



# STB23NM60ND, STF23NM60ND, STP23NM60ND, STW23NM60ND

N-channel 600 V, 0.150  $\Omega$  typ., 19.5 A, FDmesh™ II Power MOSFET  
(with fast diode) in D<sup>2</sup>PAK, TO-220FP, TO-220 and TO-247 packages

Datasheet — production data

## Features

Order codes	V <sub>DSS</sub> @ T <sub>Jmax</sub>	R <sub>DS(on)</sub> max	I <sub>D</sub>
STB23NM60ND	650 V	< 0.180 $\Omega$	19.5 A
STF23NM60ND			
STP23NM60ND			
STW23NM60ND			

- The worldwide best R<sub>DS(on)</sub> \* area amongst the fast recovery diode devices
- 100% avalanche tested
- Low input capacitance and gate charge
- Low gate input resistance
- High dv/dt and avalanche capabilities

## Applications

- Switching applications

## Description

These FDmesh™ II Power MOSFETs with intrinsic fast-recovery body diode are produced using the second generation of MDmesh™ technology. Utilizing a new strip-layout vertical structure, these revolutionary devices feature extremely low on-resistance and superior switching performance. They are ideal for bridge topologies and ZVS phase-shift converters.

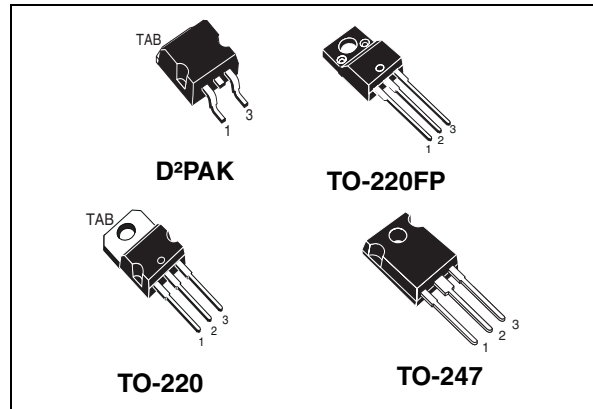


Figure 1. Internal schematic diagram

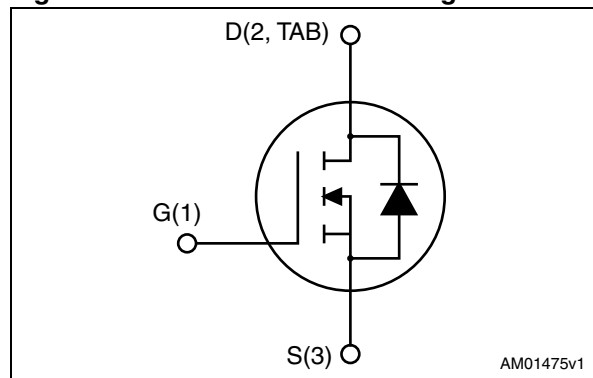


Table 1. Device summary

Order codes	Marking	Package	Packaging
STB23NM60ND	23NM60ND	D <sup>2</sup> PAK	Tape and reel
STF23NM60ND	23NM60ND	TO-220FP	Tube
STP23NM60ND	23NM60ND	TO-220	
STW23NM60ND	23NM60ND	TO-247	

# Contents

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value		Unit
		D <sup>2</sup> PAK, TO-220, TO-247	TO-220FP	
V <sub>DS</sub>	Drain-source voltage	600		V
V <sub>GS</sub>	Gate-source voltage	± 25		V
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 25 °C	19.5	19.5 <sup>(1)</sup>	A
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 100 °C	11.7	11.7 <sup>(1)</sup>	A
I <sub>DM</sub> <sup>(2)</sup>	Drain current (pulsed)	78	78 <sup>(1)</sup>	A
P <sub>TOT</sub>	Total dissipation at T <sub>C</sub> = 25 °C	150	35	W
I <sub>AS</sub>	Avalanche current, repetitive or not-repetitive (pulse width limited by T <sub>j</sub> max)	9		A
E <sub>AS</sub>	Single pulse avalanche energy (starting T <sub>j</sub> = 25 °C, I <sub>D</sub> = I <sub>AS</sub> , V <sub>DD</sub> = 50 V)	700		mJ
dv/dt <sup>(3)</sup>	Peak diode recovery voltage slope	40		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>stg</sub>	Storage temperature	-55 to 150		°C
T <sub>j</sub>	Max. operating junction temperature	150		°C

- Limited by maximum junction temperature
- Pulse width limited by safe operating area
- $I_{SD} \leq 19.5 \text{ A}$ ,  $di/dt \leq 600 \text{ A}/\mu\text{s}$ ,  $V_{DD} = 80\% V_{(BR)DSS}$ ,  $V_{DS(\text{peak})} < V_{(BR)DSS}$

**Table 3. Thermal data**

Symbol	Parameter	D <sup>2</sup> PAK	TO-220FP	TO-220	TO-247	Unit
R <sub>thj-case</sub>	Thermal resistance junction-case max	0.83	3.6	0.83		°C/W
R <sub>thj-amb</sub>	Thermal resistance junction-amb max		62.5		50	°C/W
R <sub>thj-pcb</sub>	Thermal resistance junction-pcb max <sup>(1)</sup>	30				°C/W

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

## 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	$I_D = 1\text{ mA}$ , $V_{GS} = 0$	600			V
$dv/dt^{(1)}$	Drain-source voltage slope	$V_{DD} = 480\text{ V}$ , $I_D = 19.5\text{ A}$ , $V_{GS} = 10\text{ V}$	30			V/ns
$I_{DSS}$	Zero gate voltage drain current ( $V_{GS} = 0$ )	$V_{DS} = 600\text{ V}$ , $V_{DS} = 600\text{ V}$ , $T_c = 125\text{ °C}$			1 100	$\mu\text{A}$ $\mu\text{A}$
$I_{GSS}$	Gate body leakage current ( $V_{DS} = 0$ )	$V_{GS} = \pm 20\text{ V}$			$\pm 100$	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	$V_{GS} = 10\text{ V}$ , $I_D = 10\text{ A}$		0.150	0.180	$\Omega$

1. Characteristic value at turn off on inductive load

**Table 5. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$C_{iss}$ $C_{oss}$ $C_{rss}$	Input capacitance Output capacitance Reverse transfer capacitance	$V_{DS} = 50\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GS} = 0$	-	2100 80 10	-	pF pF pF
$C_{oss\ eq.}^{(1)}$	Equivalent output capacitance	$V_{GS} = 0$ , $V_{DS} = 0\text{ to }480\text{ V}$	-	310	-	pF
$R_g$	Gate input resistance	$f = 1\text{ MHz}$ Gate DC Bias=0 Test signal level=20 mV open drain	-	4	-	$\Omega$
$Q_g$ $Q_{gs}$ $Q_{gd}$	Total gate charge Gate-source charge Gate-drain charge	$V_{DD} = 480\text{ V}$ , $I_D = 19.5\text{ A}$ $V_{GS} = 10\text{ V}$ (see Figure 18)	-	69 13 35	-	nC nC nC

