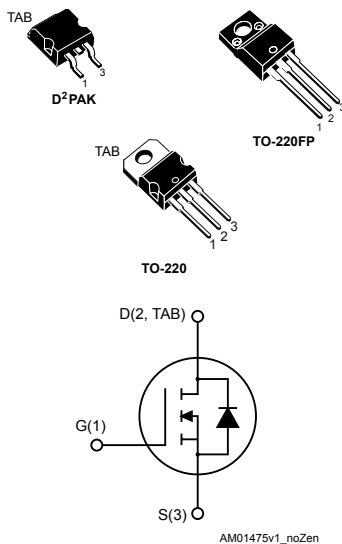


## N-channel 600 V, 0.20 $\Omega$ typ., 16 A MDmesh™ II Power MOSFETs in D<sup>2</sup>PAK, TO-220FP and TO-220 packages



### Features

Order code	$V_{DS}$ @ $T_{jmax.}$	$R_{DS(on)max.}$	$I_D$
STB22NM60N	650 V	0.22 $\Omega$	16 A
STF22NM60N			
STP22NM60N			

- 100% avalanche tested
- Low input capacitance and gate charge
- Low gate input resistance

### Applications

- Switching applications

### Description

These devices are N-channel Power MOSFETs developed using the second generation of MDmesh™ technology. This revolutionary Power MOSFET associates a vertical structure to the company's strip layout to yield one of the world's lowest on-resistance and gate charge. It is therefore suitable for the most demanding high efficiency converters.

#### Product status

STB22NM60N

STF22NM60N

STP22NM60N

# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

Symbol	Parameter	Value			Unit
		D <sup>2</sup> PAK	TO-220	TO-220FP	
V <sub>GS</sub>	Gate-source voltage	± 30			V
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 25 °C	16		16 <sup>(1)</sup>	A
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 100 °C	10		10 <sup>(1)</sup>	A
I <sub>DM</sub> <sup>(2)</sup>	Drain current (pulsed)	64		64 <sup>(1)</sup>	A
P <sub>TOT</sub>	Total dissipation at T <sub>C</sub> = 25 °C	125		30	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> ≤ 16 A, di/dt ≤ 400 A/μs, V<sub>D<sub>Speak</sub></sub> ≤ V<sub>(BR)DSS</sub>, V<sub>DD</sub> = 80% V<sub>(BR)DSS</sub>.

**Table 2. Thermal data**

Symbol	Parameter	Value			Unit
		D <sup>2</sup> PAK	TO-220	TO-220FP	
R <sub>thj-case</sub>	Thermal resistance junction-case	1		4.17	°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			°C/W

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

**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)	6	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)	300	mJ

## 2 Electrical characteristics

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

**Table 4. On/off states**

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source Breakdown voltage	$I_D = 1\text{ mA}$ , $V_{GS} = 0\text{ V}$	600			V
$I_{DSS}$	Zero gate voltage drain current	$V_{GS} = 0\text{ V}$ , $V_{DS} = 600\text{ V}$			1	$\mu\text{A}$
		$V_{GS} = 0\text{ V}$ , $V_{DS} = 600\text{ V}$ , $T_C = 125\text{ °C}^{(1)}$			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	$V_{DS} = V_{GS}$ , $I_D = 250\text{ }\mu\text{A}$	2	3	4	V
$R_{DS(on)}$	Static drain-source on resistance	$V_{GS} = 10\text{ V}$ , $I_D = 8\text{ A}$		0.20	0.22	$\Omega$

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

**Table 5. Dynamic**

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
$C_{iss}$	Input capacitance	$V_{DS} = 50\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GS} = 0\text{ V}$	-	1330	-	$\mu\text{F}$
$C_{oss}$	Output capacitance			84		
$C_{rss}$	Reverse transfer capacitance			4.6		
$C_{oss\text{ eq.}}^{(1)}$	Equivalent output capacitance	$V_{DS} = 0\text{ to }480\text{ V}$ , $V_{GS} = 0\text{ V}$	-	181	-	$\mu\text{F}$
$R_g$	Gate input resistance	$f = 1\text{ MHz}$ open drain	-	4.7	-	$\Omega$
$Q_g$	Total gate charge	$V_{DD} = 480\text{ V}$ , $I_D = 16\text{ A}$ , $V_{GS} = 0\text{ to }10\text{ V}$ (see <a href="#">Figure 15. Test circuit for gate charge behavior</a> )	-	44	-	nC
$Q_{gs}$	Gate-source charge			6		
$Q_{gd}$	Gate-drain charge			25		

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%  $V_{DSS}$ .

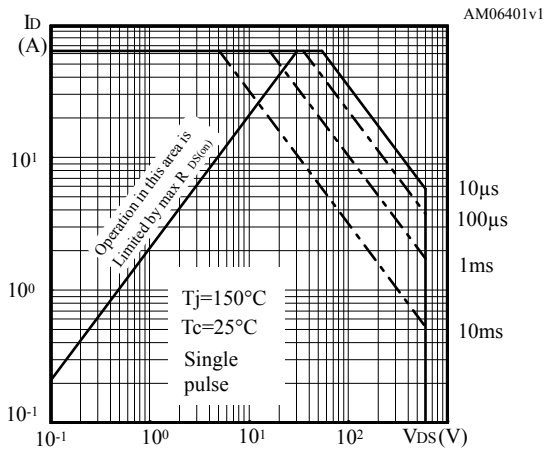
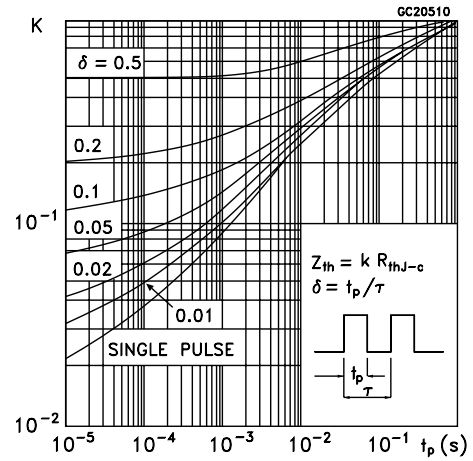
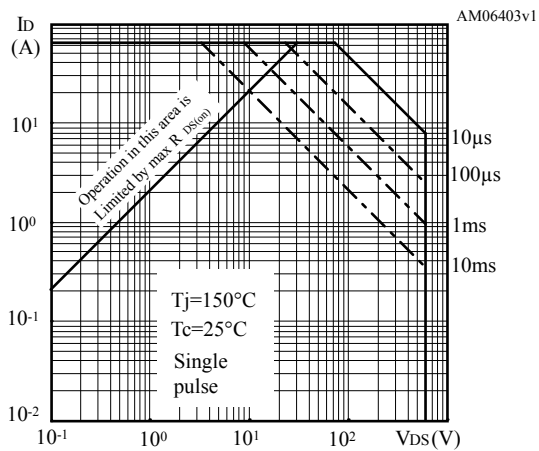
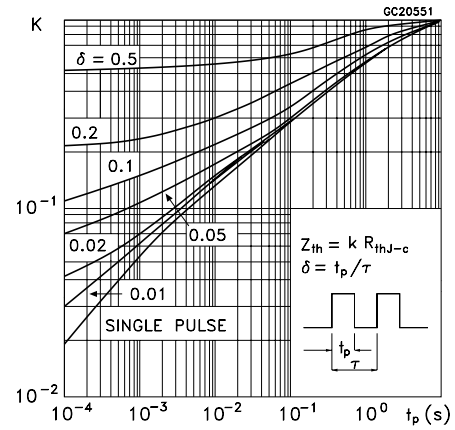
**Table 6. Switching times**

