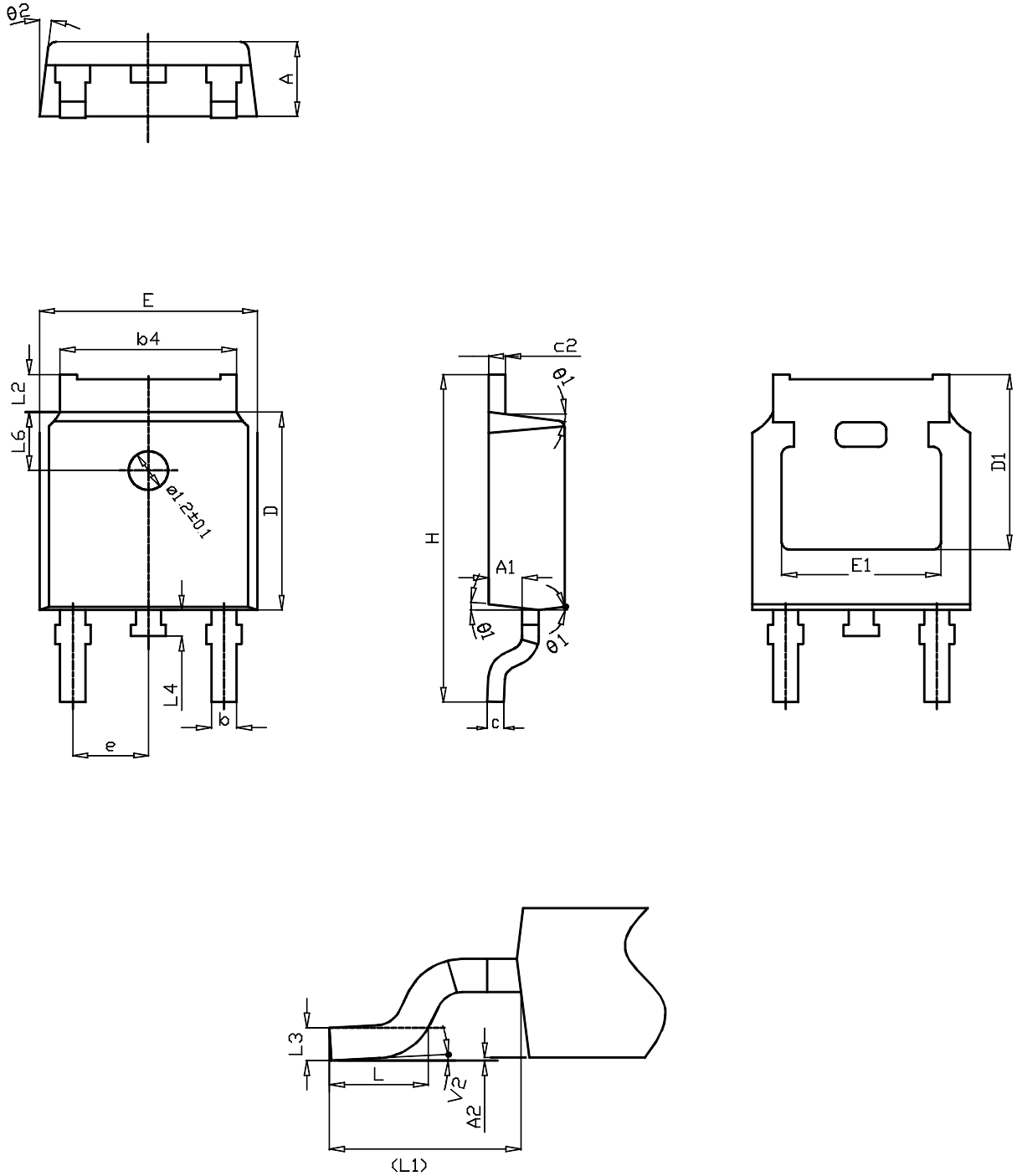
0068772_A_25

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

