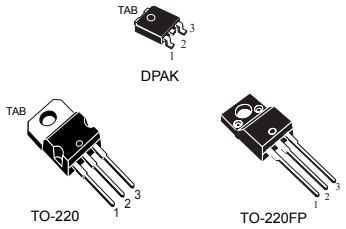
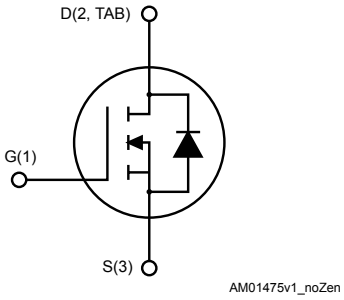
Datasheet

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





Features

Order code	V_{DS}	$R_{DS(on)}$ max.	I_D	Package
STD9NM60N	600 V	0.745 Ω	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 °C	6.5	6.5 (1)	A
I_D	Drain current (continuous) at T_C = 100 °C	4	4 (1)	A
I_{DM} (2)	Drain current (pulsed)	26	26 (1)	A
P_{TOT}	Total dissipation at T_C = 25 °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 s; T_c = 25 °C)		2.5	kV
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} ≤ 6.5 A, di/dt ≤ 400 A/µs,, V_{DD} = 80% $V_{(BR)DSS}$.*

Table 2. Thermal data

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

1. *When mounted on 1inch² 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 °C, I_D = I_{AR}, V_{DD} = 50 V)	115	mJ

2 Electrical characteristics

(T_{CASE} = 25 °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 mA, V_{GS} = 0 V	600			V
I_{DSS}	Zero gate voltage drain current	V_{GS} = 0 V, V_{DS} = 600 V			1	µA
		V_{GS} = 0 V, V_{DS} = 600 V, T_C = 125 °C (1)			100	µA
I_{GSS}	Gate body leakage current	V_{DS} = 0 V, V_{GS} = ±20 V			100	nA
$V_{GS(th)}$	Gate threshold voltage	V_{DS} = V_{GS}, I_D = 250 µA	2	3	4	V
$R_{DS(on)}$	Static drain-source on resistance	V_{GS} = 10 V, I_D = 3.25 A		0.63	0.745	Ω

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 V, f = 1 MHz, V_{GS} = 0 V	-	452	-	pF
C_{oss}	Output capacitance			30		
C_{rss}	Reverse transfer capacitance			1.45		
$C_{oss\ eq.}$ (1)	Equivalent output capacitance	V_{DS} = 0 to 480 V, V_{GS} = 0 V	-	79	-	pF
R_g	Gate input resistance	f = 1 MHz, I_D = 0 A	-	4.8	-	Ω
Q_g	Total gate charge	V_{DD} = 480 V, I_D = 6.5 A, V_{GS} = 0 to 10 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. *$C_{oss\ eq.}$ 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 V, I_D = 6.5 A, R_G = 4.7 Ω, V_{GS} = 10 V (see Figure 16. Test circuit for resistive load switching times and Figure 21. Switching time waveform)	-	28	-	ns
t_r	Rise time			23		
$t_{d(off)}$	Turn-off delay time			52.5		
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 A, V_{GS} = 0 V	-		1.6	V
t_{rr}	Reverse recovery time	I_{SD} = 6.5 A, di/dt = 100 A/µs	-	264		ns
Q_{rr}	Reverse recovery charge	V_{DD} = 60 V (see Figure 18. Test circuit for inductive load switching and diode recovery times)		1.9		µC
I_{RRM}	Reverse recovery current			14.6		A
t_{rr}	Reverse recovery time	I_{SD} = 6.5 A, di/dt = 100 A/µs	-	324		ns
Q_{rr}	Reverse recovery charge	V_{DD} = 60 V (see Figure 18. Test circuit for inductive load switching and diode recovery times)		2.3		µC
I_{RRM}	Reverse recovery current			14.2		A