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	$V_{DD} = 300\text{ V}$ , $I_D = 10\text{ A}$ , $R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$ (see Figure 17)	-	21	-	ns
$t_r$	Rise time			19		ns
$t_{d(off)}$	Turn-off delay time			92		ns
$t_f$	Fall time			42		ns

**Table 7. Source drain diode**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{SD}$	Source-drain current		-		19.5	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)				78	A
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 19.5\text{ A}$ , $V_{GS}=0$	-		1.3	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 19.5\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ , $V_{DD} = 60\text{ V}$ (see Figure 19)	-	190		ns
$Q_{rr}$	Reverse recovery charge			1.2		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current			13		A
$t_{rr}$	Reverse recovery time	$V_{DD} = 60\text{ V}$ $di/dt = 100\text{ A}/\mu\text{s}$ , $I_{SD} = 19.5\text{ A}$ $T_j = 150\text{ }^\circ\text{C}$ (see Figure 19)	-	270		ns
$Q_{rr}$	Reverse recovery charge			2.0		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current			15		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 2. Safe operating area for D<sup>2</sup>PAK and TO-220

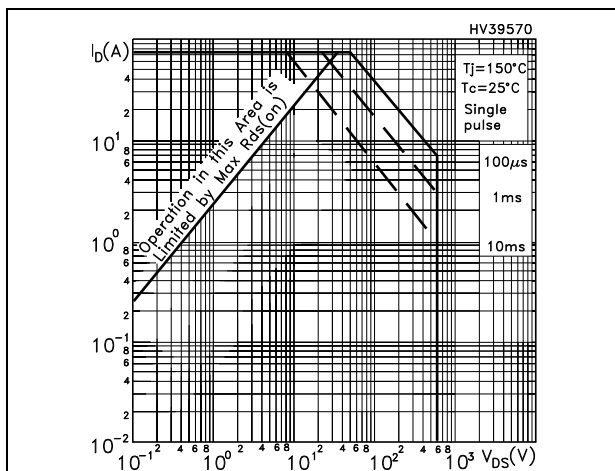


Figure 3. Thermal impedance for D<sup>2</sup>PAK and TO-220

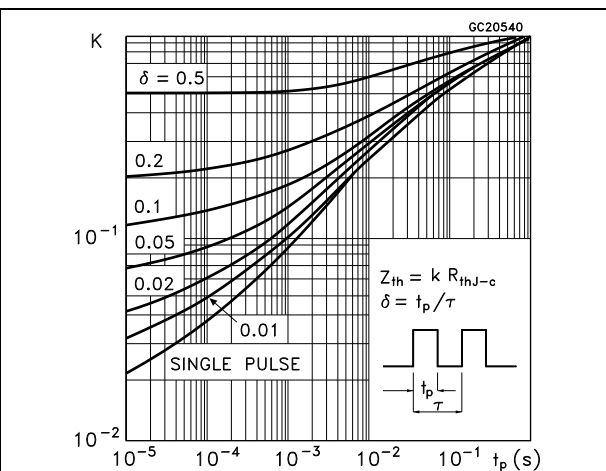


Figure 4. Safe operating area for TO-220FP

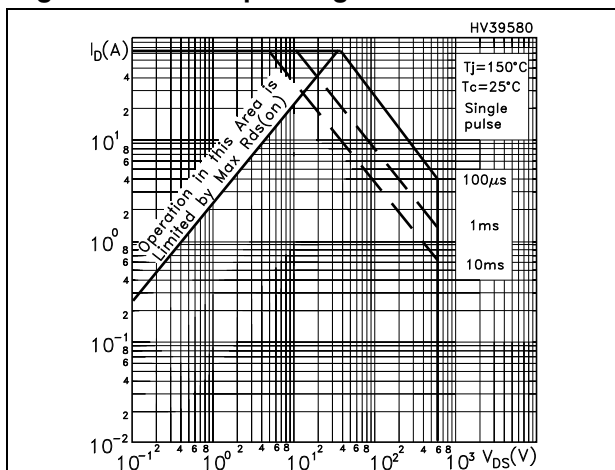


Figure 5. Thermal impedance for TO-220FP

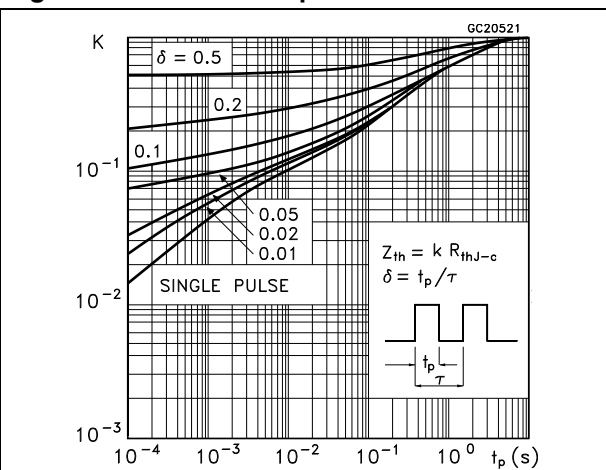


Figure 6. Safe operating area for TO-247

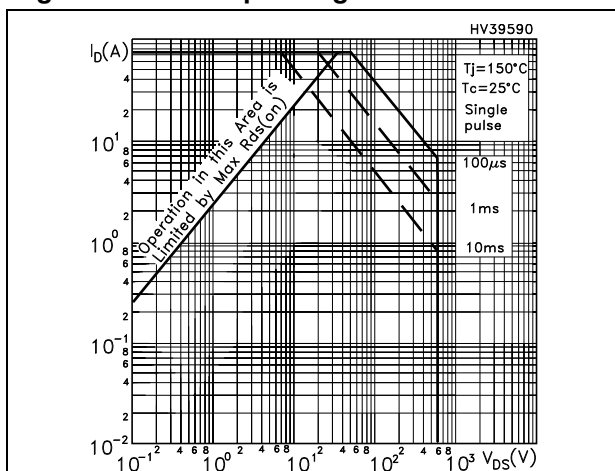


Figure 7. Thermal impedance for TO-247

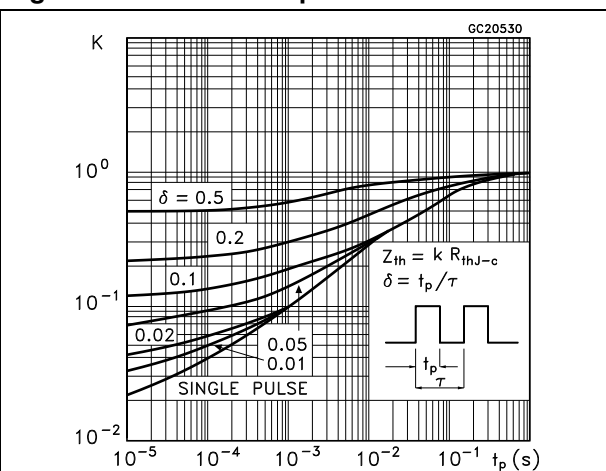


Figure 8. Output characteristics

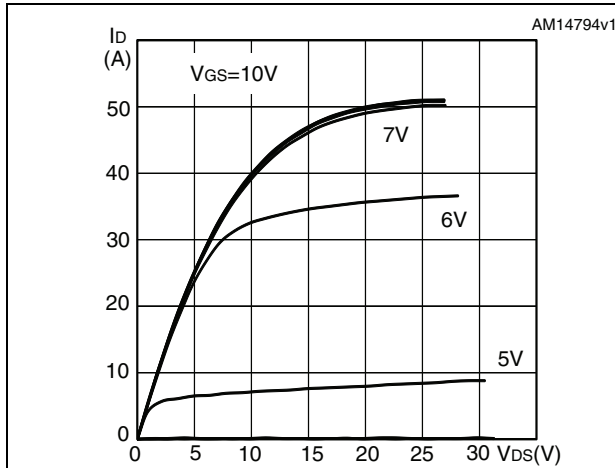


Figure 9. Transfer characteristics

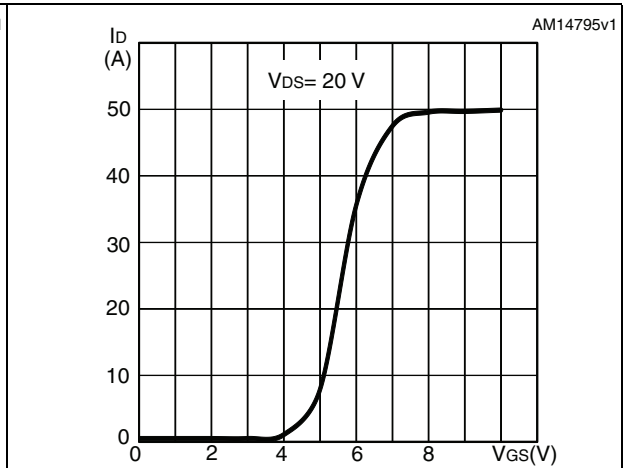


Figure 10. Static drain-source on resistance

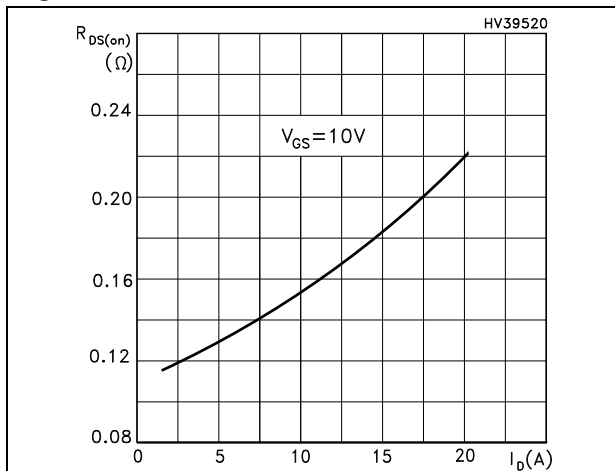


Figure 11. Gate charge vs gate-source voltage

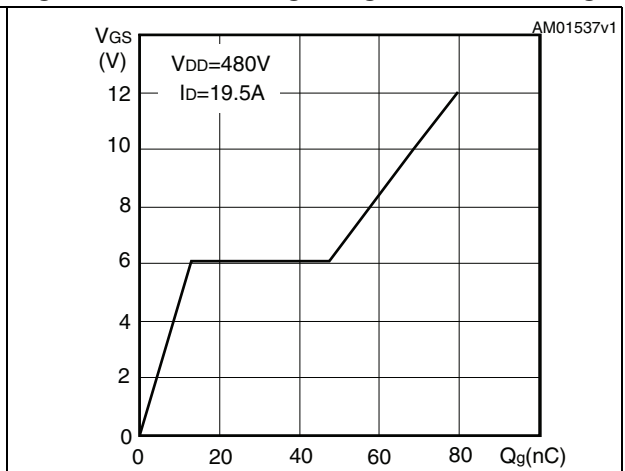


Figure 12. Capacitance variations

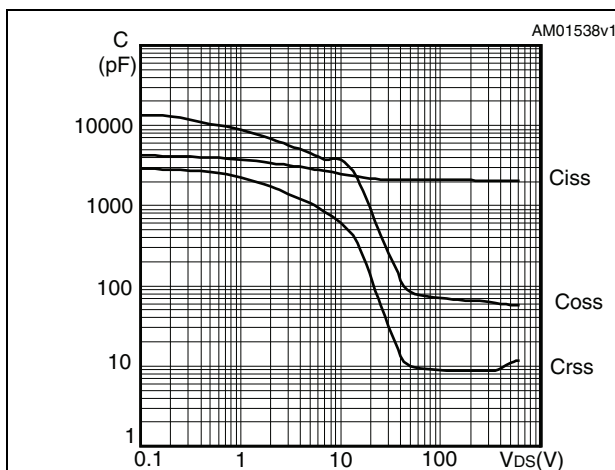
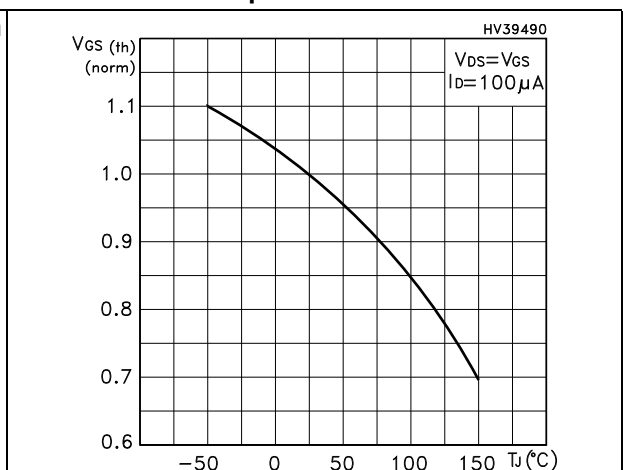
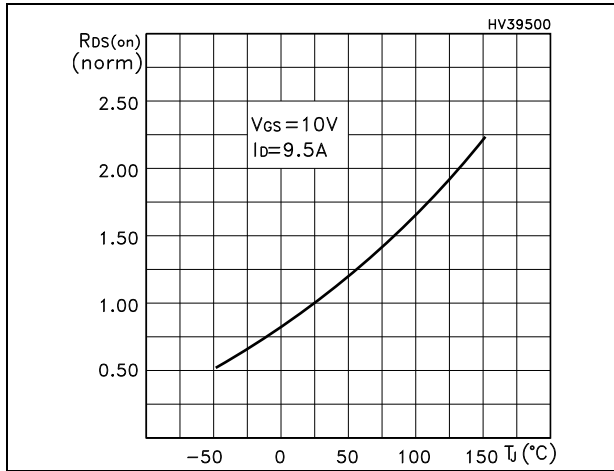


