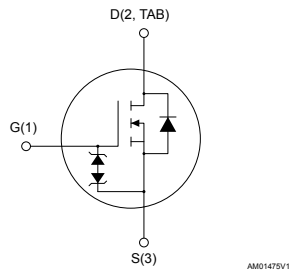
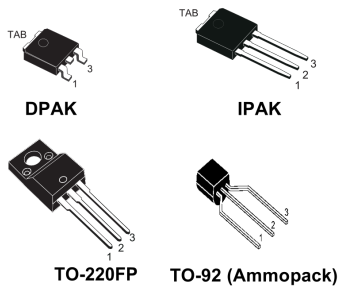


## N-channel 600 V, 3.5 $\Omega$ typ., 2 A SuperMESH™ Power MOSFETs in DPAK, IPAK, TO-220FP and TO-92 packages



### Features

Order code	$V_{DS}$	$R_{DS(on)max.}$	$I_D$	Package
STD2HMK60Z	600 V	4.8 $\Omega$	2 A	DPAK
STD2HMK60Z-1				IPAK
STF2HMK60Z				TO-220FP
STQ2HMK60ZR-AP			0.5 A	TO-92

- 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

STD2HMK60Z

STD2HMK60Z-1

STF2HMK60Z

STQ2HMK60ZR-AP

# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

Symbol	Parameter	Value			Unit
		DPAK, IPAK	TO-220FP	TO-92	
$V_{DS}$	Drain-source voltage	600			V
$V_{GS}$	Gate-source voltage	±30			V
$I_D$	Drain current (continuous) at $T_C = 25\text{ °C}$	2.0	2.0 <sup>(1)</sup>	0.5	A
$I_D$	Drain current (continuous) at $T_C = 100\text{ °C}$	1.26	1.26 <sup>(1)</sup>	0.32	A
$I_{DM}^{(2)}$	Drain current (pulsed)	8	8 <sup>(1)</sup>	2	A
$P_{TOT}$	Total dissipation at $T_C = 25\text{ °C}$	45	20	3	W
ESD	Gate-source human body model ( $R = 1.5\text{ k}\Omega$ , $C = 100\text{ pF}$ )	2			kV
$V_{ISO}$	Insulation withstand voltage (RMS) from all three leads to external heat-sink ( $t = 1\text{ s}$ , $T_C = 25\text{ °C}$ )	2500			V
$dv/dt^{(3)}$	Peak diode recovery voltage slope	4.5			V/ns
$T_j$	Operating junction temperature range	-55 to 150			°C
$T_{stg}$	Storage temperature range				

1. Limited by maximum junction temperature.
2. Pulse width limited by safe operating area.
3.  $I_{SD} \leq 2\text{ A}$ ,  $di/dt \leq 200\text{ A}/\mu\text{s}$ ,  $V_{DSpeak} \leq V_{(BR)DSS}$ ,  $V_{DD} = 80\% V_{(BR)DSS}$ .

**Table 2. Thermal data**

Symbol	Parameter	Value			Unit
		DPAK, IPAK	TO-220FP	TO-92	
$R_{thj-case}$	Thermal resistance junction-case	2.77	6.25		°C/W
$R_{thj-amb}$	Thermal resistance junction-ambient	100	62.5	120	°C/W
$R_{thj-pcb}^{(1)}$	Thermal resistance junction-pcb	50			°C/W
$R_{thj-lead}$	Thermal resistance junction-lead			40	°C/W

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 (pulse width limited by $T_j$ Max)	2	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

( $T_{CASE} = 25\text{ °C}$  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	$\mu\text{A}$
		$V_{GS} = 0\text{ V}$ , $V_{DS} = 600\text{ V}$ , $T_C = 125\text{ °C}$ <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	$V_{GS} = 10\text{ V}$ , $I_D = 1\text{ A}$		3.5	4.8	$\Omega$

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

**Table 5. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$C_{iss}$	Input capacitance	$V_{DS} = 25\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GS} = 0\text{ V}$	-	280		$\mu\text{F}$
$C_{oss}$	Output capacitance			38		
$C_{rss}$	Reverse transfer capacitance			7		
$C_{oss\text{ eq.}}^{(1)}$	Equivalent output capacitance	$V_{DS} = 0\text{ to }480\text{ V}$ , $V_{GS} = 0\text{ V}$	-	30		$\mu\text{F}$
$Q_g$	Total gate charge	$V_{DD} = 480\text{ V}$ , $I_D = 2\text{ A}$ , $V_{GS} = 0\text{ to }10\text{ V}$ (see Figure 18. Test circuit for gate charge behavior)	-	11	15	nC
$Q_{gs}$	Gate-source charge			2.25		
$Q_{gd}$	Gate-drain charge			6		

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	$V_{DD} = 300\text{ V}$ , $I_D = 1\text{ A}$ , $R_G = 4.7\text{ }\Omega$ , $V_{GS} = 10\text{ V}$ (see Figure 17. Test circuit for resistive load switching times and Figure 22. Switching time waveform)	-	10	-	ns
$t_r$	Voltage rise time			30		
$t_{d(off)}$	Turn-off delay time			23		
$t_f$	Fall time			50		

**Table 7. Source drain diode**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{SD}$	Source-drain current				2	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)		-		8	
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 2\text{ A}$ , $V_{GS} = 0\text{ V}$	-		1.3	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 2\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$		178		ns
$Q_{rr}$	Reverse recovery charge	$V_{DD} = 20\text{ V}$ (see <a href="#">Figure 19. Test circuit for inductive load switching and diode recovery times</a> )	-	445		nC
$I_{RRM}$	Reverse recovery current			5		A
$t_{rr}$	Reverse recovery time	$I_{SD} = 2\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$		200		ns
$Q_{rr}$	Reverse recovery charge	$V_{DD} = 20\text{ V}$ , $T_j = 150\text{ }^\circ\text{C}$ (see <a href="#">Figure 19. Test circuit for inductive load switching and diode recovery times</a> )	-	500		nC
$I_{RRM}$	Reverse recovery current			5		A