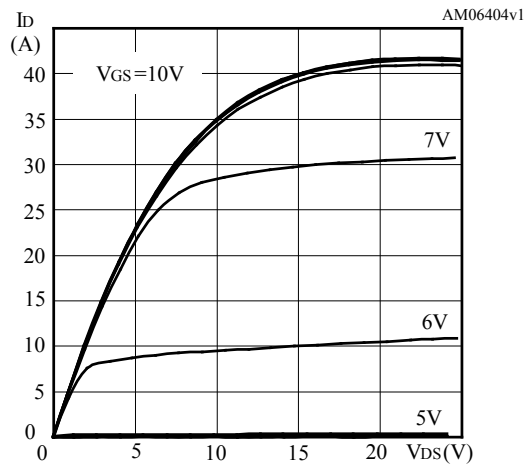
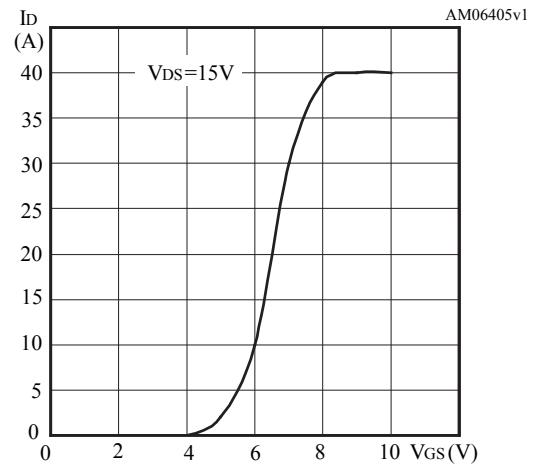
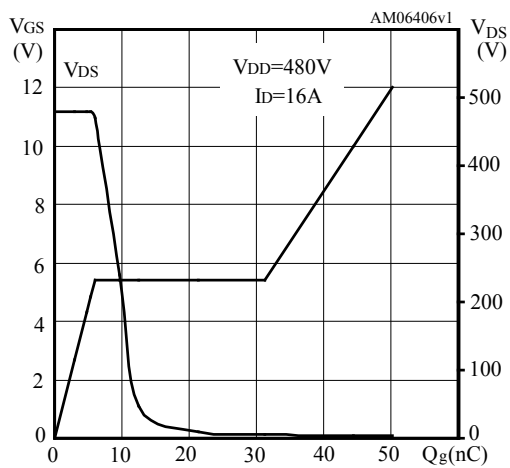
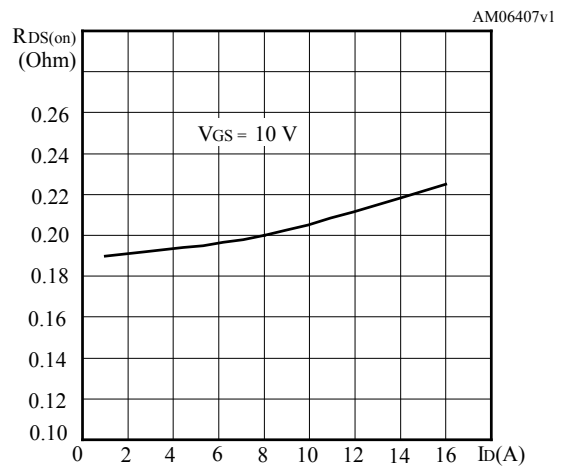
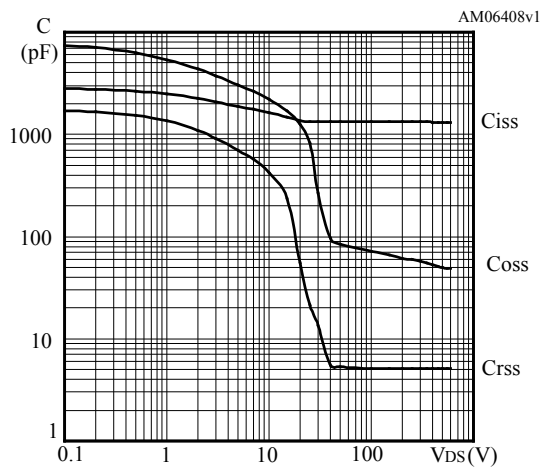
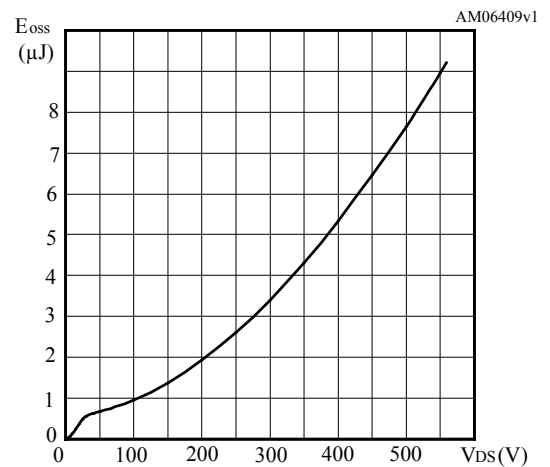
Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 300\text{ V}$ , $I_D = 8\text{ A}$ , $R_G = 4.7\text{ }\Omega$ , $V_{GS} = 10\text{ V}$ (see <a href="#">Figure 14. Test circuit for resistive load switching times</a> and <a href="#">Figure 19. Switching time waveform</a> )	-	11	-	ns
$t_{r(v)}$	Voltage rise time			18		
$t_{d(off)}$	Turn-off delay time			74		
$t_{f(i)}$	Fall time			38		