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 DPAK

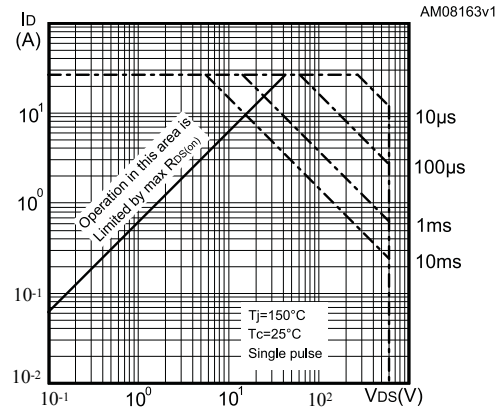


Figure 2. Thermal impedance for DPAK

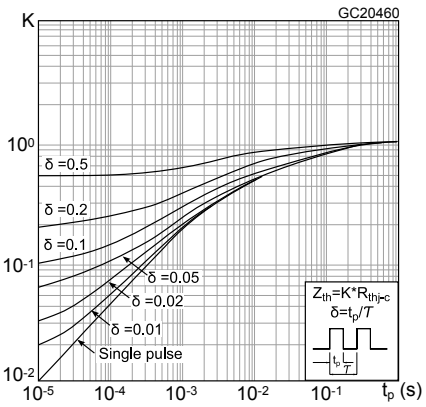


Figure 3. Safe operating area for TO-220FP

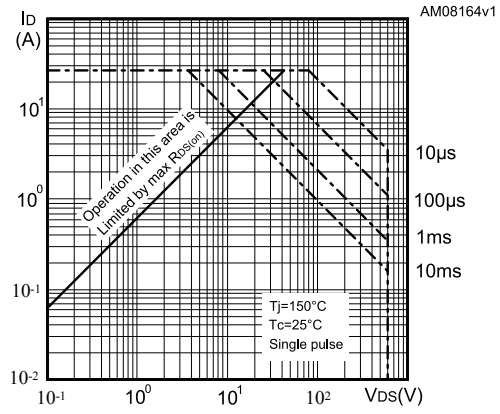


Figure 4. Thermal impedance for TO-220FP

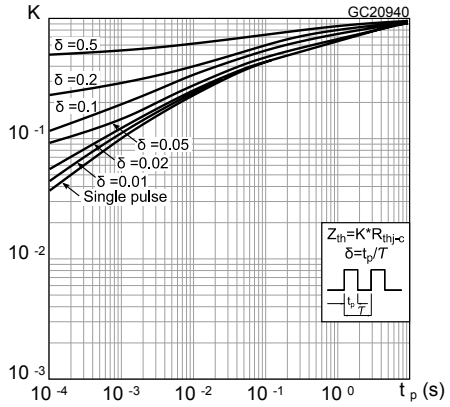


Figure 5. Safe operating area for TO-220

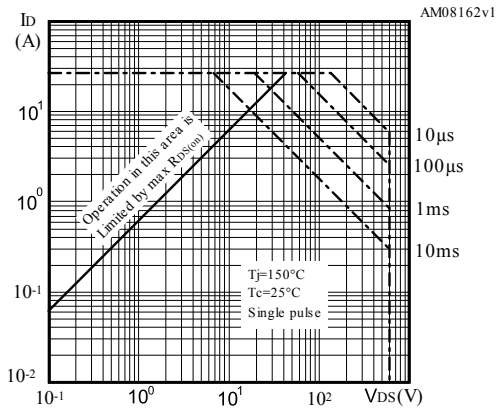


Figure 6. Thermal impedance for TO-220

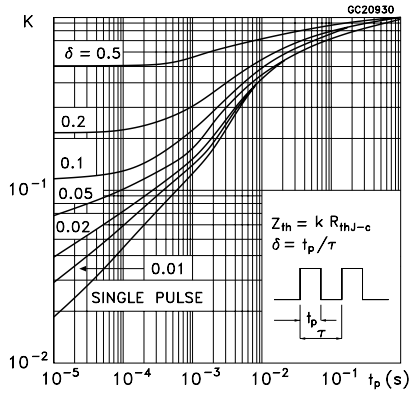


Figure 7. Output characterisics

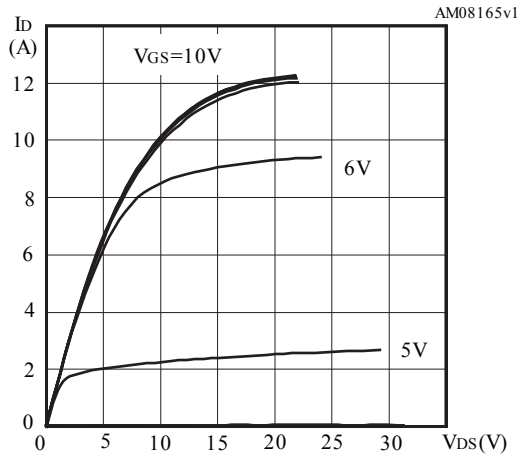


Figure 8. Transfer characteristics

