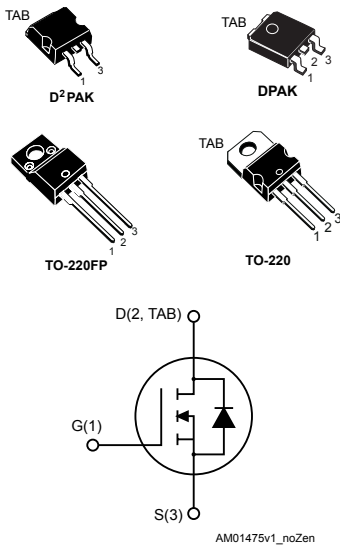


## N-channel 650 V, 0.43 $\Omega$ typ., 9 A MDmesh™ M5 Power MOSFETs in a DPAK, D<sup>2</sup>PAK, TO-220FP and TO-220 packages



### Features

Order code	$V_{DS}$ @ $T_{jmax.}$	$R_{DS(on)max.}$	$I_D$
STB11N65M5	710 V	0.48 $\Omega$	9 A
STD11N65M5			
STF11N65M5			
STP11N65M5			

- Extremely low  $R_{DS(on)}$
- Low gate charge and input capacitance
- Excellent switching performance
- 100% avalanche tested

### Applications

- Switching applications

### Description

These devices are N-channel Power MOSFET based on the MDmesh™ M5 innovative vertical process technology combined with the well-known PowerMESH™ horizontal layout. The resulting products offer extremely low on-resistance, making them particularly suitable for applications requiring high power and superior efficiency.

Product status
<a href="#">STB11N65M5</a>
<a href="#">STD11N65M5</a>
<a href="#">STF11N65M5</a>
<a href="#">STP11N65M5</a>

# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

Symbol	Parameter	Value		Unit
		D <sup>2</sup> PAK DPAK TO-220	TO-220FP	
V <sub>GS</sub>	Gate-source voltage	±25		V
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 25 °C	9	9 <sup>(1)</sup>	A
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 100 °C	5.6	5.6 <sup>(1)</sup>	A
I <sub>DM</sub> <sup>(2)</sup>	Drain current (pulsed)	36	36 <sup>(1)</sup>	A
P <sub>TOT</sub>	Total dissipation at T <sub>C</sub> = 25 °C	85	25	W
dv/dt <sup>(3)</sup>	Peak diode recovery voltage slope	15		V/ns
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)		2500	V
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<sub>SD</sub> ≤ 9 A, di/dt ≤ 400 A/μs; V<sub>DS peak</sub> < V<sub>(BR)DSS</sub>; V<sub>DD</sub> = 400 V.

**Table 2. Thermal data**

Symbol	Parameter	Value				Unit
		D <sup>2</sup> PAK	DPAK	TO-220FP	TO-220	
R <sub>thj-case</sub>	Thermal resistance junction-case	1.47		5.0	1.47	°C/W
R <sub>thj-amb</sub>	Thermal resistance junction-ambient			62.5		°C/W
R <sub>thj-pcb</sub> <sup>(1)</sup>	Thermal resistance junction-pcb	30	50			°C/W

- When mounted on 1 inch<sup>2</sup> FR-4, 2 Oz copper 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	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)	130	mJ

## 2 Electrical characteristics

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

**Table 4. On/off states**

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source Breakdown voltage	$I_D = 1\text{ mA}$ , $V_{GS} = 0\text{ V}$	650			V
$I_{DSS}$	Zero gate voltage drain current	$V_{GS} = 0\text{ V}$ , $V_{DS} = 650\text{ V}$			1	$\mu\text{A}$
		$V_{GS} = 0\text{ V}$ , $V_{DS} = 650\text{ V}$ , $T_C = 125\text{ }^{\circ}\text{C}^{(1)}$			100	$\mu\text{A}$
$I_{GSS}$	Gate body leakage current	$V_{DS} = 0\text{ V}$ , $V_{GS} = \pm 25\text{ V}$			$\pm 100$	nA
$V_{GS(th)}$	Gate threshold voltage	$V_{DS} = V_{GS}$ , $I_D = 250\text{ }\mu\text{A}$	3	4	5	V
$R_{DS(on)}$	Static drain-source on resistance	$V_{GS} = 10\text{ V}$ , $I_D = 4.5\text{ A}$		0.43	0.48	$\Omega$

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

**Table 5. Dynamic**

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
$C_{iss}$	Input capacitance	$V_{DS} = 100\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GS} = 0\text{ V}$	-	644	-	$\mu\text{F}$
$C_{oss}$	Output capacitance			18		
$C_{rss}$	Reverse transfer capacitance			2.5		
$C_{o(tr)}^{(1)}$	Equivalent capacitance time related	$V_{DS} = 0\text{ to }520\text{ V}$ , $V_{GS} = 0\text{ V}$	-	55	-	$\mu\text{F}$
$C_{o(er)}^{(2)}$	Equivalent capacitance energy related			17		
$R_g$	Gate input resistance	$f = 1\text{ MHz}$ open drain	-	5	-	$\Omega$
$Q_g$	Total gate charge	$V_{DD} = 520\text{ V}$ , $I_D = 4.5\text{ A}$ ,	-	17	-	nC
$Q_{gs}$	Gate-source charge	$V_{GS} = 0\text{ to }10\text{ V}$ (see Figure 20. Test circuit for gate charge behavior)		4.6		
$Q_{gd}$	Gate-drain charge			8.5		

1. Time related is defined as a constant equivalent capacitance giving the same charging time as  $C_{oss}$  when  $V_{DS}$  increases from 0 to 80%  $V_{DSS}$ .

2. Energy related is defined as a constant equivalent capacitance giving the same stored energy as  $C_{oss}$  when  $V_{DS}$  increases from 0 to 80%  $V_{DSS}$ .

**Table 6. Switching times**

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
$t_{d(v)}$	Voltage delay time	$V_{DD} = 400\text{ V}$ , $I_D = 7.5\text{ A}$ , $R_G = 4.7\text{ }\Omega$ , $V_{GS} = 10\text{ V}$ (see Figure 21. Test circuit for inductive load switching and diode recovery times and Figure 24. Switching time waveform)	-	23	-	ns
$t_{r(v)}$	Voltage rise time			10		
$t_{c(off)}$	Crossing time			13		
$t_{f(i)}$	Fall time			13.5		

