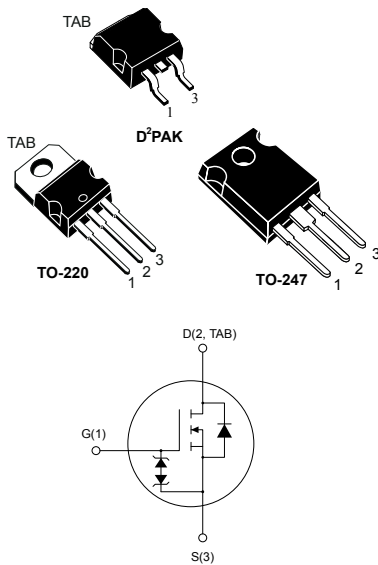


## N-channel 600 V, 110 mΩ typ., 24 A MDmesh DM2 Power MOSFET in D<sup>2</sup>PAK, TO-220 and TO-247 packages



AM01476v1\_lab

### Features

Order code	$V_{DS} @ T_{Jmax.}$	$R_{DS(on)}$ max.	$I_D$
STB33N60DM2	650 V	130 mΩ	24 A
STP33N60DM2			
STW33N60DM2			

- Fast-recovery body diode
- Extremely low gate charge and input capacitance
- Low on-resistance
- 100% avalanche tested
- Extremely high dv/dt ruggedness
- Zener-protected

### Applications

- Switching applications

### Description

These high voltage N-channel Power MOSFETs are part of the MDmesh DM2 fast recovery diode series. They offer very low recovery charge ( $Q_{rr}$ ) and time ( $t_{rr}$ ) combined with low  $R_{DS(on)}$ , rendering them suitable for the most demanding high efficiency converters and ideal for bridge topologies and ZVS phase-shift converters.



#### Product status link

[STB33N60DM2](#)
[STP33N60DM2](#)
[STW33N60DM2](#)

# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

Symbol	Parameter	Value	Unit
V <sub>GS</sub>	Gate-source voltage (static)	±25	V
	Gate-source voltage (dynamic AC, f > 1 Hz)	±30	
I <sub>D</sub>	Drain current (continuous) at T <sub>case</sub> = 25 °C	24	A
	Drain current (continuous) at T <sub>case</sub> = 100 °C	15.5	
I <sub>DM</sub> <sup>(1)</sup>	Drain current (pulsed)	96	A
P <sub>TOT</sub>	Total power dissipation at T <sub>case</sub> = 25 °C	190	W
dv/dt <sup>(2)</sup>	Peak diode recovery voltage slope	100	V/ns
di/dt <sup>(2)</sup>	Peak diode recovery current slope	1000	A/μs
dv/dt <sup>(3)</sup>	MOSFET dv/dt ruggedness	100	V/ns
T <sub>stg</sub>	Storage temperature range	-55 to 150	°C
T <sub>j</sub>	Operating junction temperature range		

1. Pulse width is limited by safe operating area.
2.  $I_{SD} \leq 24$  A,  $V_{DS\ peak} < V_{(BR)DSS}$ ,  $V_{DD} = 400$  V.
3.  $V_{DS} \leq 480$  V.

**Table 2. Thermal data**

Symbol	Parameter	Value			Unit
		D <sup>2</sup> PAK	TO-220	TO-247	
R <sub>thj-case</sub>	Thermal resistance junction-case	0.66			°C/W
R <sub>thj-pcb</sub> <sup>(1)</sup>	Thermal resistance junction-pcb	30			
R <sub>thj-amb</sub>	Thermal resistance junction-ambient		62.5	50	

1. 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>jmax</sub> )	5.5	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)	570	mJ

## 2 Electrical characteristics

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

**Table 4. Static**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source breakdown voltage	$V_{GS} = 0\text{ V}, I_D = 1\text{ mA}$	600			V
$I_{DSS}$	Zero gate voltage drain current	$V_{GS} = 0\text{ V}, V_{DS} = 600\text{ V}$			1	$\mu\text{A}$
		$V_{GS} = 0\text{ V}, V_{DS} = 600\text{ V}, T_{case} = 125\text{ °C}$ <sup>(1)</sup>			100	
$I_{GSS}$	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	$V_{DS} = V_{GS}, I_D = 250\text{ }\mu\text{A}$	3	4	5	V
$R_{DS(on)}$	Static drain-source on-resistance	$V_{GS} = 10\text{ V}, I_D = 12\text{ A}$		110	130	m $\Omega$

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

**Table 5. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$C_{iss}$	Input capacitance	$V_{DS} = 100\text{ V}, f = 1\text{ MHz}, V_{GS} = 0\text{ V}$	-	1870	-	$\mu\text{F}$
$C_{oss}$	Output capacitance		-	87	-	
$C_{rss}$	Reverse transfer capacitance		-	2	-	
$C_{oss\text{ eq.}}$ <sup>(1)</sup>	Equivalent output capacitance	$V_{DD} = 480\text{ V}, V_{GS} = 0\text{ V}$	-	157	-	$\mu\text{F}$
$R_G$	Intrinsic gate resistance	$f = 1\text{ MHz}, I_D = 0\text{ A}$	-	4.5	-	$\Omega$
$Q_g$	Total gate charge	$V_{DD} = 480\text{ V}, I_D = 24\text{ A}, V_{GS} = 10\text{ V}$ (see Figure 18. Test circuit for gate charge behavior)	-	43	-	nC
$Q_{gs}$	Gate-source charge		-	9.8	-	
$Q_{gd}$	Gate-drain charge		-	21	-	

