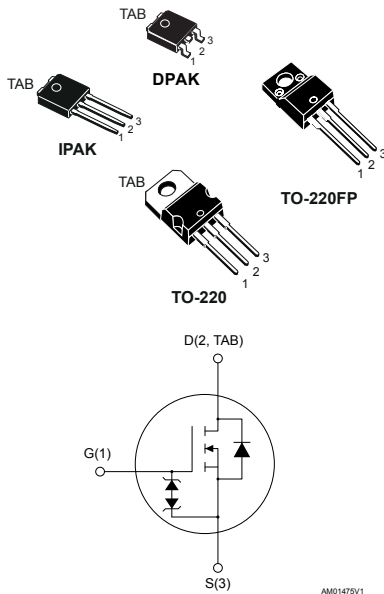


## N-channel 650 V, 0.79 $\Omega$ typ., 5 A MDmesh M2 Power MOSFETs in DPAK, TO-220FP, TO-220 and IPAK packages



### Features

Order codes	$V_{DS}$	$R_{DS(on)}$ max.	$I_D$	Package
STD9N65M2	650 V	0.90 $\Omega$	5 A	DPAK
STF9N65M2				TO-220FP
STP9N65M2				TO-220
STU9N65M2				IPAK

- Extremely low gate charge
- Excellent output capacitance ( $C_{OSS}$ ) profile
- 100% avalanche tested
- Zener-protected

### Applications

- Switching applications

### Description

These devices are N-channel Power MOSFETs developed using the 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.



#### Product status link

[STD9N65M2](#)

[STF9N65M2](#)

[STP9N65M2](#)

[STU9N65M2](#)

# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

Symbol	Parameter	Value		Unit
		DPAK, TO-220, IPAK	TO-220FP	
$V_{GS}$	Gate-source voltage	±25		V
$I_D$	Drain current (continuous) at $T_C = 25\text{ °C}$	5	5 <sup>(1)</sup>	A
$I_D$	Drain current (continuous) at $T_C = 100\text{ °C}$	3.2	3.2 <sup>(1)</sup>	
$I_{DM}$ <sup>(2)</sup>	Drain current (pulsed)	20		A
$P_{TOT}$	Total power dissipation at $T_C = 25\text{ °C}$	60	20	W
$V_{ISO}$	Insulation withstand voltage (RMS) from all three leads to external heat sink ( $t = 1\text{ s}$ ; $T_C = 25\text{ °C}$ )	2.5		kV
$dv/dt$ <sup>(3)</sup>	Peak diode recovery voltage slope	15		V/ns
$dv/dt$ <sup>(4)</sup>	MOSFET $dv/dt$ ruggedness	50		
$T_{stg}$	Storage temperature range	-55 to 150		°C
$T_J$	Operating junction temperature range			

1. Current limited by package.
2. Pulse width is limited by safe operating area.
3.  $I_{SD} \leq 5\text{ A}$ ,  $di/dt = 400\text{ A}/\mu\text{s}$ ;  $V_{DS(peak)} < V_{(BR)DSS}$ ;  $V_{DD} = 400\text{ V}$ .
4.  $V_{DS} \leq 520\text{ V}$ .

**Table 2. Thermal data**

Symbol	Parameter	Value				Unit
		DPAK	TO-220FP	TO-220	IPAK	
$R_{thj-case}$	Thermal resistance junction-case	2.08	6.25	2.08		°C/W
$R_{thj-pcb}$	Thermal resistance junction-pcb	50				°C/W
$R_{thj-amb}$ <sup>(1)</sup>	Thermal resistance junction-ambient		62.5		100	°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)	1	A
$E_{AS}$	Single pulse avalanche energy (starting $T_J = 25\text{ °C}$ , $I_D = I_{AR}$ ; $V_{DD} = 50\text{ V}$ )	105	mJ

## 2 Electrical characteristics

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

**Table 4. On/off states**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source breakdown voltage	$V_{GS} = 0\text{ V}$ , $I_D = 1\text{ mA}$	650			V
$I_{DSS}$	Zero gate voltage drain current	$V_{GS} = 0\text{ V}$ , $V_{DS} = 650\text{ V}$			1	$\mu\text{A}$
		$V_{GS} = 0\text{ V}$ , $V_{DS} = 650\text{ V}$ , $T_C = 125\text{ °C}$ <sup>(1)</sup>			100	$\mu\text{A}$
$I_{GSS}$	Gate-body leakage current	$V_{DS} = 0\text{ V}$ , $V_{GS} = \pm 25\text{ V}$			$\pm 10$	$\mu\text{A}$
$V_{GS(th)}$	Gate threshold voltage	$V_{DS} = V_{GS}$ , $I_D = 250\text{ }\mu\text{A}$	2	3	4	V
$R_{DS(on)}$	Static drain-source on-resistance	$V_{GS} = 10\text{ V}$ , $I_D = 2.5\text{ A}$		0.79	0.90	$\Omega$

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

**Table 5. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$C_{iss}$	Input capacitance	$V_{DS} = 100\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GS} = 0\text{ V}$	-	310	-	pF
$C_{oss}$	Output capacitance		-	18	-	pF
$C_{riss}$	Reverse transfer capacitance		-	0.9	-	pF
$C_{oss\text{ eq.}}$ <sup>(1)</sup>	Equivalent capacitance energy related	$V_{DS} = 0\text{ to }520\text{ V}$ , $V_{GS} = 0\text{ V}$	-	109	-	pF
$R_g$	Intrinsic gate resistance	$f = 1\text{ MHz}$ open drain	-	6.6	-	$\Omega$
$Q_g$	Total gate charge	$V_{DD} = 520\text{ V}$ , $I_D = 5\text{ A}$	-	10.3	-	nC
$Q_{gs}$	Gate-source charge	$V_{GS} = 0\text{ to }10\text{ V}$	-	2.4	-	nC
$Q_{gd}$	Gate-drain charge	(see Figure 18. Test circuit for gate charge behavior)	-	4.8	-	nC

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%  $V_{DSS}$ .