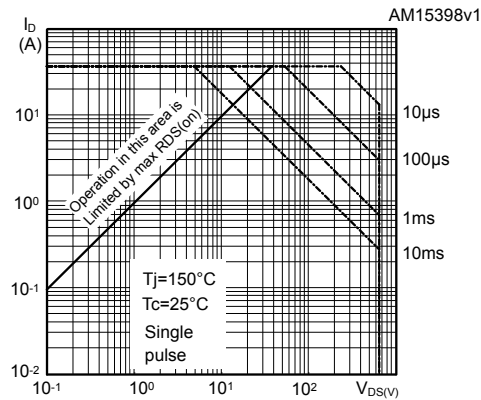
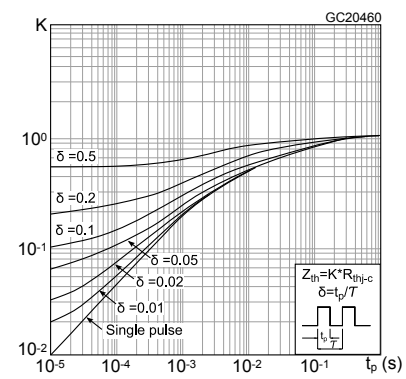
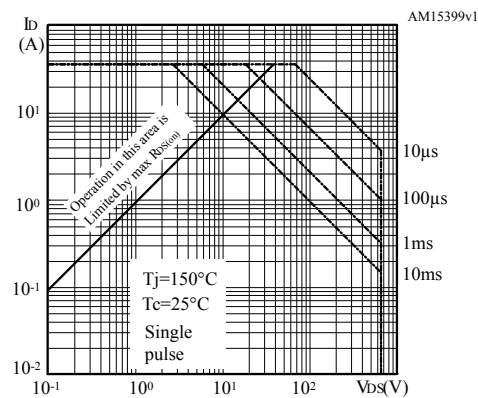
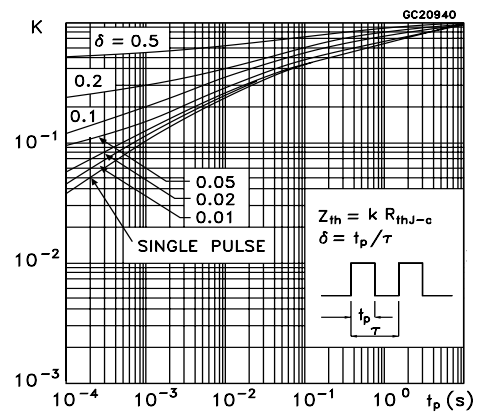
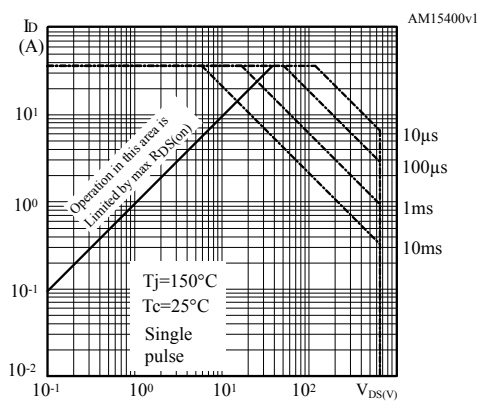
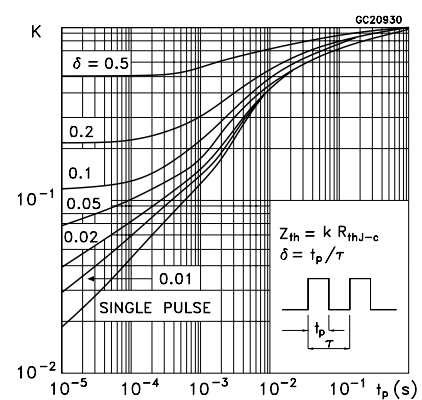
**Table 7. Source drain diode**

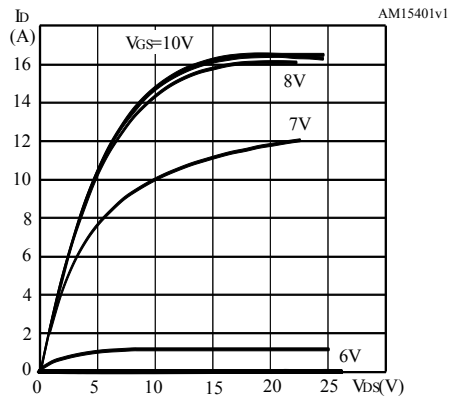
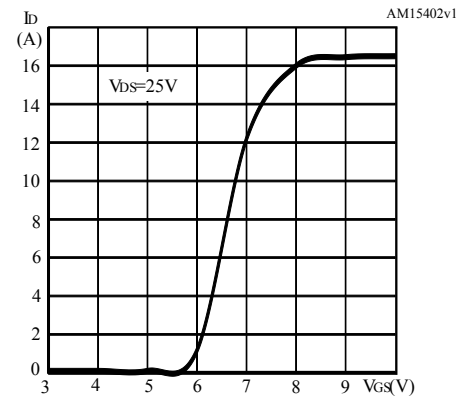
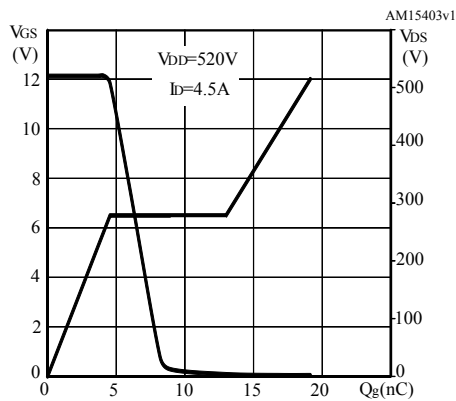
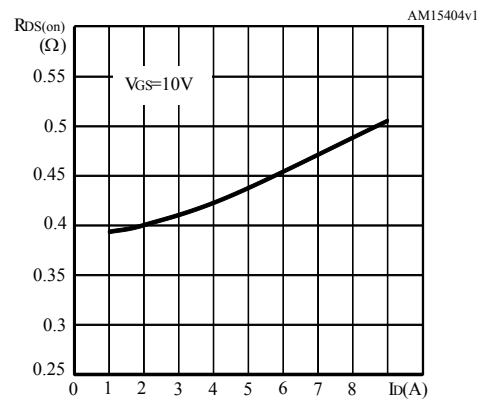
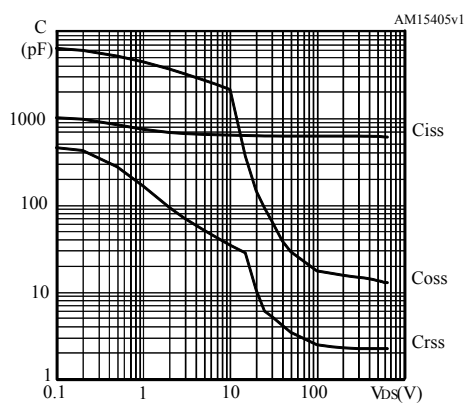
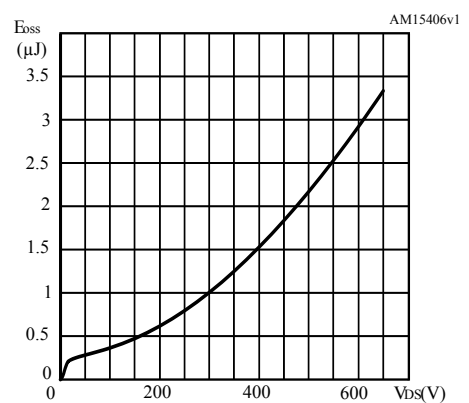
Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
$I_{SD}$	Source-drain current				9	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)		-		36	
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 9\text{ A}$ , $V_{GS} = 0\text{ V}$	-		1.5	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 9\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$		232		ns
$Q_{rr}$	Reverse recovery charge	$V_{DD} = 100\text{ V}$ (see Figure 21. Test circuit for inductive load switching and diode recovery times)	-	2		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current			17.5		A
$t_{rr}$	Reverse recovery time	$I_{SD} = 9\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$		328		ns
$Q_{rr}$	Reverse recovery charge	$V_{DD} = 100\text{ V}$ , $T_j = 150\text{ }^\circ\text{C}$ (see Figure 21. Test circuit for inductive load switching and diode recovery times)	-	2.8		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current			17		A