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**

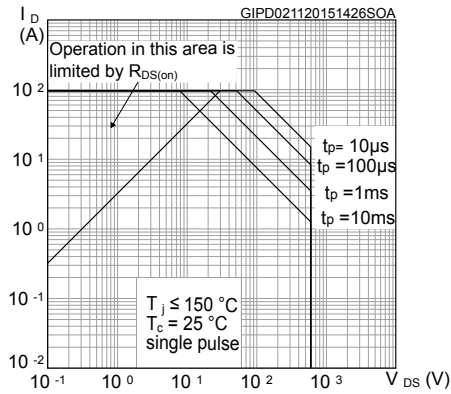
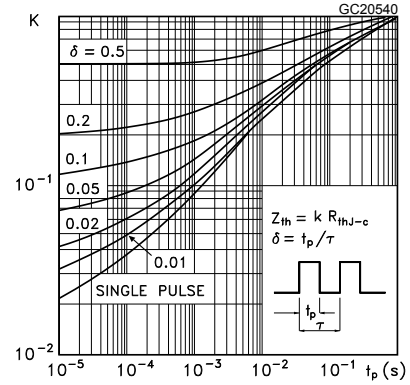
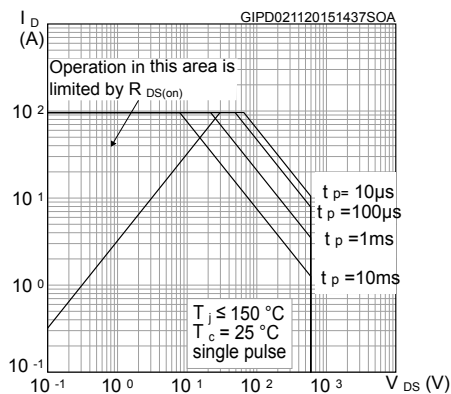
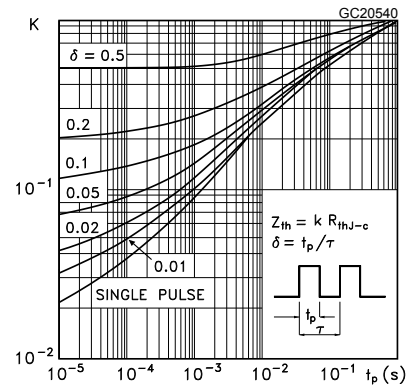
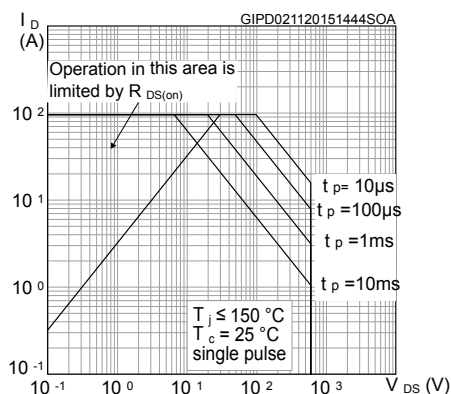
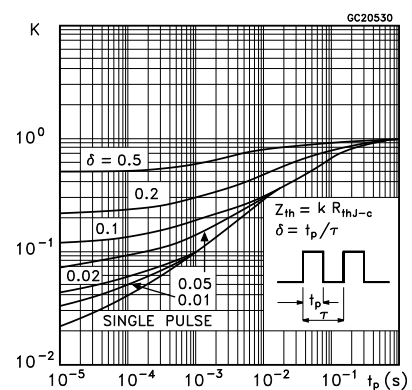
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 300\text{ V}, I_D = 12\text{ A}, R_G = 4.7\text{ }\Omega,$ $V_{GS} = 10\text{ V}$ (see Figure 17. Test circuit for resistive load switching times and Figure 22. Switching time waveform)	-	17	-	ns
$t_r$	Rise time		-	8	-	
$t_{d(off)}$	Turn-off delay time		-	62	-	
$t_f$	Fall time		-	9	-	