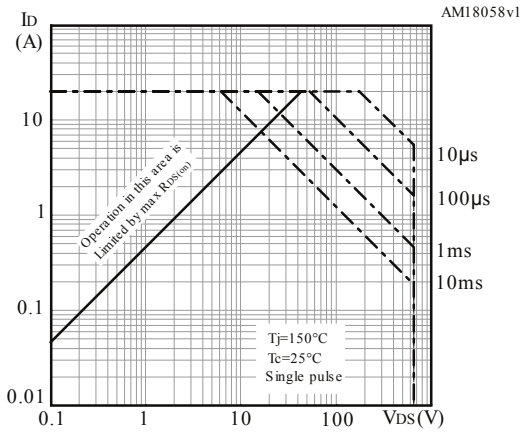
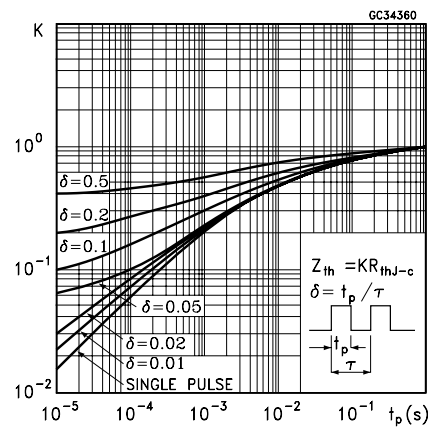
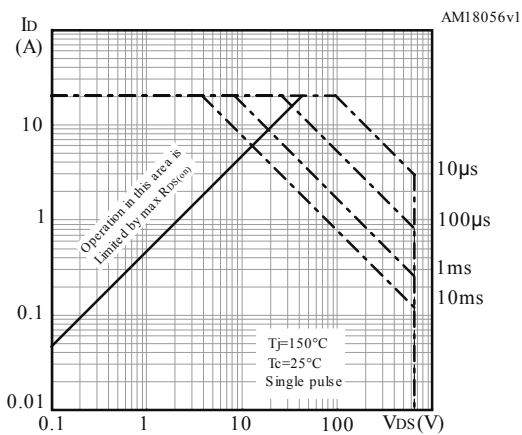
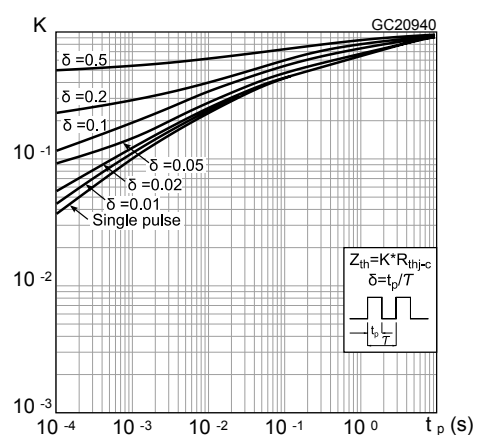
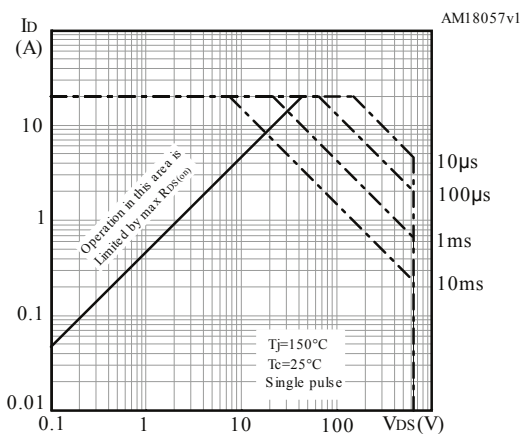
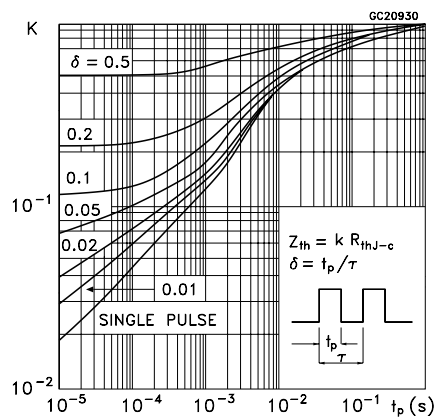
**Table 6. Switching times**

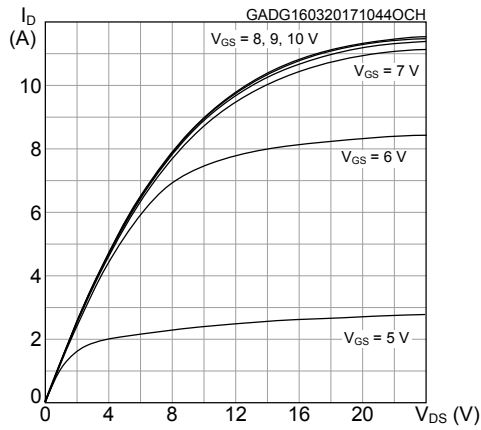
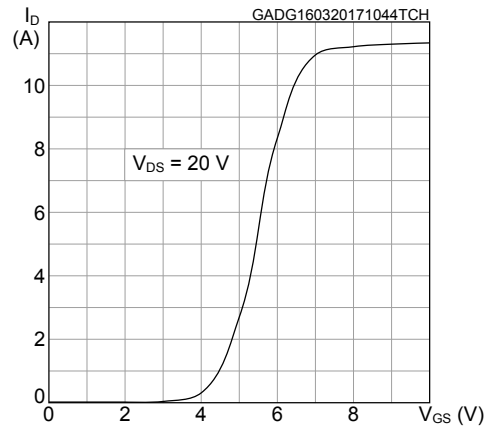
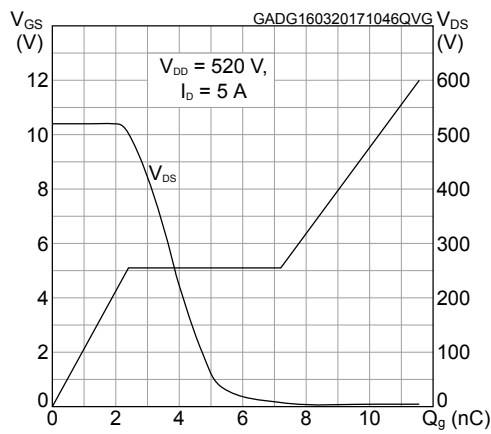
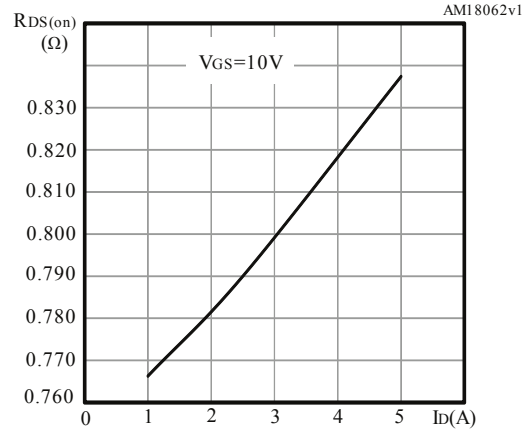
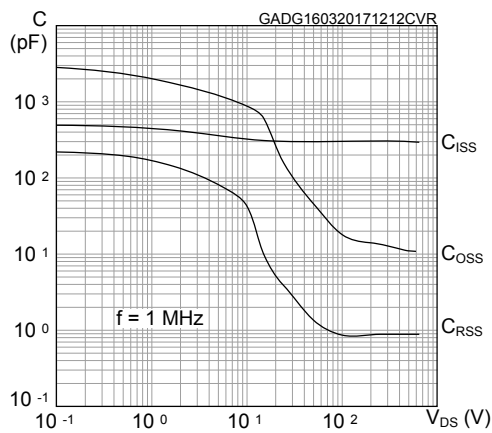
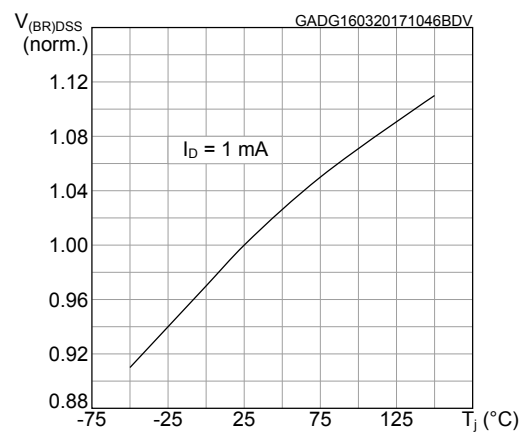
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 325\text{ V}$ , $I_D = 2.5\text{ A}$ ,	-	7.5	-	ns
$t_r$	Rise time	$R_G = 4.7\text{ }\Omega$ , $V_{GS} = 10\text{ V}$	-	6.6	-	ns
$t_{d(off)}$	Turn-off delay time	(see Figure 17. Test circuit for resistive load switching times and	-	22.5	-	ns
$t_f$	Fall time	Figure 22. Switching time waveform)	-	18	-	ns