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

## 2.1 Electrical characteristics curves

Figure 1. Safe operating area for DPAK/IPAK

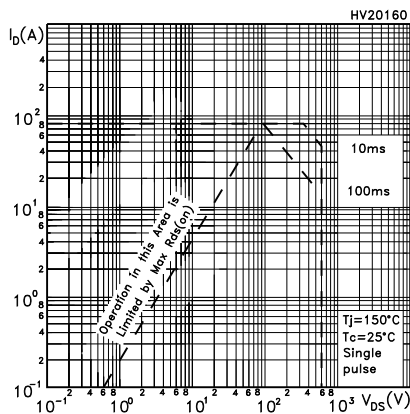


Figure 2. Thermal impedance for DPAK/IPAK

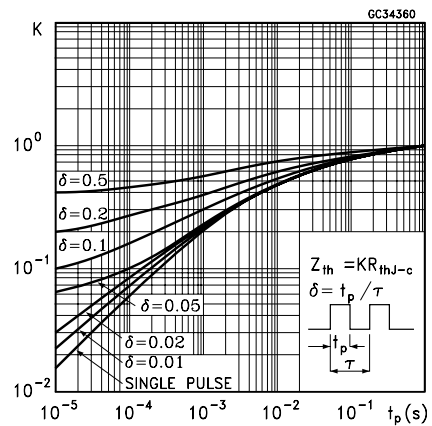


Figure 3. Safe operating area for TO-220FP

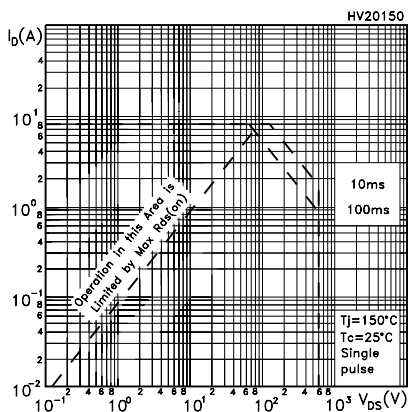


Figure 4. Thermal impedance for TO-220FP

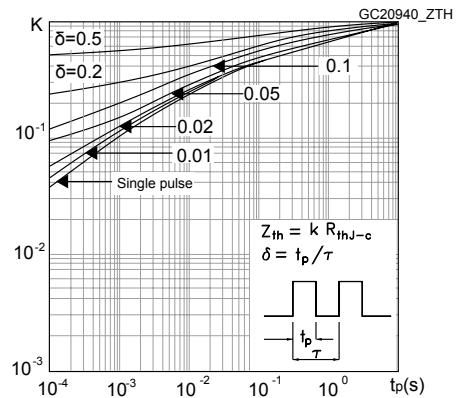


Figure 5. Safe operating area for TO-92

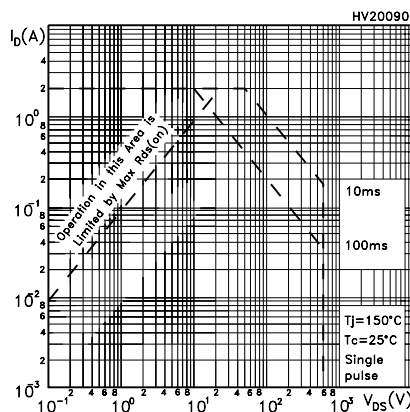


Figure 6. Thermal impedance for TO-92

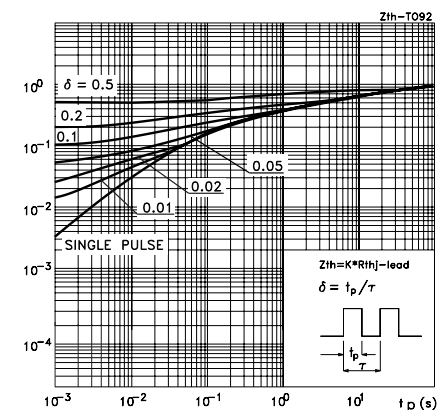


Figure 7. Output characteristics

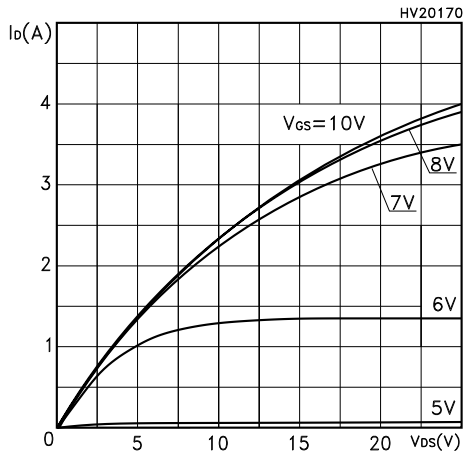