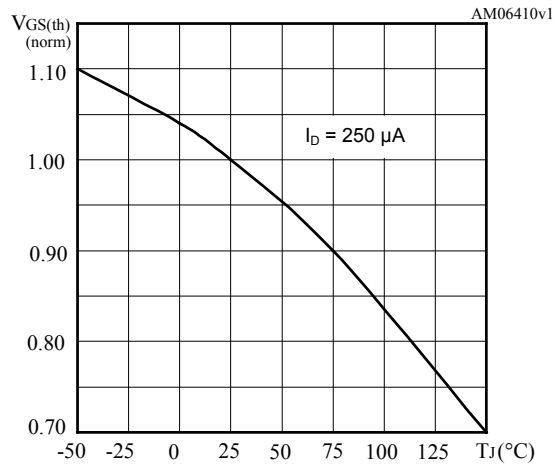
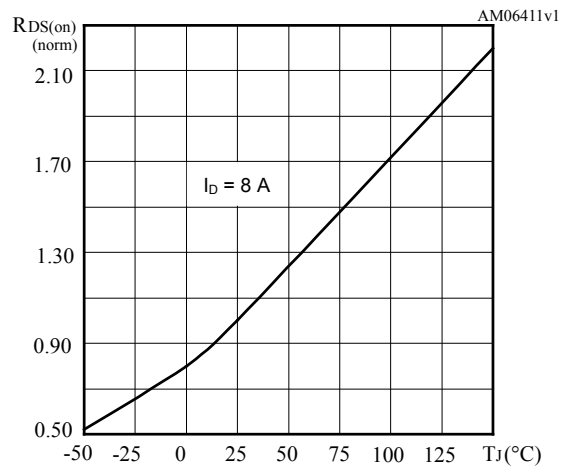
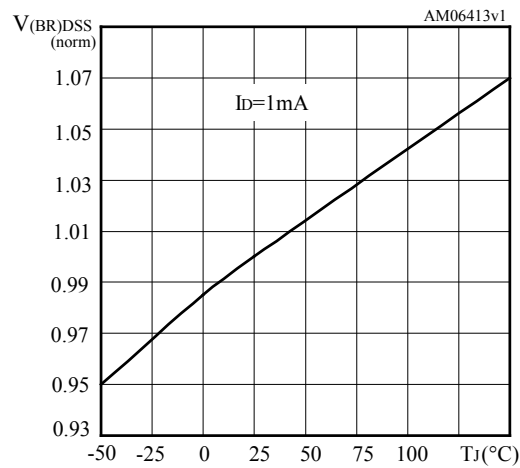
**Table 7. Source drain diode**

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit	
$I_{SD}$	Source-drain current		-		16	A	
$I_{SDM}^{(1)}$	Source-drain current (pulsed)				64		
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 16\text{ A}$ , $V_{GS} = 0\text{ V}$	-		1.6	V	
$t_{rr}$	Reverse recovery time	$I_{SD} = 16\text{ A}$ , $di/dt = 100\text{ V}$ $V_{DD} = 60\text{ V}$ (see <a href="#">Figure 16. Test circuit for inductive load switching and diode recovery times</a> )	-	296		ns	
$Q_{rr}$	Reverse recovery charge			4			μC
$I_{RRM}$	Reverse recovery current			26.8			
$t_{rr}$	Reverse recovery time	$I_{SD} = 16\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ $V_{DD} = 60\text{ V}$ (see <a href="#">Figure 16. Test circuit for inductive load switching and diode recovery times</a> )	-	350		ns	
$Q_{rr}$	Reverse recovery charge			4.7			μC
$I_{RRM}$	Reverse recovery current			27			

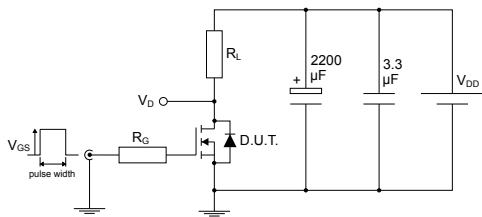
1. Pulse width limited by safe operating area.
2. Pulsed: pulse duration = 300 μs, duty cycle 1.5%.

**2.1 Electrical characteristics curves**
**Figure 1. Safe operating area for TO-220, D<sup>2</sup>PAK**

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

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

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


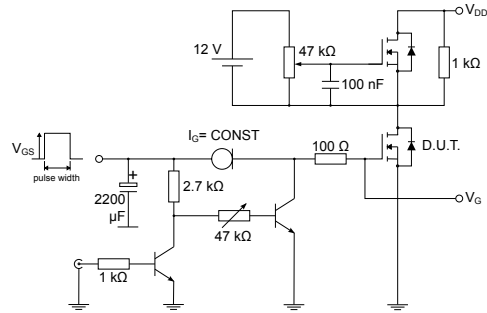
**Figure 5. Output characteristics**

**Figure 6. Transfer characteristics**

**Figure 7. Gate charge vs gate-source voltage**

**Figure 8. Static drain-source on resistance**

**Figure 9. Capacitance variations**

**Figure 10. Output capacitance stored energy**


**Figure 11. Normalized gate threshold voltage vs temperature**

**Figure 12. Normalized on resistance vs temperature**

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


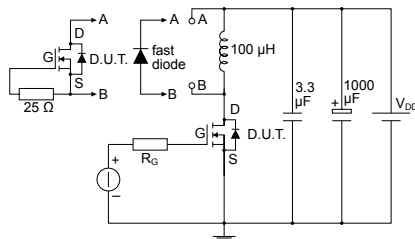
### 3 Test circuits

**Figure 14. Test circuit for resistive load switching times**


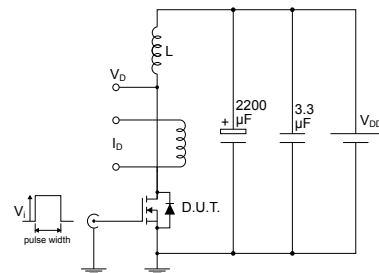
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**Figure 15. Test circuit for gate charge behavior**