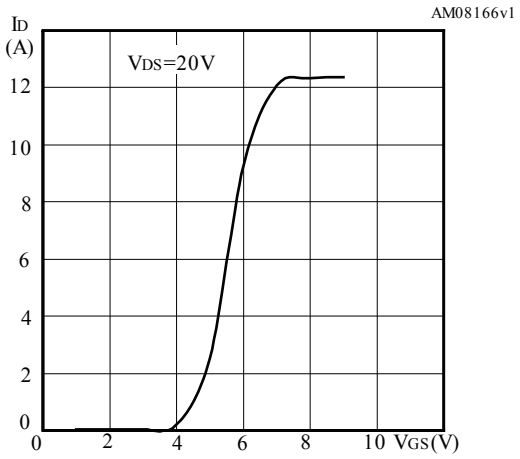


Figure 9. Gate charge vs gate-source voltage

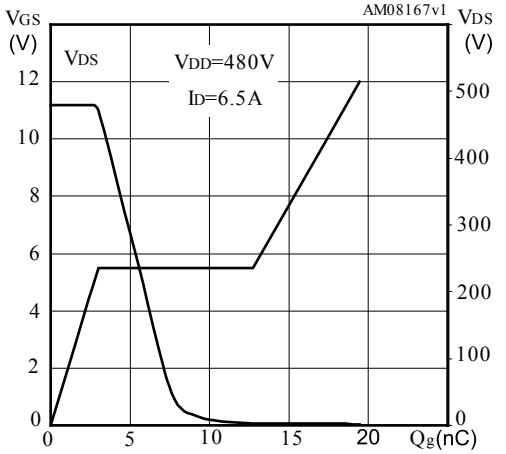


Figure 10. Static drain-source on resistance

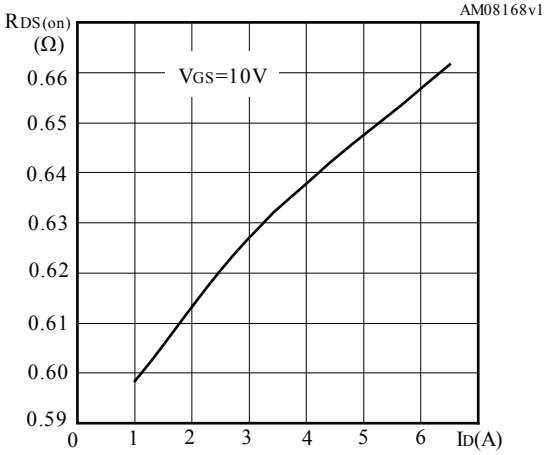


Figure 11. Capacitance variations

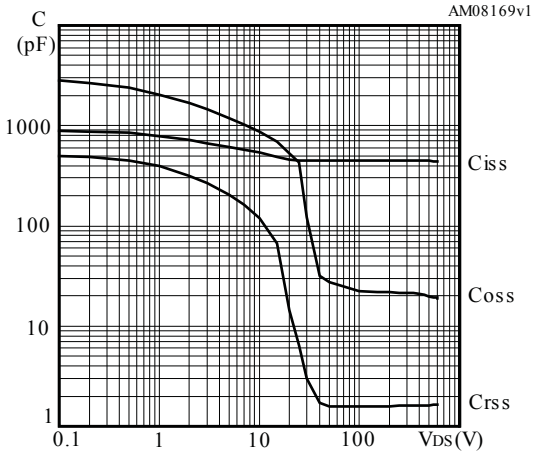


Figure 12. Output capacitance stored energy

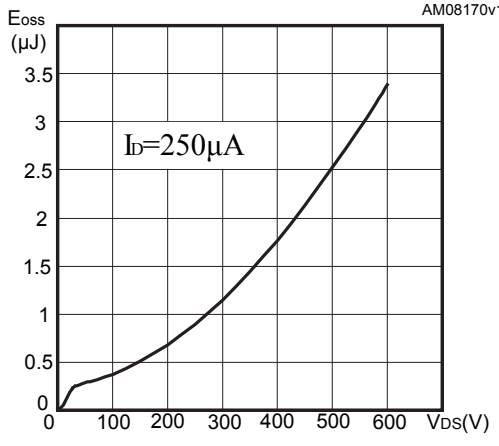


Figure 13. Normalized gate threshold voltage vs temperature

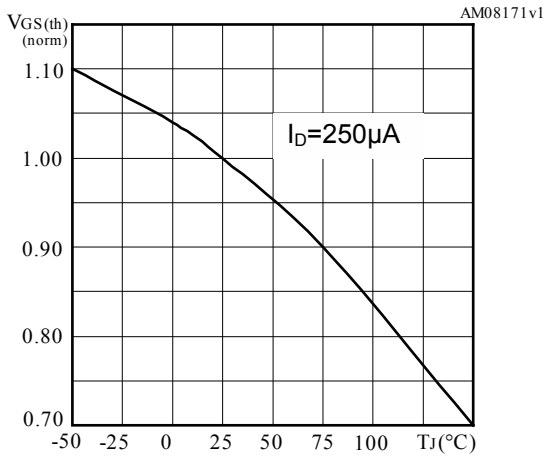


Figure 14. Normalized on resistance vs temperature

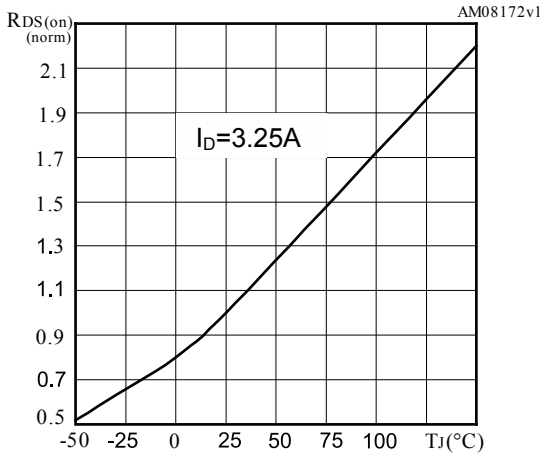
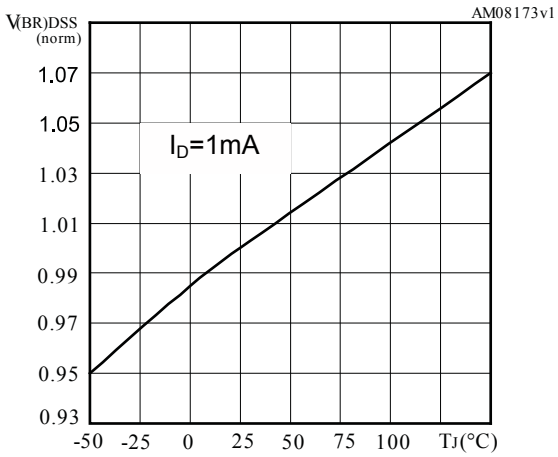