Figure 8. Transfer characteristics

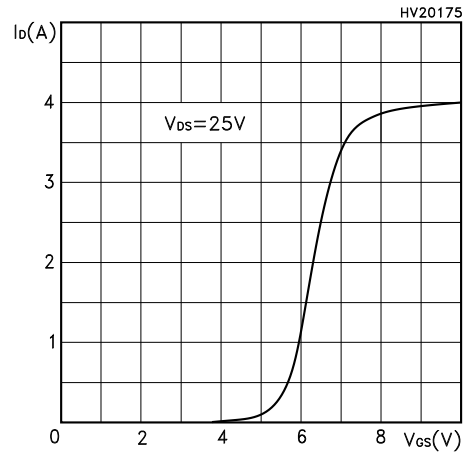


Figure 9. Normalized  $V_{(BR)DSS}$  vs temperature

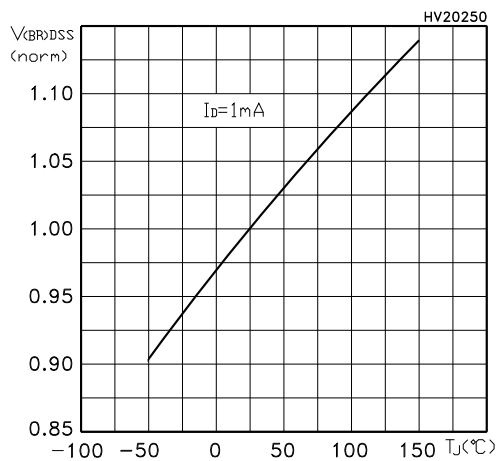


Figure 10. Static drain-source on-resistance

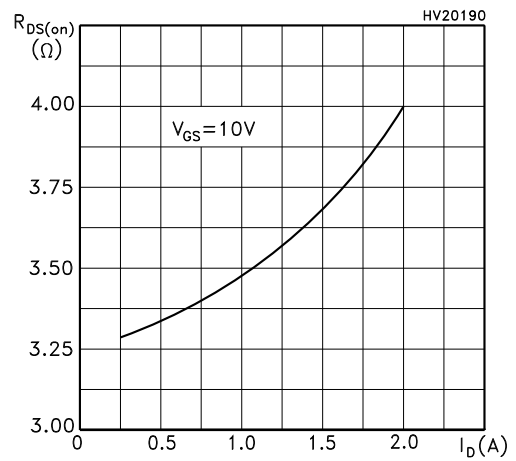


Figure 11. Gate charge vs gate-source voltage

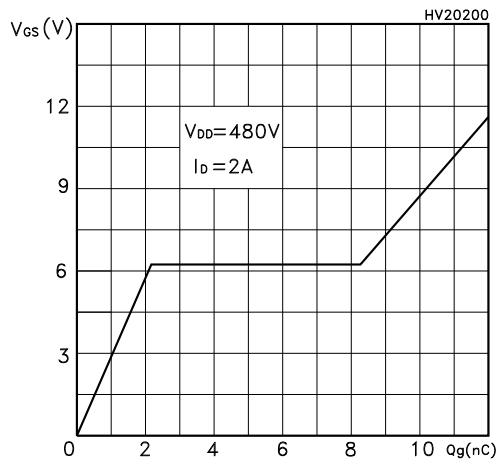
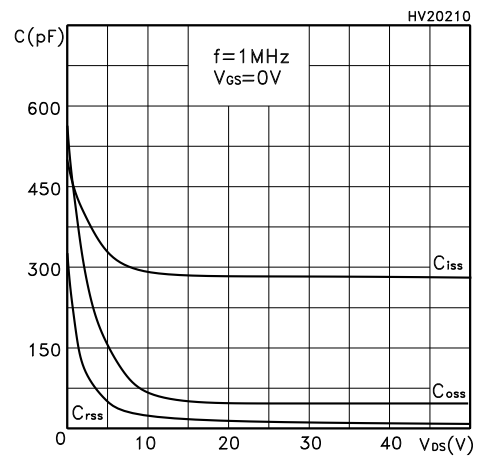
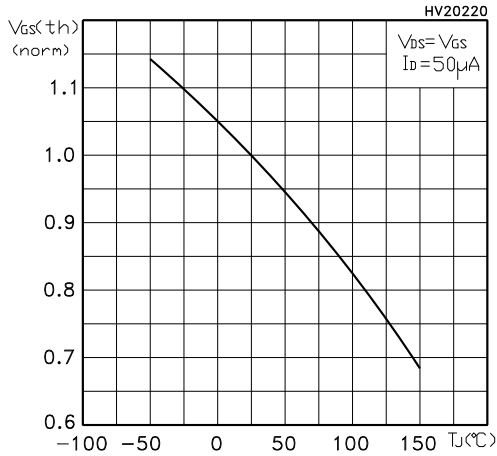


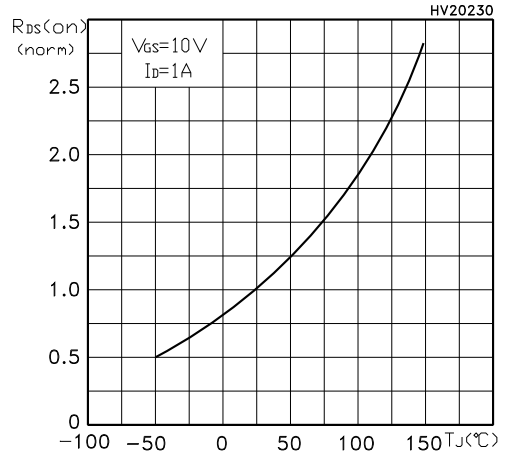
Figure 12. Capacitance variations



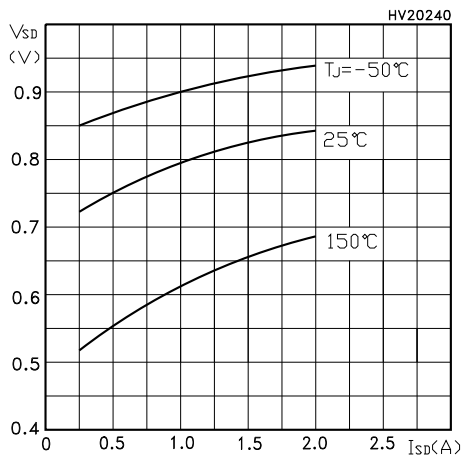
**Figure 13. Normalized gate threshold voltage vs temperature**



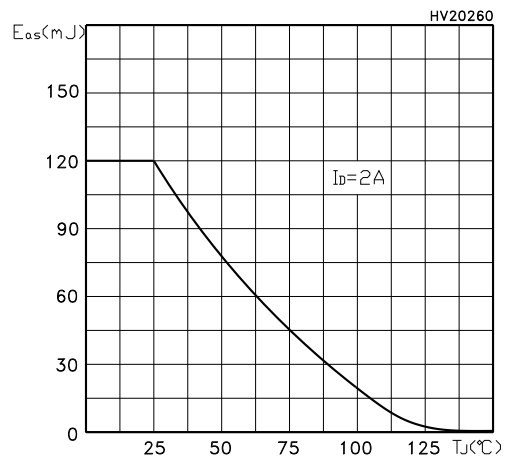
**Figure 14. Normalized on-resistance vs temperature**



