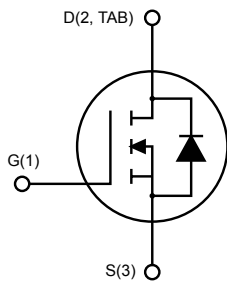
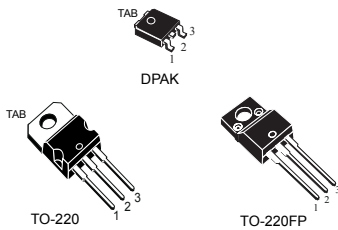


## N-channel 600 V, 0.63 $\Omega$ typ., 6.5 A MDmesh™ II Power MOSFETs in DPAK, TO-220FP and TO-220 packages



AM01475v1\_noZen

### Features

Order code	$V_{DS}$	$R_{DS(on)}$ max.	$I_D$	Package
STD9NM60N	600 V	0.745 $\Omega$	6.5 A	DPAK
STF9NM60N				TO-220FP
STP9NM60N				TO-220

- 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. These revolutionary Power MOSFETs associate a vertical structure to the company's strip layout to yield one of the world's lowest on-resistance and gate charge. They are therefore suitable for the most demanding high-efficiency converters.

#### Product status link

[STD9NM60N](#)
[STF9NM60N](#)
[STP9NM60N](#)

# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

Symbol	Parameter	Value		Unit
		DPAK, TO-220	TO-220FP	
$V_{DS}$	Drain-source voltage	600		V
$V_{GS}$	Gate-source voltage	±25		V
$I_D$	Drain current (continuous) at $T_C = 25\text{ °C}$	6.5	6.5 <sup>(1)</sup>	A
$I_D$	Drain current (continuous) at $T_C = 100\text{ °C}$	4	4 <sup>(1)</sup>	A
$I_{DM}^{(2)}$	Drain current (pulsed)	26	26 <sup>(1)</sup>	A
$P_{TOT}$	Total dissipation at $T_C = 25\text{ °C}$	70	25	W
$dv/dt^{(3)}$	Peak diode recovery voltage slope	15		V/ns
$V_{ISO}$	Insulation withstand voltage (RMS) from all three leads to external heat sink ( $t = 1\text{ s}$ ; $T_C = 25\text{ °C}$ )	2.5		kV
$T_j$	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.
- $I_{SD} \leq 6.5\text{ A}$ ,  $di/dt \leq 400\text{ A}/\mu\text{s}$ ,  $V_{DD} = 80\% V_{(BR)DSS}$ .

**Table 2. Thermal data**

Symbol	Parameter	Value			Unit
		DPAK	TO-220	TO-220FP	
$R_{thj-case}$	Thermal resistance junction-case	1.79		5	°C/W
$R_{thj-amb}$	Thermal resistance junction-ambient	62.5			
$R_{thj-pcb}^{(1)}$	Thermal resistance junction-pcb	50			

- When mounted on 1inch<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)	2.5	A
$E_{AS}$	Single pulse avalanche energy (starting $T_j = 25\text{ °C}$ , $I_D = I_{AR}$ , $V_{DD} = 50\text{ V}$ )	115	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>			100	$\mu\text{A}$
$I_{GSS}$	Gate body leakage current	$V_{DS} = 0\text{ V}$ , $V_{GS} = \pm 20\text{ V}$			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	$V_{GS} = 10\text{ V}$ , $I_D = 3.25\text{ A}$		0.63	0.745	$\Omega$

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

**Table 5. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$C_{iss}$	Input capacitance	$V_{DS} = 50\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GS} = 0\text{ V}$	-	452	-	$\mu\text{F}$
$C_{oss}$	Output capacitance			30		
$C_{rSS}$	Reverse transfer capacitance			1.45		
$C_{oss\text{ eq.}}^{(1)}$	Equivalent output capacitance	$V_{DS} = 0\text{ to }480\text{ V}$ , $V_{GS} = 0\text{ V}$	-	79	-	$\mu\text{F}$
$R_g$	Gate input resistance	$f = 1\text{ MHz}$ , $I_D = 0\text{ A}$	-	4.8	-	$\Omega$
$Q_g$	Total gate charge	$V_{DD} = 480\text{ V}$ , $I_D = 6.5\text{ A}$ , $V_{GS} = 0\text{ to }10\text{ V}$ (see Figure 17. Test circuit for gate charge behavior)	-	17.4	-	nC
$Q_{gs}$	Gate-source charge			3		
$Q_{gd}$	Gate-drain charge			9.7		

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%  $V_{DSS}$ .