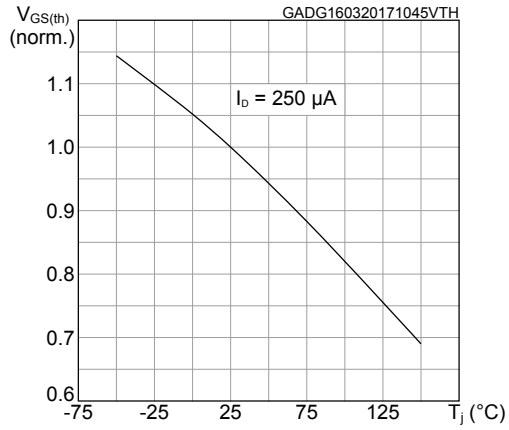
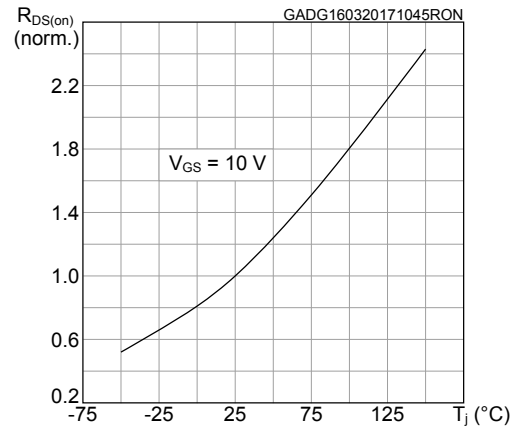
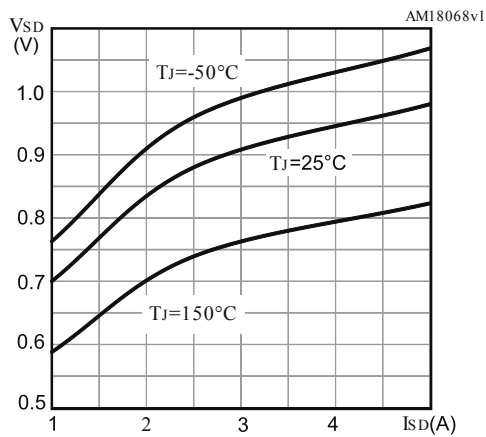
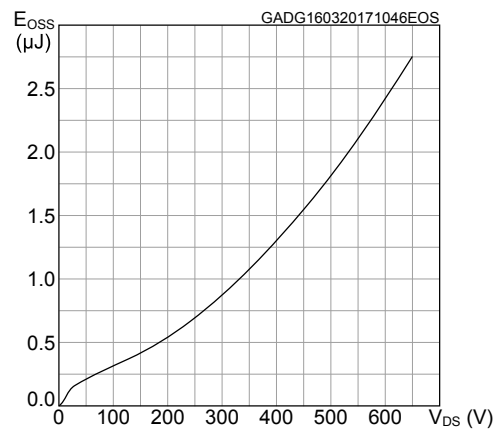
**Table 7. Source-drain diode**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{SD}$	Source-drain current		-		5	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)		-		20	A
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 5\text{ A}$ , $V_{GS} = 0\text{ V}$	-		1.6	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 5\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ , $V_{DD} = 60\text{ V}$ (see Figure 19. Test circuit for inductive load switching and diode recovery times)	-	276		ns
$Q_{rr}$	Reverse recovery charge		-	1.7		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current	$I_{SD} = 5\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ , $V_{DD} = 60\text{ V}$ , $T_J = 150\text{ }^\circ\text{C}$ (see Figure 19. Test circuit for inductive load switching and diode recovery times)	-	12.5		A
$t_{rr}$	Reverse recovery time		-	312		ns
$Q_{rr}$	Reverse recovery charge		-	1.9		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current		-	12.4		A

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

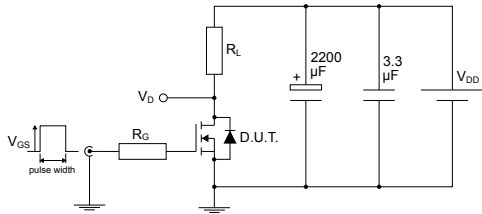
**2.1 Electrical characteristics (curves)**
**Figure 1. Safe operating area for DPAK and IPAK**

**Figure 2. Thermal impedance for DPAK and IPAK**

**Figure 3. Safe operating area for TO-220FP**

**Figure 4. Thermal impedance for TO-220FP**

**Figure 5. Safe operating area for TO-220**

**Figure 6. Thermal impedance for TO-220**


**Figure 7. Output characteristics**

**Figure 8. Transfer characteristics**

**Figure 9. Gate charge vs gate-source voltage**

**Figure 10. Static drain-source on-resistance**

**Figure 11. Capacitance variations**

**Figure 12. Normalized  $V_{(BR)DSS}$  vs temperature**


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

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

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

**Figure 16. Output capacitance stored energy**


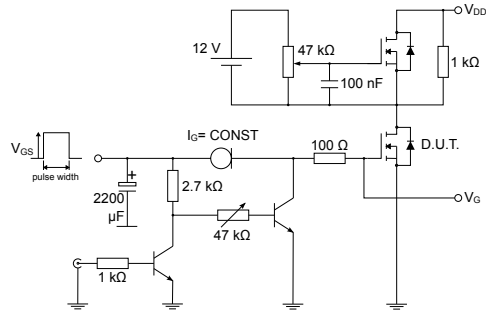
### 3 Test circuits

Figure 17. Test circuit for resistive load switching times



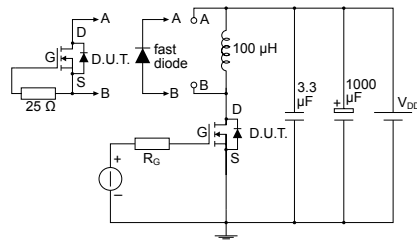
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Figure 18. Test circuit for gate charge behavior