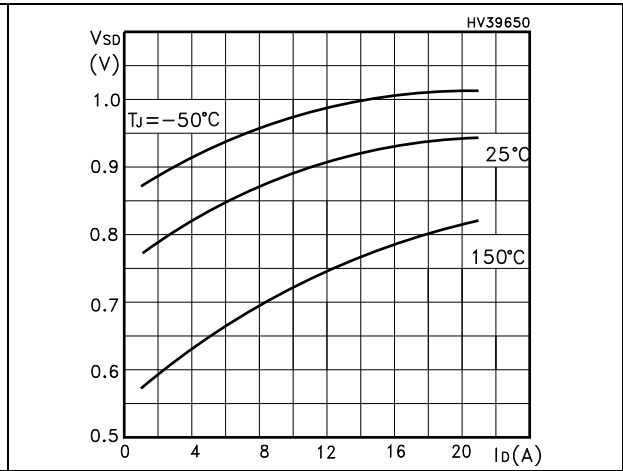
Figure 13. Normalized gate threshold voltage vs temperature



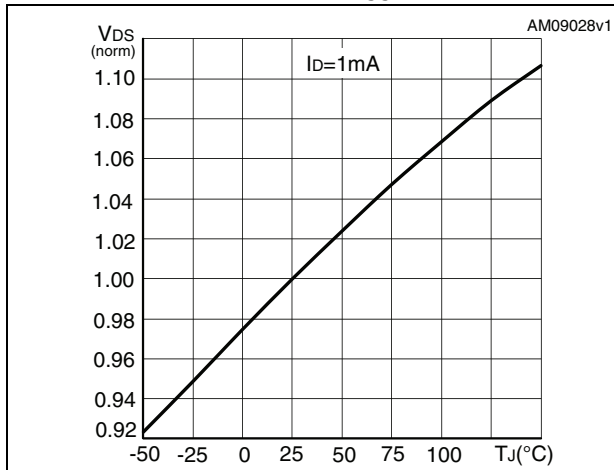
**Figure 14. Normalized on resistance vs temperature**



**Figure 15. Source-drain diode forward characteristics**



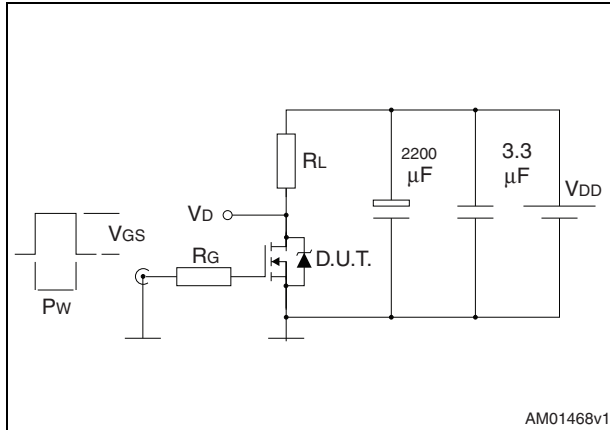
**Figure 16. Normalized  $B_{V_{DSS}}$  vs temperature**