**Figure 15. Source-drain diode forward characteristics**



**Figure 16. Maximum avalanche energy vs temperature**



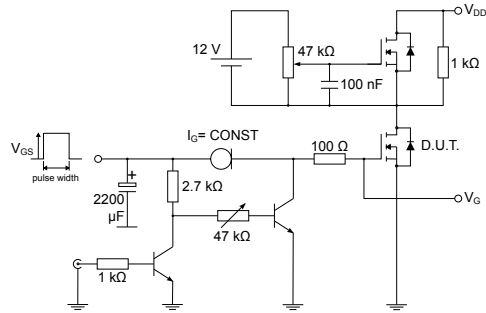
### 3 Test circuits

Figure 17. Test circuit for resistive load switching times



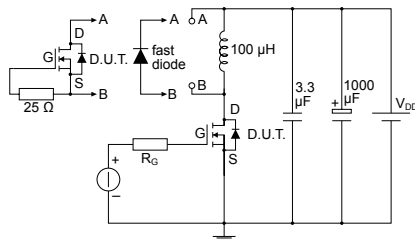
AM01468v1

Figure 18. Test circuit for gate charge behavior



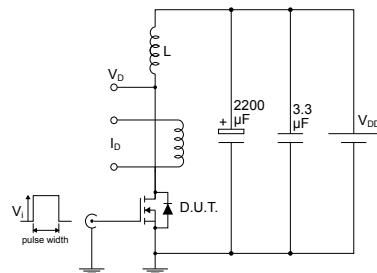
AM01469v1

Figure 19. Test circuit for inductive load switching and diode recovery times



AM01470v1

Figure 20. Unclamped inductive load test circuit



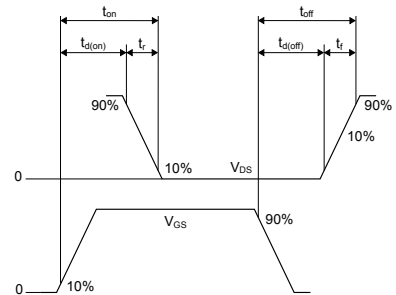
AM01471v1

Figure 21. Unclamped inductive waveform



AM01472v1

Figure 22. Switching time waveform



AM01473v1





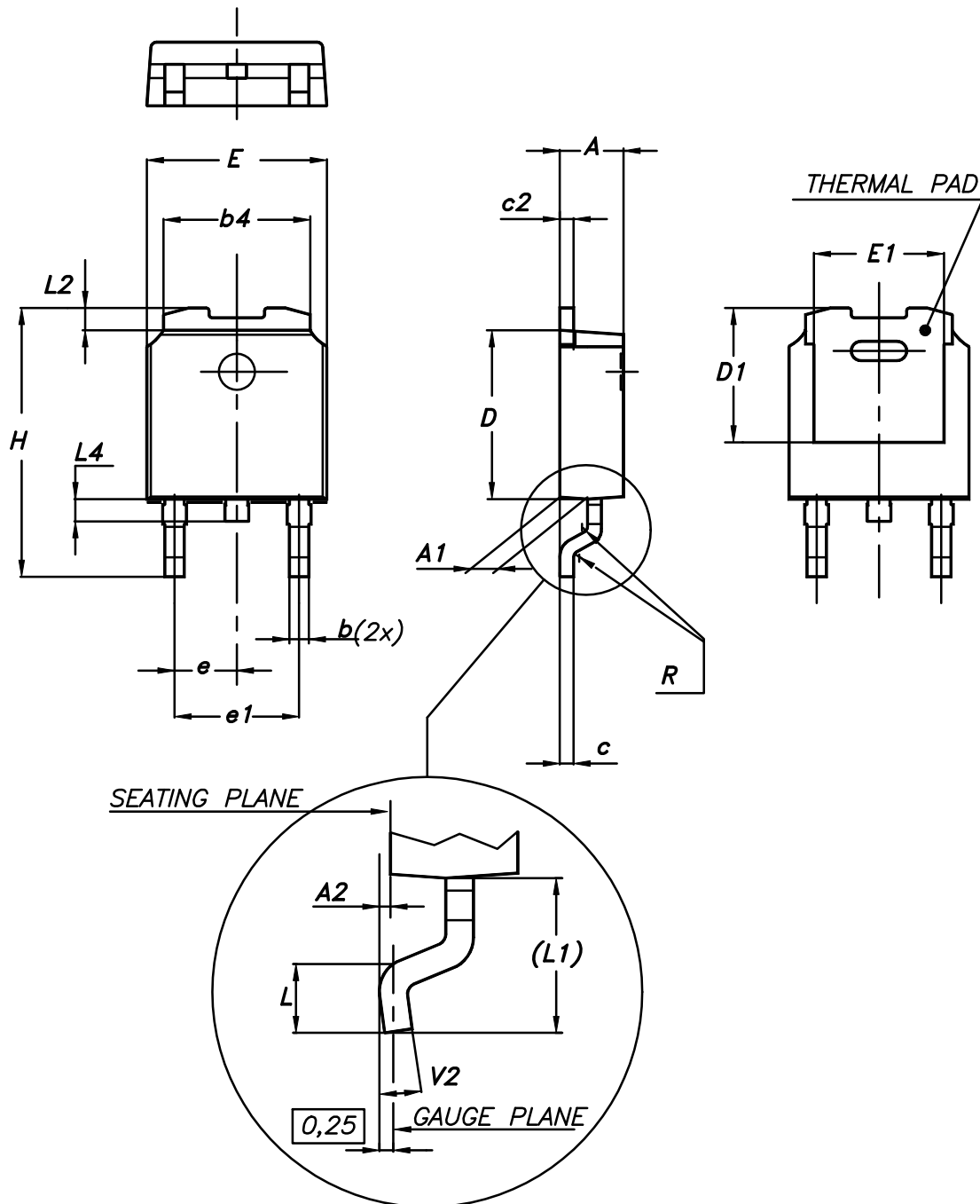
## 4 Package information

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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 DPAK (TO-252) type A package information