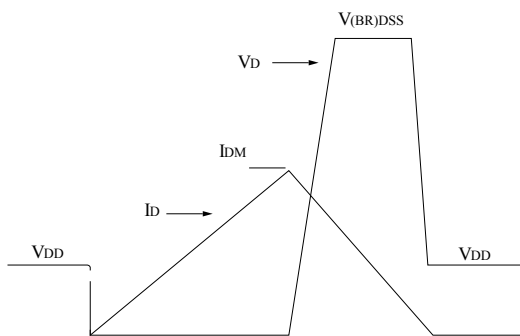
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**Figure 16. Test circuit for inductive load switching and diode recovery times**


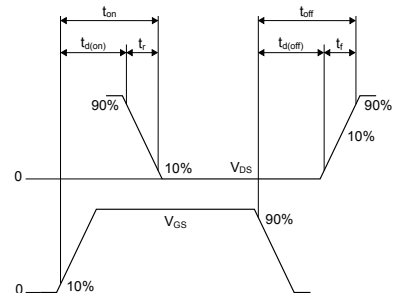
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**Figure 17. Unclamped inductive load test circuit**


AM01471v1

**Figure 18. Unclamped inductive waveform**


AM01472v1

**Figure 19. Switching time waveform**


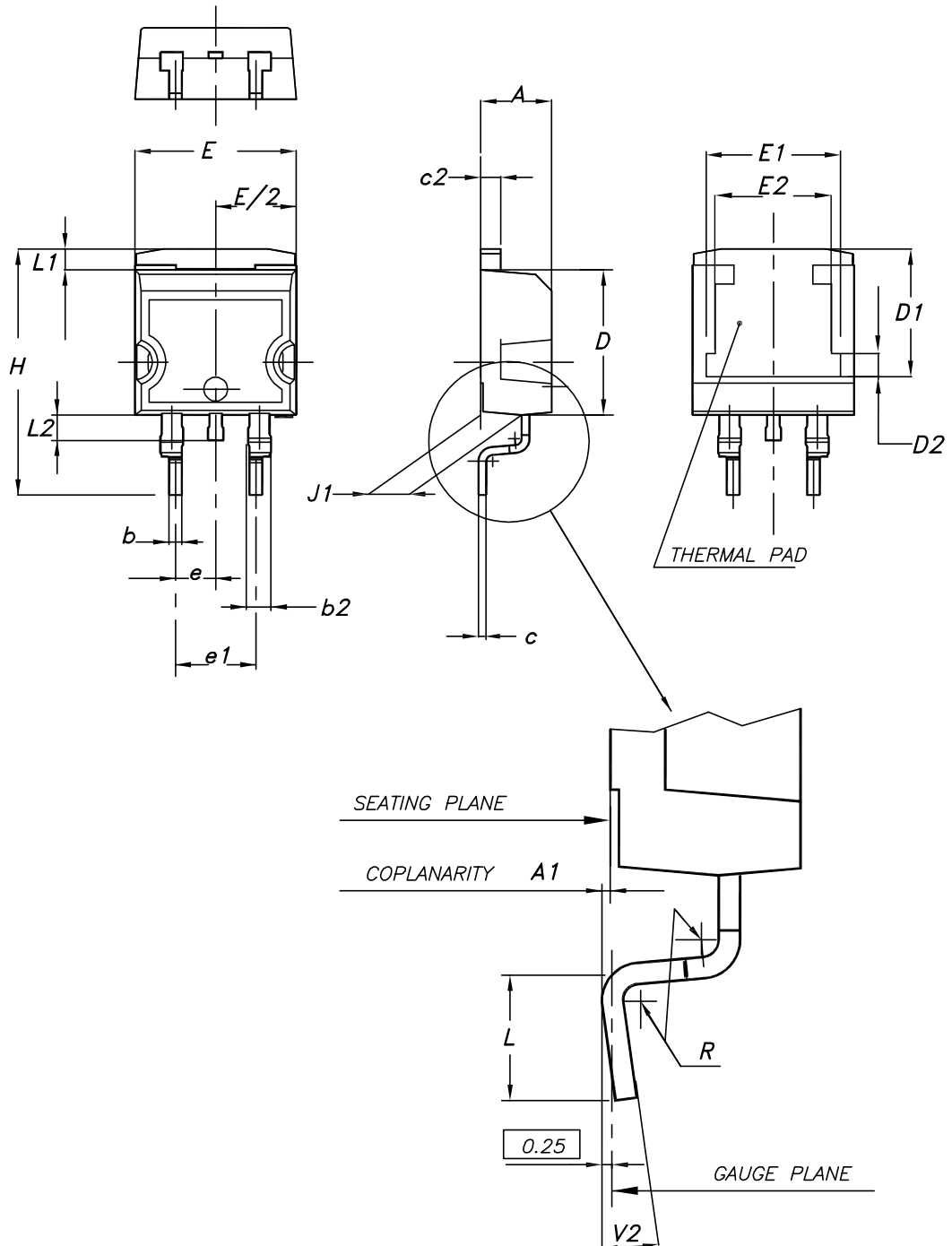
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## 4 Package information