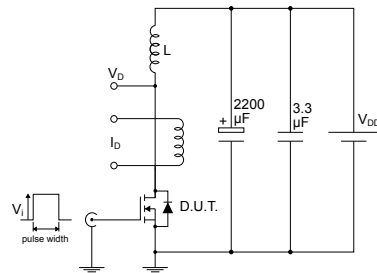
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Figure 19. Test circuit for inductive load switching and diode recovery times



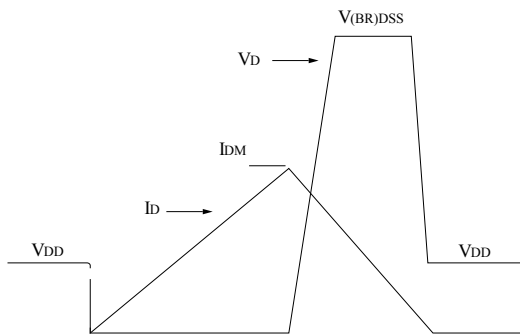
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Figure 20. Unclamped inductive load test circuit



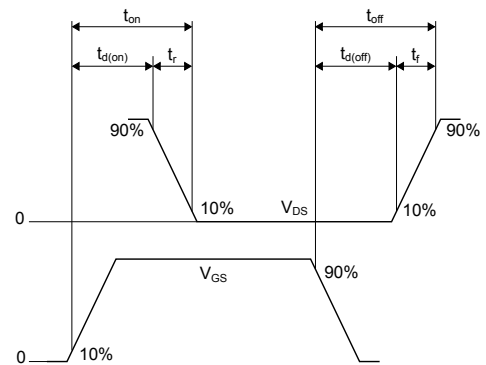
AM01471v1

Figure 21. Unclamped inductive waveform



AM01472v1

Figure 22. Switching time waveform



AM01473v1

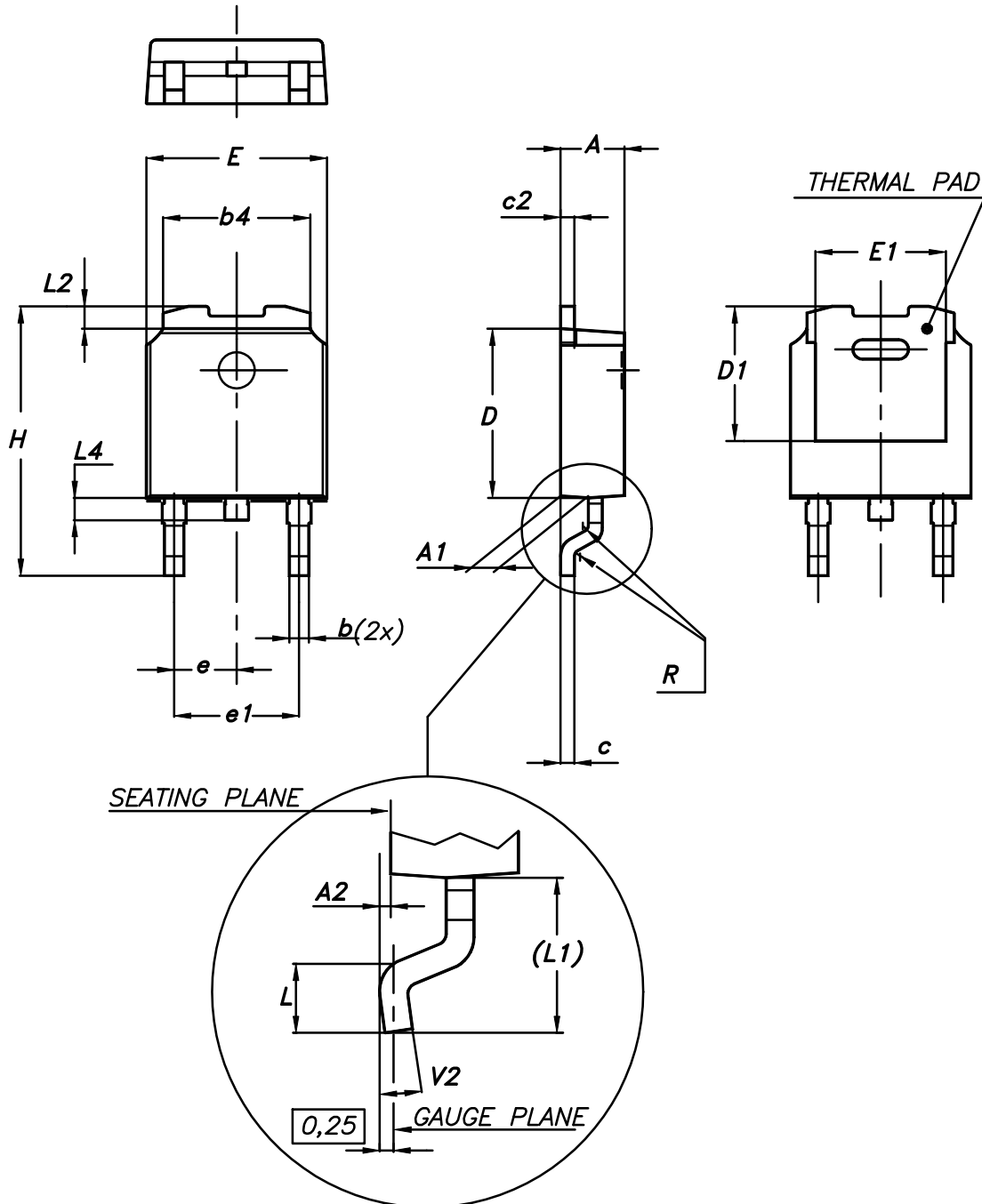
## 4 Package information

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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