Figure 15. Normalized $V_{(BR)DSS}$ vs temperature



3 Test circuits

Figure 16. Test circuit for resistive load switching times

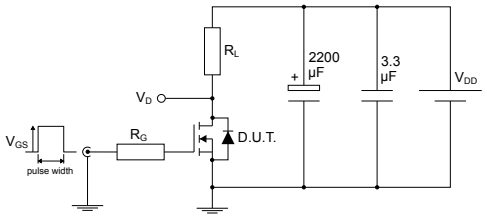


Figure 17. Test circuit for gate charge behavior

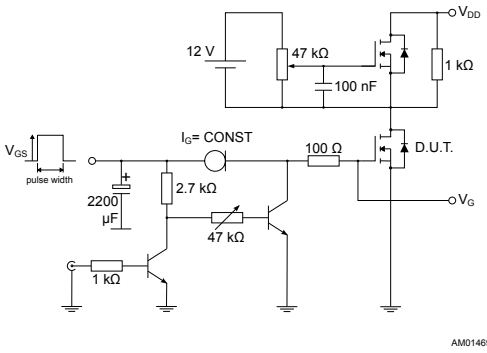


Figure 18. Test circuit for inductive load switching and diode recovery times

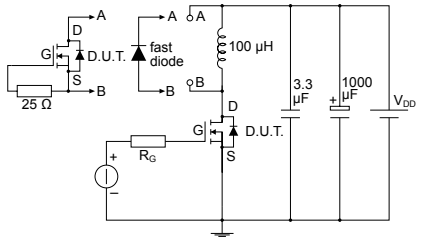


Figure 19. Unclamped inductive load test circuit

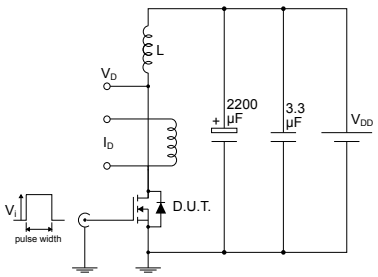


Figure 20. Unclamped inductive waveform

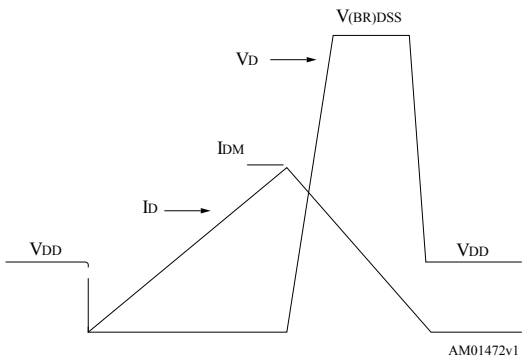
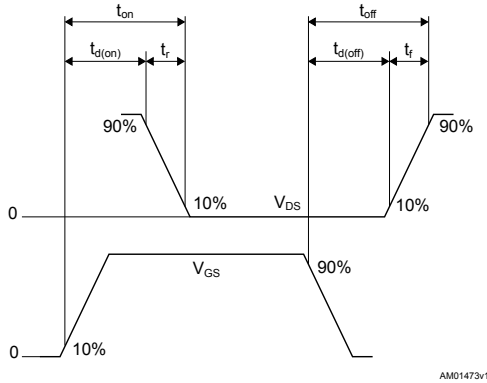