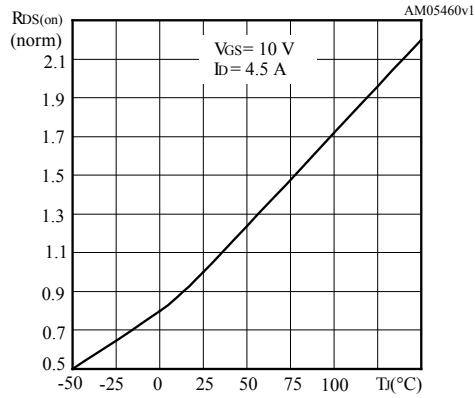
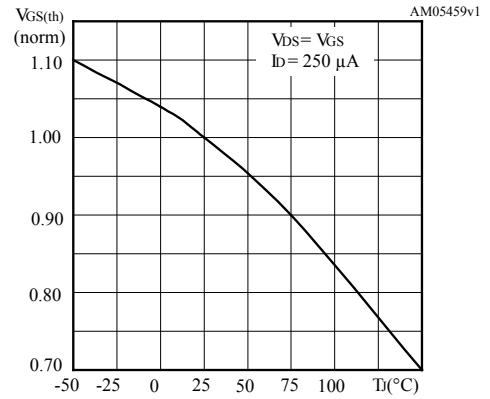
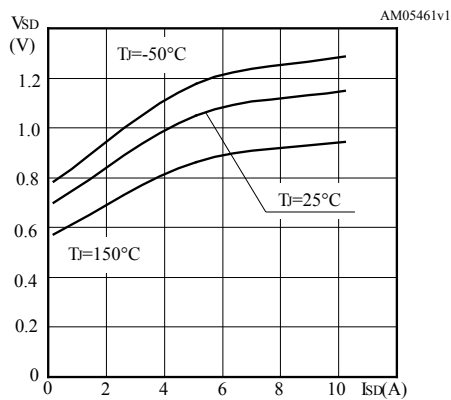
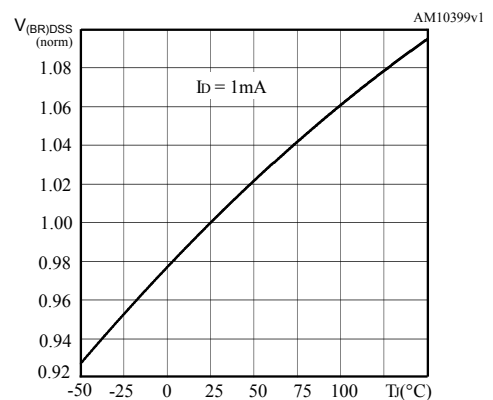
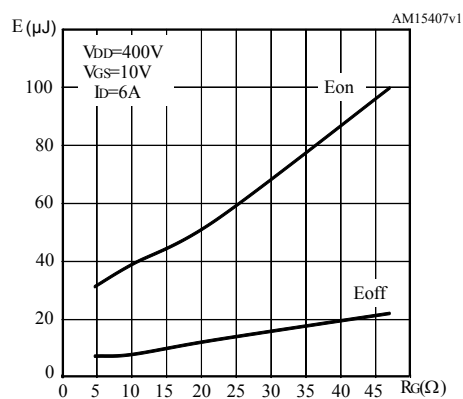
1. Pulse width limited by safe operating area.

2. Pulsed: pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%.

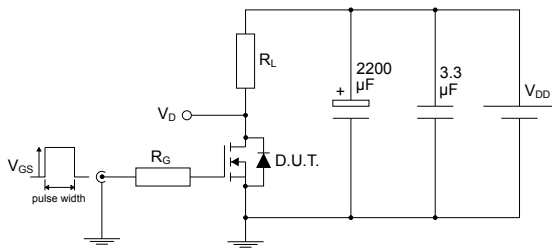
## 2.1 Electrical characteristics curves