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



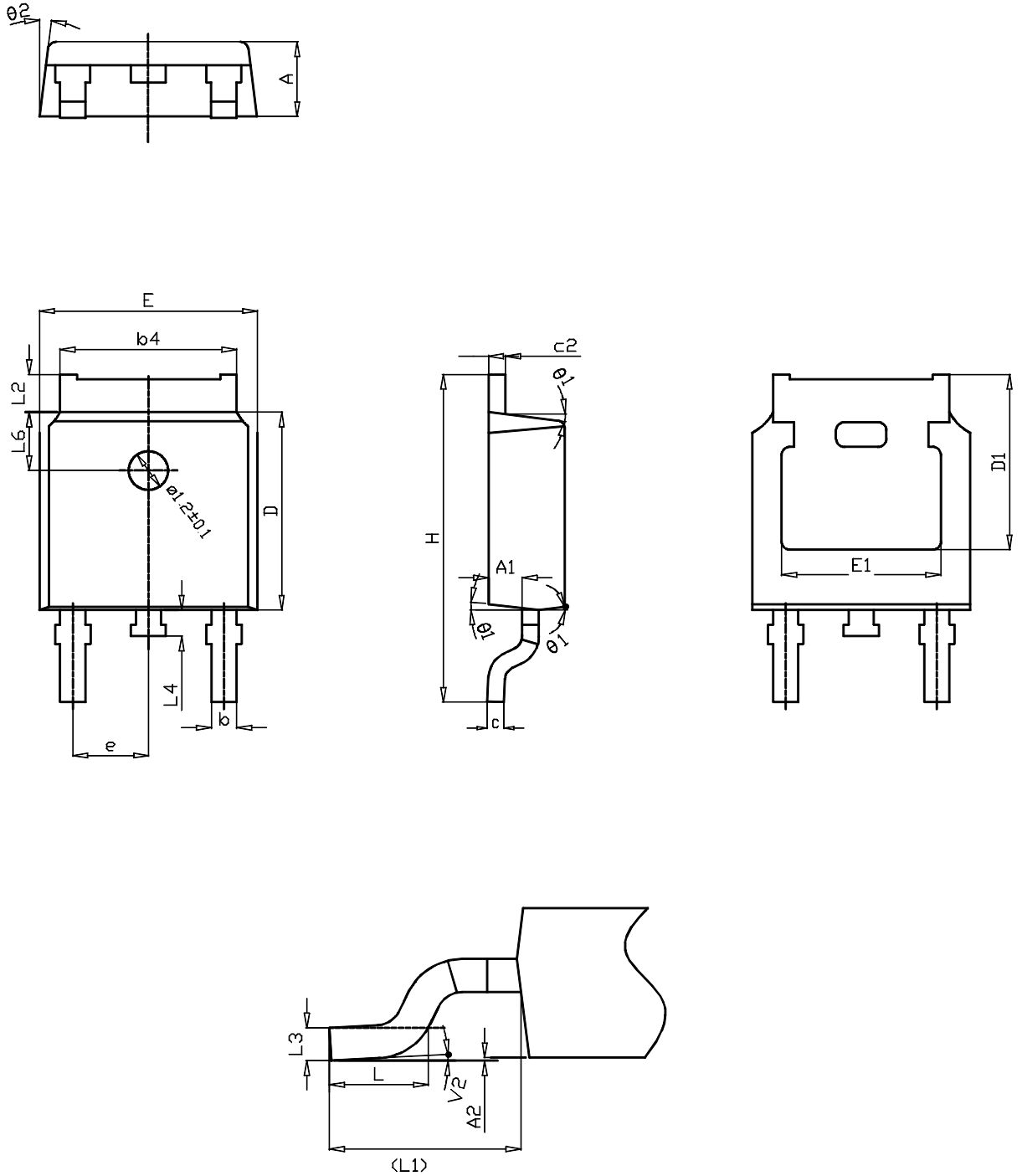
0068772\_A\_25

**Table 8. 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°

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

Figure 24. DPAK (TO-252) type C package outline



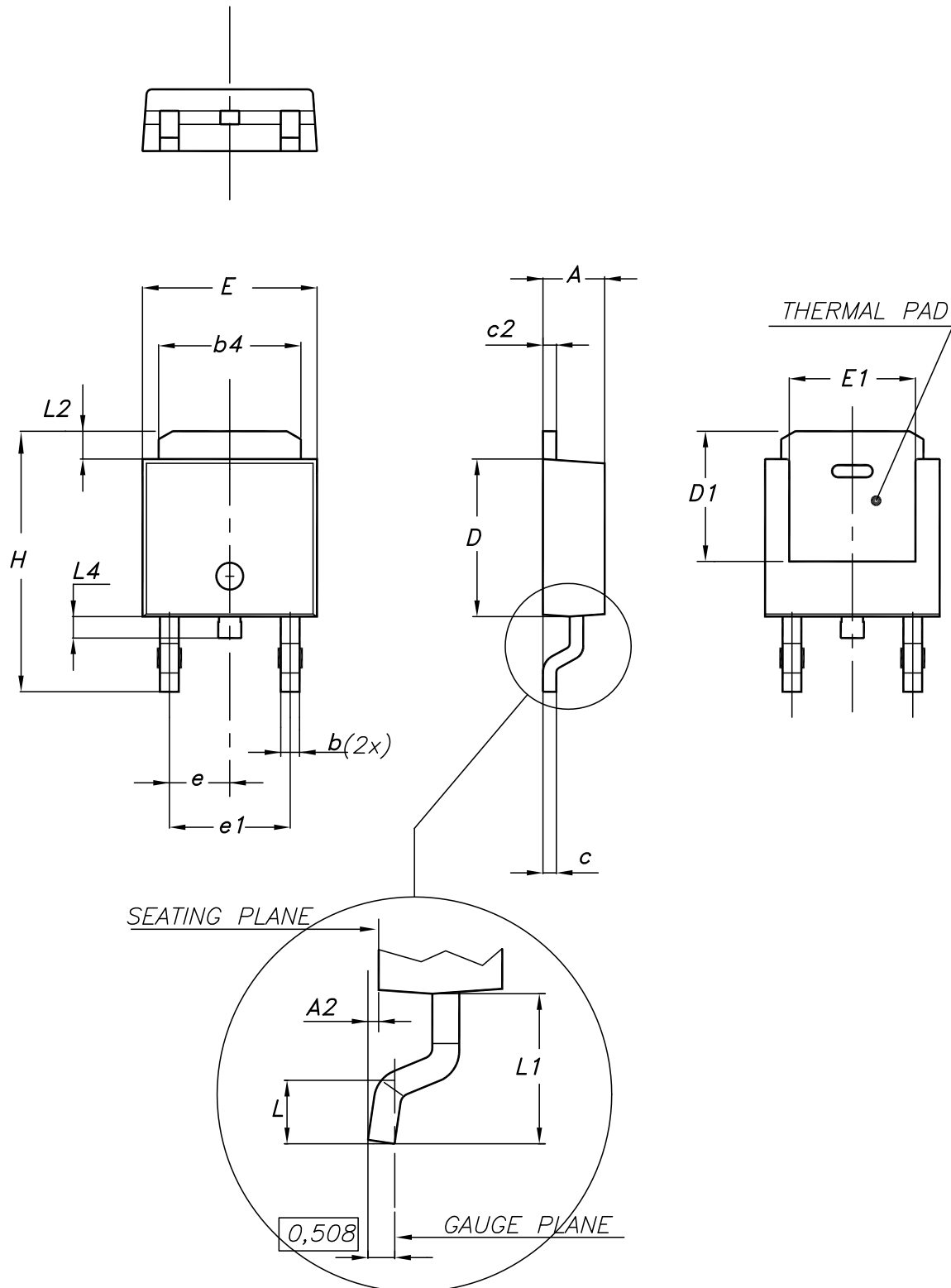
0068772\_C\_25

**Table 9. 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°

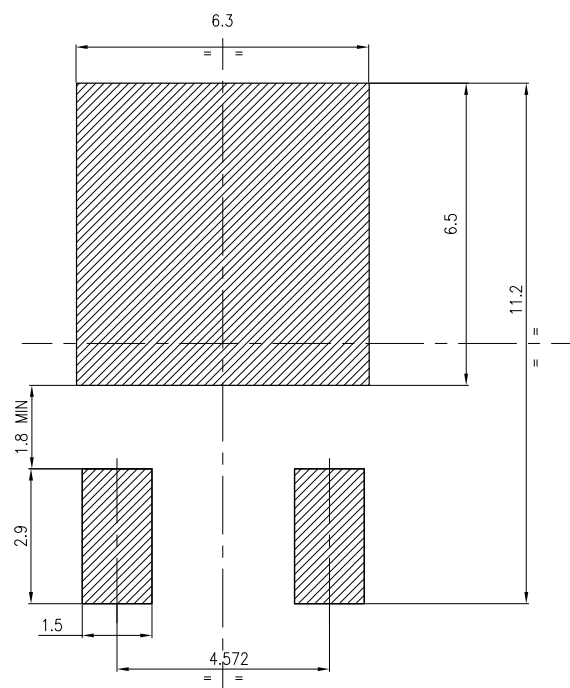
### 4.3 DPAK (TO-252) type E package information

