

N-channel 600 V, 0.13  $\Omega$  typ., 21 A MDmesh™ DM2  
Power MOSFETs in D<sup>2</sup>PAK, TO-220 and TO-247 packages

Datasheet - production data

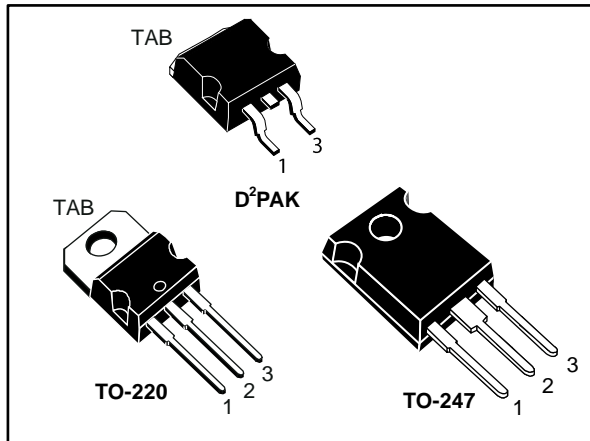
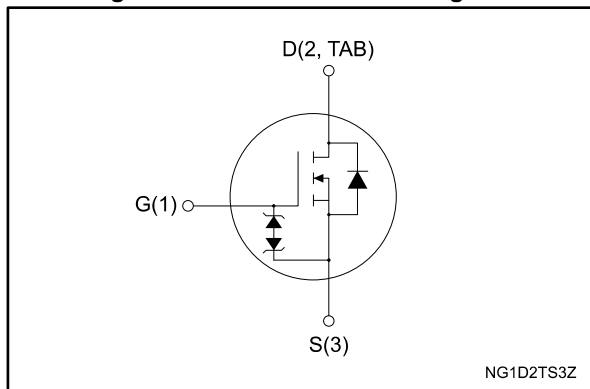


Figure 1: Internal schematic diagram



## Features

Order code	V <sub>DS</sub> @ T <sub>Jmax.</sub>	R <sub>DS(on)</sub> max.	I <sub>D</sub>	P <sub>TOT</sub>
STB28N60DM2	650 V	0.16 $\Omega$	21 A	170 W
STP28N60DM2				
STW28N60DM2				

- 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.

Table 1: Device summary

Order code	Marking	Package	Packing
STB28N60DM2	28N60DM2	D <sup>2</sup> PAK	Tape and reel
STP28N60DM2		TO-220	Tube
STW28N60DM2		TO-247	Tube

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# 1 Electrical ratings

**Table 2: Absolute maximum ratings**

Symbol	Parameter	Value	Unit
$V_{GS}$	Gate-source voltage	±25	V
$I_D$	Drain current (continuous) at $T_{case} = 25\text{ °C}$	21	A
	Drain current (continuous) at $T_{case} = 100\text{ °C}$	14	
$I_{DM}^{(1)}$	Drain current (pulsed)	84	A
$P_{TOT}$	Total dissipation at $T_{case} = 25\text{ °C}$	170	W
$dv/dt^{(2)}$	Peak diode recovery voltage slope	50	V/ns
$dv/dt^{(3)}$	MOSFET $dv/dt$ ruggedness	50	
$T_{stg}$	Storage temperature range	-55 to 150	°C
$T_j$	Operating junction temperature range		

**Notes:**

- (1) Pulse width is limited by safe operating area.  
(2)  $I_{SD} \leq 21\text{ A}$ ,  $di/dt=900\text{ A}/\mu\text{s}$ ;  $V_{DS\text{ peak}} < V_{(BR)DSS}$ ,  $V_{DD} = 400\text{ V}$   
(3)  $V_{DS} \leq 480\text{ V}$ .

**Table 3: Thermal data**

Symbol	Parameter	Value			Unit
		D <sup>2</sup> PAK	TO-220	TO-247	
$R_{thj-case}$	Thermal resistance junction-case	0.74			°C/W
$R_{thj-pcb}^{(1)}$	Thermal resistance junction-pcb	30			
$R_{thj-amb}$	Thermal resistance junction-ambient		62.5	50	

**Notes:**

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

**Table 4: Avalanche characteristics**

Symbol	Parameter	Value	Unit
$I_{AR}^{(1)}$	Avalanche current, repetitive or not repetitive	4	A
$E_{AS}^{(2)}$	Single pulse avalanche energy	350	mJ

**Notes:**

- (1) pulse width limited by  $T_{jmax}$   
(2) starting  $T_j = 25\text{ °C}$ ,  $I_D = I_{AR}$ ,  $V_{DD} = 50\text{ V}$ .