Figure 21. Switching time waveform

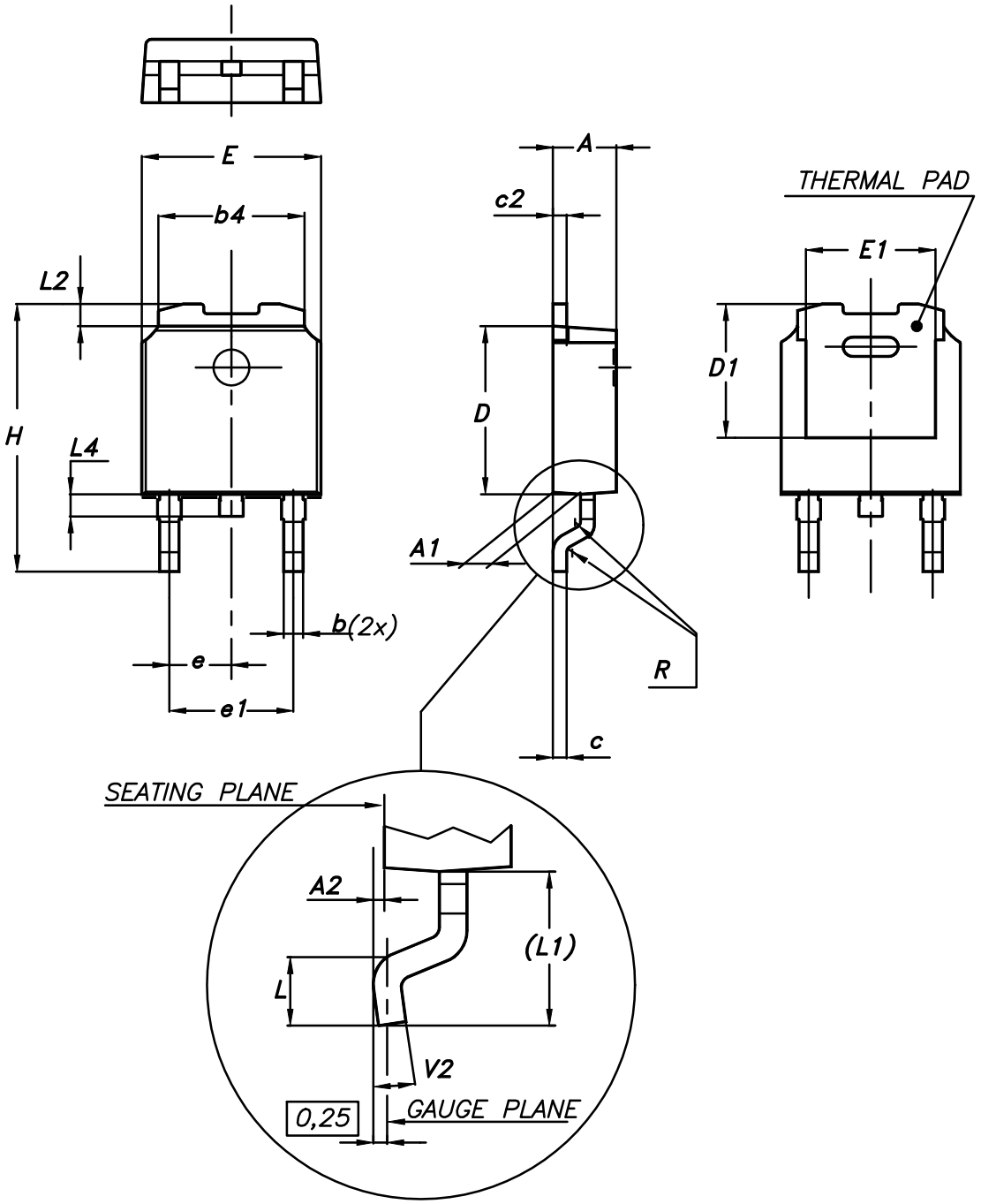


4 Package information

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. ECOPACK® is an ST trademark.