**Figure 1. Safe operating area for DPAK**

**Figure 2. Thermal impedance DPAK**

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

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

**Figure 5. Safe operating area for TO-220 and D<sup>2</sup>PAK**

**Figure 6. Thermal impedance for TO-220 and D<sup>2</sup>PAK**


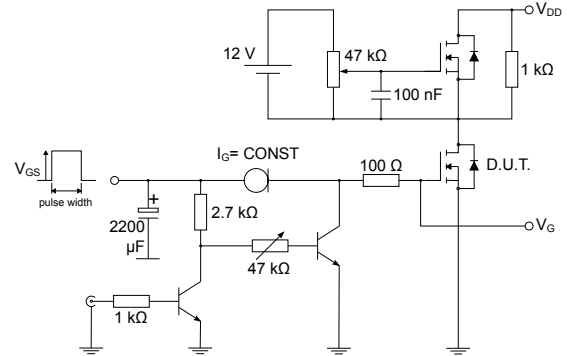
**Figure 8. Output characteristics**

**Figure 9. Transfer characteristics**

**Figure 10. Gate charge vs gate-source voltage**

**Figure 11. Static drain-source on resistance**

**Figure 12. Capacitance variations**

**Figure 13. Output capacitance stored energy**


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

**Figure 15. Normalized gate threshold voltage vs temperature**

**Figure 16. Drain-source diode forward characteristics**

**Figure 17. Normalized  $V_{(BR)DSS}$  vs temperature**

**Figure 18. Switching energy vs gate resistance**


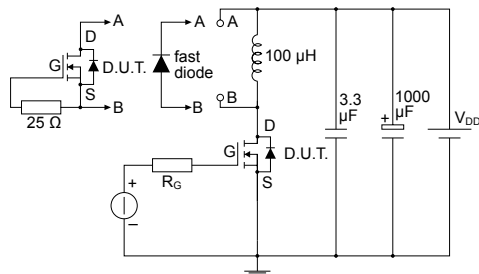
### 3 Test circuits

**Figure 19. Test circuit for resistive load switching times**


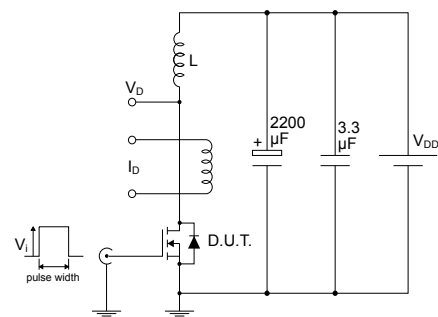
AM01468v1

**Figure 20. Test circuit for gate charge behavior**


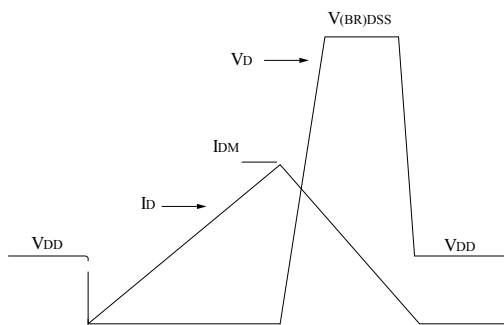
AM01469v1

**Figure 21. Test circuit for inductive load switching and diode recovery times**


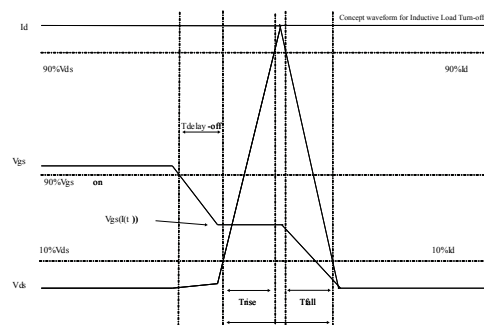
AM01470v1

**Figure 22. Unclamped inductive load test circuit**


AM01471v1

**Figure 23. Unclamped inductive waveform**


AM01472v1

**Figure 24. Switching time waveform**


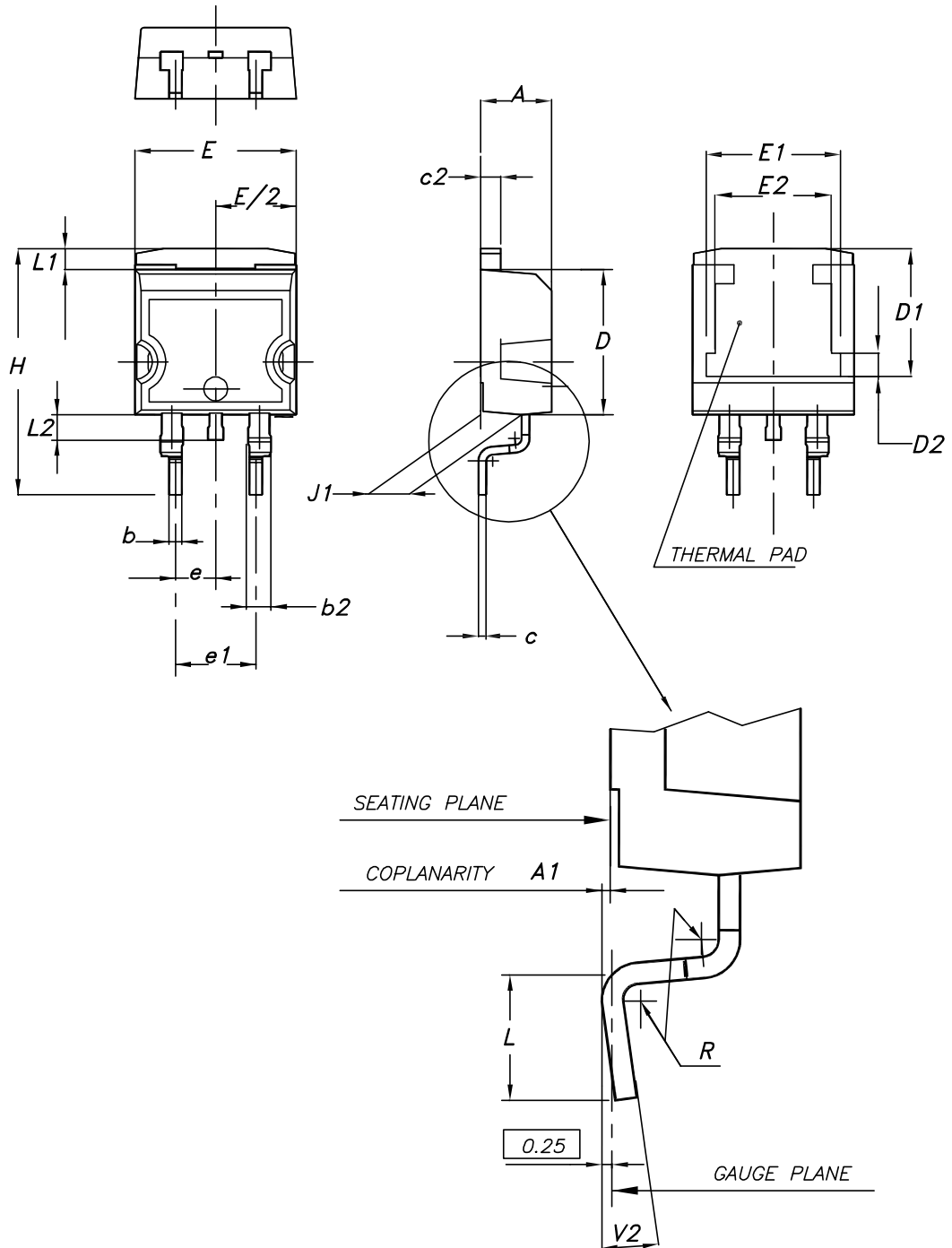
AM05540v2\_for\_M5



## **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.

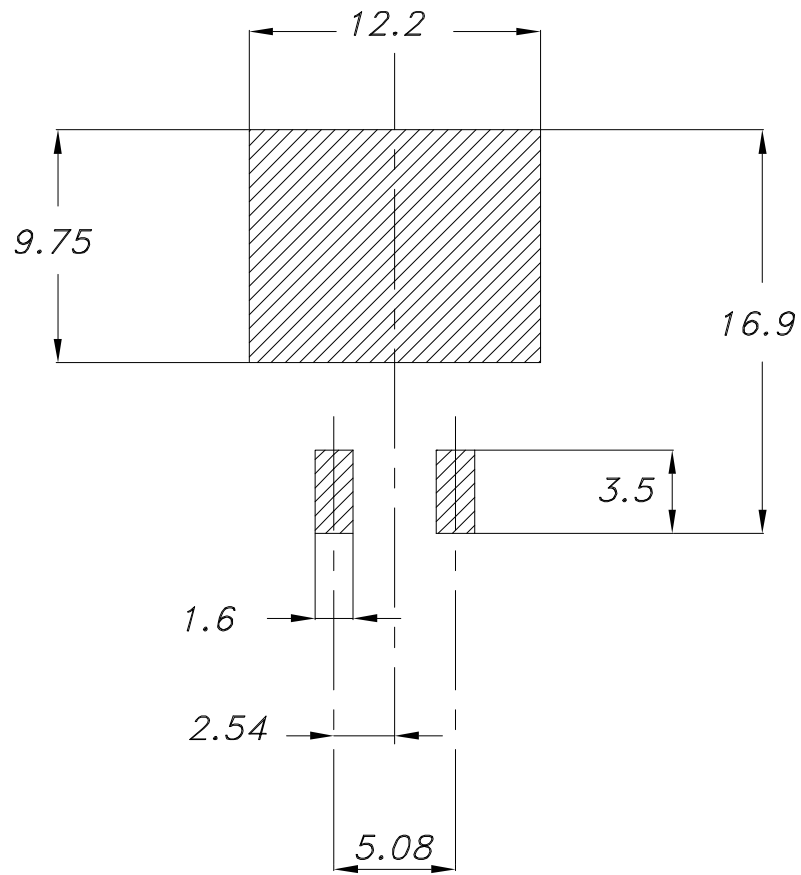
**4.1 D<sup>2</sup>PAK (TO-263) type A package information**
**Figure 25. D<sup>2</sup>PAK (TO-263) type A package outline**


0079457\_25

**Table 8. 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°

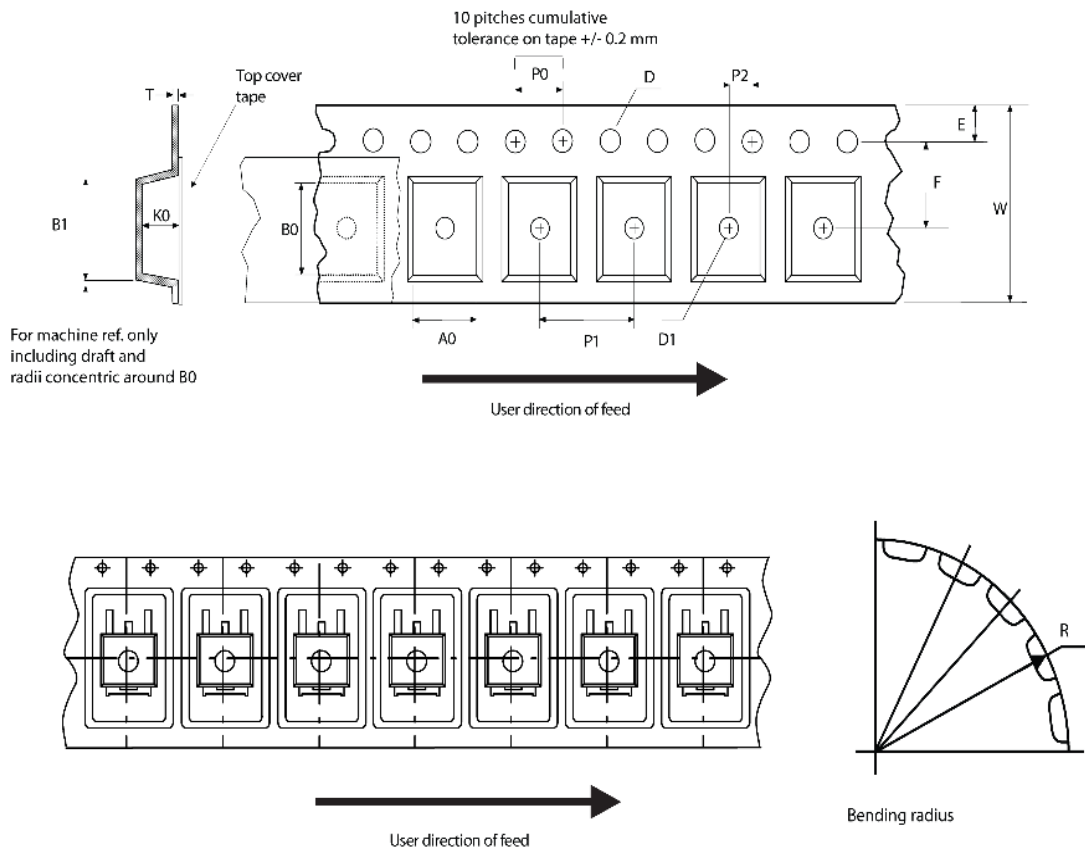
Figure 26. D<sup>2</sup>PAK (TO-263) recommended footprint (dimensions are in mm)