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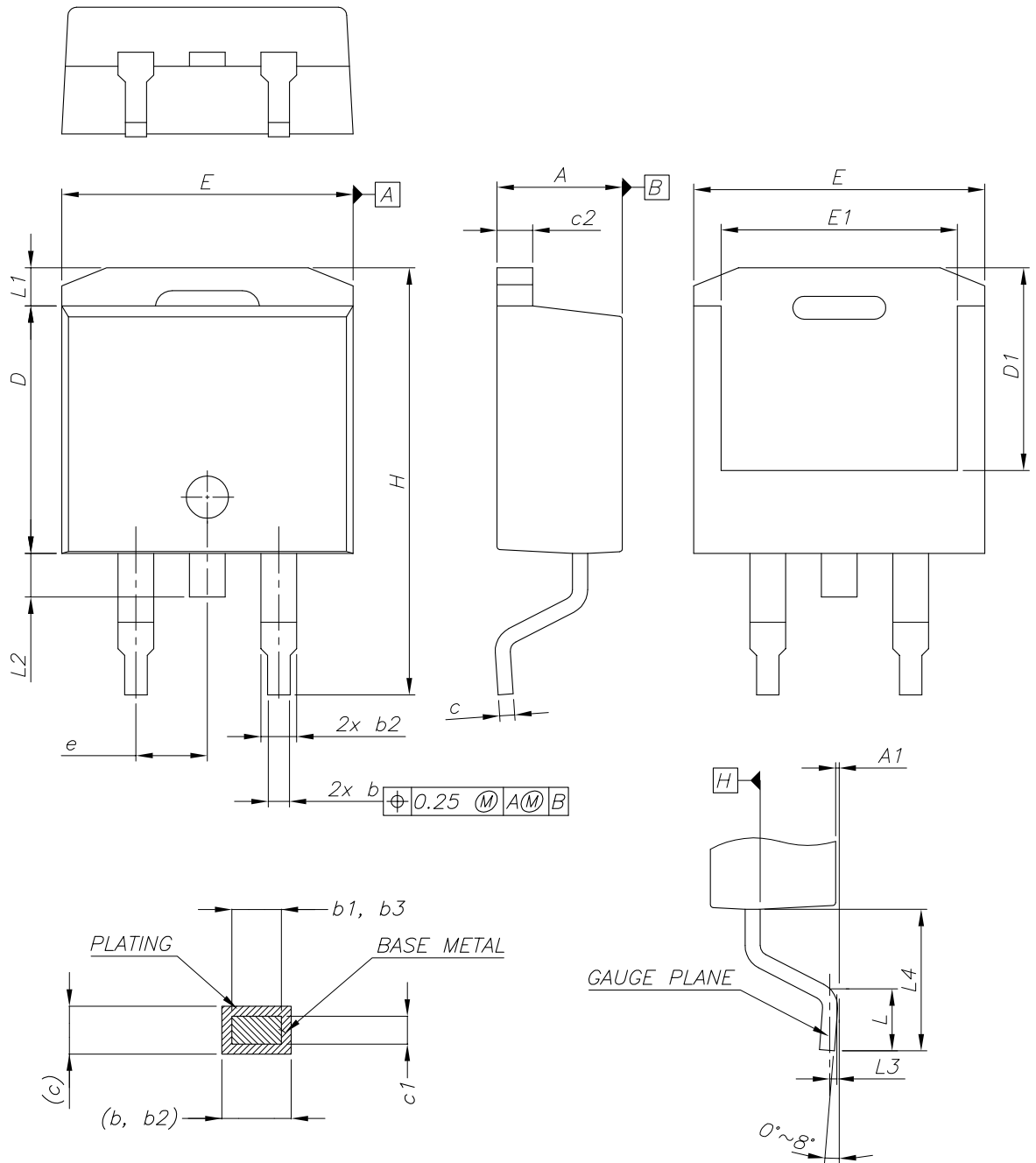
In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK® is an ST trademark.

**4.1 D<sup>2</sup>PAK (TO-263) type A package information**
**Figure 20. 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**

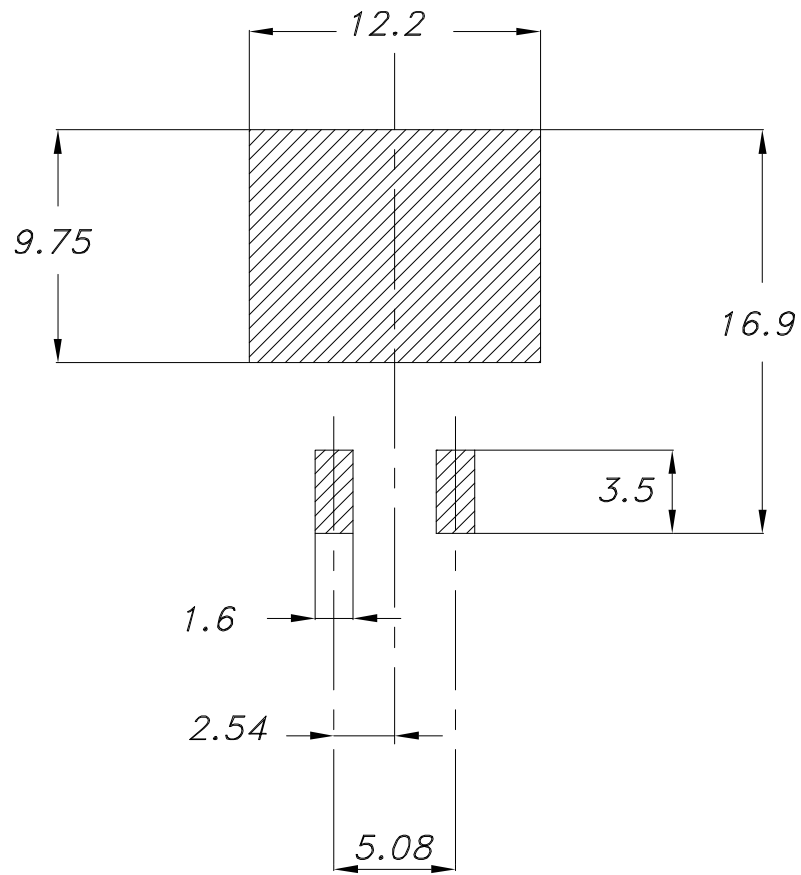
Dim.	mm		
	Min.	Typ.	Max.
A	4.40		4.60
A1	0.03		0.23
b	0.70		0.93
b2	1.14		1.70
c	0.45		0.60
c2	1.23		1.36
D	8.95		9.35
D1	7.50	7.75	8.00
D2	1.10	1.30	1.50
E	10.00		10.40
E1	8.30	8.50	8.70
E2	6.85	7.05	7.25
e		2.54	
e1	4.88		5.28
H	15.00		15.85
J1	2.49		2.69
L	2.29		2.79
L1	1.27		1.40
L2	1.30		1.75
R		0.40	
V2	0°		8°

**4.2 D<sup>2</sup>PAK (TO-263) type B package information**
**Figure 21. D<sup>2</sup>PAK (TO-263) type B package outline**