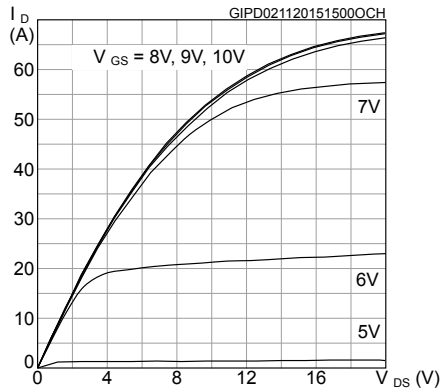
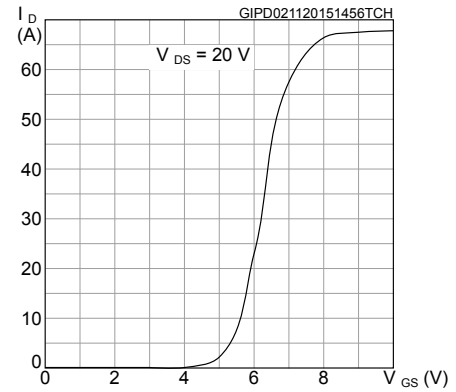
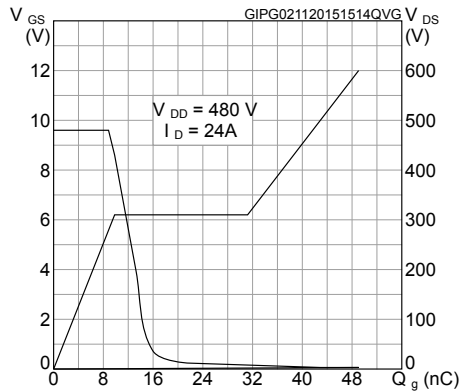
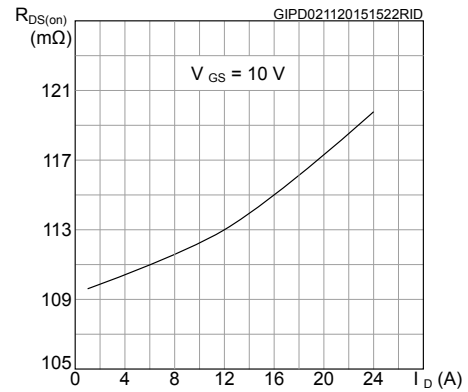
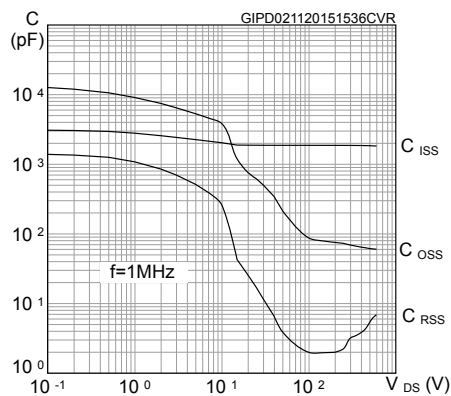
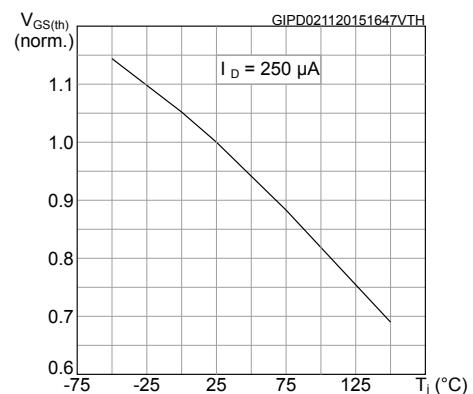
**Table 7. Source-drain diode**

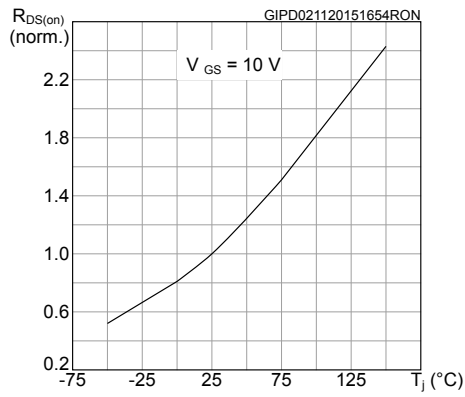
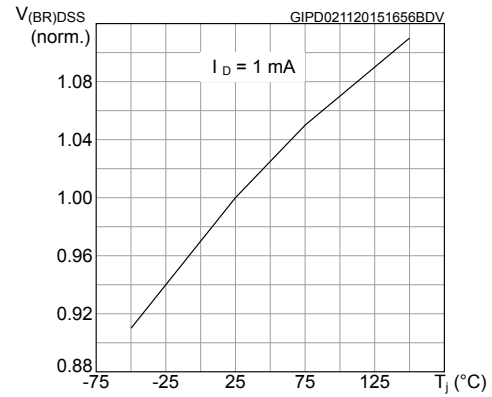
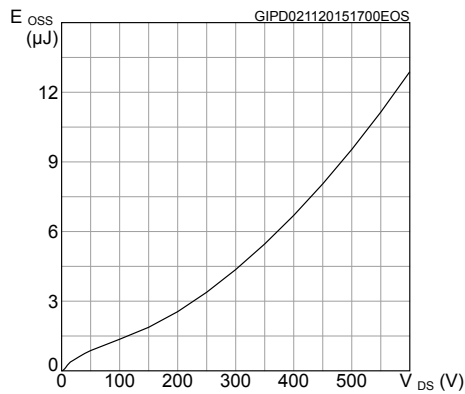
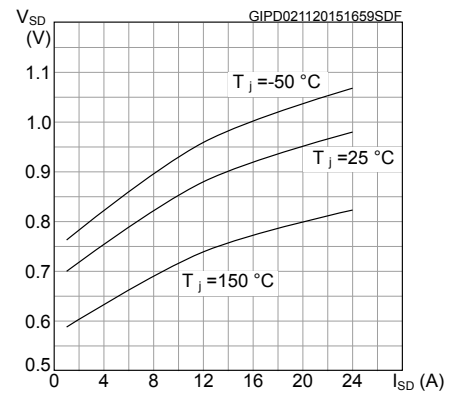
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{SD}$	Source-drain current		-		24	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)		-		96	A
$V_{SD}^{(2)}$	Forward on voltage	$V_{GS} = 0\text{ V}$ , $I_{SD} = 24\text{ A}$	-		1.6	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 24\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ , $V_{DD} = 60\text{ V}$ (see Figure 19. Test circuit for inductive load switching and diode recovery times)	-	150		ns
$Q_{rr}$	Reverse recovery charge		-	0.5		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current		-	8.8		A
$t_{rr}$	Reverse recovery time	$I_{SD} = 24\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ , $V_{DD} = 60\text{ V}$ , $T_j = 150\text{ }^\circ\text{C}$ (see Figure 19. Test circuit for inductive load switching and diode recovery times)	-	316		ns
$Q_{rr}$	Reverse recovery charge		-	2.85		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current		-	18		A