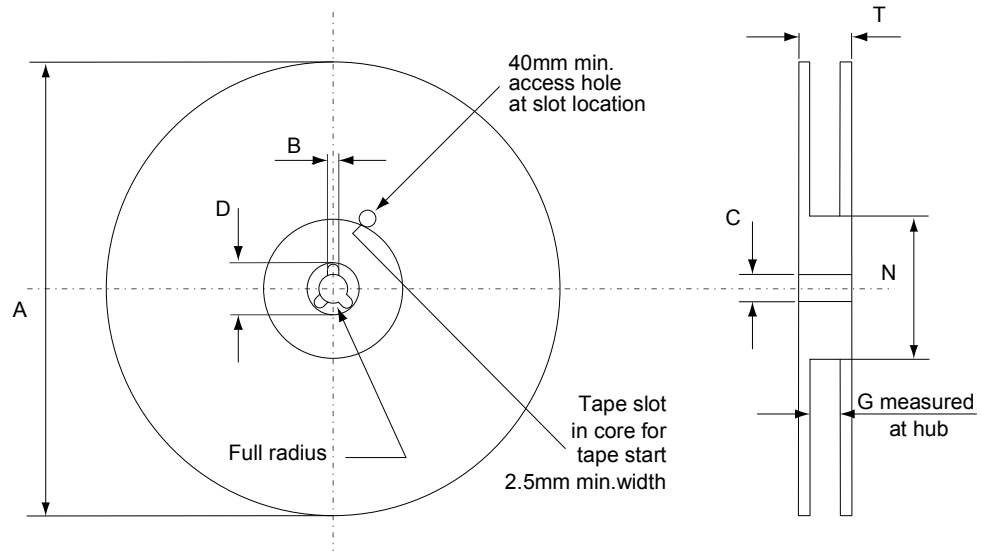
Footprint

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

Figure 27. D<sup>2</sup>PAK tape outline



AM08852v1

**Figure 28. D<sup>2</sup>PAK reel outline**


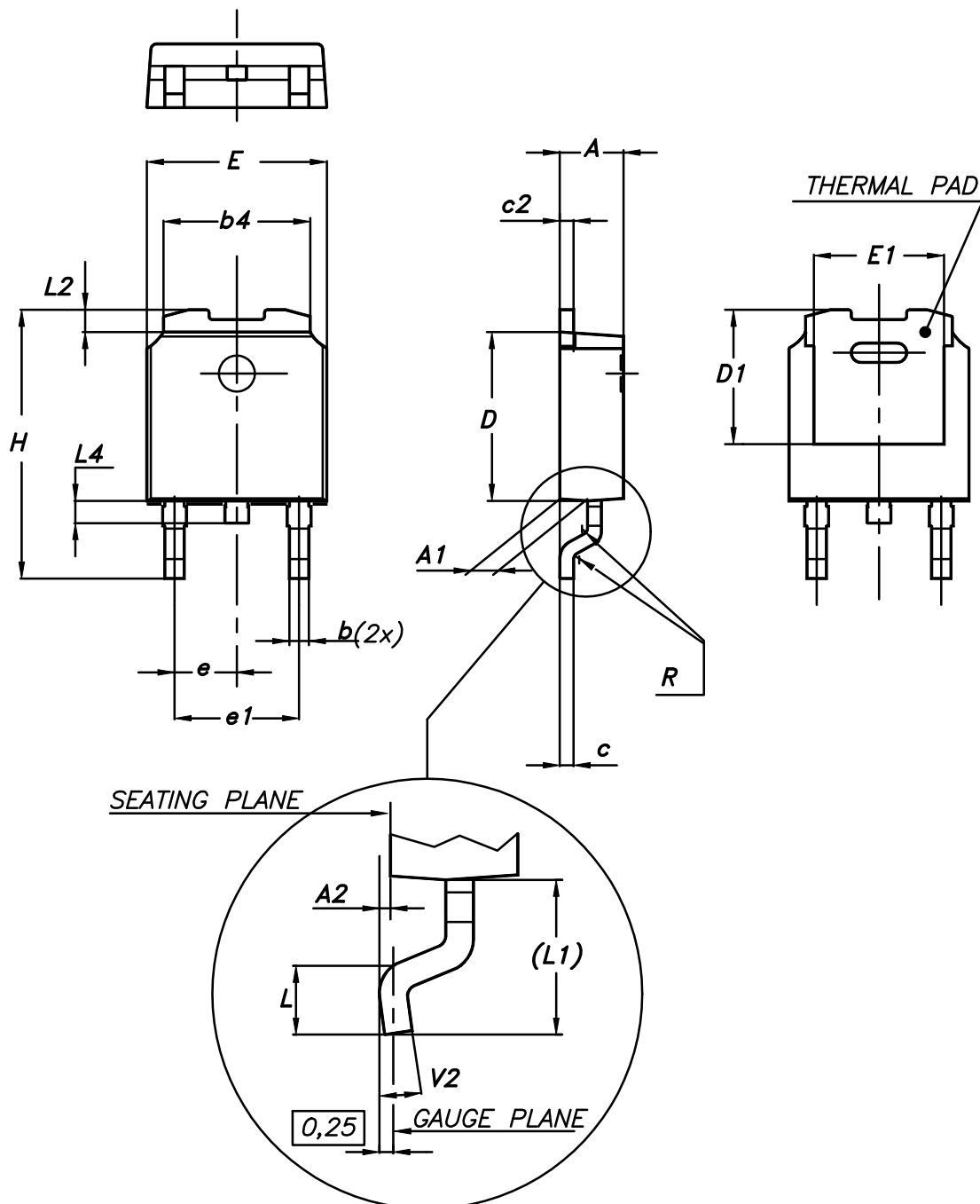
AM06038v1

**Table 9. 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 DPAK (TO-252) type A package information

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



0068772\_A\_25

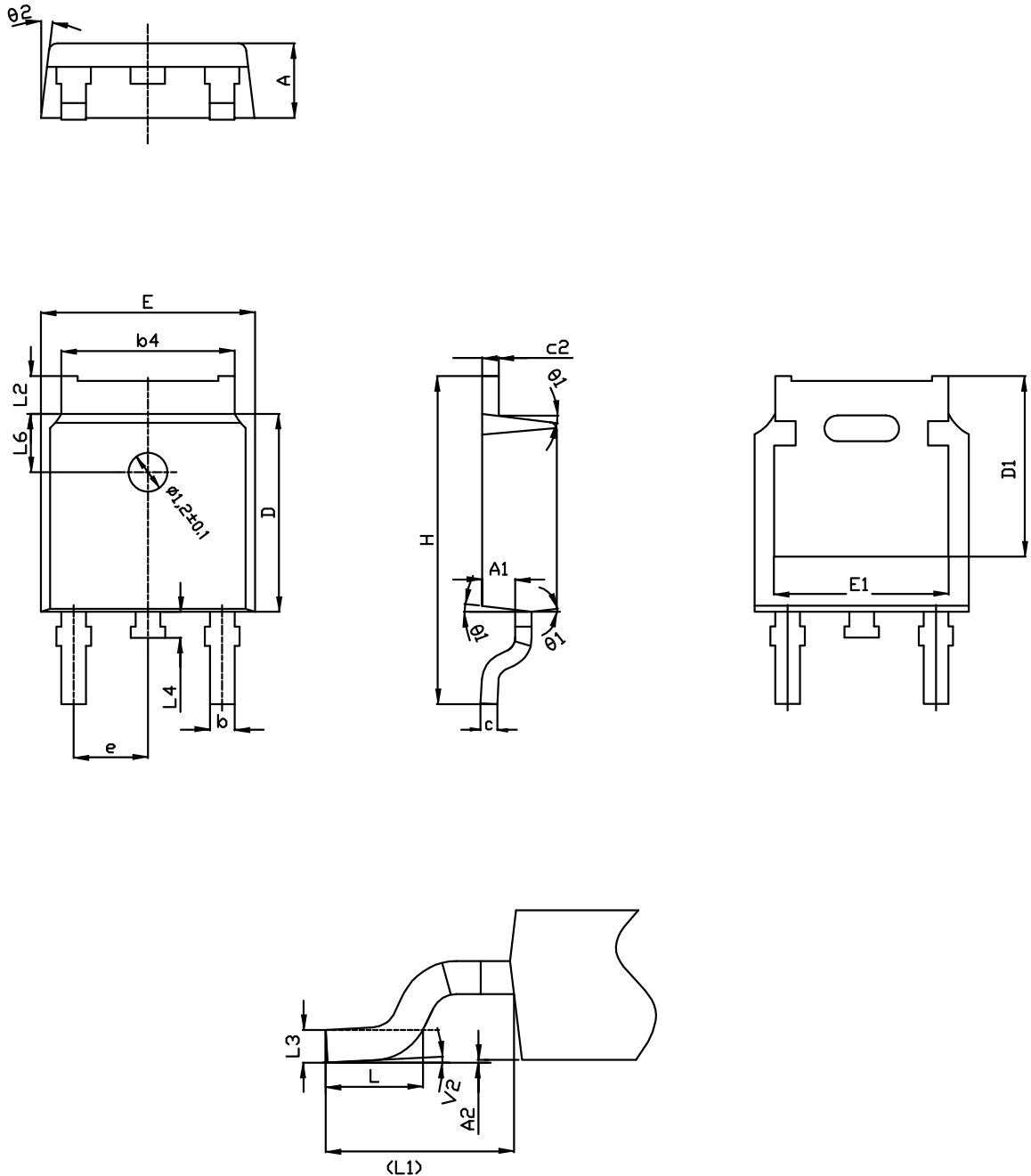