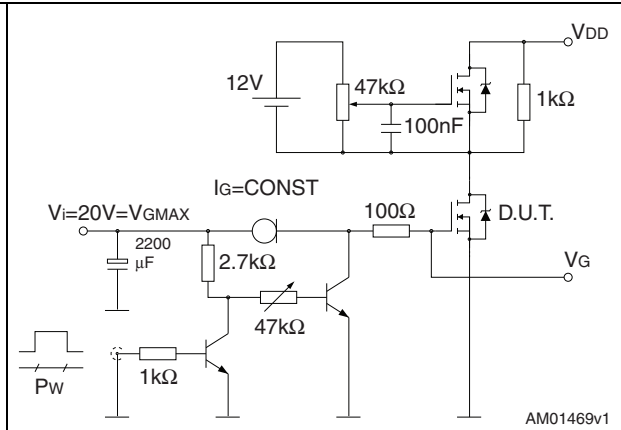
### 3 Test circuits

**Figure 17. Switching times test circuit for resistive load**



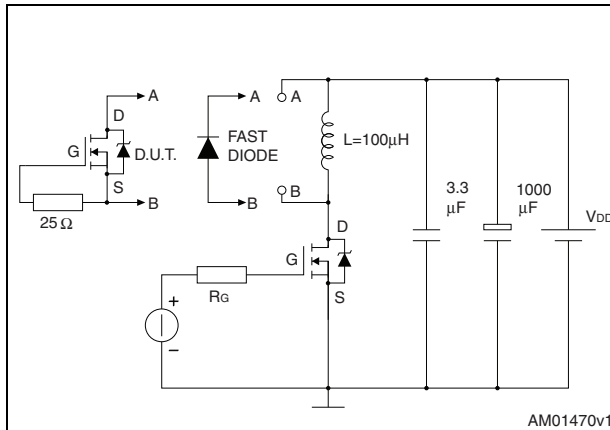
AM01468v1

**Figure 18. Gate charge test circuit**



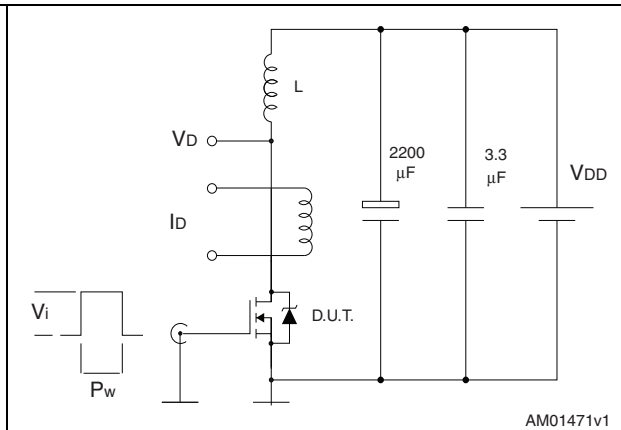
AM01469v1

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



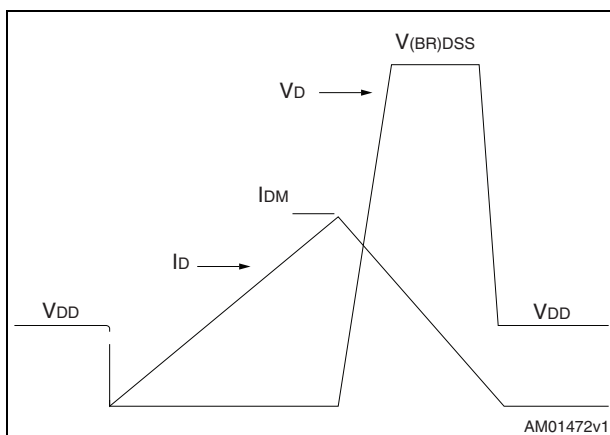
AM01470v1

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



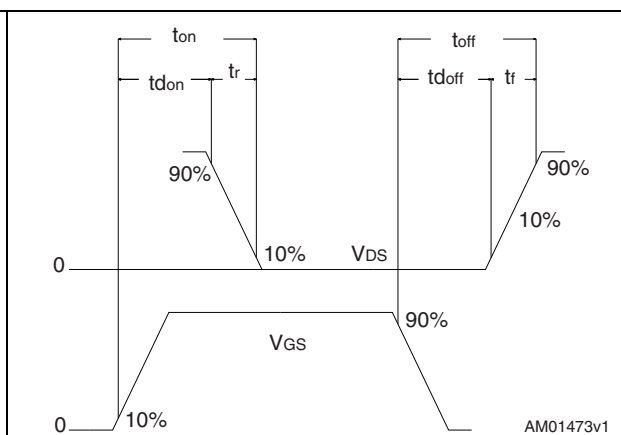
AM01471v1

**Figure 21. Unclamped inductive waveform**



AM01472v1

**Figure 22. Switching time waveform**



AM01473v1

## 4 Package mechanical data

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

Table 8. D<sup>2</sup>PAK (TO-263) 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		
E	10		10.40
E1	8.50		
e		2.54	
e1	4.88		5.28
H	15		15.85
J1	2.49		2.69
L	2.29		2.79
L1	1.27		1.40
L2	1.30		1.75
R		0.4	
V2	0°		8°

Figure 23. D<sup>2</sup>PAK (TO-263) drawing

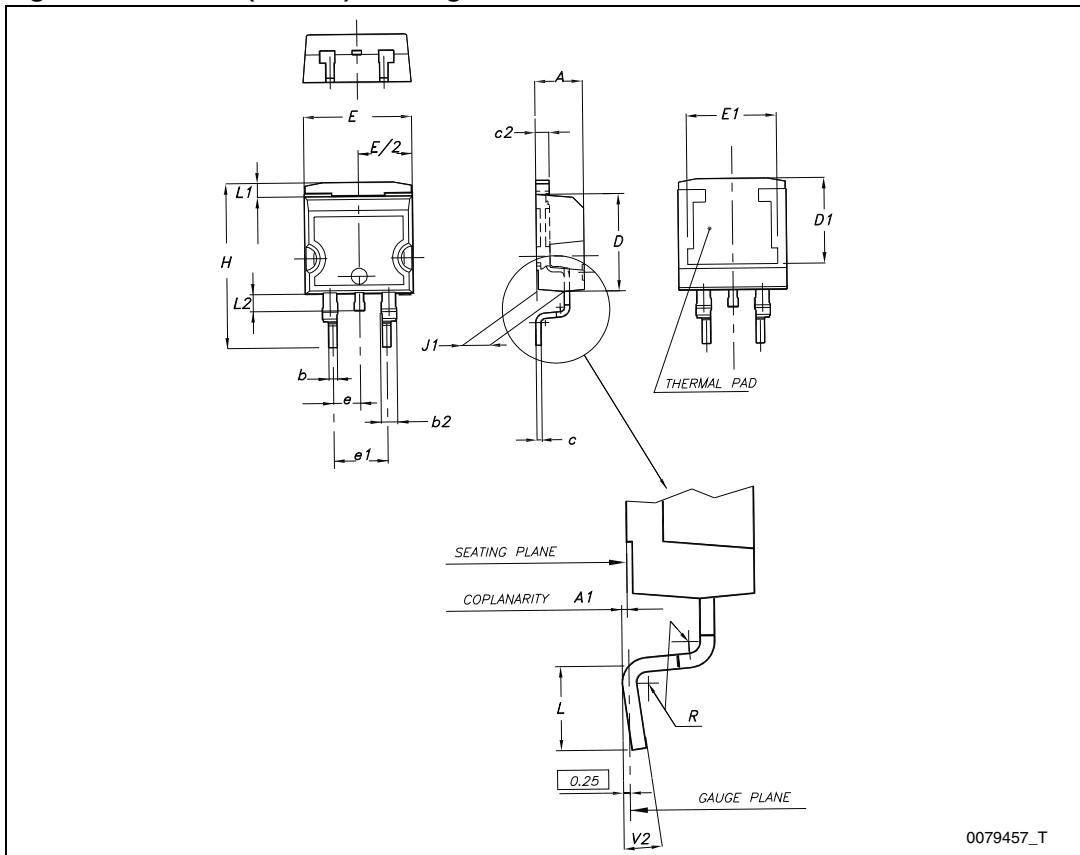
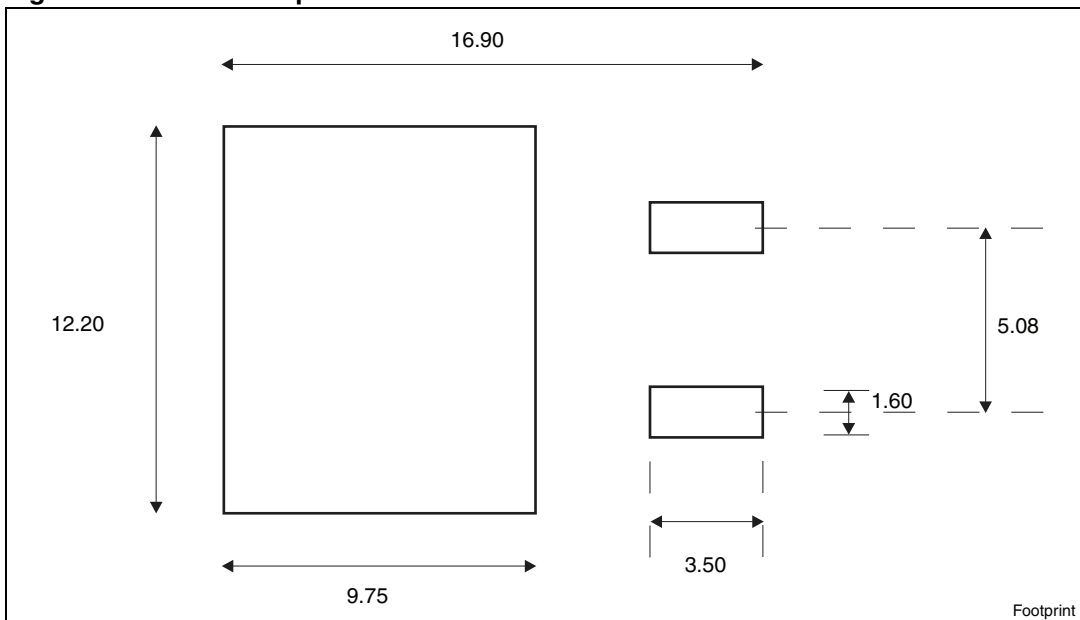