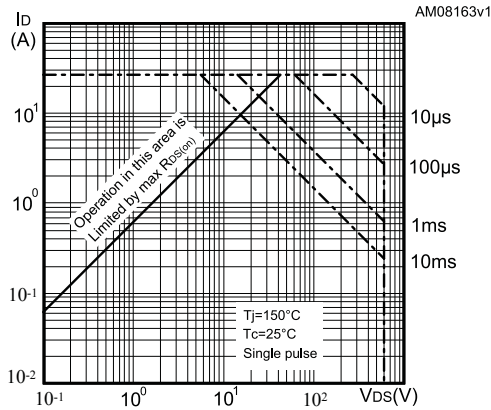
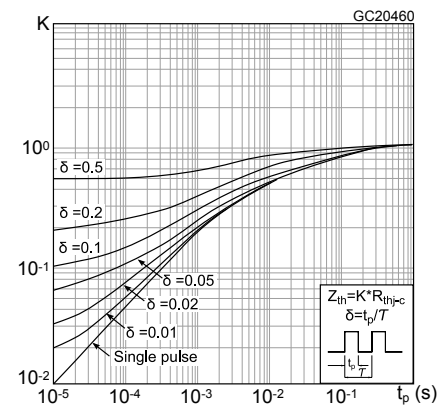
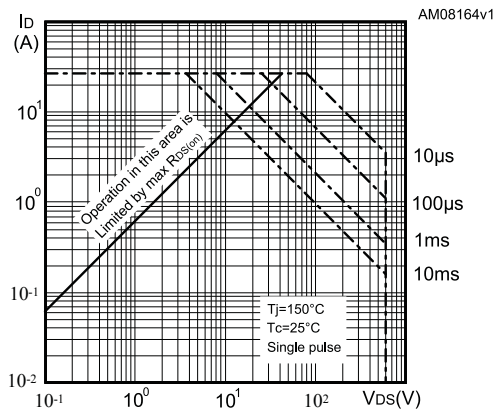
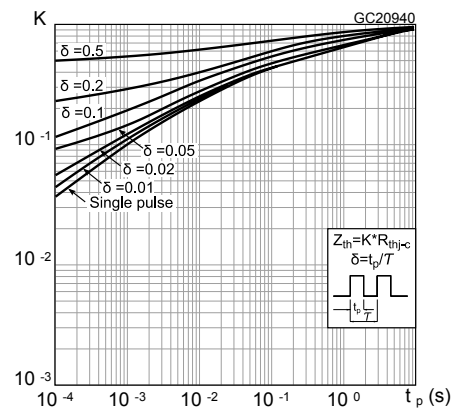
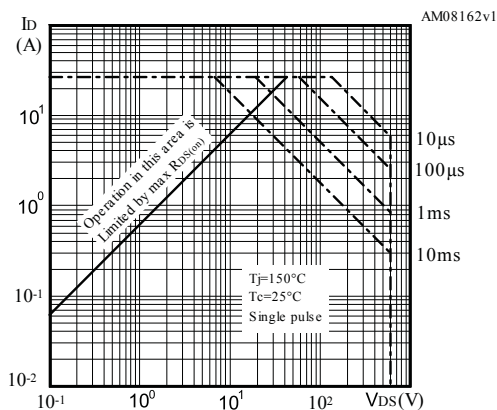
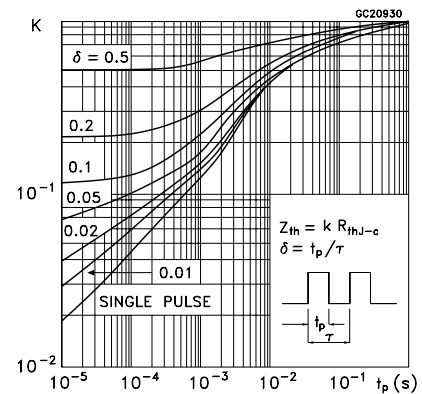
**Table 6. Switching times**