1. Pulse width is limited by safe operating area.

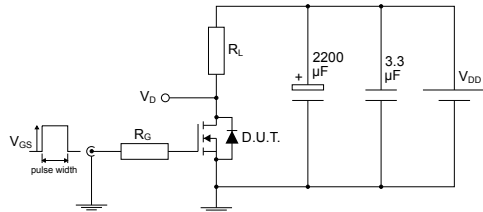
2. Pulse test: pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%.

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

**Figure 2. Thermal impedance for D<sup>2</sup>PAK**

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

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

**Figure 5. Safe operating area for TO-247**

**Figure 6. Thermal impedance for TO-247**


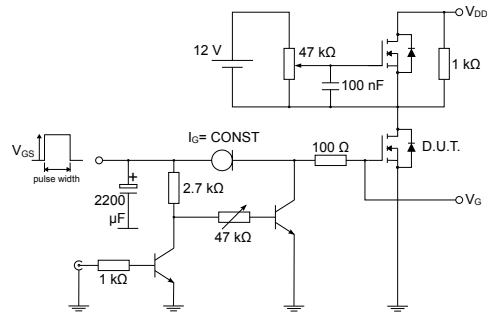
**Figure 7. Output characteristics**

**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 gate threshold voltage vs temperature**


**Figure 13. Normalized on-resistance vs temperature**

**Figure 14. Normalized  $V_{(BR)DSS}$  vs temperature**

**Figure 15. Output capacitance stored energy**

**Figure 16. Source-drain diode forward characteristics**


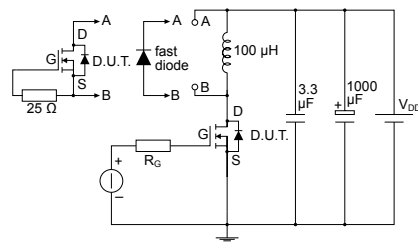
### 3 Test circuits

**Figure 17. Test circuit for resistive load switching times**


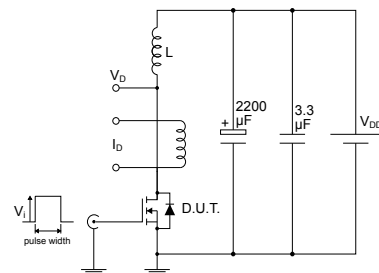
AM01468v1

**Figure 18. Test circuit for gate charge behavior**


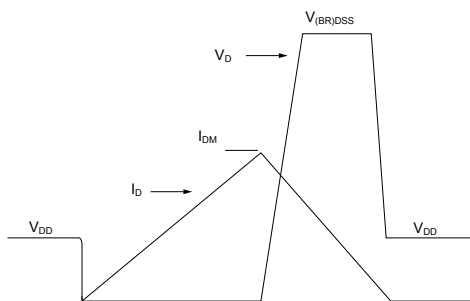
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**Figure 19. Test circuit for inductive load switching and diode recovery times**


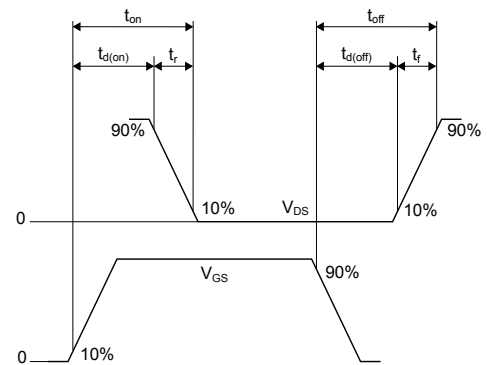
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**Figure 20. Unclamped inductive load test circuit**