4.1 DPAK (TO-252) type A package information

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



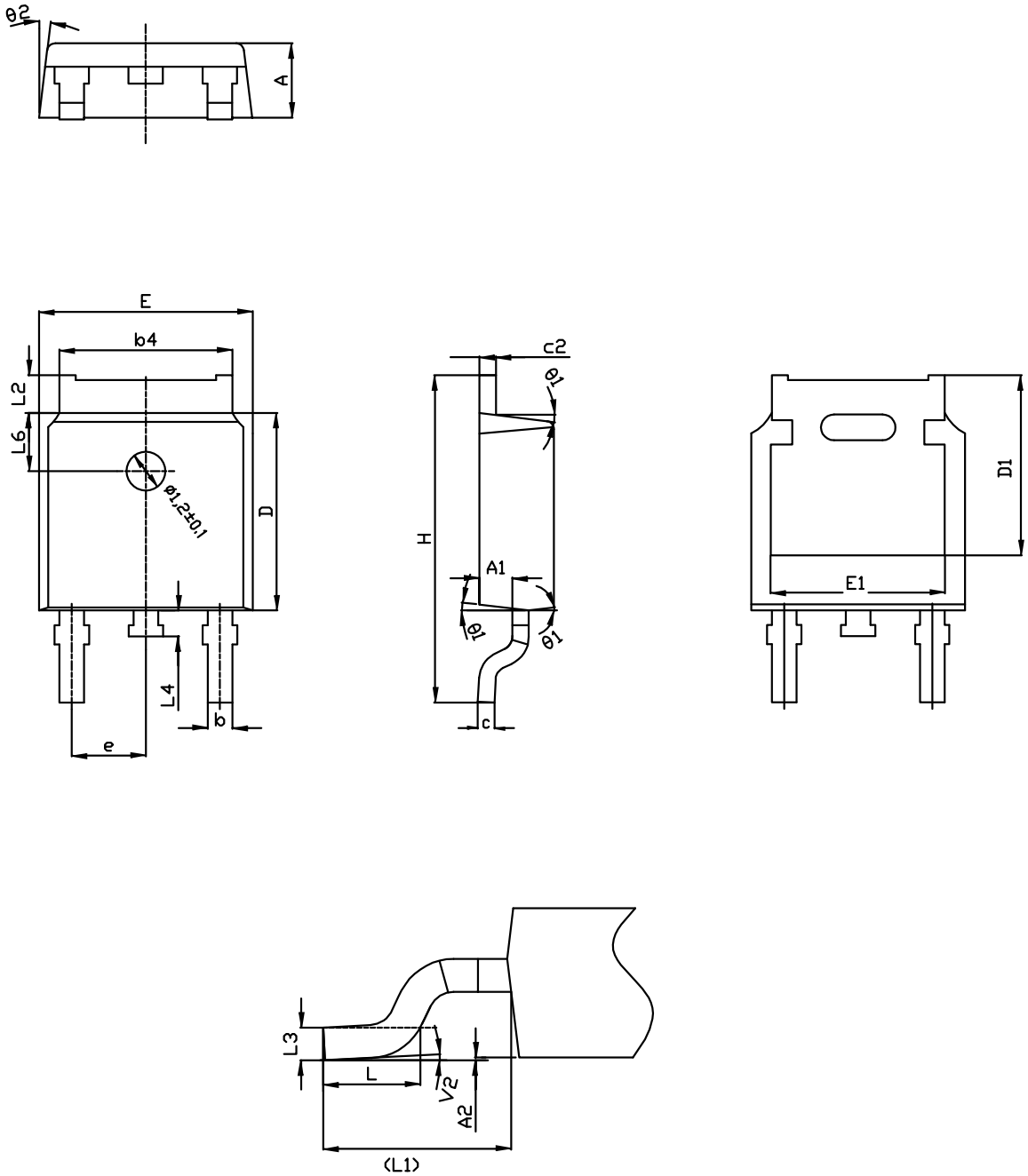
0068772_A_25

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 C2 package information

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

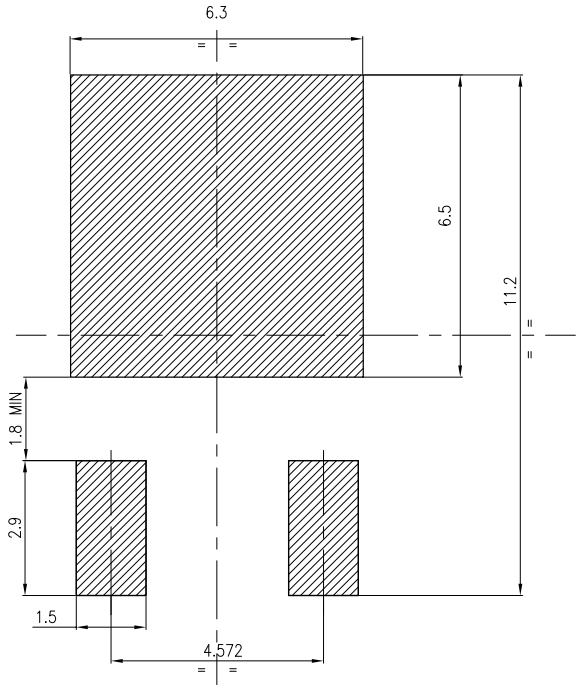


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Table 9. DPAK (TO-252) type C2 mechanical data

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)