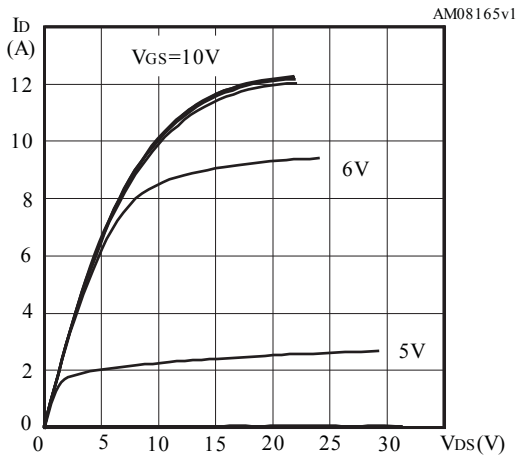
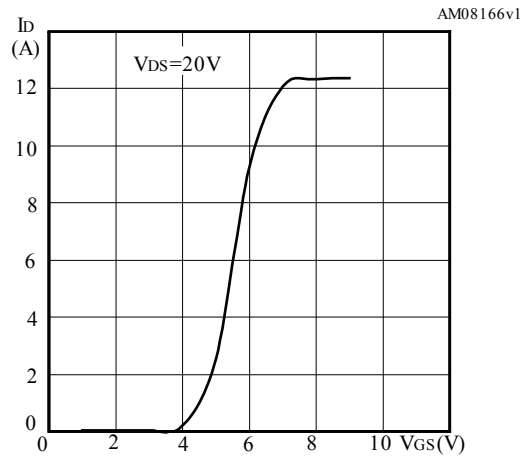
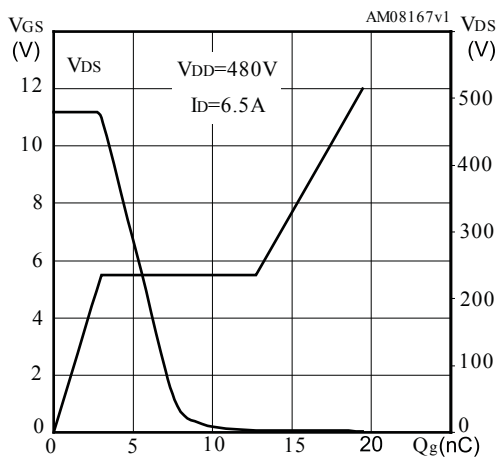
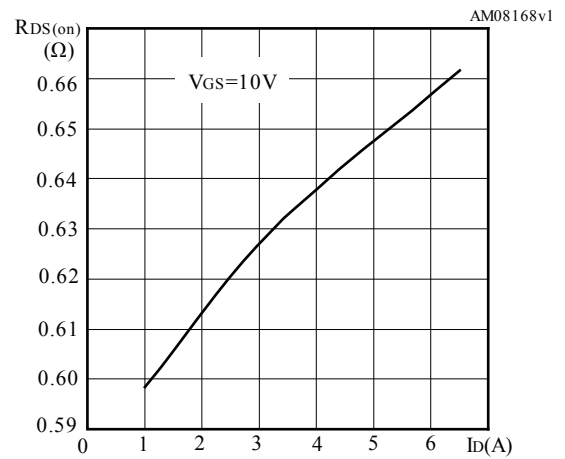
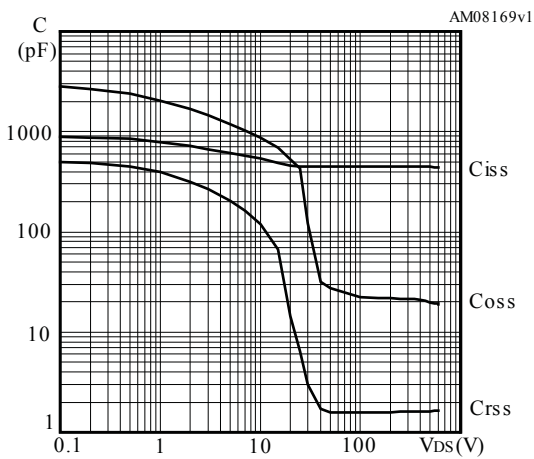
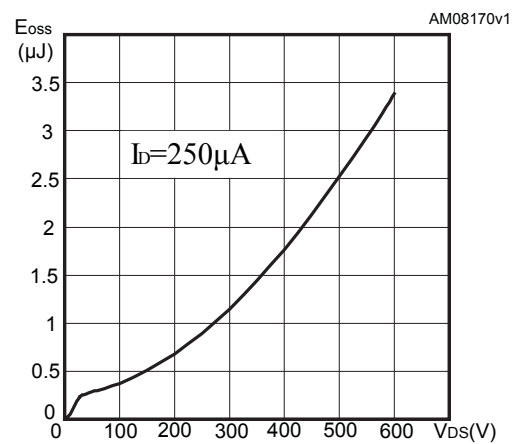
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 480\text{ V}$ , $I_D = 6.5\text{ A}$ , $R_G = 4.7\text{ }\Omega$ , $V_{GS} = 10\text{ V}$	-	28	-	ns
$t_r$	Rise time			23		
$t_{d(off)}$	Turn-off delay time	(see Figure 16. Test circuit for resistive load switching times and Figure 21. Switching time waveform)	-	52.5	-	ns
$t_f$	Fall time			26.7		

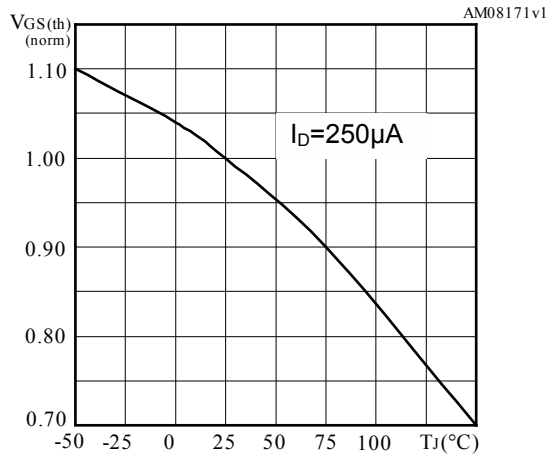
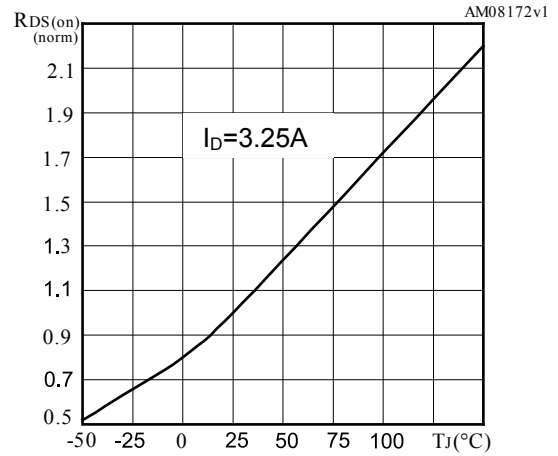
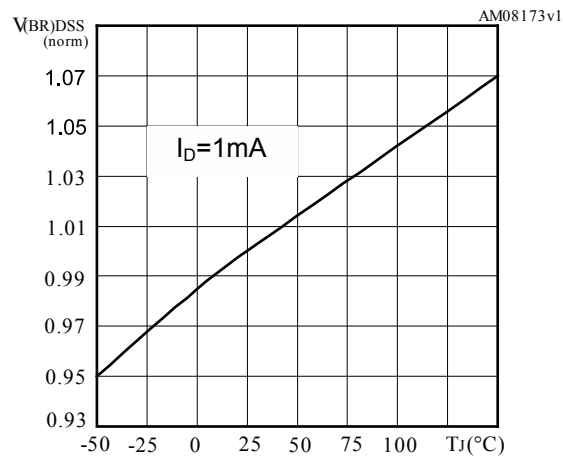
**Table 7. Source drain diode**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{SD}$	Source-drain current				6.5	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)		-		26	
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 6.5 \text{ A}$ , $V_{GS} = 0 \text{ V}$	-		1.6	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 6.5 \text{ A}$ , $di/dt = 100 \text{ A}/\mu\text{s}$		264		ns
$Q_{rr}$	Reverse recovery charge	$V_{DD} = 60 \text{ V}$ (see Figure 18. Test circuit for inductive load switching and diode recovery times)	-	1.9		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current			14.6		A
$t_{rr}$	Reverse recovery time	$I_{SD} = 6.5 \text{ A}$ , $di/dt = 100 \text{ A}/\mu\text{s}$		324		ns
$Q_{rr}$	Reverse recovery charge	$V_{DD} = 60 \text{ V}$ (see Figure 18. Test circuit for inductive load switching and diode recovery times)	-	2.3		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current			14.2		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 for DPAK**