0079457\_25\_B

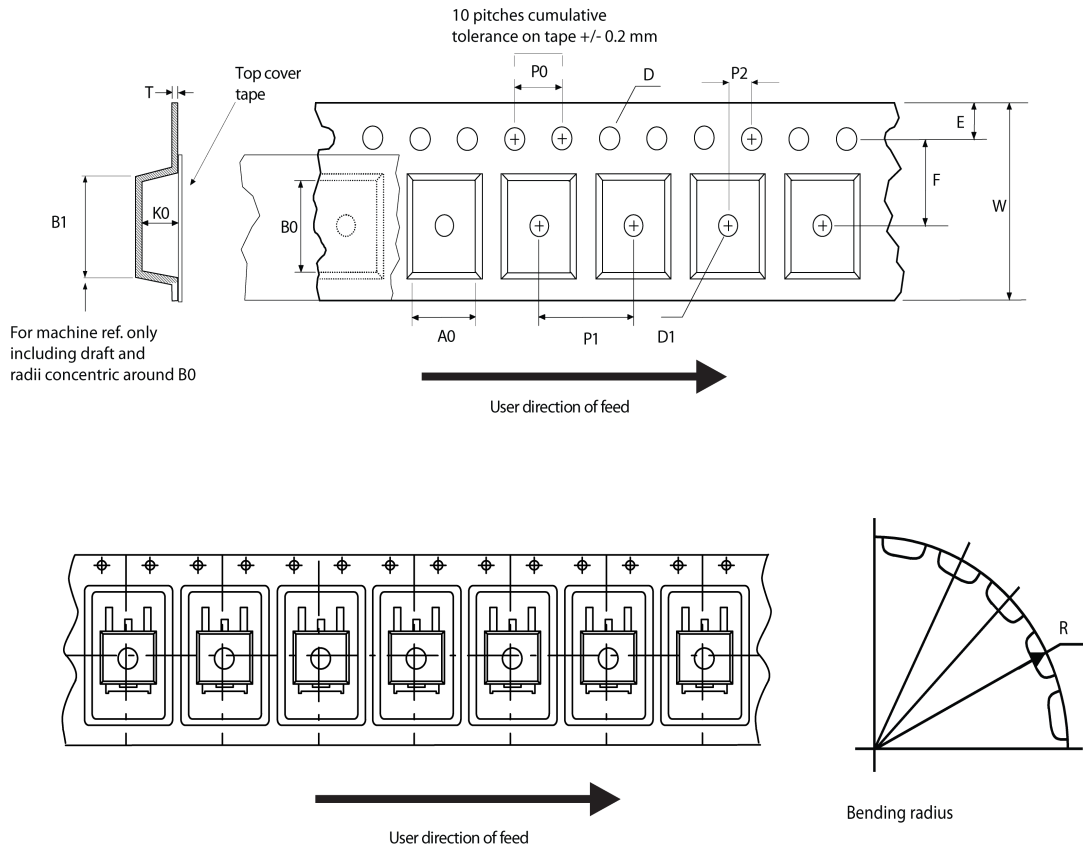
**Table 9. D<sup>2</sup>PAK (TO-263) type B mechanical data**

Dim.	mm		
	Min.	Typ.	Max.
A	4.36		4.56
A1	0		0.25
b	0.70		0.90
b1	0.51		0.89
b2	1.17		1.37
b3	1.36		1.46
c	0.38		0.694
c1	0.38		0.534
c2	1.19		1.34
D	8.60		9.00
D1	6.90		7.50
E	10.15		10.55
E1	8.10		8.70
e	2.54 BSC		
H	15.00		15.60
L	1.90		2.50
L1			1.65
L2			1.78
L3		0.25	
L4	4.78		5.28

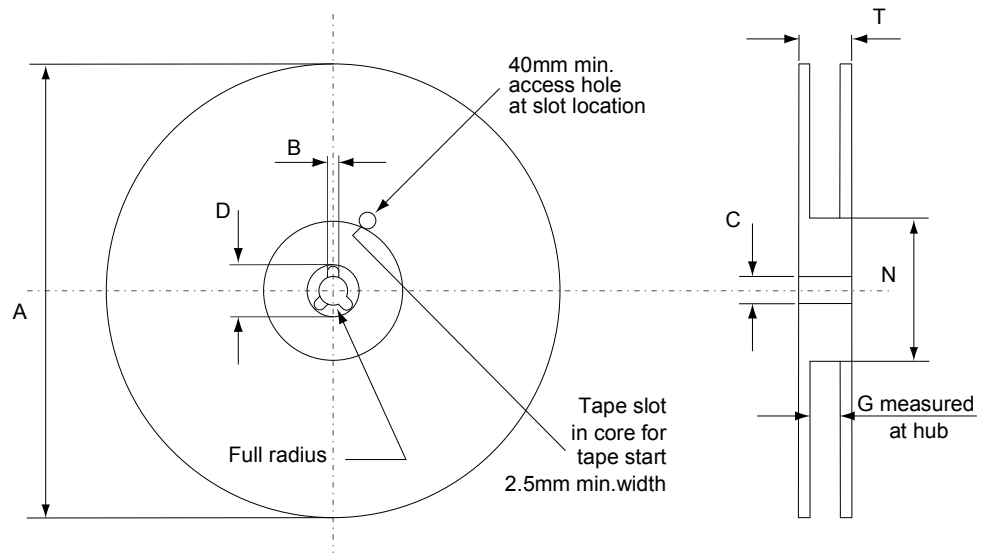
**Figure 22. D<sup>2</sup>PAK (TO-263) recommended footprint (dimensions are in mm)**