4.3 DPAK (TO-252) packing information

Figure 25. **DPAK (TO-252) tape outline**

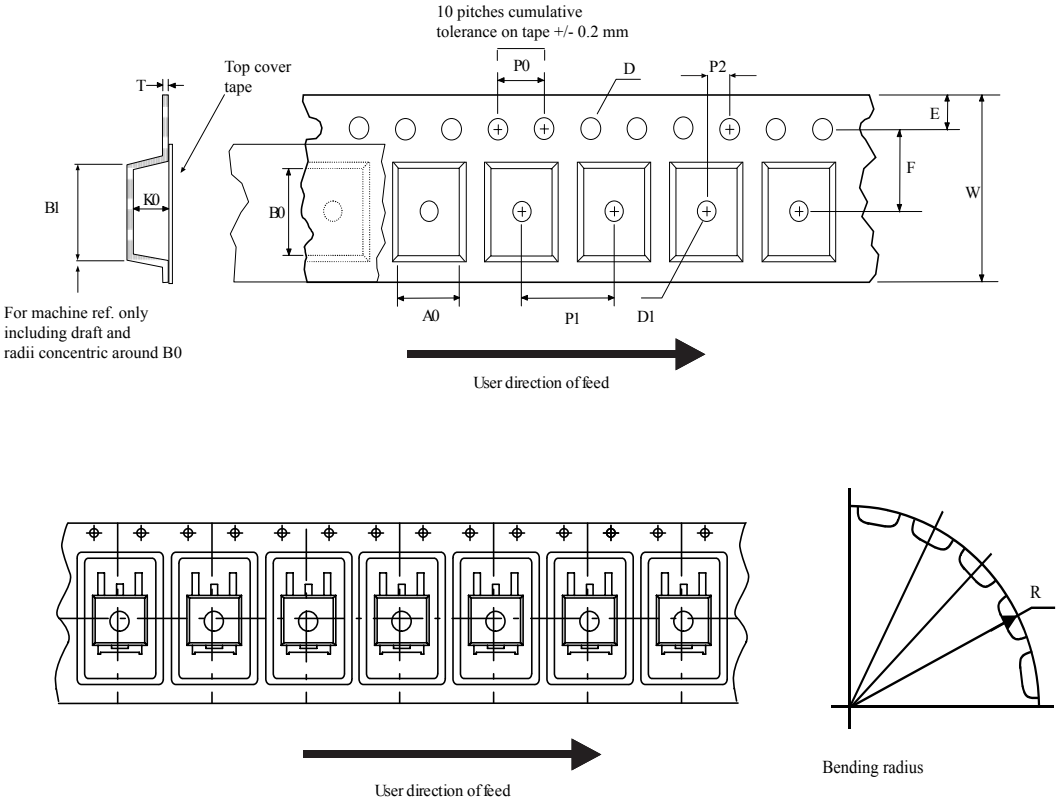
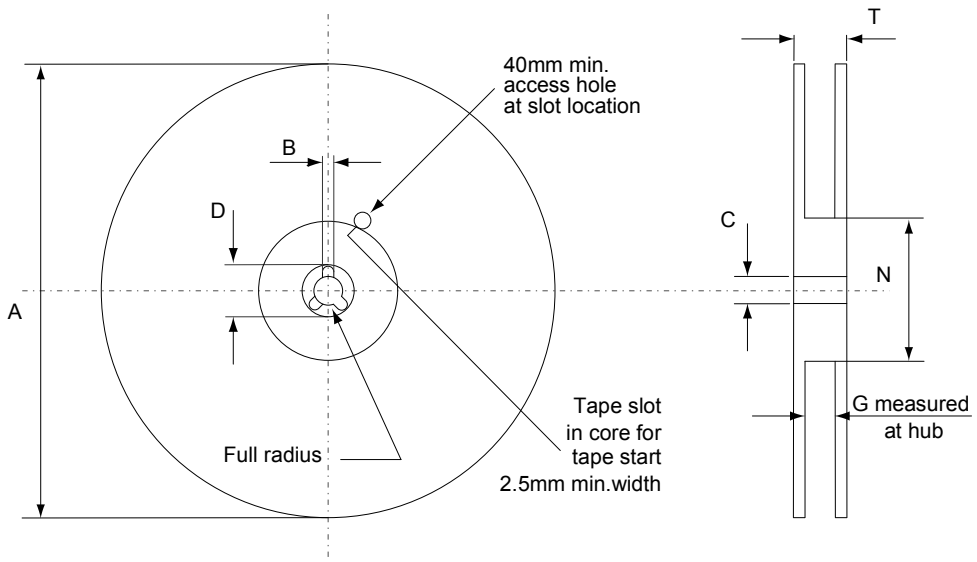