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



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

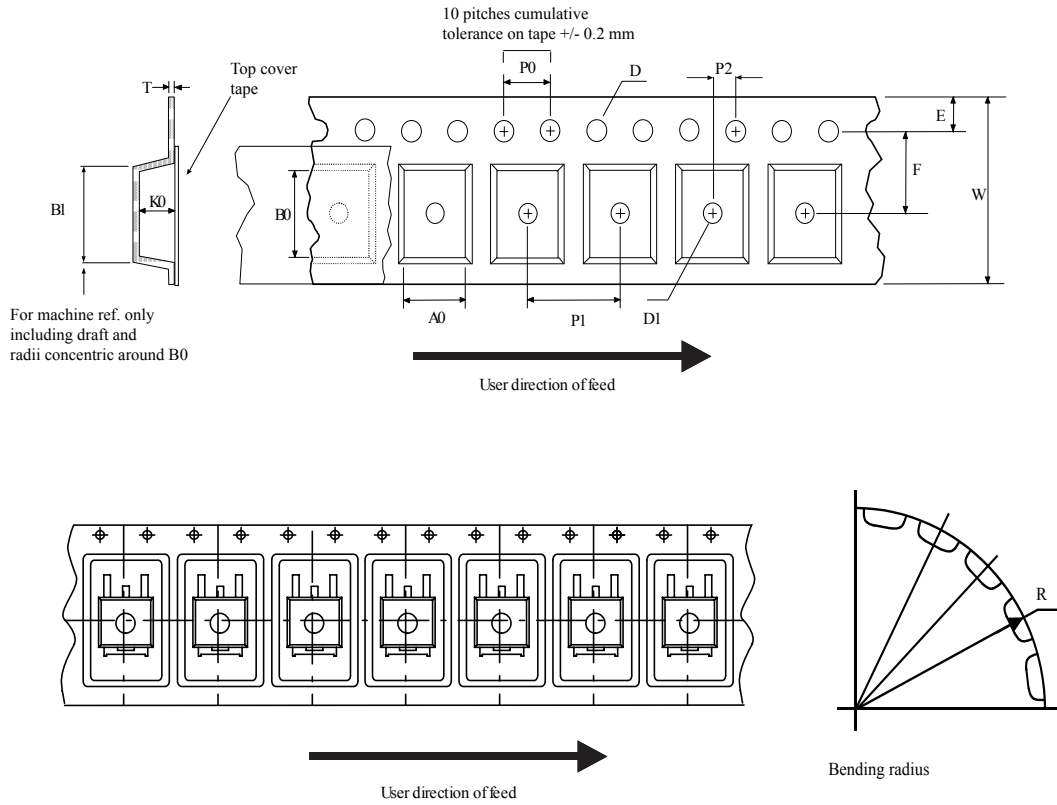
Dim.	mm		
	Min.	Typ.	Max.
A	2.18		2.39
A2			0.13
b	0.65		0.884
b4	4.95		5.46
c	0.46		0.61
c2	0.46		0.60
D	5.97		6.22
D1	5.21		
E	6.35		6.73
E1	4.32		
e		2.286	
e1		4.572	
H	9.94		10.34
L	1.50		1.78
L1		2.74	
L2	0.89		1.27
L4			1.02

**Figure 26. DPAK (TO-252) recommended footprint (dimensions are in mm)**


FP\_0068772\_25

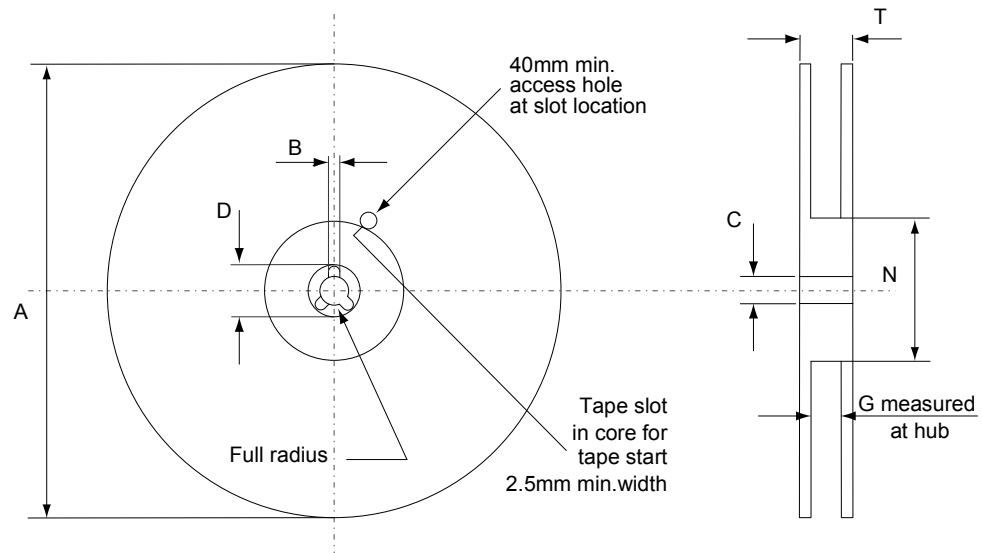
#### 4.4 DPAK (TO-252) packing information