**Table 10. DPAK (TO-252) type A mechanical data**

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°



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

Figure 30. DPAK (TO-252) type C2 package outline



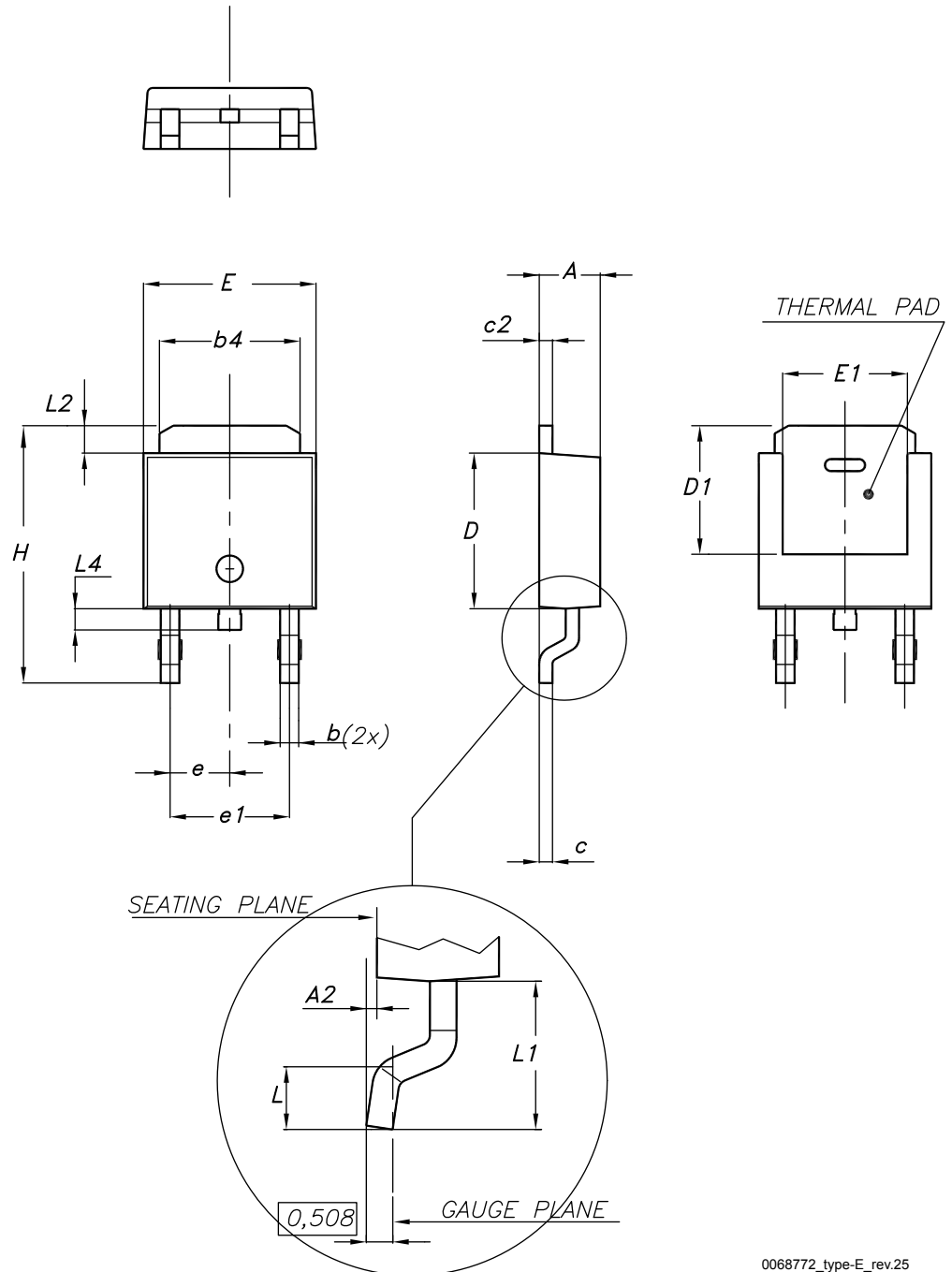
0068772\_C2\_25

**Table 11. 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°

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

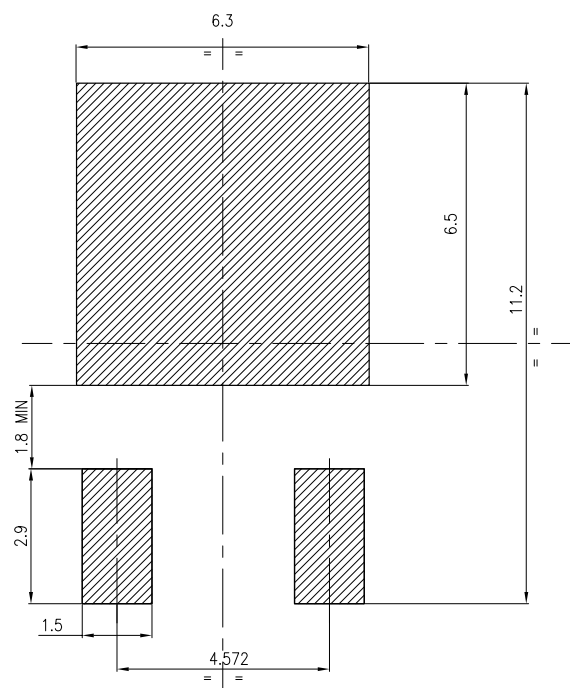
Figure 31. DPAK (TO-252) type E package outline