**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**


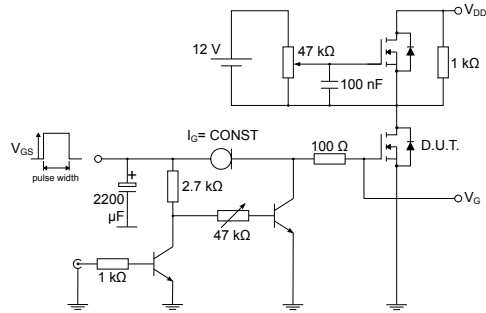
**Figure 7. Output characteristics**

**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. Output capacitance stored energy**


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

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

**Figure 15. Normalized  $V_{(BR)DSS}$  vs temperature**


### 3 Test circuits

**Figure 16. Test circuit for resistive load switching times**


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**Figure 17. Test circuit for gate charge behavior**


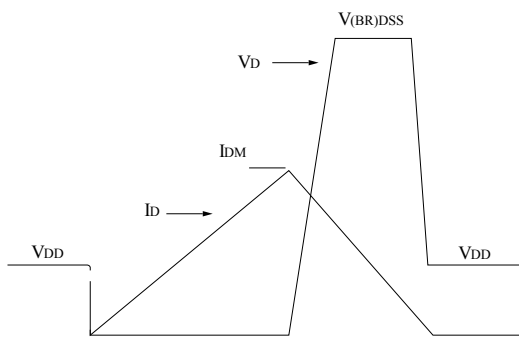
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**Figure 18. Test circuit for inductive load switching and diode recovery times**


AM01470v1

**Figure 19. Unclamped inductive load test circuit**


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**Figure 20. Unclamped inductive waveform**