## 2 Electrical characteristics

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

**Table 5: Static**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(\text{BR})\text{DSS}}$	Drain-source breakdown voltage	$V_{\text{GS}} = 0\text{ V}$ , $I_{\text{D}} = 1\text{ mA}$	600			V
$I_{\text{DSS}}$	Zero gate voltage drain current	$V_{\text{GS}} = 0\text{ V}$ , $V_{\text{DS}} = 600\text{ V}$			1	$\mu\text{A}$
		$V_{\text{GS}} = 0\text{ V}$ , $V_{\text{DS}} = 600\text{ V}$ , $T_{\text{case}} = 125\text{ °C}^{(1)}$			100	
$I_{\text{GSS}}$	Gate-body leakage current	$V_{\text{DS}} = 0\text{ V}$ , $V_{\text{GS}} = \pm 25\text{ V}$			$\pm 10$	$\mu\text{A}$
$V_{\text{GS(th)}}$	Gate threshold voltage	$V_{\text{DS}} = V_{\text{GS}}$ , $I_{\text{D}} = 250\text{ }\mu\text{A}$	3	4	5	V
$R_{\text{DS(on)}}$	Static drain-source on-resistance	$V_{\text{GS}} = 10\text{ V}$ , $I_{\text{D}} = 10.5\text{ A}$		0.13	0.16	$\Omega$

**Notes:**

<sup>(1)</sup>Defined by design, not subject to production test.

**Table 6: Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$C_{\text{iss}}$	Input capacitance	$V_{\text{DS}} = 100\text{ V}$ , $f = 1\text{ MHz}$ , $V_{\text{GS}} = 0\text{ V}$	-	1500	-	$\mu\text{F}$
$C_{\text{oss}}$	Output capacitance		-	70	-	
$C_{\text{riss}}$	Reverse transfer capacitance		-	1.6	-	
$C_{\text{oss eq.}}^{(1)}$	Equivalent output capacitance	$V_{\text{DS}} = 0\text{ to }480\text{ V}$ , $V_{\text{GS}} = 0\text{ V}$	-	134	-	$\mu\text{F}$
$R_{\text{G}}$	Intrinsic gate resistance	$f = 1\text{ MHz}$ , $I_{\text{D}} = 0\text{ A}$	-	4.6	-	$\Omega$
$Q_{\text{g}}$	Total gate charge	$V_{\text{DD}} = 480\text{ V}$ , $I_{\text{D}} = 21\text{ A}$ , $V_{\text{GS}} = 0$ to $10\text{ V}$ (see <a href="#">Figure 19: "Test circuit for gate charge behavior"</a> )	-	34	-	nC
$Q_{\text{gs}}$	Gate-source charge		-	8	-	
$Q_{\text{gd}}$	Gate-drain charge		-	18.5	-	

**Notes:**

<sup>(1)</sup>  $C_{\text{oss eq.}}$  is defined as a constant equivalent capacitance giving the same charging time as  $C_{\text{oss}}$  when  $V_{\text{DS}}$  increases from 0 to 80%  $V_{\text{DSS}}$ .

Table 7: Switching times

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 300\text{ V}$ , $I_D = 10.5\text{ A}$ $R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$ (see <a href="#">Figure 18: "Test circuit for resistive load switching times"</a> and <a href="#">Figure 23: "Switching time waveform"</a> )	-	16	-	ns
$t_r$	Rise time		-	7.3	-	
$t_{d(off)}$	Turn-off delay time		-	53	-	
$t_f$	Fall time		-	9.3	-	

Table 8: Source-drain diode

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{SD}^{(1)}$	Source-drain current		-		21	A
$I_{SDM}^{(2)}$	Source-drain current (pulsed)		-		84	A
$V_{SD}^{(3)}$	Forward on voltage	$V_{GS} = 0\text{ V}$ , $I_{SD} = 21\text{ A}$	-		1.6	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 21\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ , $V_{DD} = 60\text{ V}$ (see <a href="#">Figure 20: "Test circuit for inductive load switching and diode recovery times"</a> )	-	140		ns
$Q_{rr}$	Reverse recovery charge		-	0.5		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current		-	7.4		A
$t_{rr}$	Reverse recovery time	$I_{SD} = 21\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ , $V_{DD} = 60\text{ V}$ , $T_J = 150\text{ }^\circ\text{C}$ (see <a href="#">Figure 20: "Test circuit for inductive load switching and diode recovery times"</a> )	-	309		ns
$Q_{rr}$	Reverse recovery charge		-	2.6		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current		-	16.8		A