0068772\_type-E\_rev.25

**Table 12. DPAK (TO-252) type E mechanical data**

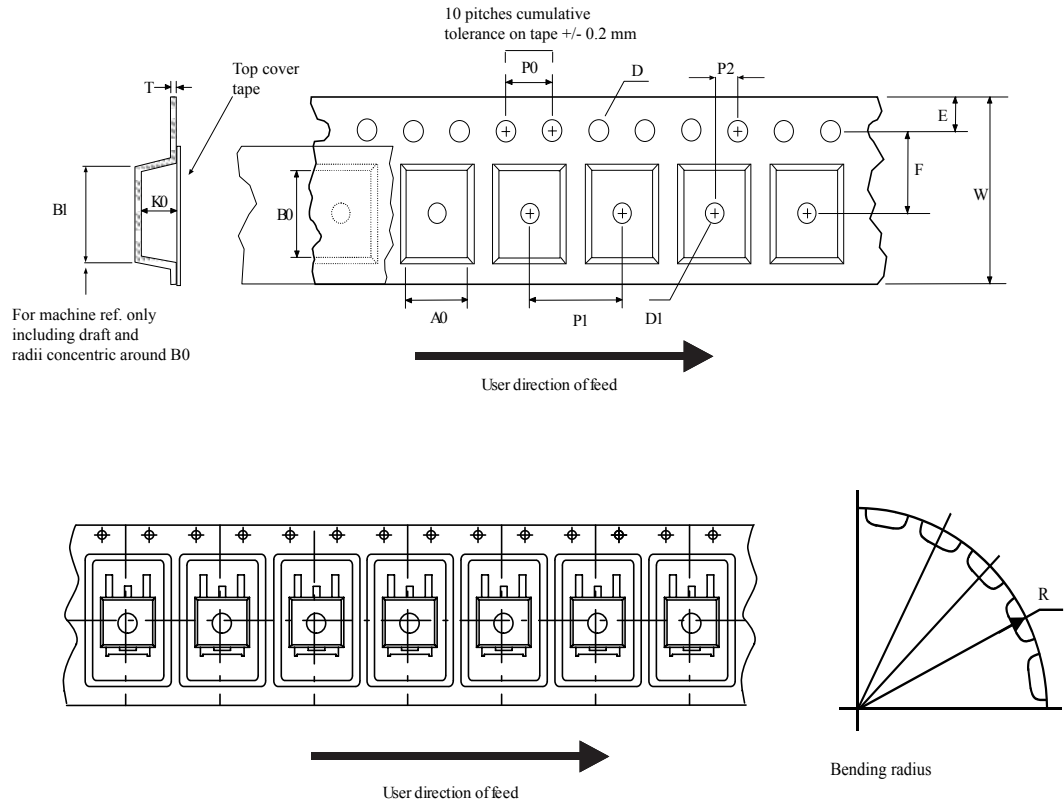
Dim.	mm		
	Min.	Typ.	Max.
A	2.18		2.39
A2			0.13
b	0.65		0.884
b4	4.95		5.46
c	0.46		0.61
c2	0.46		0.60
D	5.97		6.22
D1	5.21		
E	6.35		6.73
E1	4.32		
e		2.286	
e1		4.572	
H	9.94		10.34
L	1.50		1.78
L1		2.74	
L2	0.89		1.27
L4			1.02