AM01472v1

**Figure 21. Switching time waveform**


AM01473v1



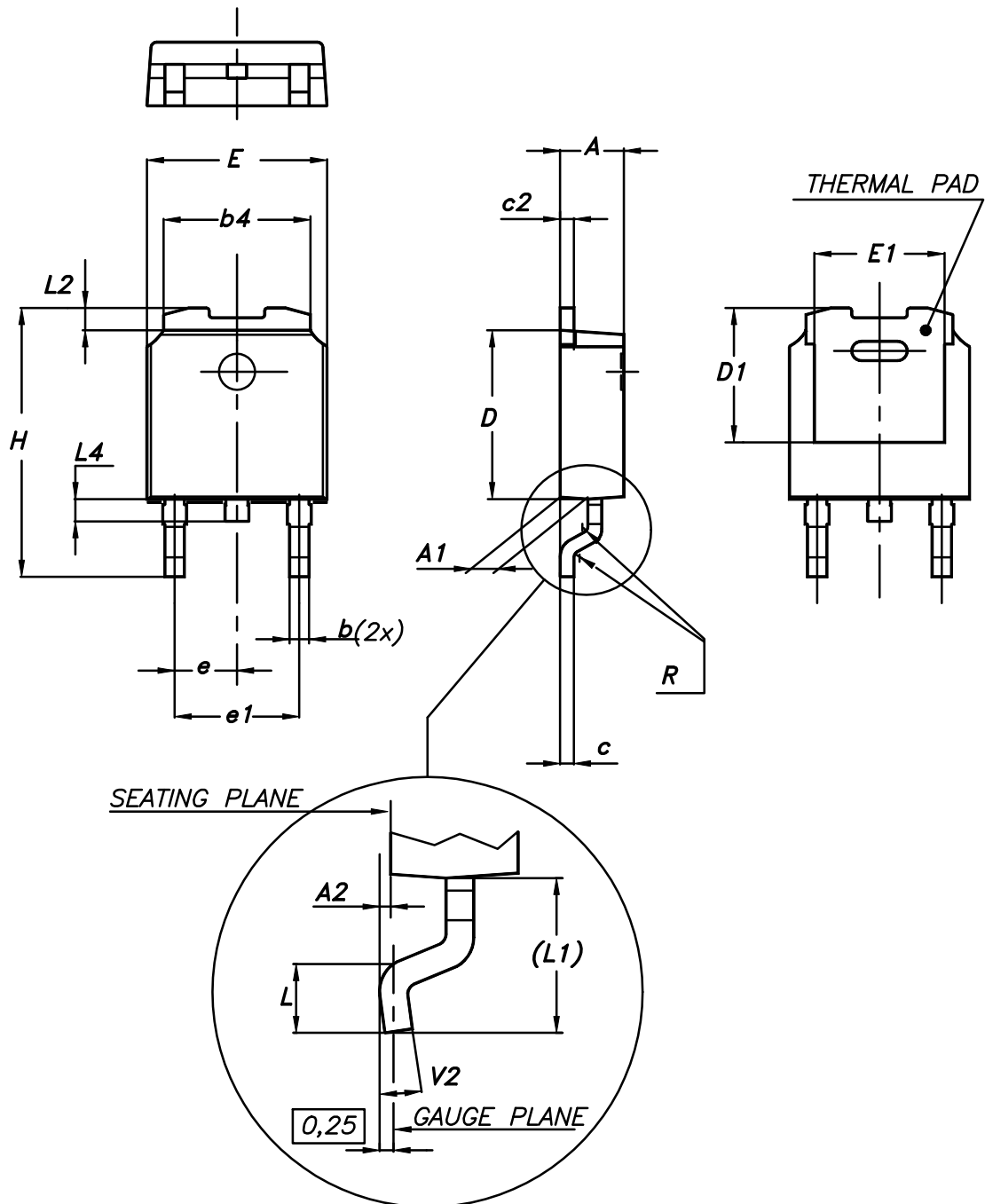
## 4 Package information

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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 22. DPAK (TO-252) type A package outline



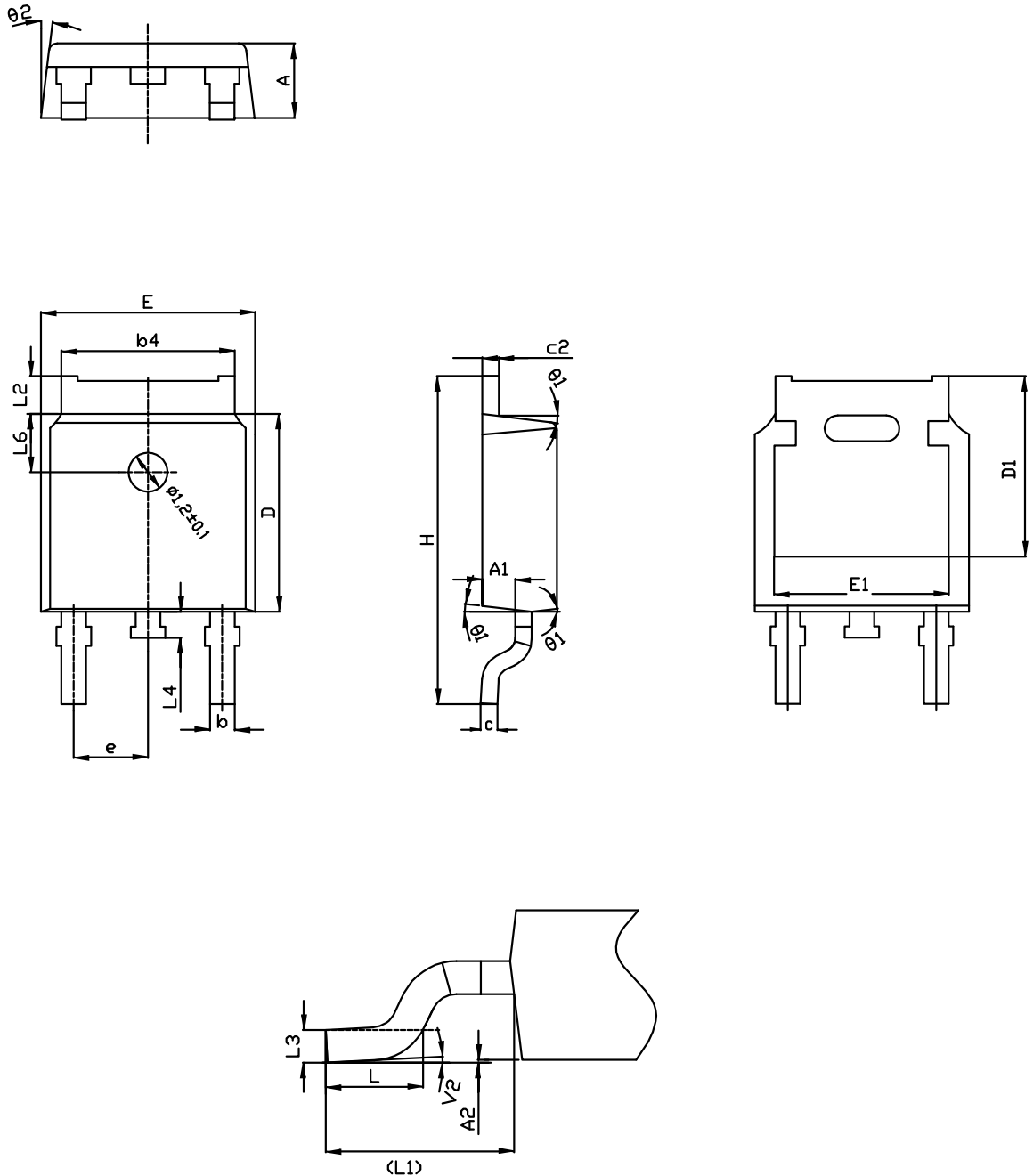
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**Table 8. DPAK (TO-252) type A mechanical data**