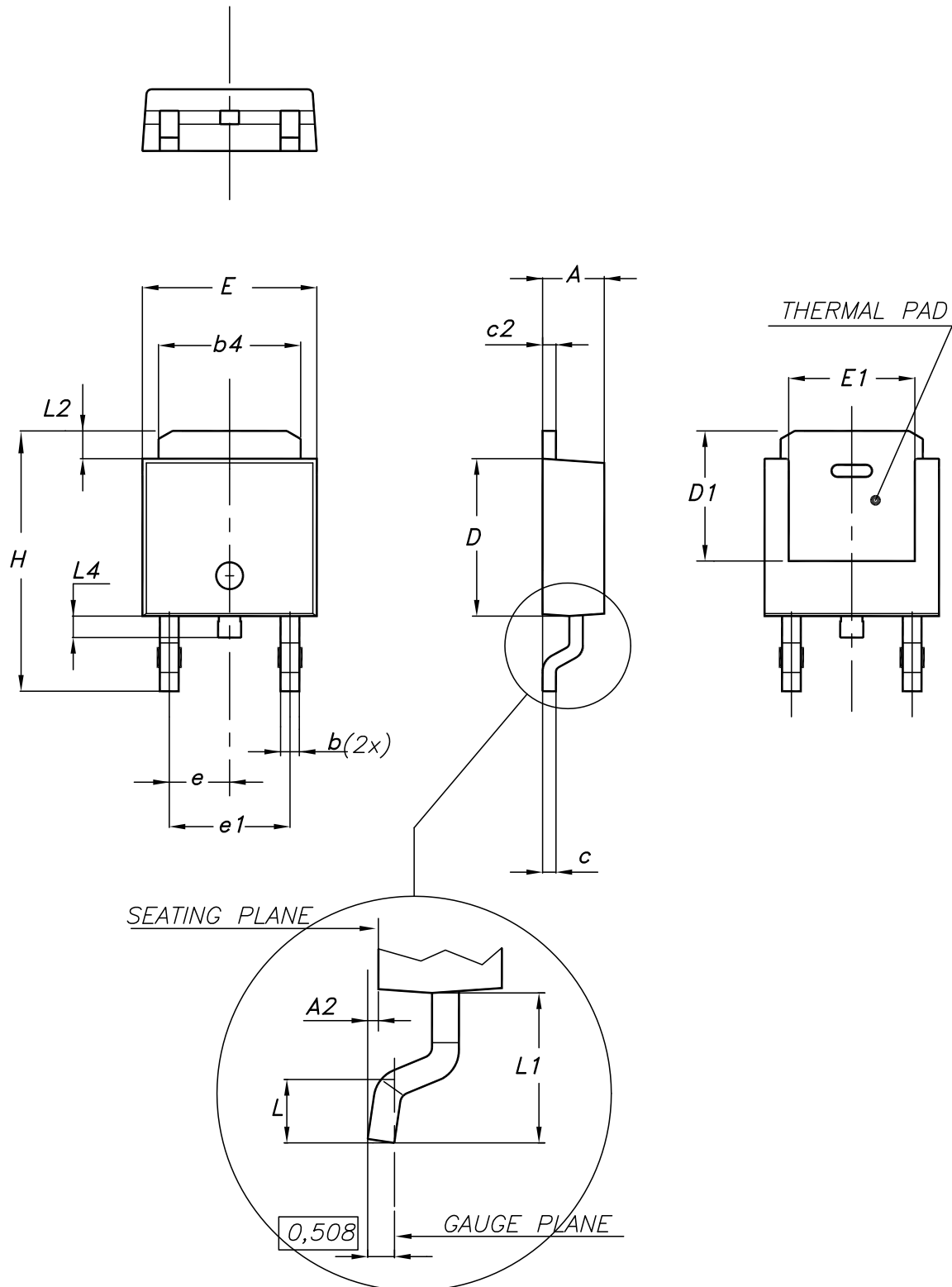
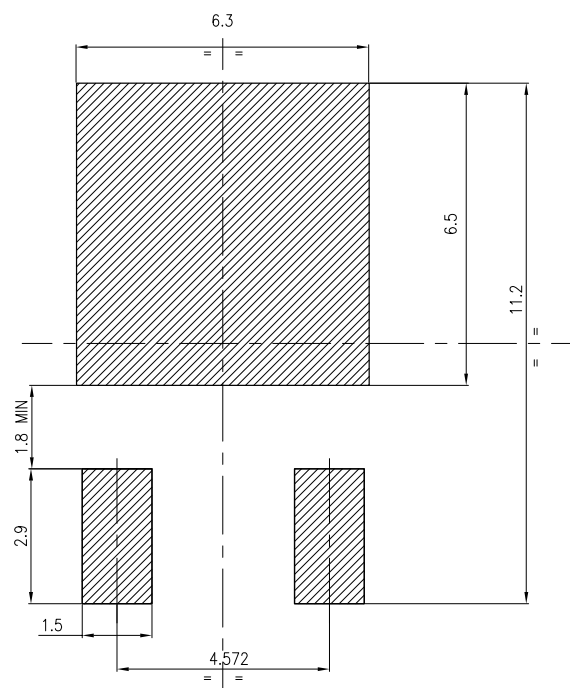