AM01471v1

**Figure 21. Unclamped inductive waveform**


AM01472v1

**Figure 22. Switching time waveform**


AM01473v1

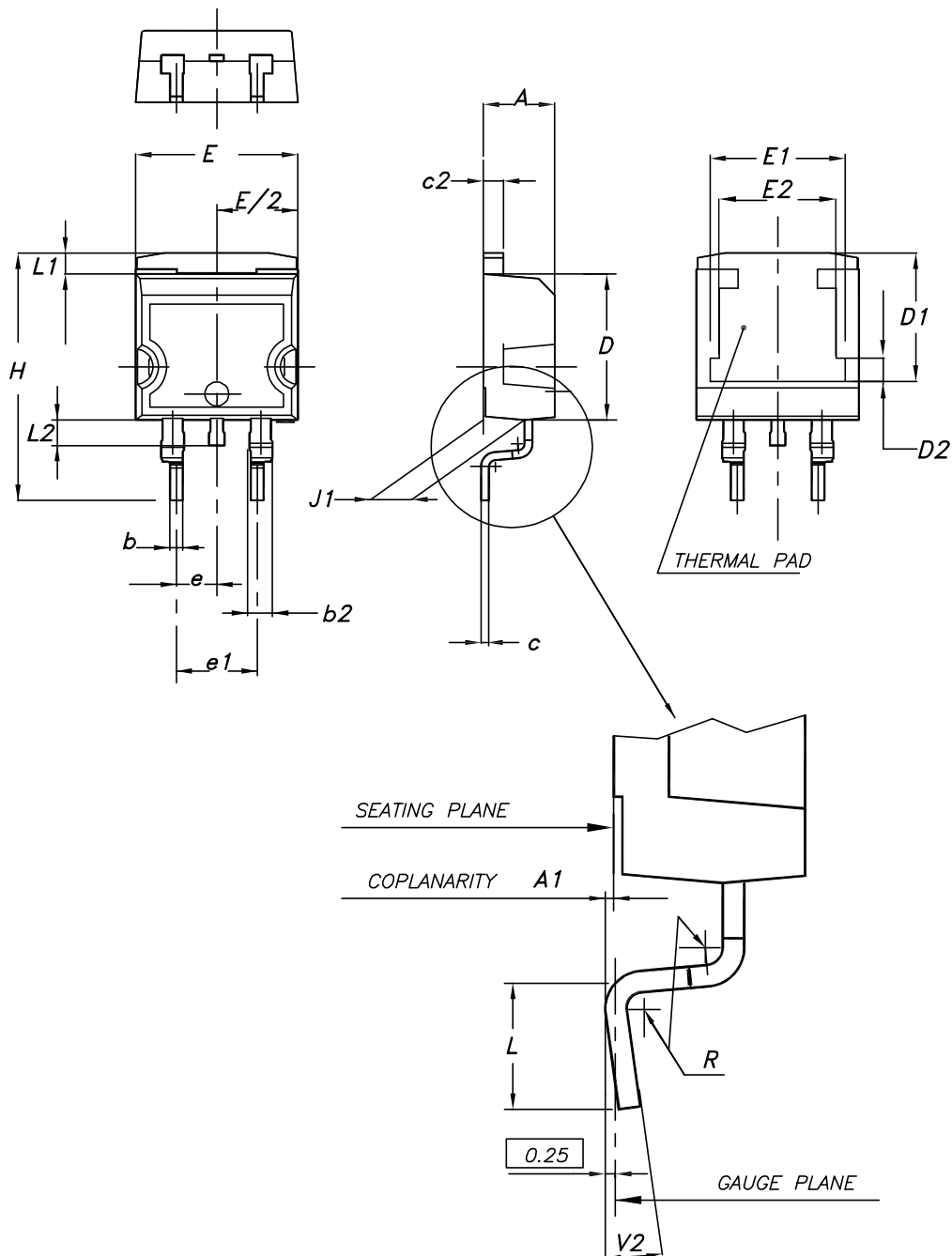


## 4 Package information

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 23. D<sup>2</sup>PAK (TO-263) type A package outline