Figure 27. DPAK (TO-252) tape outline



AM08852v1



**Figure 28. DPAK (TO-252) reel outline**


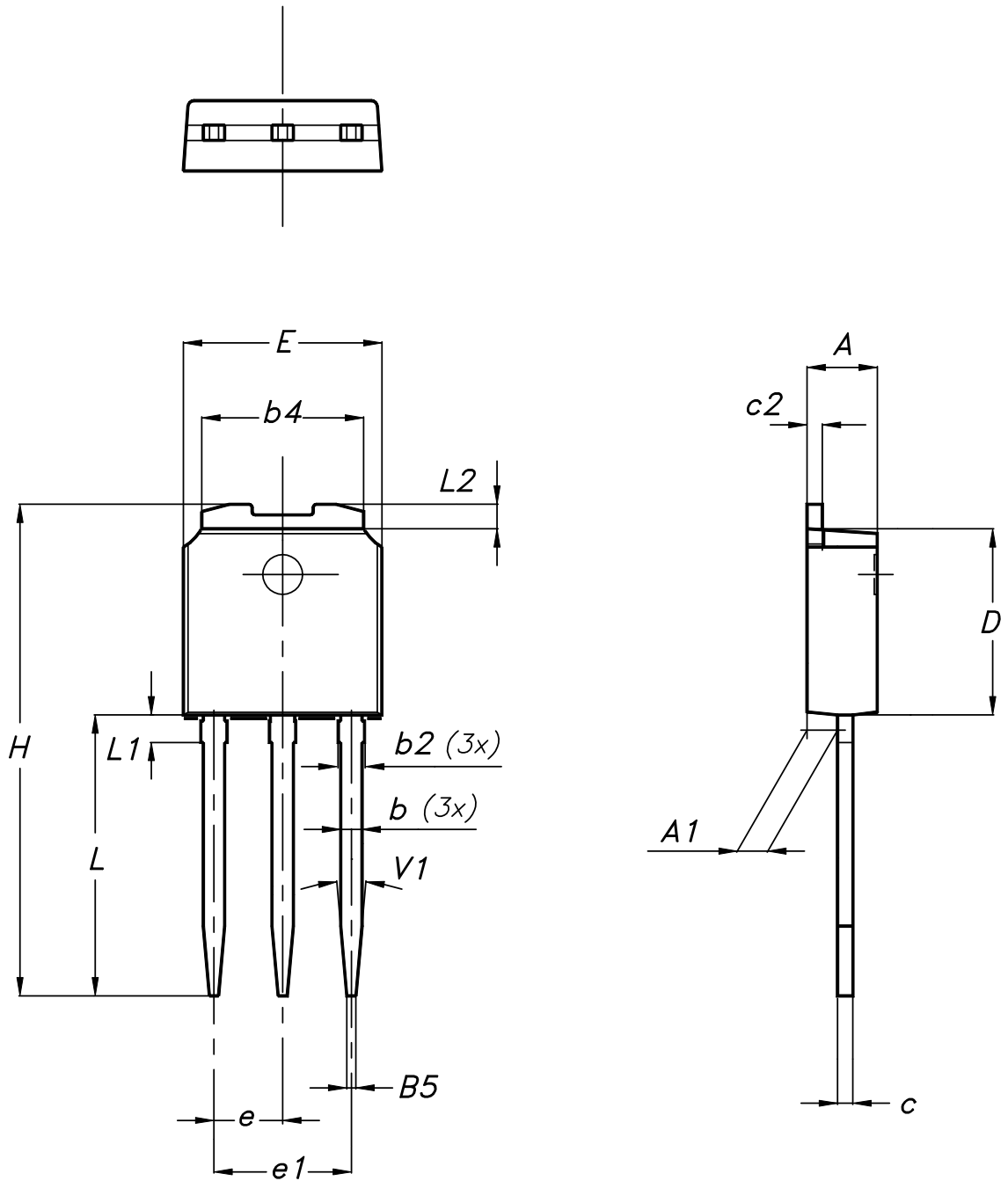
AM06038v1

**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 IPAk (TO-251) type A package information

Figure 29. IPAk (TO-251) type A package outline



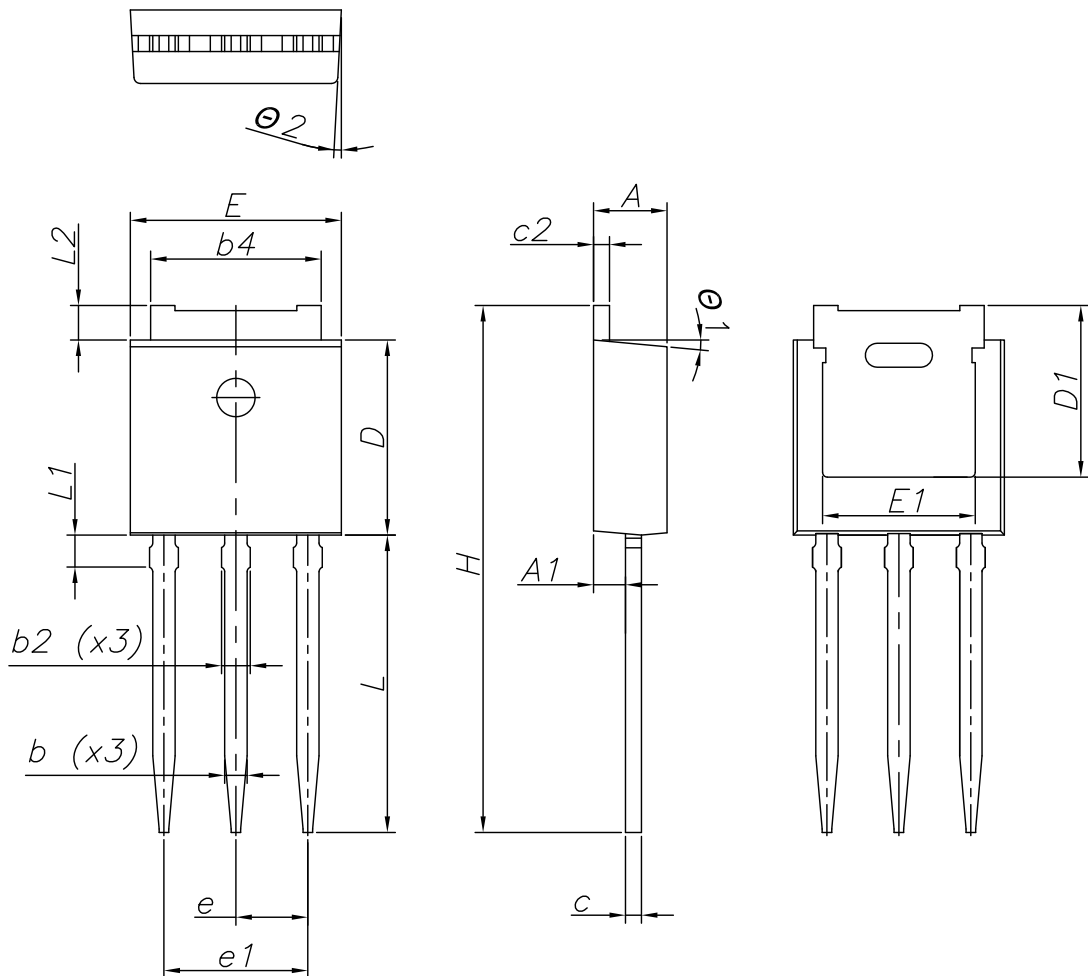
0068771\_IK\_typeA\_rev14

**Table 12. 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°	

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

Figure 30. IPAK (TO-251) type C package outline



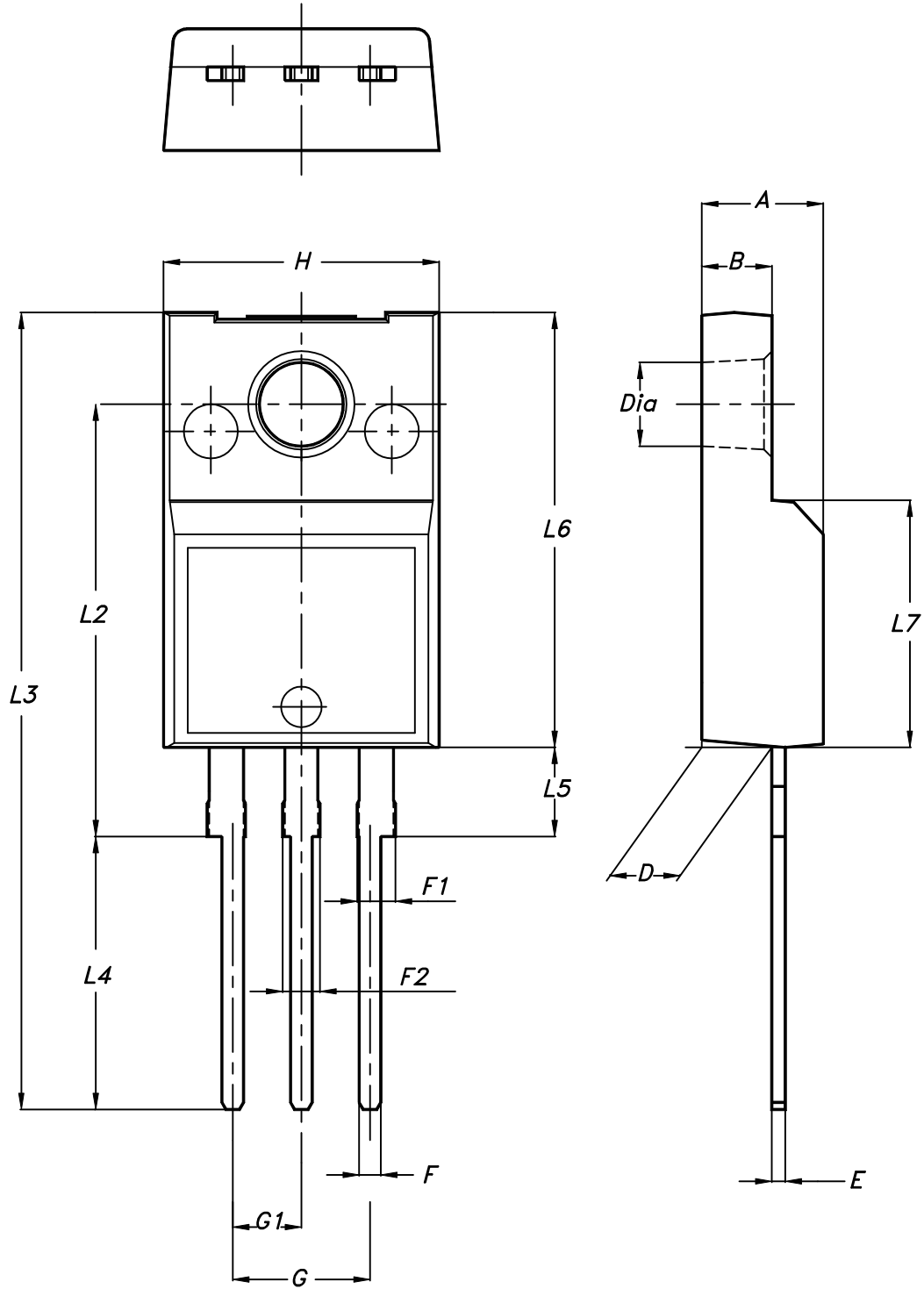
0068771\_IK\_typeC\_rev14

**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	0.80	1.00	1.20
L2	0.90	1.08	1.25
θ1	3°	5°	7°
θ2	1°	3°	5°

4.7 TO-220FP package information

Figure 31. TO-220FP package outline



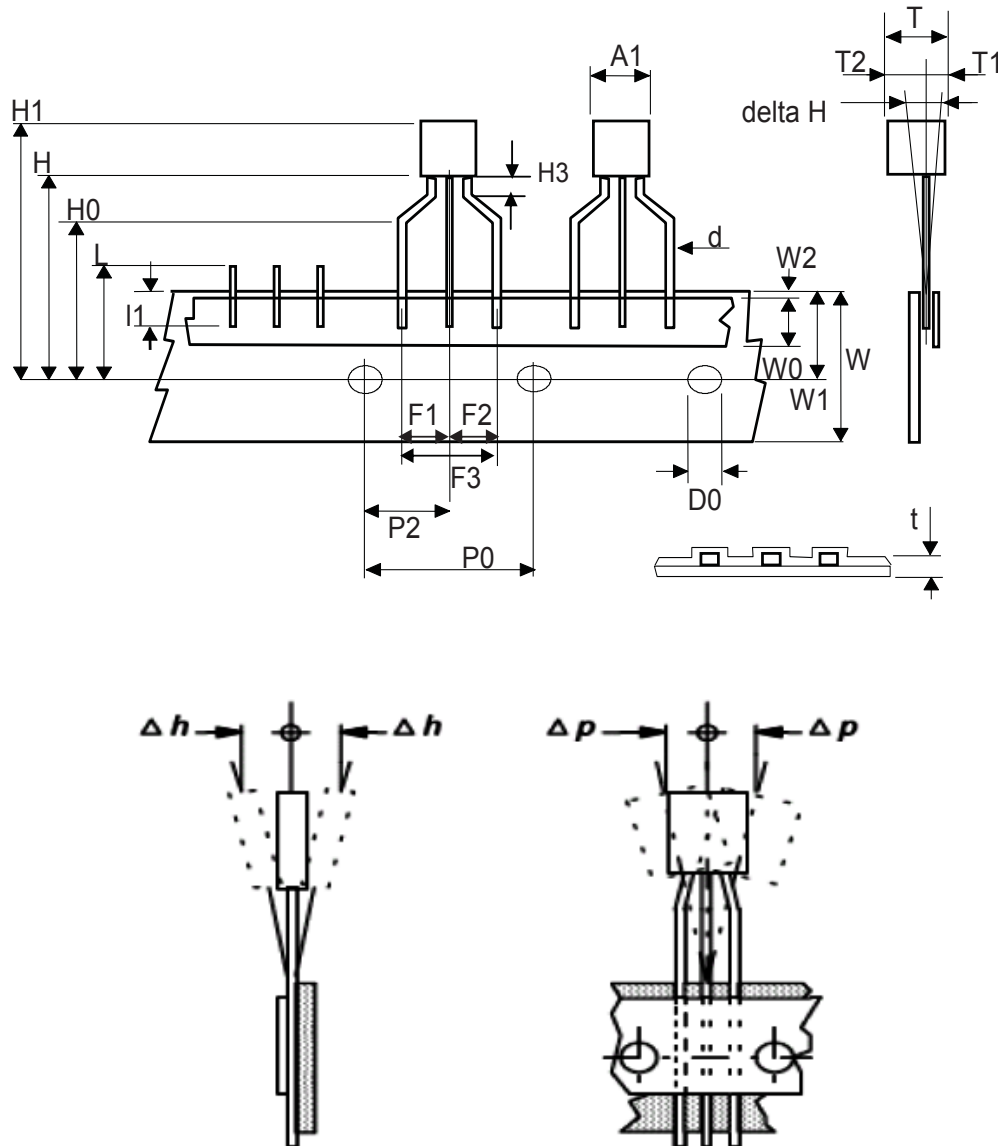
7012510\_Rev\_12\_B

**Table 14. 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

## 4.8 TO-92 Ammopack package information

Figure 32. TO-92 Ammopack package outline



0050910\_Rev\_22



**Table 15. TO-92 Ammopack mechanical data**

Dim.	mm		
	Min.	Typ.	Max.
A1			4.80
T			3.80
T1			1.60