Figure 24. D<sup>2</sup>PAK footprint<sup>(a)</sup>

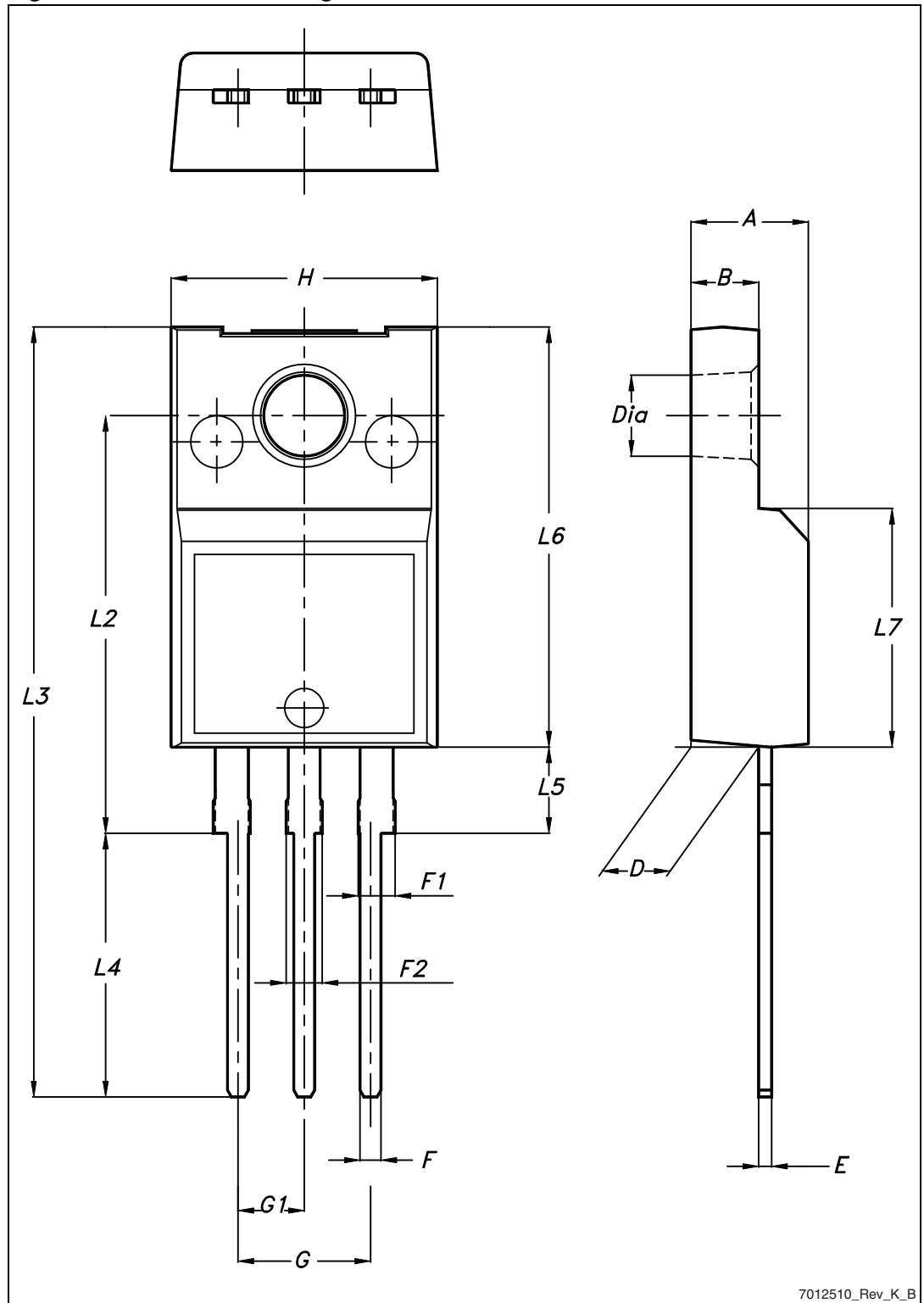


a. All dimensions are in millimeters

Table 9. TO-220FP 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

Figure 25. TO-220FP drawing



7012510\_Rev\_K\_B

Table 10. TO-220 type A mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	4.40		4.60
b	0.61		0.88
b1	1.14		1.70
c	0.48		0.70
D	15.25		15.75
D1		1.27	
E	10		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		14
L1	3.50		3.93
L20		16.40	
L30		28.90	
ØP	3.75		3.85
Q	2.65		2.95