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 C2 package information**

Figure 23. DPAK (TO-252) type C2 package outline

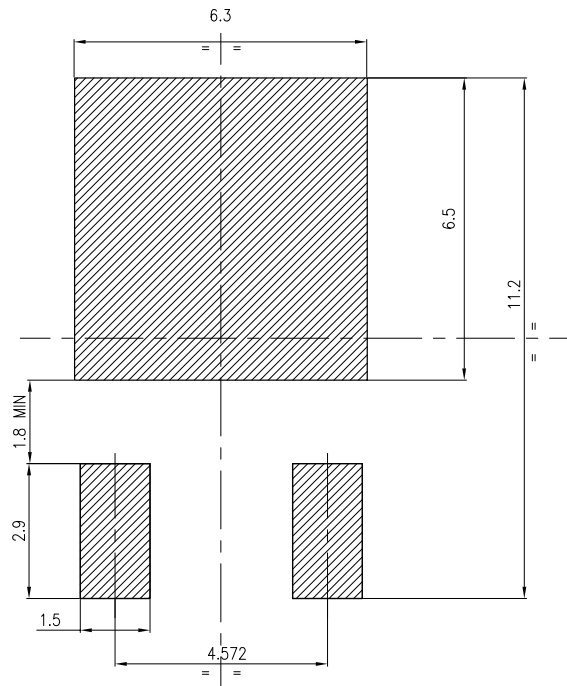


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**Table 9. DPAK (TO-252) type C2 mechanical data**

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°

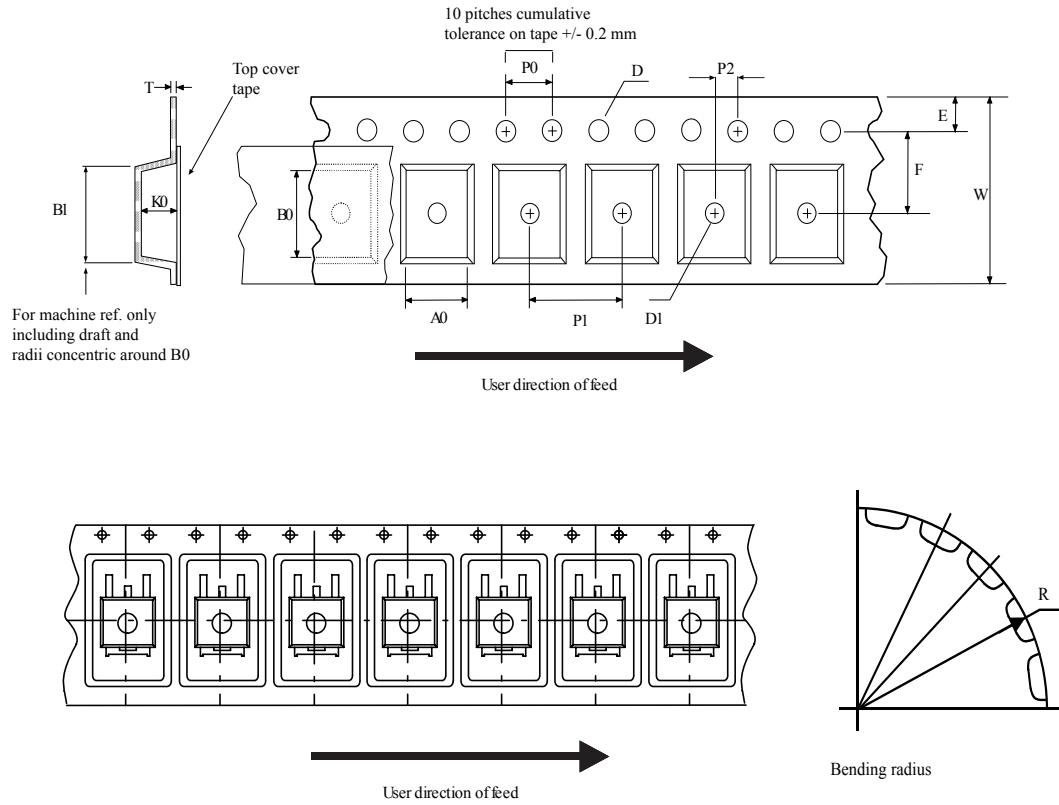
Figure 24. DPAK (TO-252) recommended footprint (dimensions are in mm)