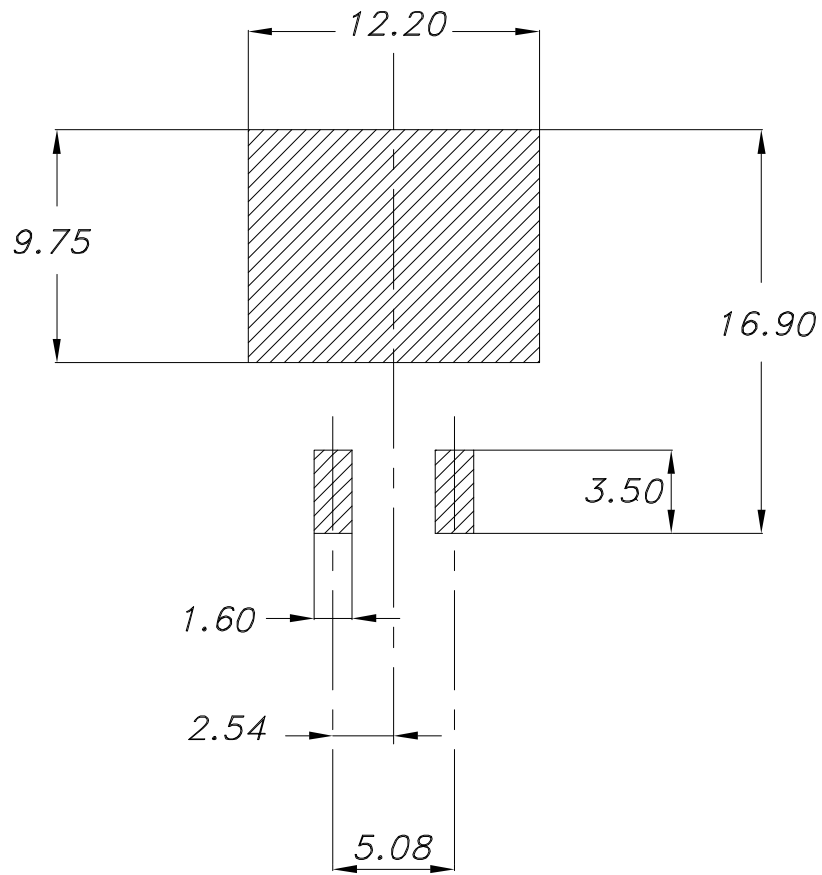


0079457\_26

**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°

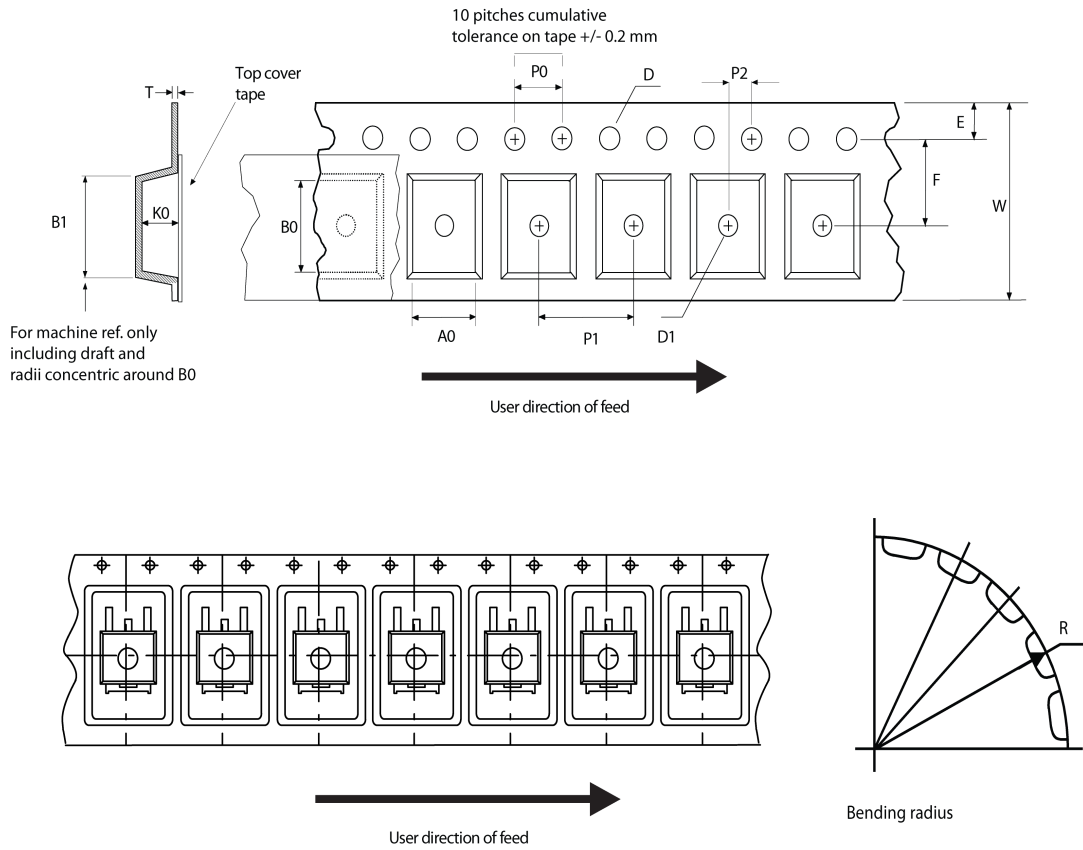
Figure 24. D<sup>2</sup>PAK (TO-263) recommended footprint (dimensions are in mm)