Table 15. DPAK (TO-252) type E mechanical data

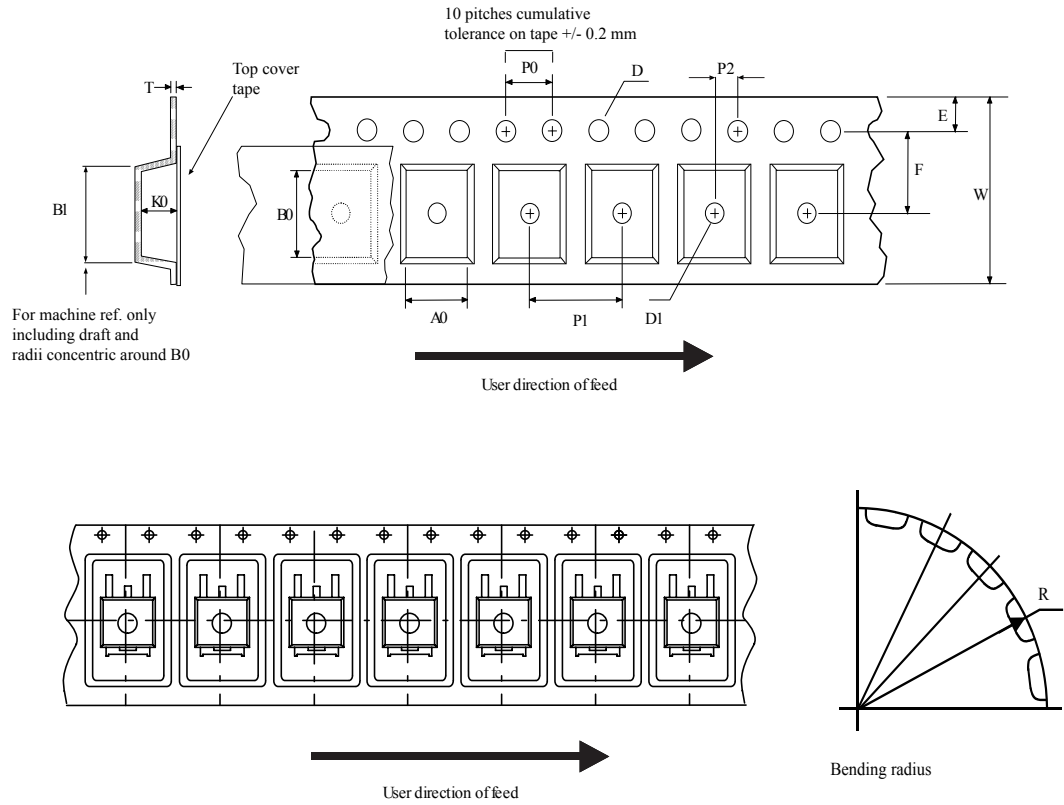
Dim.	mm		
	Min.	Typ.	Max.
A	2.18		2.39
A2			0.13
b	0.65		0.884
b4	4.95		5.46
c	0.46		0.61
c2	0.46		0.60
D	5.97		6.22
D1	5.21		
E	6.35		6.73
E1	4.32		
e		2.286	
e1		4.572	
H	9.94		10.34
L	1.50		1.78
L1		2.74	
L2	0.89		1.27
L4			1.02