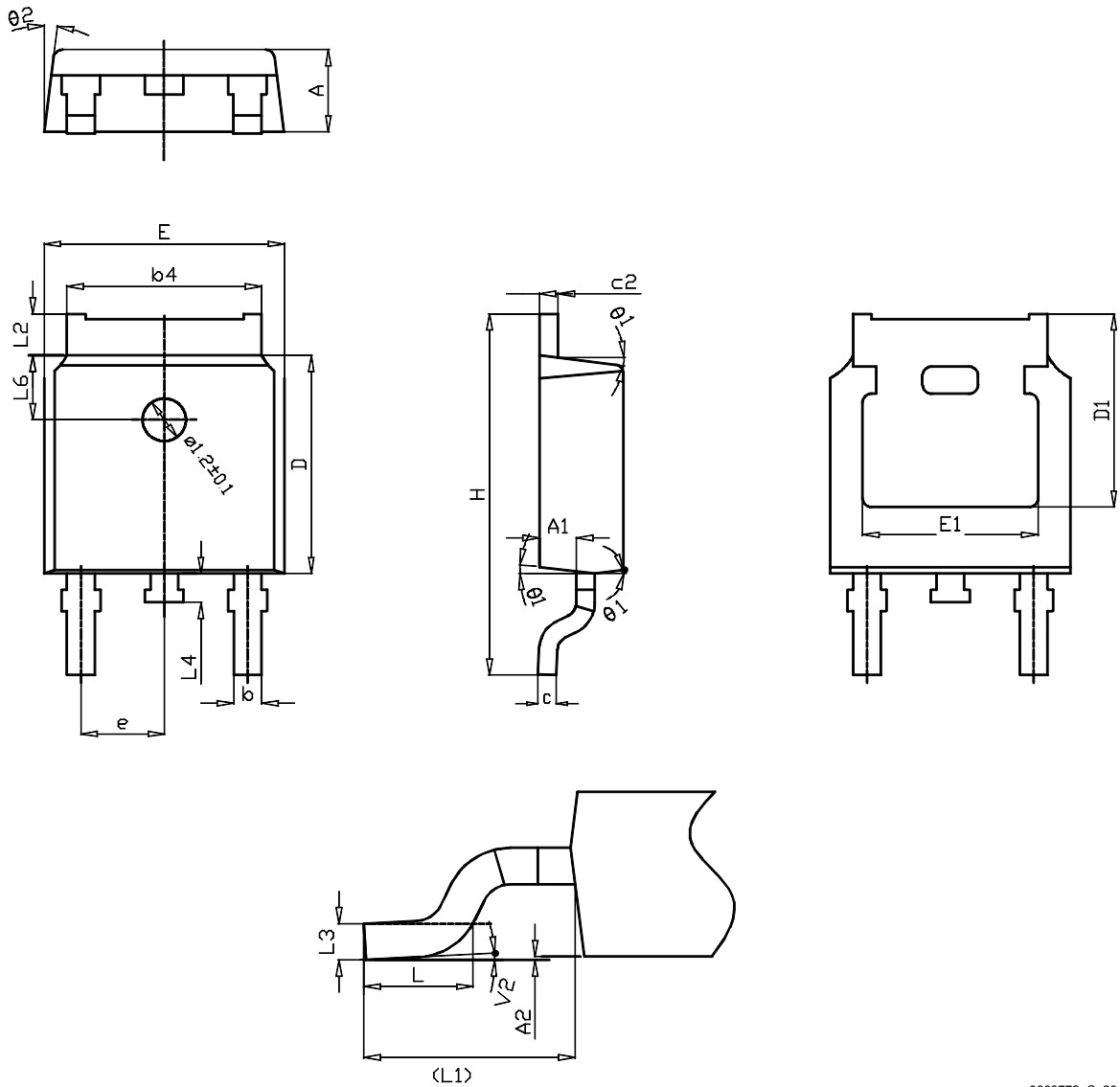
0068772\_A\_26

**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

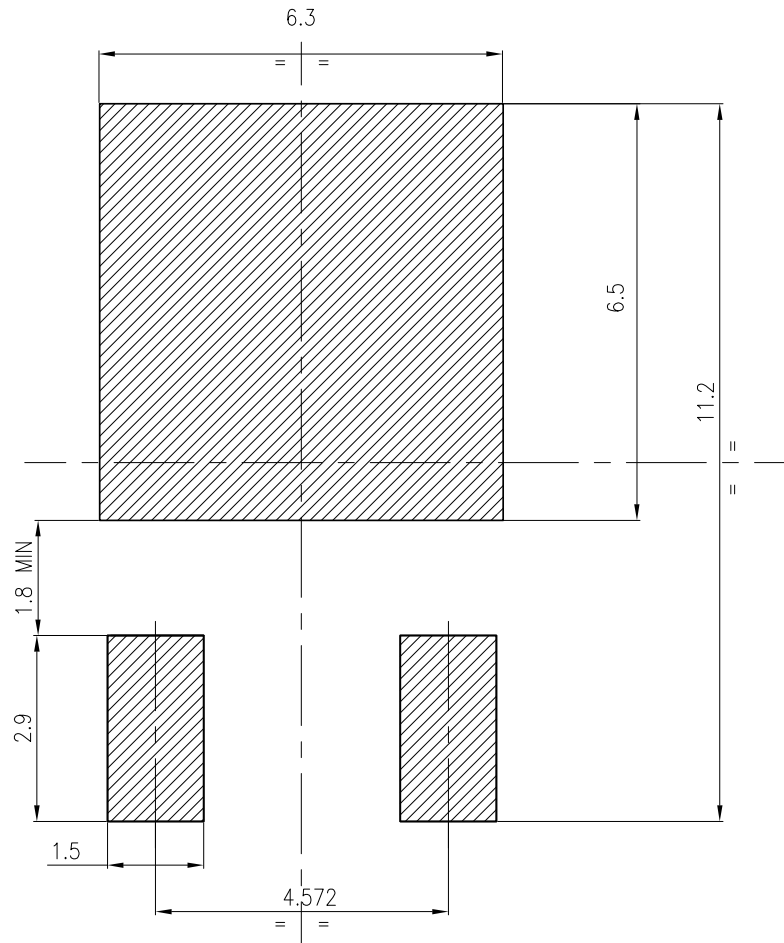


0068772\_C\_26

**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°

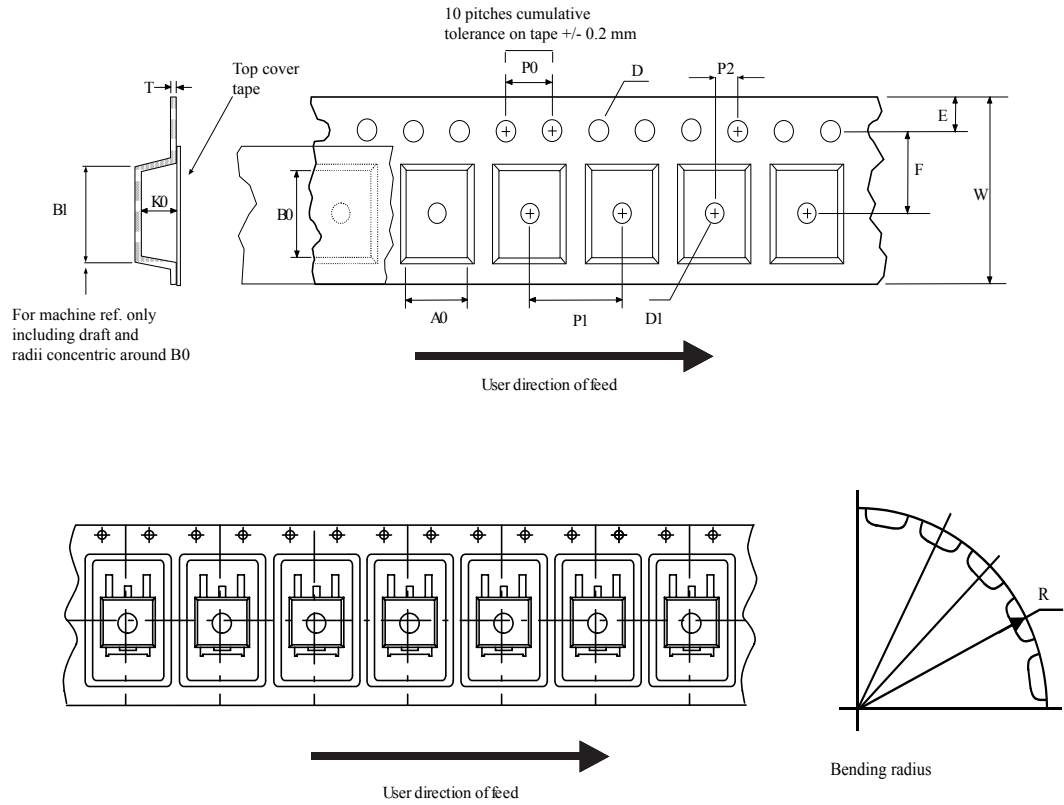
Figure 25. DPAK (TO-252) recommended footprint (dimensions are in mm)