**Notes:**

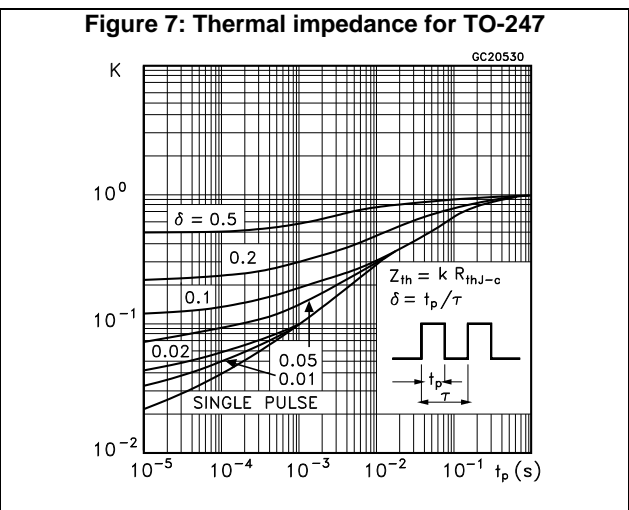
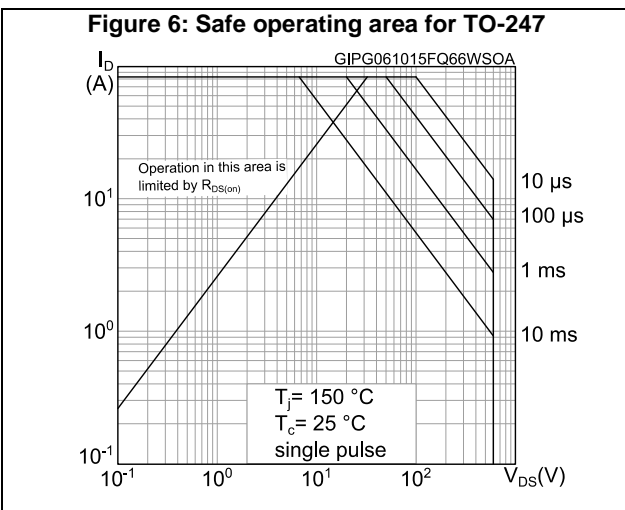
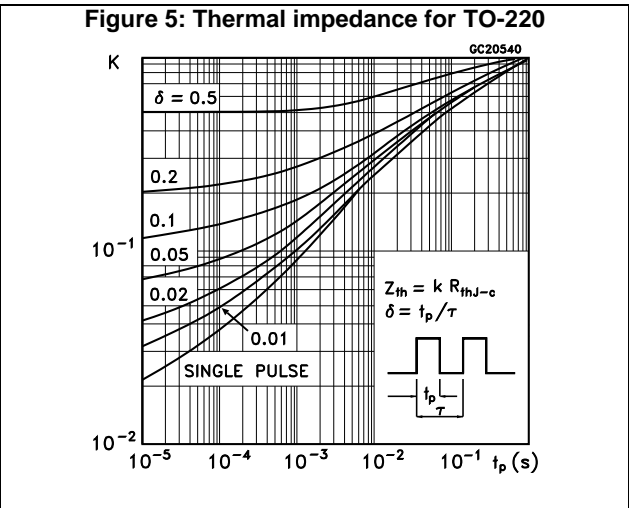
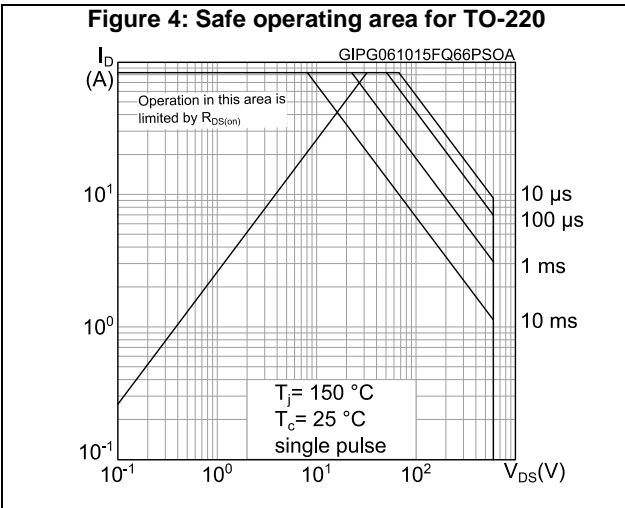
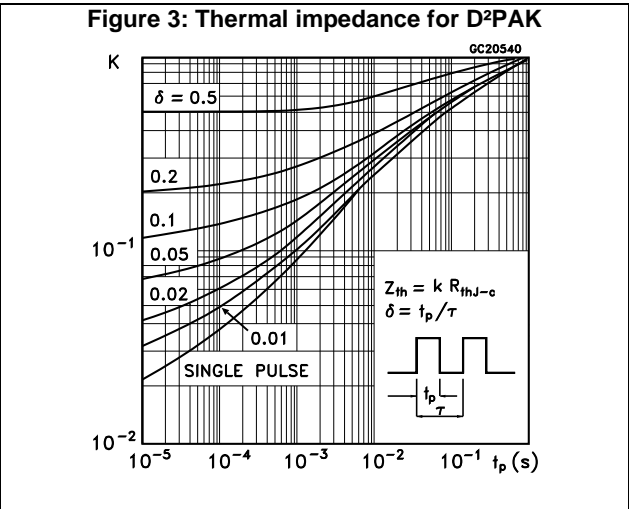
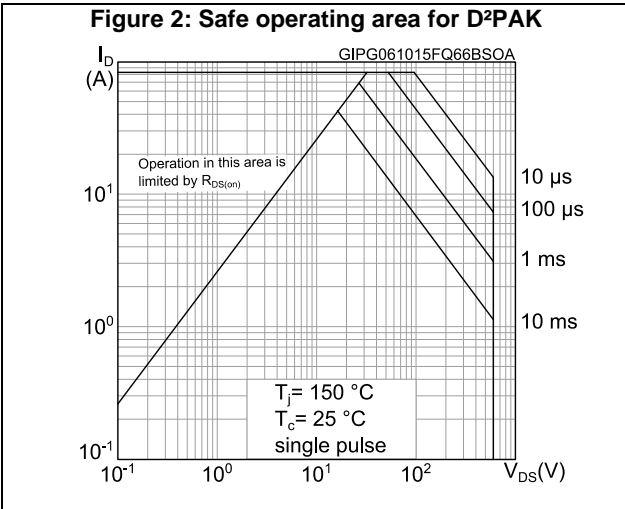
- (1) Limited by maximum junction temperature.  
(2) Pulse width is limited by safe operating area.  
(3) Pulse test: pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%.