Figure 26. TO-220 type A drawing

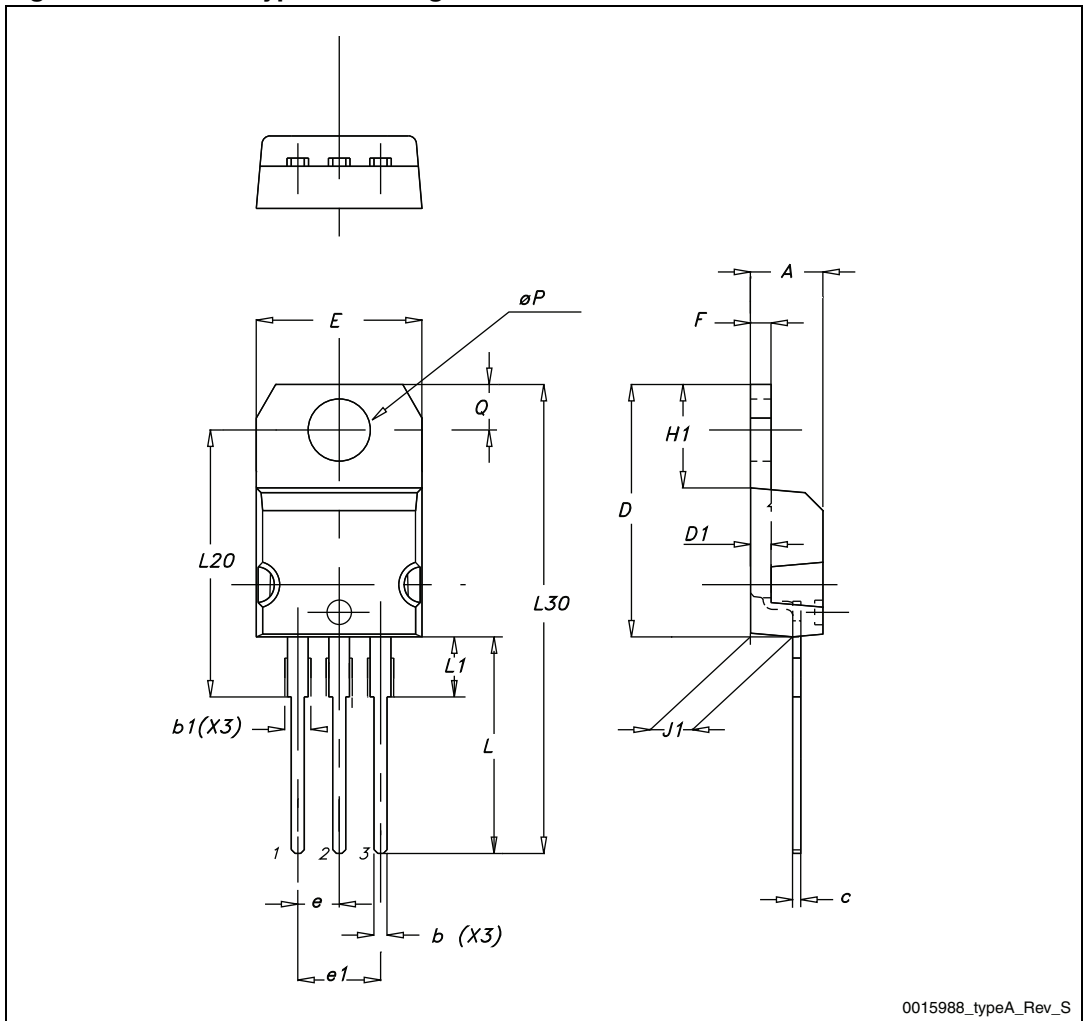
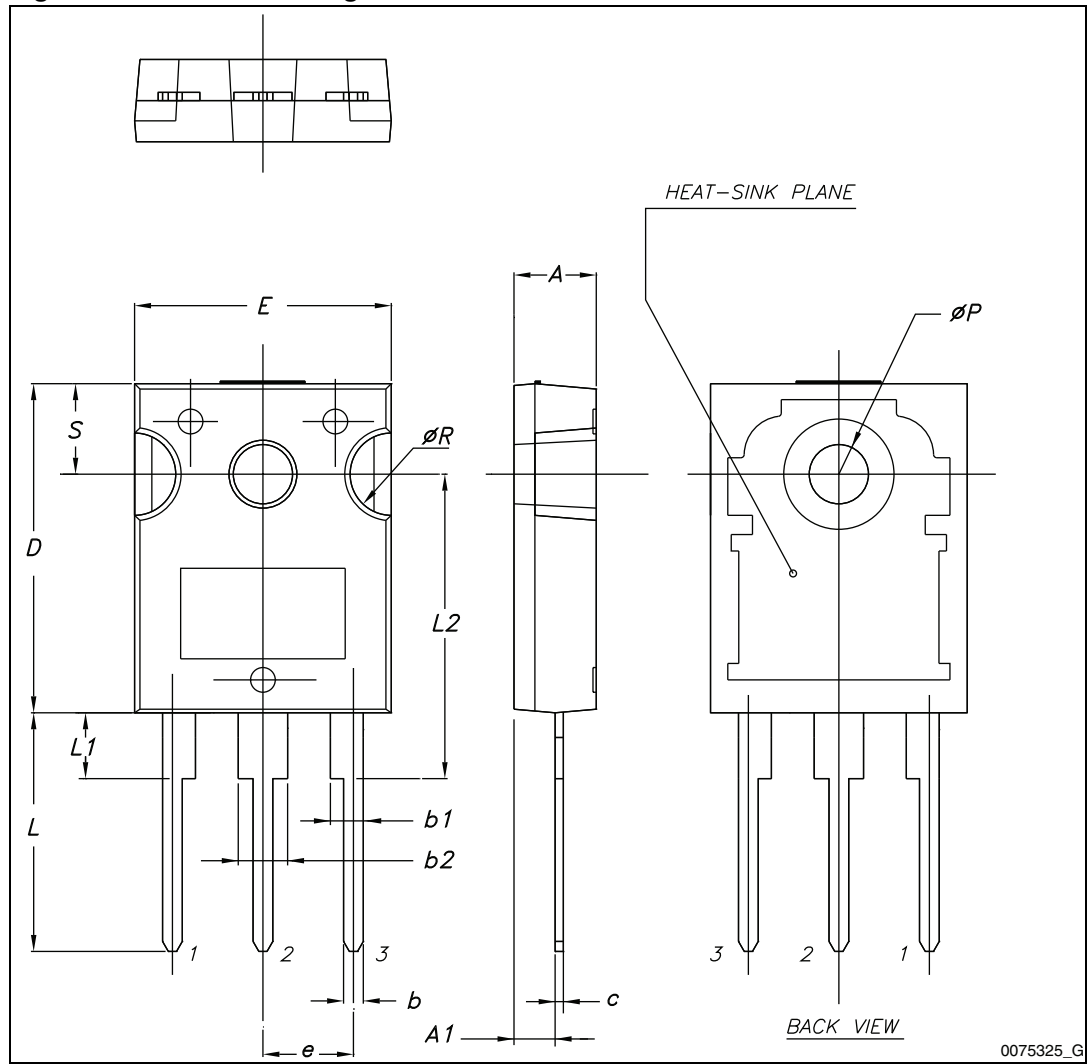