Footprint

### 4.3 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

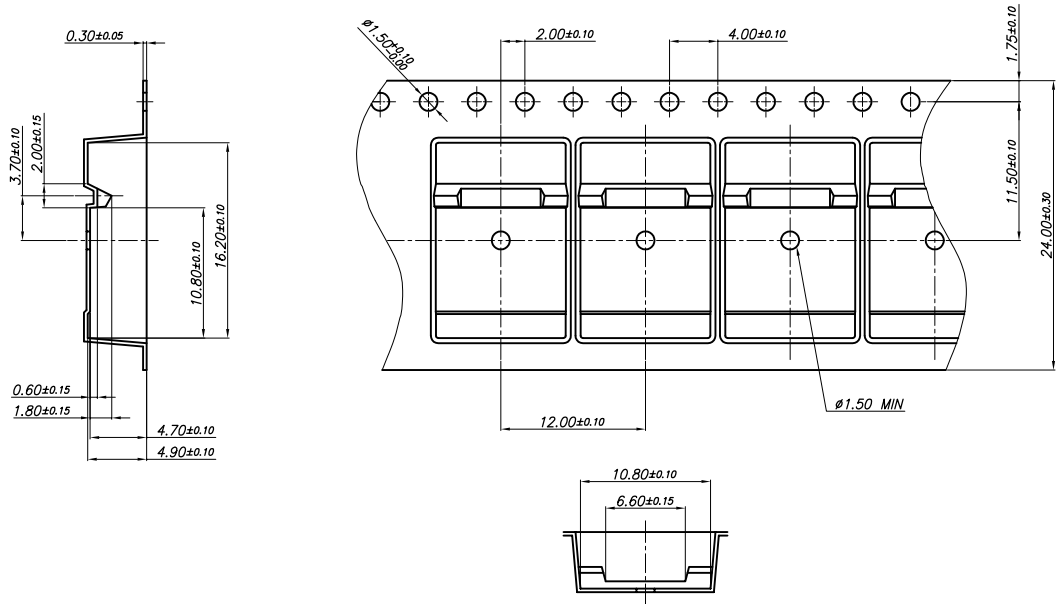
**Table 10. D<sup>2</sup>PAK tape and reel mechanical data**

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		
P1	11.9	12.1			
P2	1.9	2.1	Bulk quantity		
R	50				
T	0.25	0.35			
W	23.7	24.3			