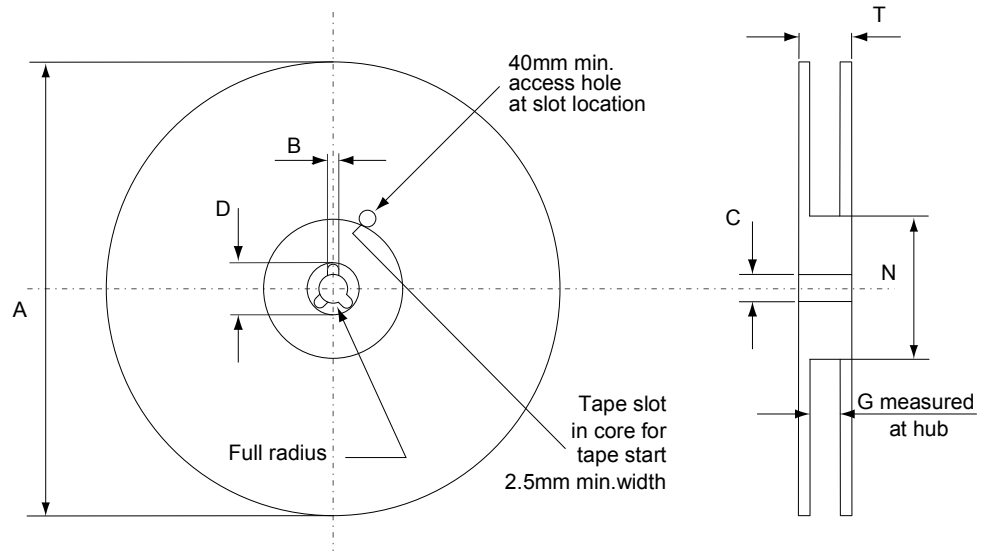
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### 4.3 DPAK (TO-252) packing information

Figure 25. DPAK (TO-252) tape outline



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**Figure 26. DPAK (TO-252) reel outline**


AM06038v1

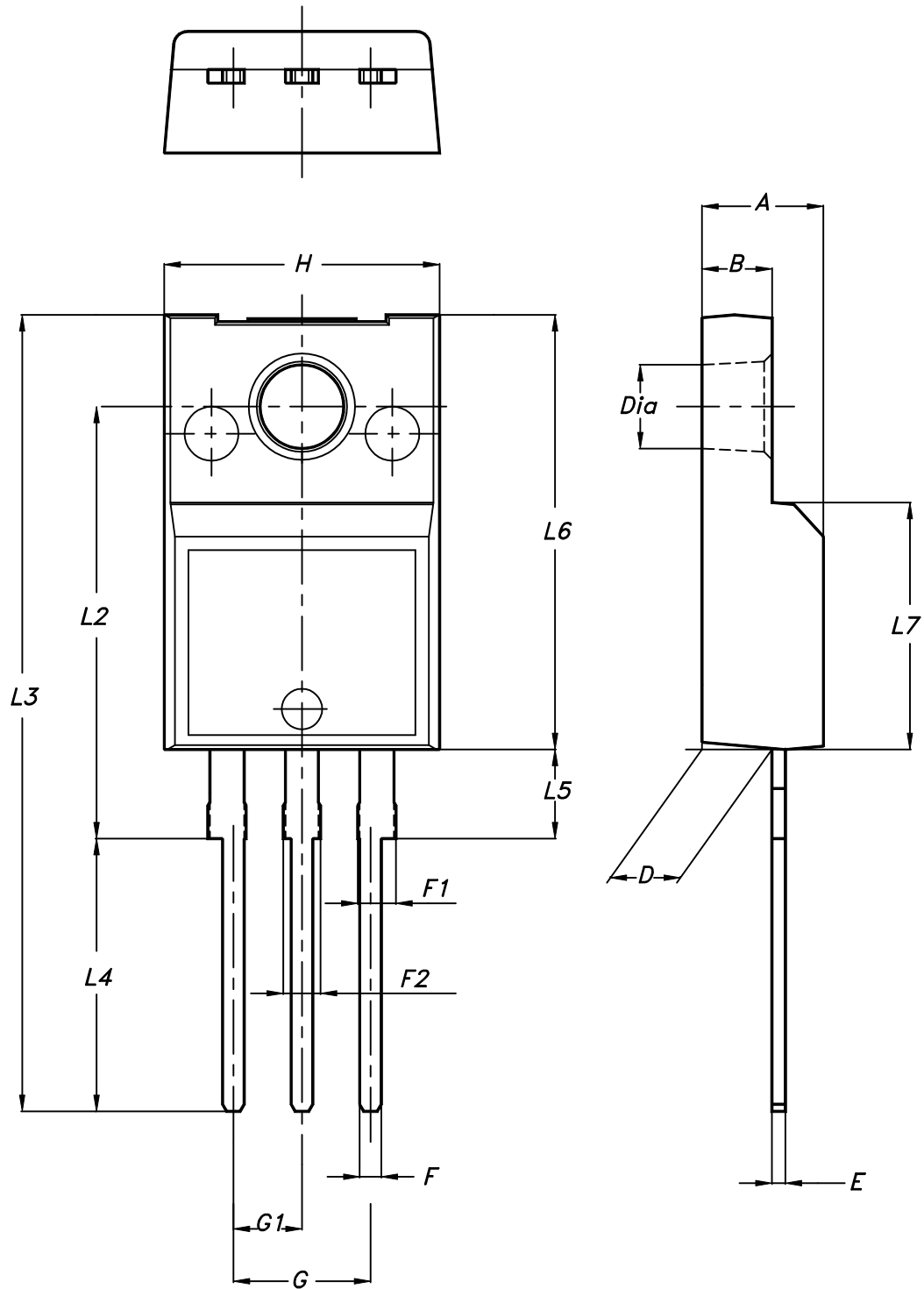
**Table 10. DPAK (TO-252) tape and reel mechanical data**