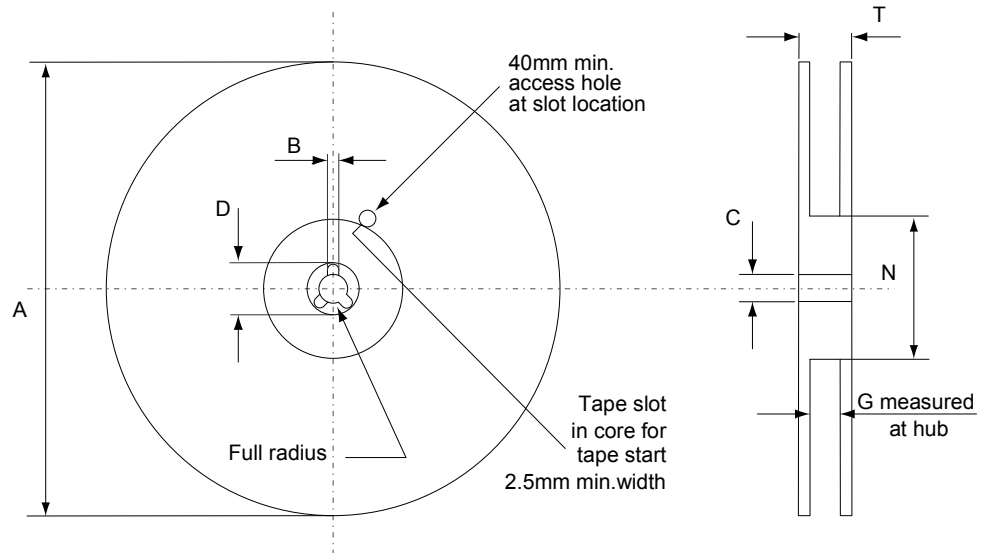
Footprint\_26

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

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



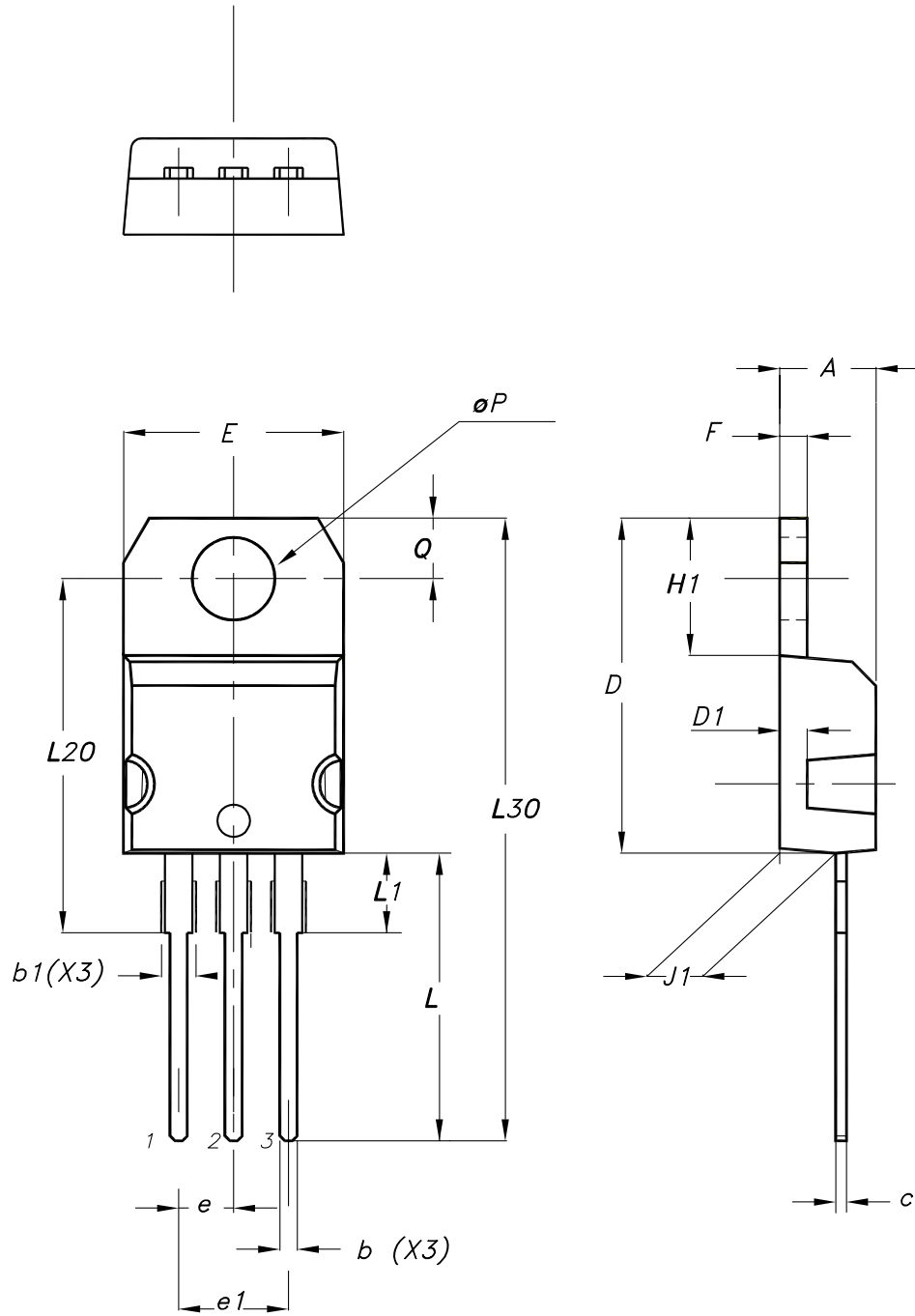
AM08852v1

**Figure 26. 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 TO-220 type A package information**
**Figure 27. TO-220 type A package outline**