Figure 26. **DPAK (TO-252) reel outline**



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**

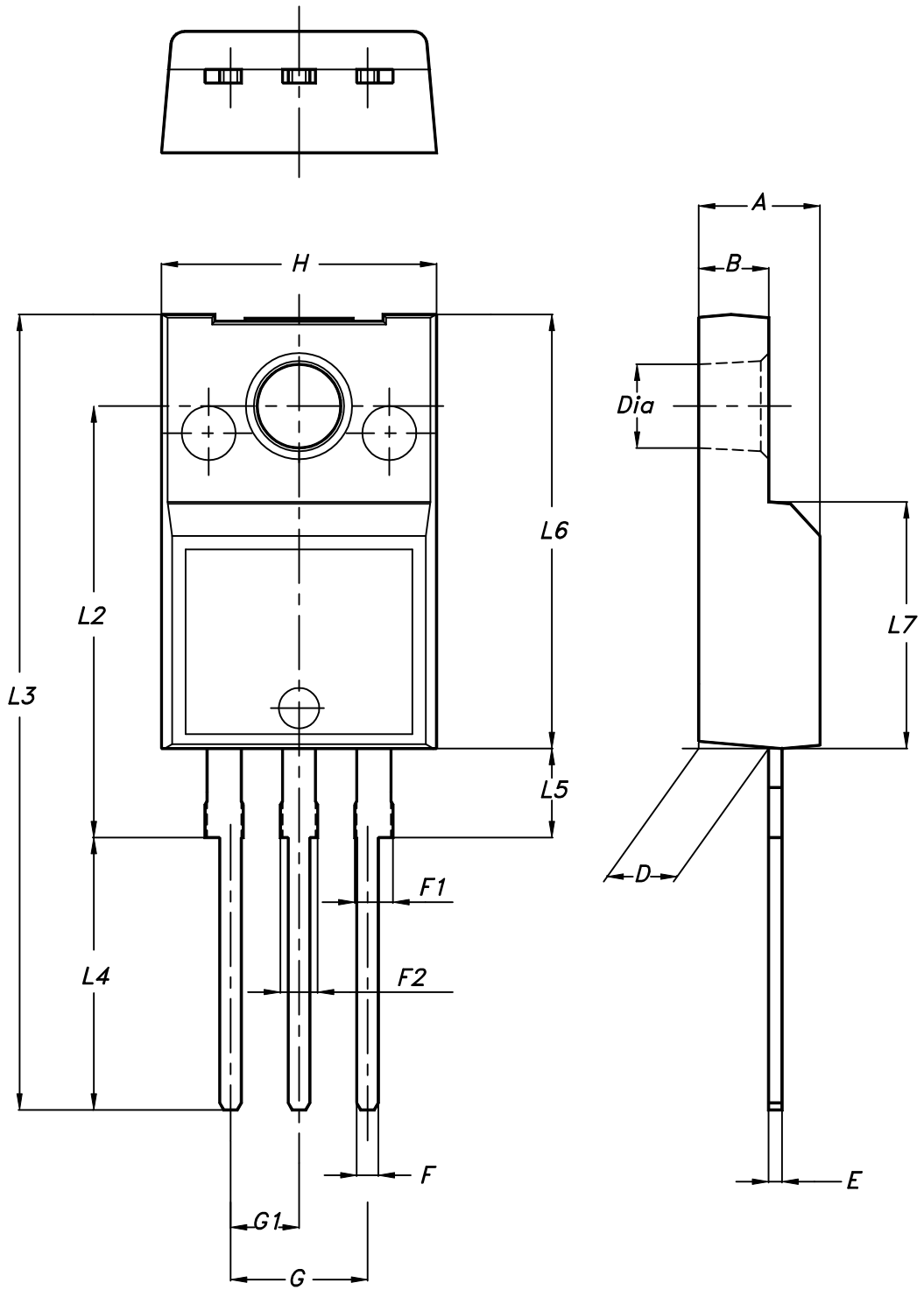
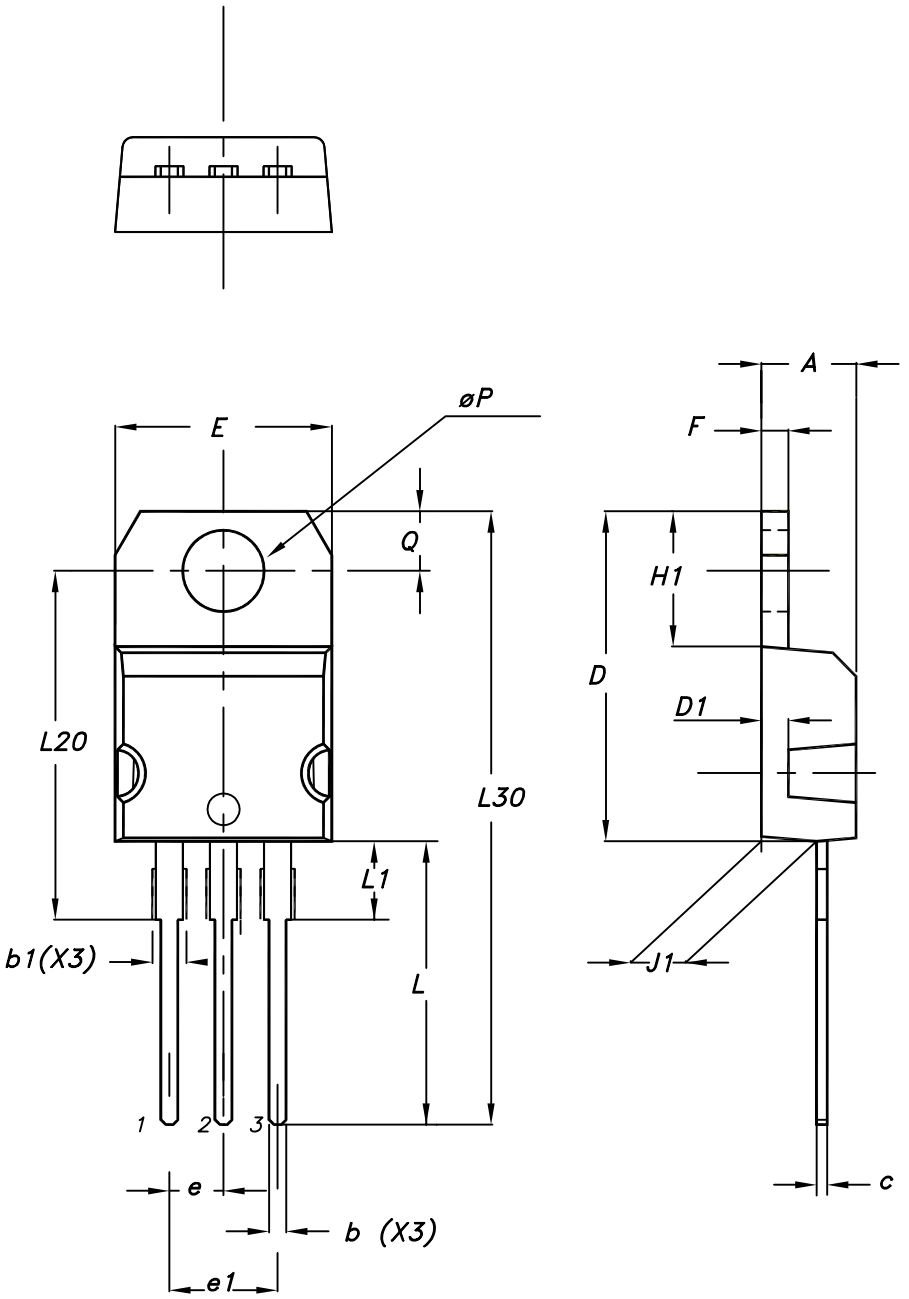


Table 11. **TO-220FP package mechanical data**

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 Section 4 Package information. Minor text changes.

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