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


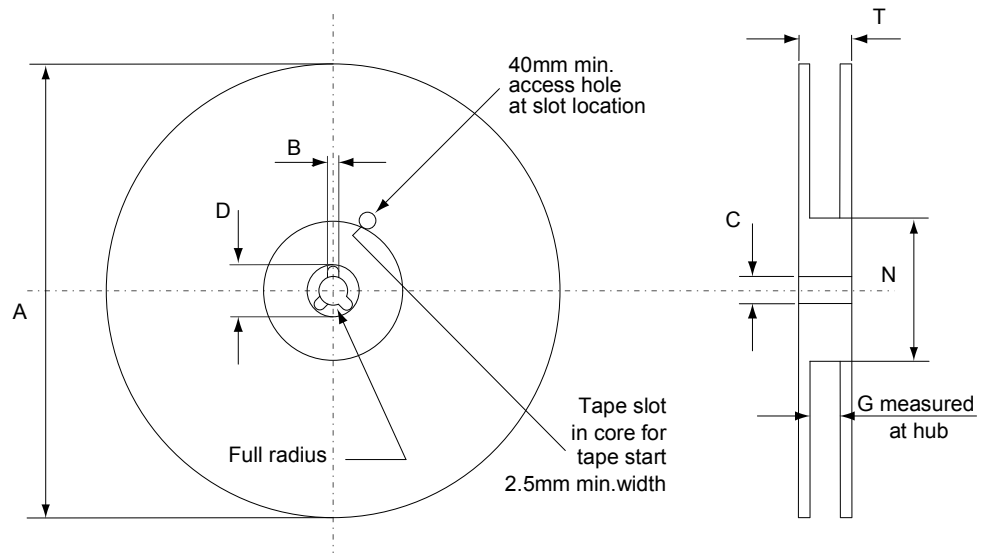
FP_0068772_25

4.8 DPAK (TO-252) packing information

Figure 31. DPAK (TO-252) tape outline



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Figure 32. DPAK (TO-252) reel outline