T2			2.30
d	0.45	0.47	0.48
P0	12.50	12.70	12.90
P2	5.65	6.35	7.05
F1, F2	2.40	2.50	2.94
F3	4.98	5.08	5.48
delta H	-2.00		2.00
W	17.50	18.00	19.00
W0	5.50	6.00	6.50
W1	8.50	9.00	9.25
W2			0.50
H		18.50	21.00
H0	15.50	16.00	18.20
H1		25.00	27.00
H3	0.50	1.00	2.00
D0	3.80	4.00	4.20
t			0.90
L			11.00
l1	3.00		
delta P	-1.00		1.00

## 5 Ordering information

Table 16. Order codes

Order code	Marking	Package	Packing
STD2Hnk60Z	D2Hnk60Z	DPAK	Tape and reel
STD2Hnk60Z-1	D2Hnk60Z	IPAK	Tube
STF2Hnk60Z	F2Hnk60Z	TO-220FP	Tube
STQ2Hnk60ZR-AP	Q2Hnk60ZR	TO-92	Ammopack

## Revision history

**Table 17. Document revision history**

Date	Version	Changes
09-Mar-2004	1	First release
23-Mar-2004	2	Modified title
02-Apr-2005	3	Added new section: Electrical characteristics (curves)
06-Mar-2006	4	Inserted DPAK. The document has been reformatted
25-May-2012	5	Corrected unit in Table 5: On/off states
04-Jun-2018	6	Removed maturity status indication from cover page. The document status is production data. Updated title and features in cover page, <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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