FP\_0068772\_26

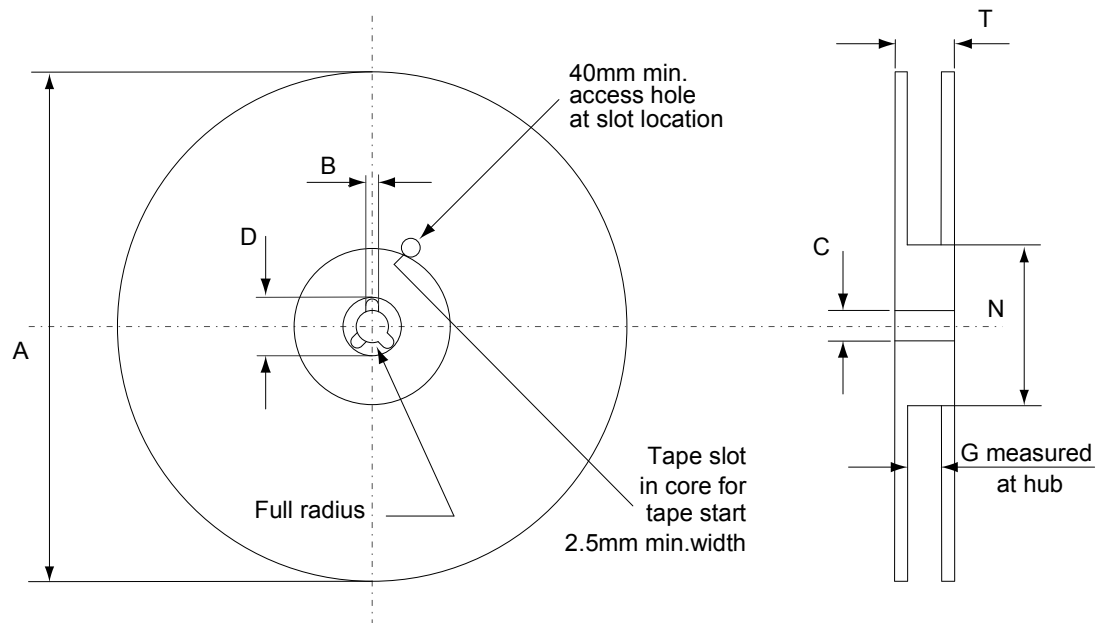
### 4.3 DPAK (TO-252) packing information

Figure 26. DPAK (TO-252) tape outline



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Figure 27. DPAK (TO-252) reel outline



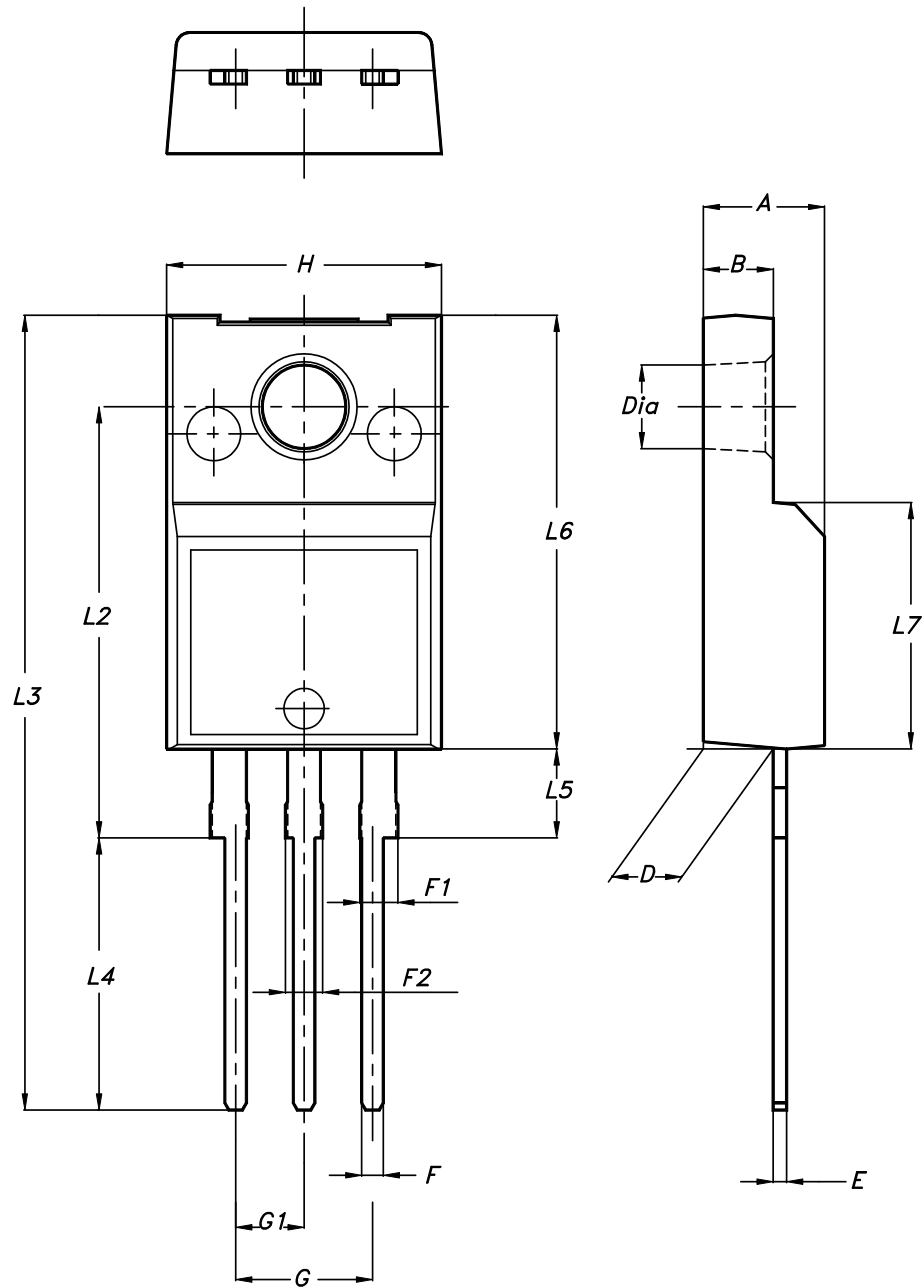
AM06038v1

Table 10. DPAK (TO-252) tape and reel mechanical data

Dim.	Tape		Dim.	Reel	
	mm			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-220FP package information