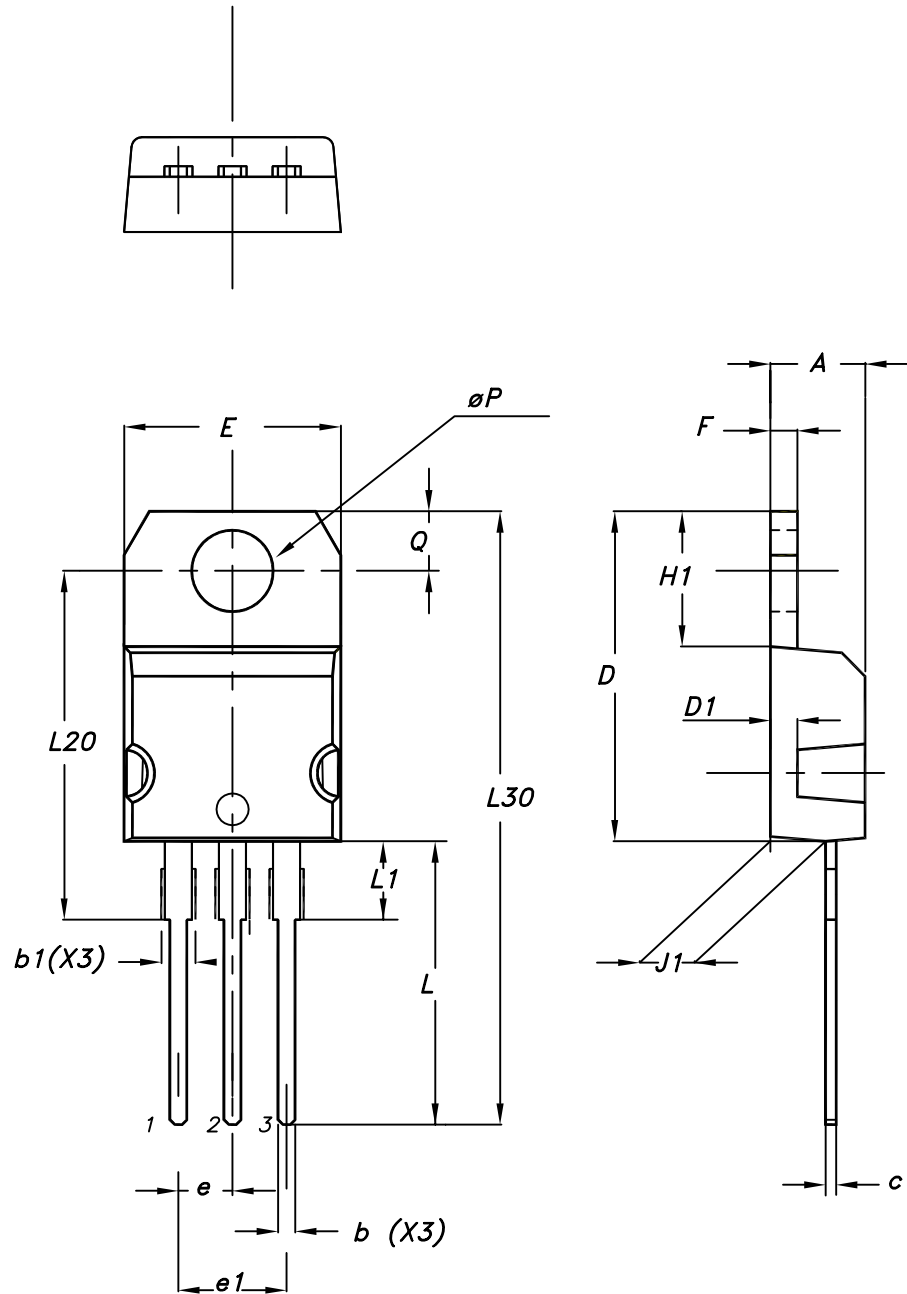
AM06038v1

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



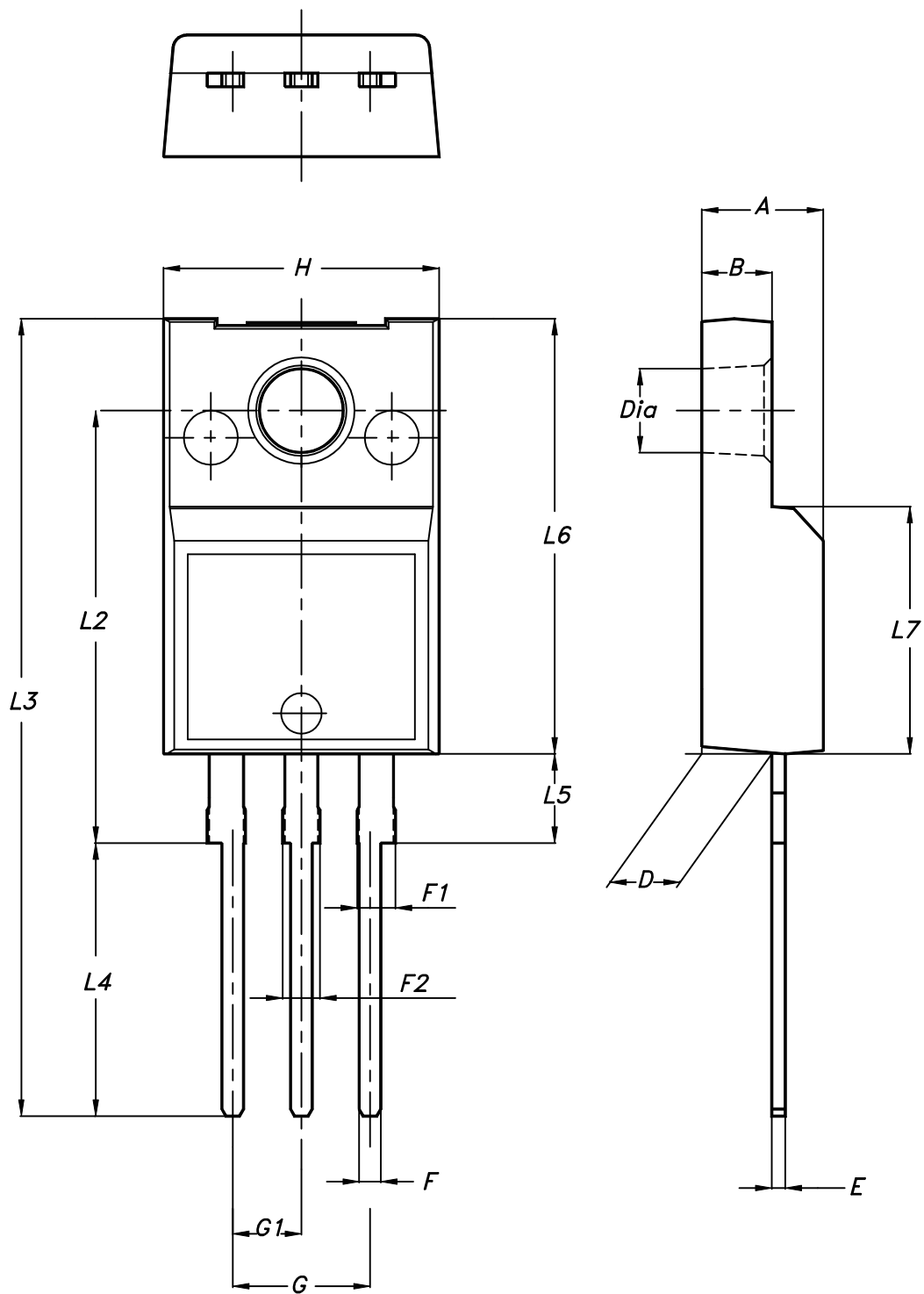
0015988_typeA_Rev_21

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



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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 ² 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 Section 1 Electrical ratings , Section 2 Electrical characteristics and Section 4 Package information . Minor text changes.

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