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			



#### 4.4 TO-220FP package information

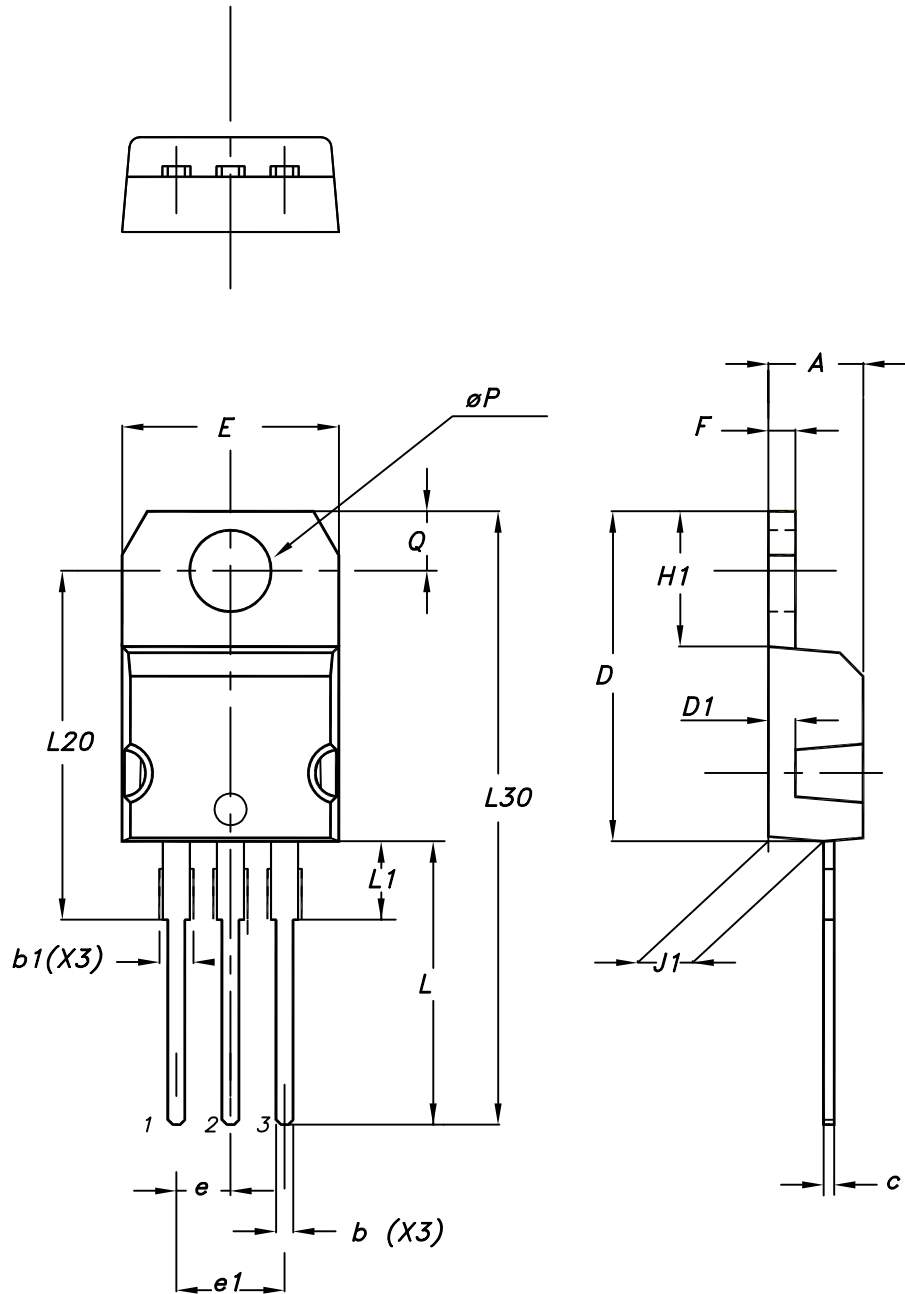
Figure 27. TO-220FP package outline



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**Table 11. 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

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


0015988\_typeA\_Rev\_21

**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

## 5 Ordering information

**Table 13. Order codes**

Order code	Marking	Package	Packing
STD9NM60N	9NM60N	DPAK	Tape and reel
STF9NM60N		TO-220FP	Tube
STP9NM60N		TO-220	

## Revision history

**Table 14. Document revision history**

Date	Version	Changes
20-Oct-2010	1	First release.
25-Sep-2018	2	Removed maturity status indication from cover page. The document status is production data. Updated <a href="#">Section 4 Package information</a> . Minor text changes.

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