**Figure 32. DPAK (TO-252) recommended footprint (dimensions are in mm)**


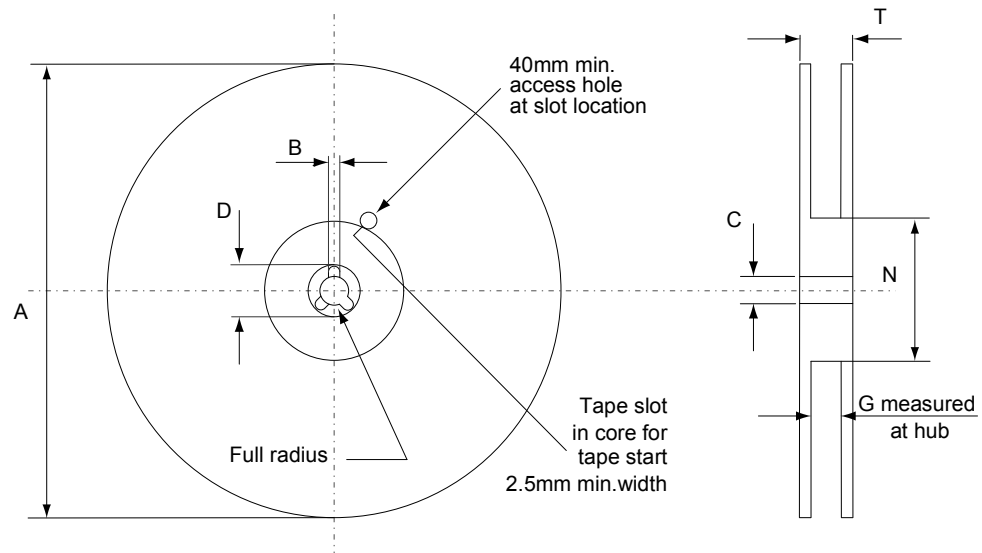
FP\_0068772\_25

## 4.6 DPAK (TO-252) packing information

Figure 33. DPAK (TO-252) tape outline



AM08852v1

**Figure 34. DPAK (TO-252) reel outline**


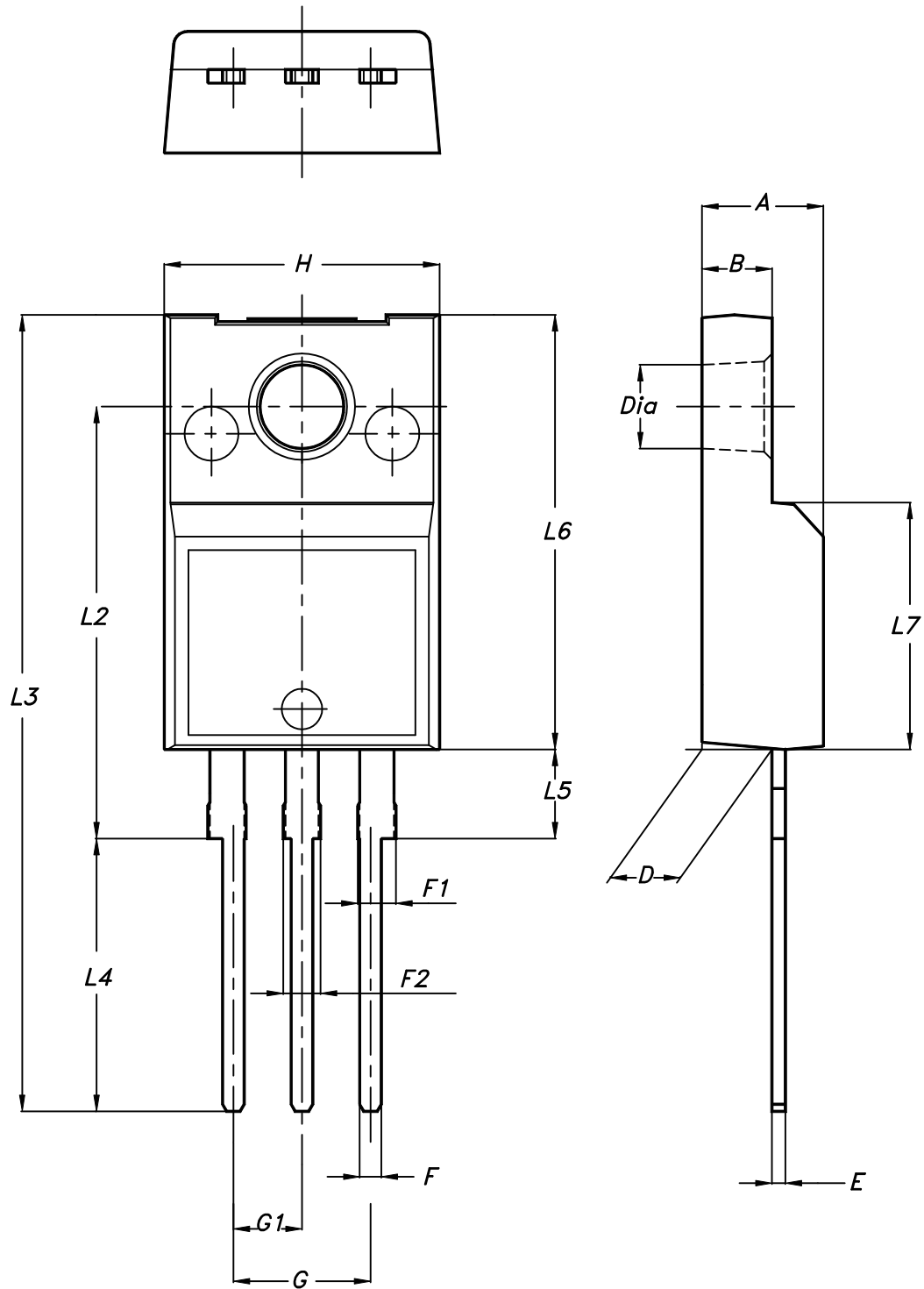
AM06038v1

**Table 13. 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			

4.7 TO-220FP package information

Figure 35. TO-220FP package outline

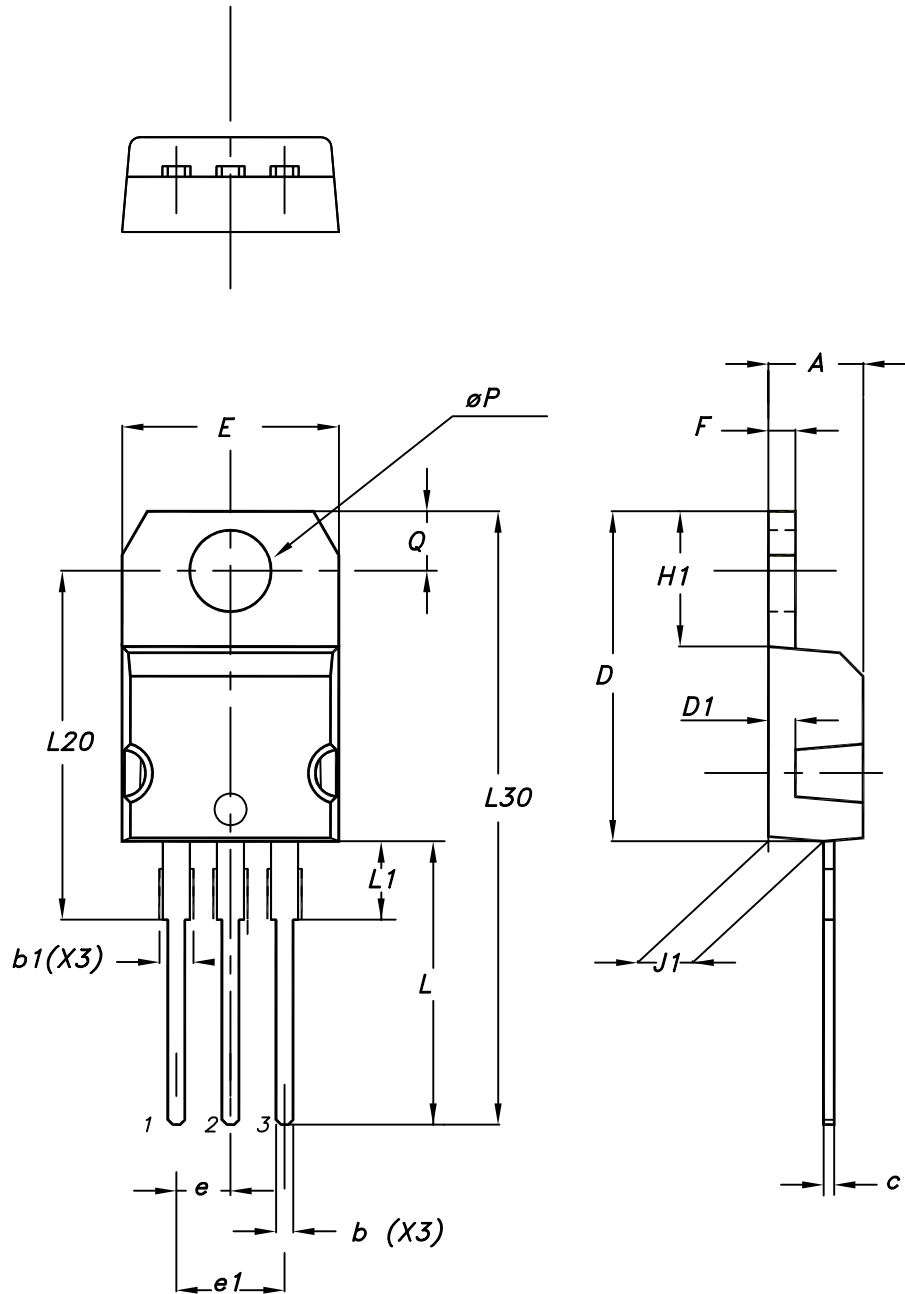


7012510\_Rev\_12\_B

**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-220 type A package information**
**Figure 36. TO-220 type A package outline**


0015988\_typeA\_Rev\_21

**Table 15. 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

## 5 Ordering information

**Table 16. Order codes**

Order code	Marking	Package	Packing
STB11N65M5	11N65M5	D <sup>2</sup> PAK	Tape and reel
STD11N65M5		DPAK	
STF11N65M5		TO-220FP	Tube
STP11N65M5		TO-220	

## Revision history

**Table 17. Document revision history**

Date	Version	Changes
23-Feb-2012	1	First release.
03-Dec-2012	2	<ul style="list-style-type: none"> <li>– Minor text changes in cover page</li> <li>– Added IPAK packages</li> <li>– Added <i>Section 2.1: Electrical characteristics (curves)</i></li> <li>– Updated <i>Section 5: Packaging mechanical data</i></li> <li>– Modified: <i>note 2</i> on <i>Table 2</i></li> <li>– Updated: mechanical data for TO-220FP package</li> </ul>
02-May-2018	3	<p>The part number STU11N65M5 has been moved to a separate datasheet.</p> <p>Removed maturity status indication from cover page. The document status is production data.</p> <p>Updated title and features in cover page, <a href="#">Section 1 Electrical ratings</a>, <a href="#">Section 2 Electrical characteristics</a>, <a href="#">Section 2.1 Electrical characteristics curves</a> and <a href="#">Section 4 Package information</a>.</p> <p>Minor text changes.</p>

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