Table 11. TO-247 mechanical data

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

Figure 27. TO-247 drawing



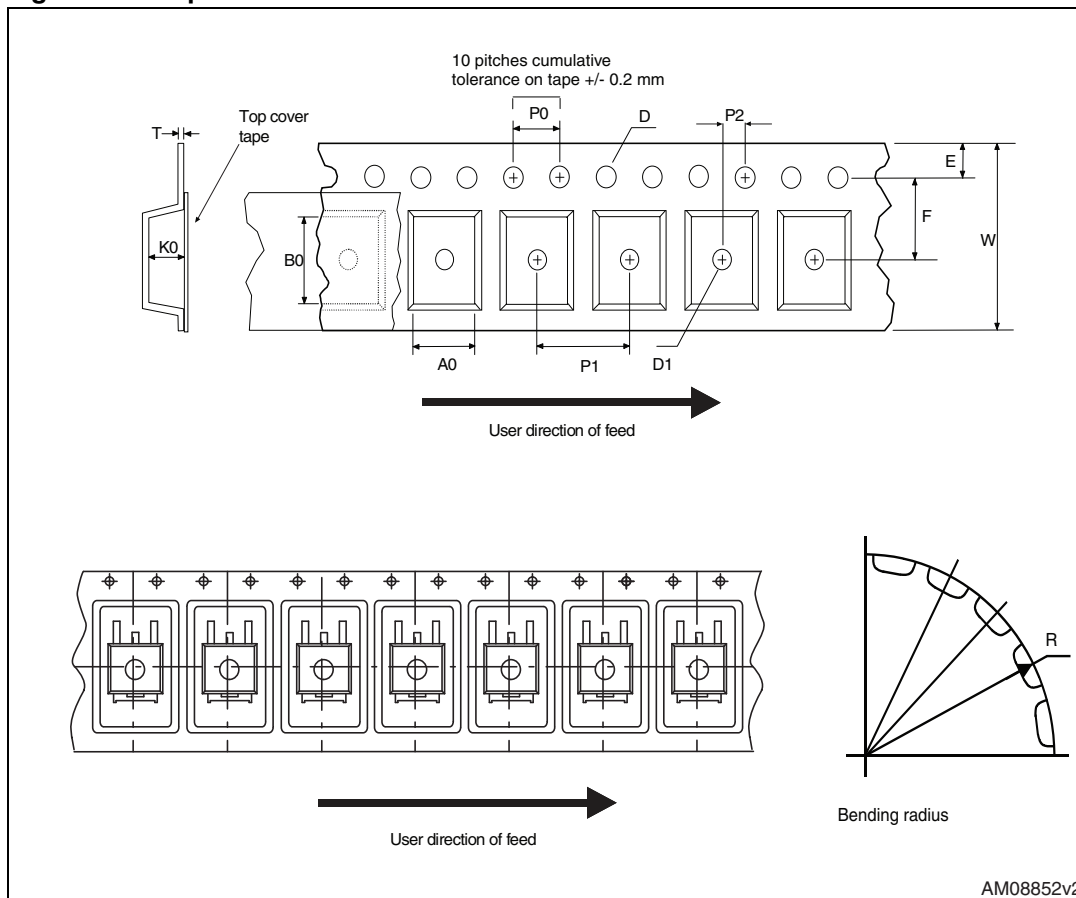
0075325\_G

## 5 Packaging mechanical data

Table 12. D<sup>2</sup>PAK (TO-263) tape and reel mechanical data

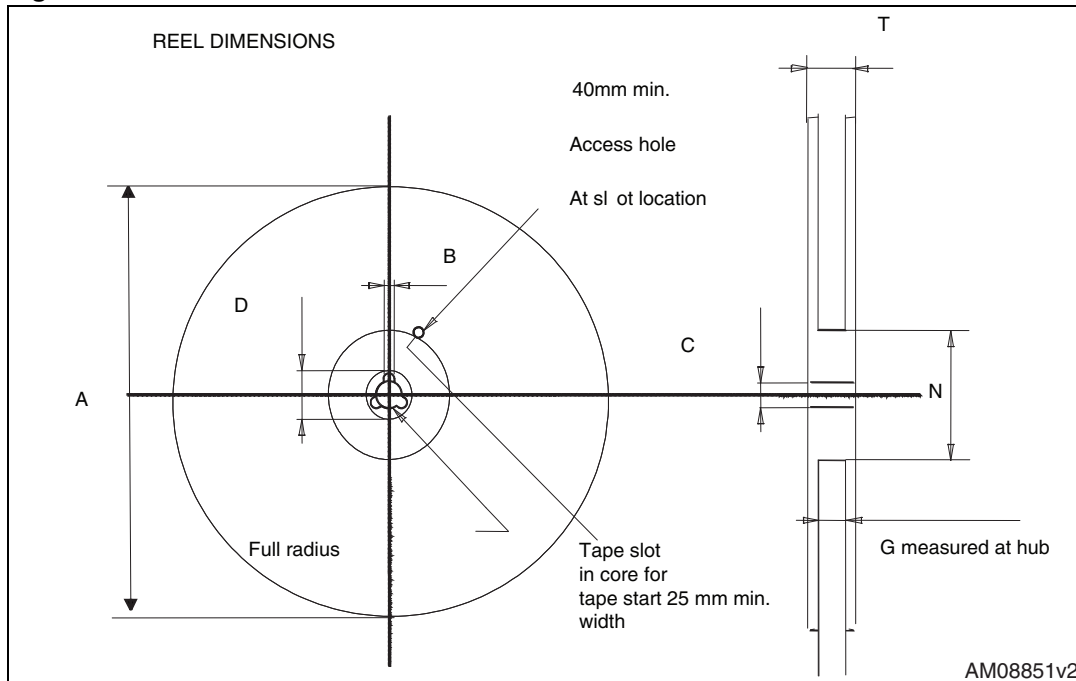
Tape			Reel		
Dim.	mm		Dim.	mm	
	Min.	Max.		Min.	Max.
A0	10.5	10.7	A		330
B0	15.7	15.9	B	1.5	
D	1.5	1.6	C	12.8	13.2
D1	1.59	1.61	D	20.2	
E	1.65	1.85	G	24.4	26.4
F	11.4	11.6	N	100	
K0	4.8	5.0	T		30.4
P0	3.9	4.1			
P1	11.9	12.1		Base qty	1000
P2	1.9	2.1		Bulk qty	1000
R	50				
T	0.25	0.35			
W	23.7	24.3			

Figure 28. Tape



AM08852v2

Figure 29. Reel



AM08851v2

## 6 Revision history

**Table 13. Document revision history**

Date	Revision	Changes
22-Jan-2008	1	First release
11-Dec-2008	2	Document status promoted from preliminary data to datasheet.
06-Oct-2010	3	Corrected unit in <a href="#">Table 4: On/off states</a>
18-Dec-2012	4	<ul style="list-style-type: none"><li>– Minor text changes in cover page</li><li>– The part number STI23NM60ND has been moved to a separate datasheet</li><li>– Modified: <a href="#">Note 1</a> and <a href="#">Note 3</a> in <a href="#">Table 2</a></li><li>– Added <math>R_{thj-pcb}</math> in <a href="#">Table 3</a> and <a href="#">Note 1</a></li><li>– Modified: typ values in <a href="#">Table 5</a> and <a href="#">6</a></li><li>– Modified: <a href="#">Figure 8, 9, 11</a> and <a href="#">16</a></li><li>– Updated: <a href="#">Section 4: Package mechanical data</a> and <a href="#">Section 5: Packaging mechanical data</a></li></ul>

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