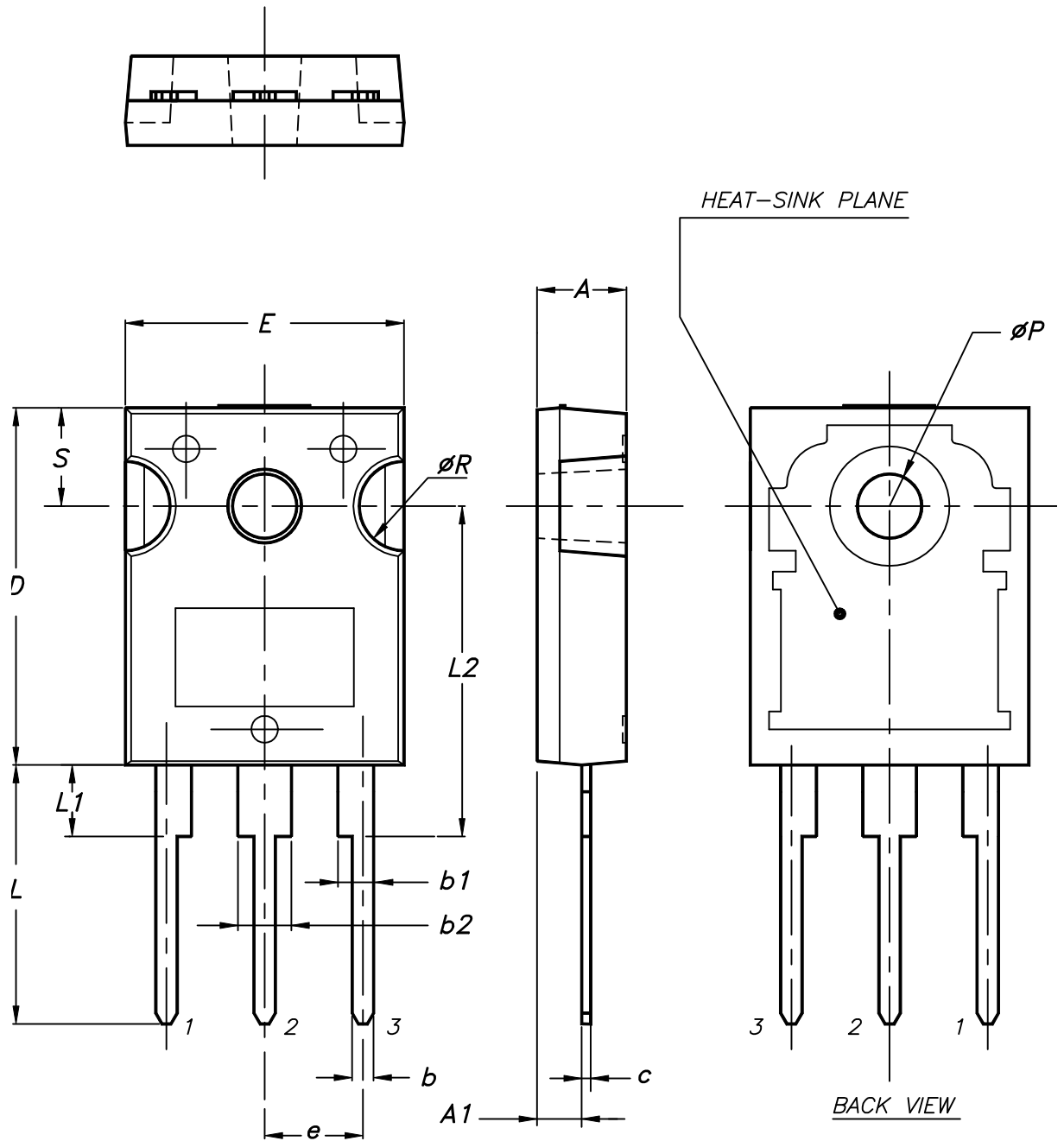
0015988\_typeA\_Rev\_23

**Table 10. 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
Slug flatness		0.03	0.10

**4.4 TO-247 package information**

Figure 28. TO-247 package outline



0075325\_9



**Table 11. TO-247 package mechanical data**

Dim.	mm		
	Min.	Typ.	Max.
A	4.85		5.15
A1	2.20		2.60
b	1.0		1.40
b1	2.0		2.40
b2	3.0		3.40
c	0.40		0.80
D	19.85		20.15
E	15.45		15.75
e	5.30	5.45	5.60
L	14.20		14.80
L1	3.70		4.30
L2		18.50	
ØP	3.55		3.65
ØR	4.50		5.50
S	5.30	5.50	5.70

## 5 Ordering information

**Table 12. Order codes**

Order code	Marking	Package	Packing
STB33N60DM2	33N60DM2	D <sup>2</sup> PAK	Tape e reel
STP33N60DM2		TO-220	Tube
STW33N60DM2		TO-247	Tube

## Revision history

**Table 13. Document revision history**

Date	Revision	Changes
16-Oct-2014	1	First release.
02-Nov-2015	2	Document status promoted from preliminary to production data. Updated title and features in cover page. Updated <i>Table 2: "Absolute maximum ratings"</i> , <i>Table 4: "Avalanche characteristics"</i> , <i>Table 5: "Static"</i> , <i>Table 6: "Dynamic"</i> , <i>Table 7: "Switching times"</i> and <i>Table 8: "Source-drain diode"</i> . Added <i>Section 2.1 Electrical characteristics (curves)</i> .
19-Oct-2020	3	Updated <a href="#">Section 1 Electrical ratings</a> . Minor text changes.



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[SSM6P69NU,LF](#) [DMP22D4UFO-7B](#)