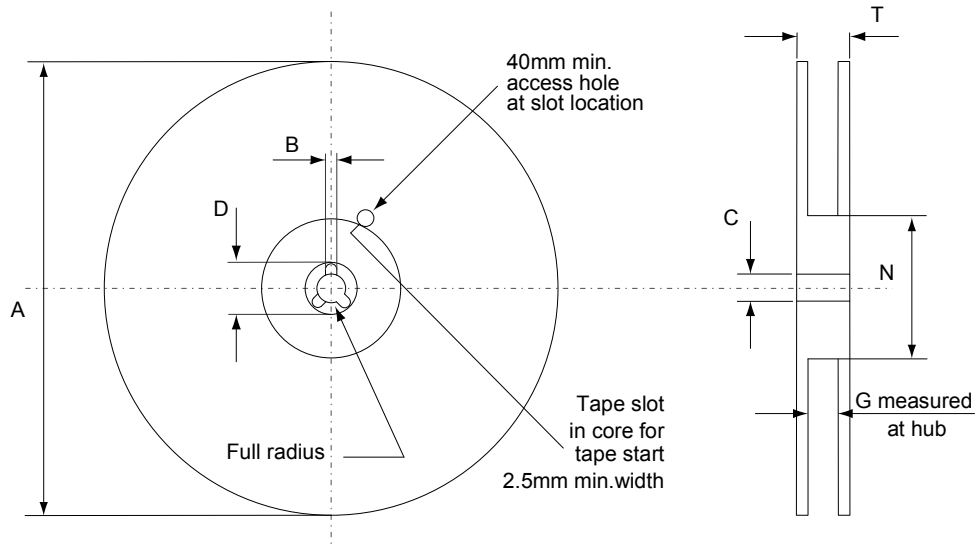


#### 4.4 D<sup>2</sup>PAK type B packing information

**Figure 25. D<sup>2</sup>PAK type B tape outline**



**Figure 26. D<sup>2</sup>PAK type B reel outline**



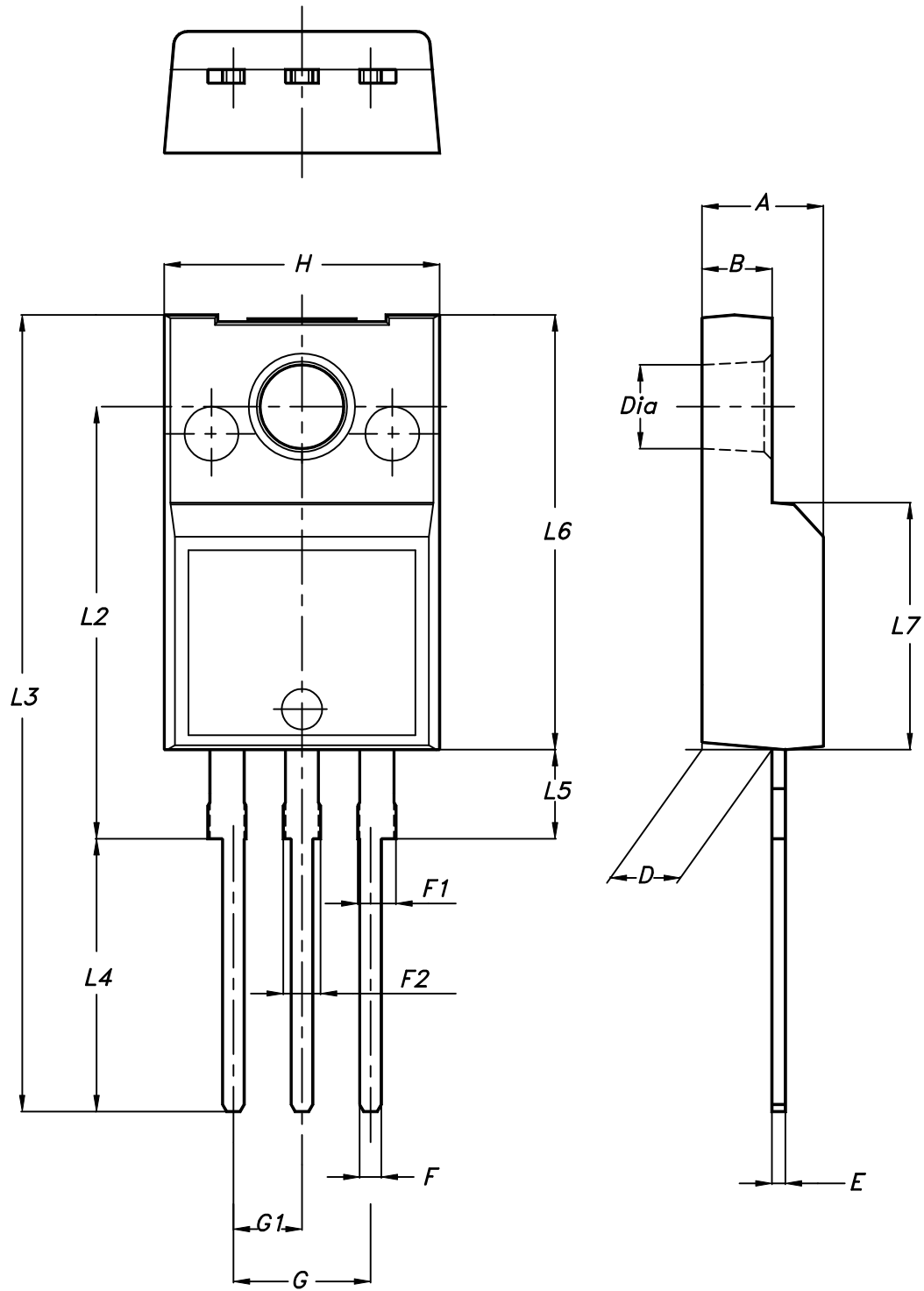
AM06038v1

**Table 11. D<sup>2</sup>PAK type B reel mechanical data**

Dim.	mm	
	Min.	Max.
A		330
B	1.5	
C	12.8	13.2
D	20.2	
G	24.4	26.4
N	100	
T		30.4

### 4.5 TO-220FP package information

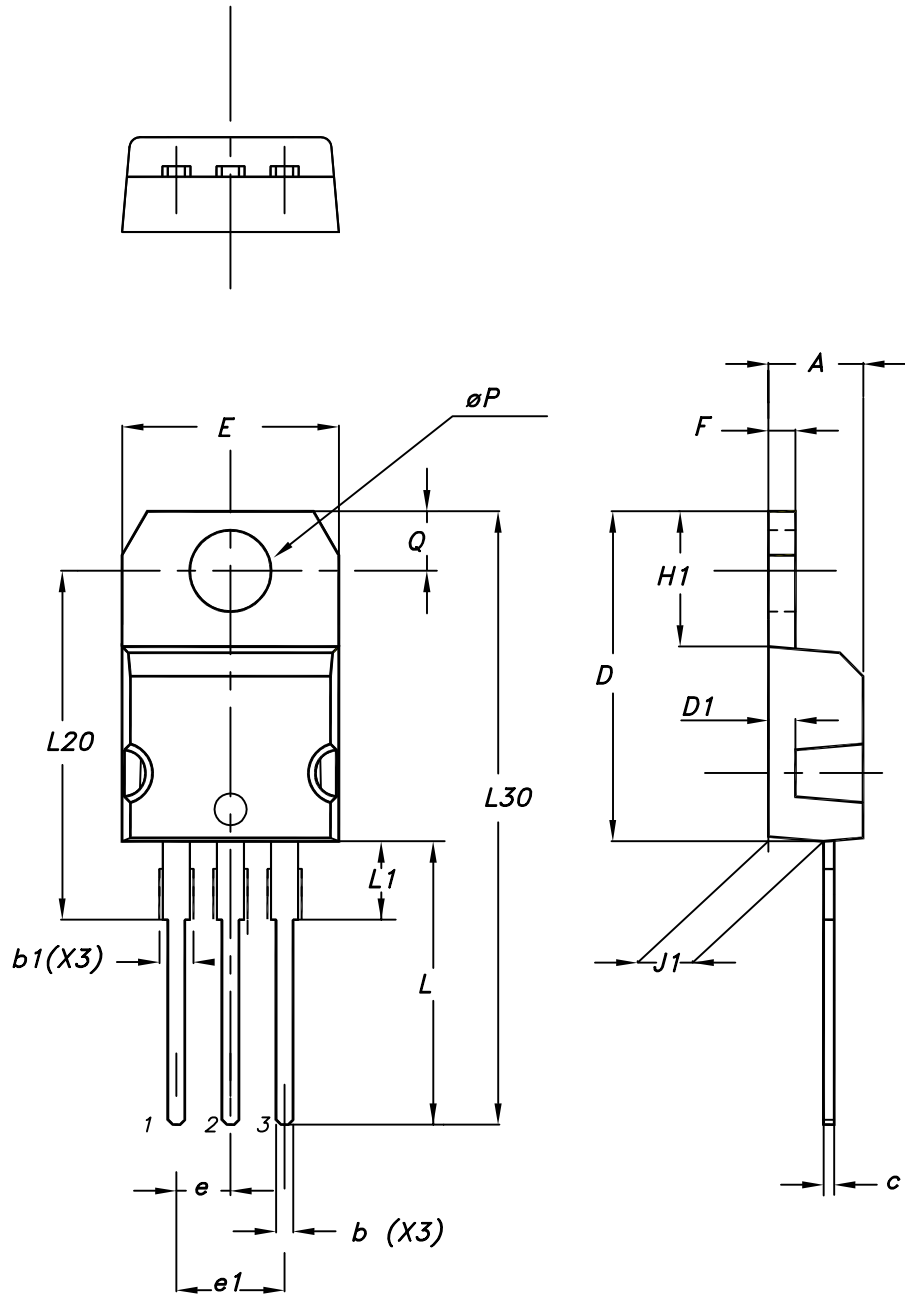
Figure 27. TO-220FP package outline



7012510\_Rev\_12\_B

**Table 12. 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

**4.6 TO-220 type A package information**
**Figure 28. TO-220 type A package outline**


0015988\_typeA\_Rev\_21

**Table 13. 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 14. Order codes**

Order code	Marking	Package	Packing
STB22NM60N	22NM60N	D <sup>2</sup> PAK	Tape and reel
STF22NM60N		TO-220FP	Tube
STP22NM60N		TO-220	

## Revision history

**Table 15. Document revision history**

Date	Version	Changes
02-Jul-2009	1	First release.
18-Feb-2010	2	Document status promoted from preliminary data to datasheet.
27-Aug-2010	3	New package, mechanical data has been inserted: I <sup>2</sup> PAK.
05-Nov-2011	4	Some value changed in <i>Table 5: On /off states</i> .
02-May-2018	5	<p>The part numbers STI22NM60N and STW22NM60N have 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.</p> <p>Updated <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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