Figure 28. TO-220FP package outline



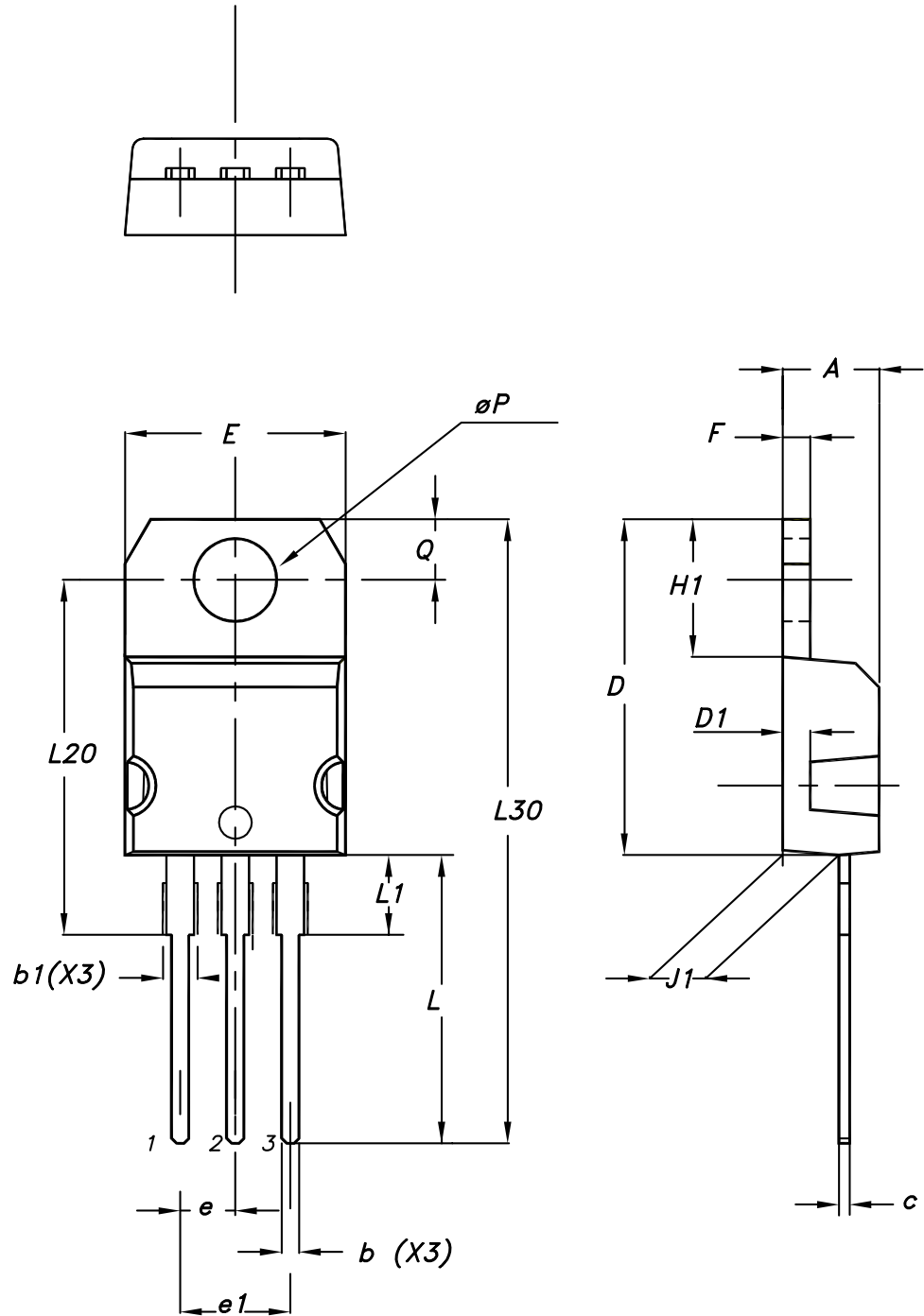
7012510\_Rev\_13\_B

**Table 11. TO-220FP package mechanical data**

Dim.	mm		
	Min.	Typ.	Max.
A	4.40		4.60
B	2.50		2.70
D	2.50		2.75
E	0.45		0.70
F	0.75		1.00
F1	1.15		1.70
F2	1.15		1.70
G	4.95		5.20
G1	2.40		2.70
H	10.00		10.40
L2		16.00	
L3	28.60		30.60
L4	9.80		10.60
L5	2.90		3.60
L6	15.90		16.40
L7	9.00		9.30
Dia	3.00		3.20

### 4.5 TO-220 type A package information

Figure 29. TO-220 type A package outline



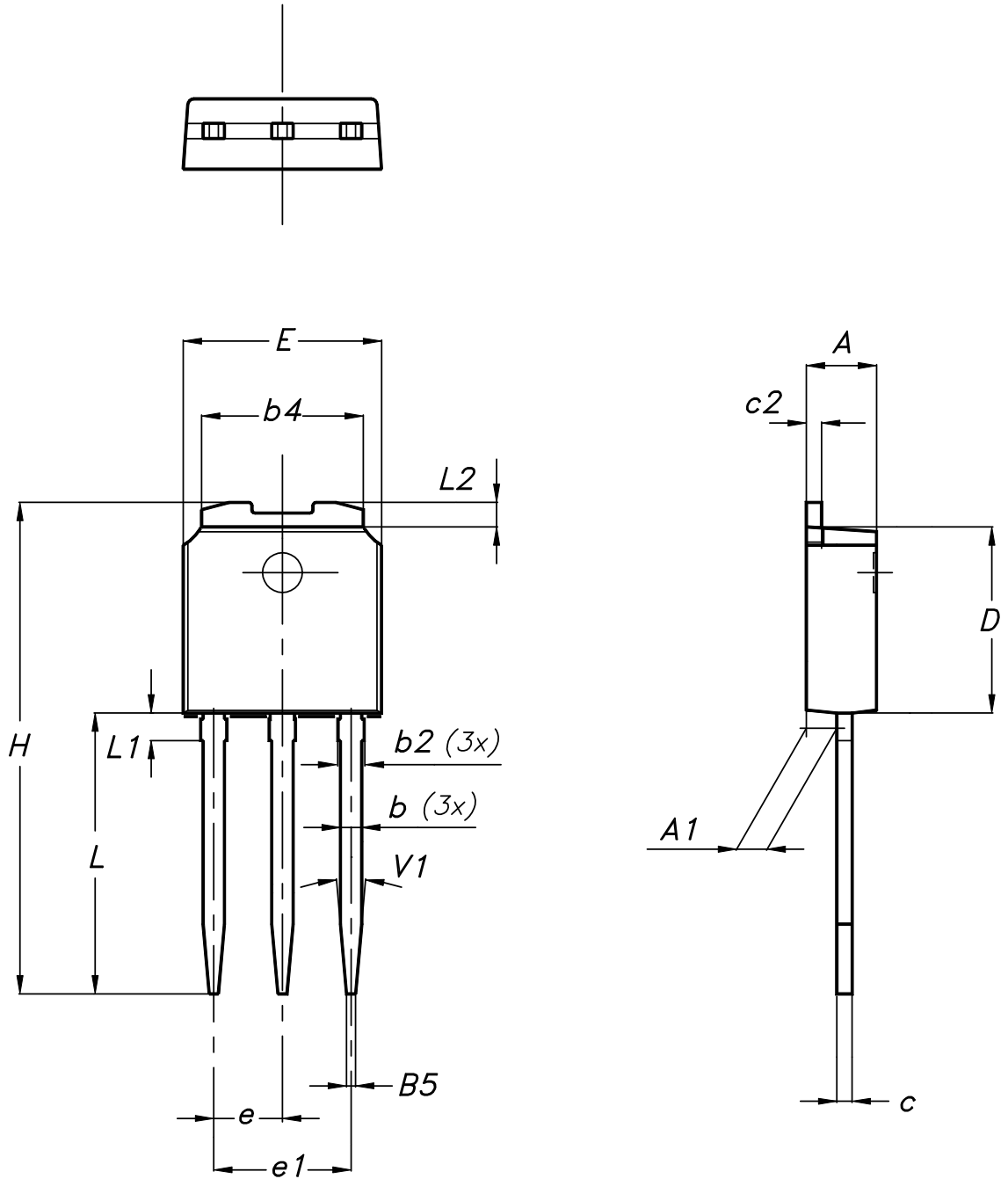
0015988\_typeA\_Rev\_22

**Table 12. 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

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

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



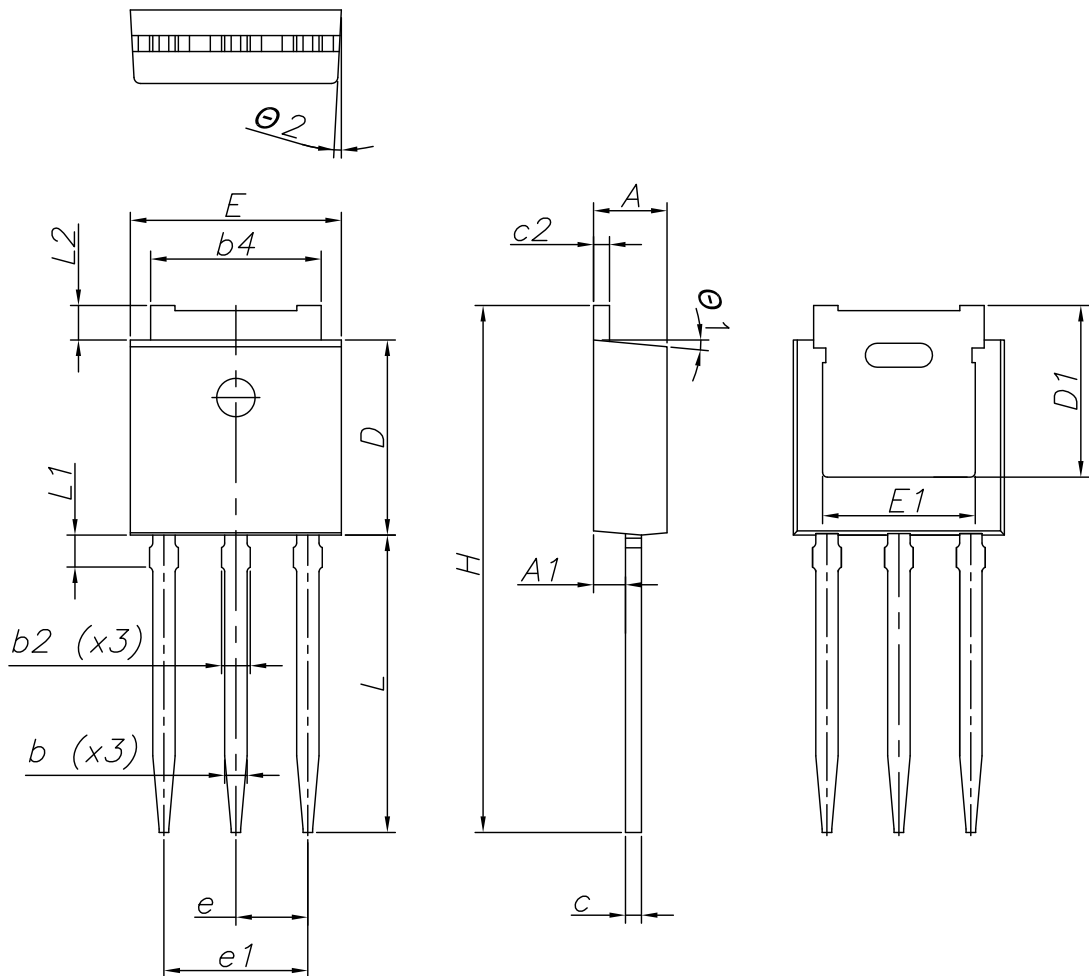
0068771\_IK\_typeA\_rev14

**Table 13. 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°	

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

Figure 31. IPAK (TO-251) type C package outline



0068771\_IK\_typeC\_rev14

**Table 14. 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°

## 5 Ordering information

**Table 15. Order codes**

Order code	Marking	Package	Packing
STD9N65M2	9N65M2	DPAK	Tape and reel
STF9N65M2		TO-220FP	Tube
STP9N65M2		TO-220	
STU9N65M2		IPAK	

## Revision history

**Table 16. Document revision history**

Date	Version	Changes
24-Feb-2014	1	First release.
15-Jul-2014	2	<ul style="list-style-type: none"> <li>– Modified: title, <i>Features</i> and <i>Description</i></li> <li>– Modified: <i>Figure 5</i> and <i>15</i></li> <li>– Updated: <i>Figure 28</i> and <i>Table 12</i></li> <li>– Minor text changes.</li> </ul>
19-Jun-2019	3	<p>Removed maturity status indication from cover page. The document status is production data.</p> <p>Updated <a href="#">Section 1 Electrical ratings</a>, <a href="#">Section 2 Electrical characteristics</a> and <a href="#">Section 2.1 Electrical characteristics (curves)</a></p> <p>Minor text changes.</p>

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