Table 9: Gate-source Zener diode

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)GSO}$	Gate-source breakdown voltage	$I_{GS} = \pm 250\ \mu\text{A}$ , $I_D = 0\text{ A}$	$\pm 25$	-	-	V

The built-in back-to-back Zener diodes are specifically designed to enhance the ESD performance of the device. The Zener voltage facilitates efficient and cost-effective device integrity protection, thus eliminating the need for additional external componentry.

## 2.1 Electrical characteristics (curves)



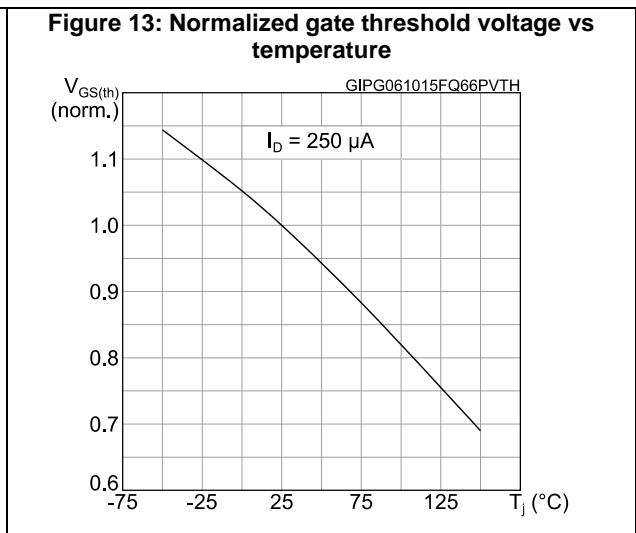
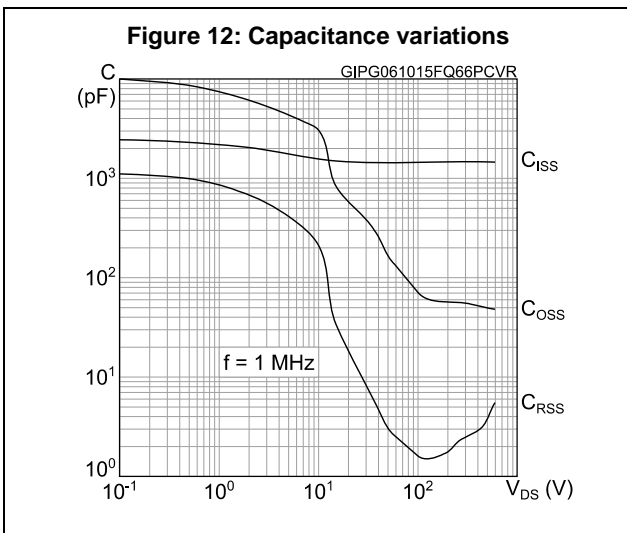
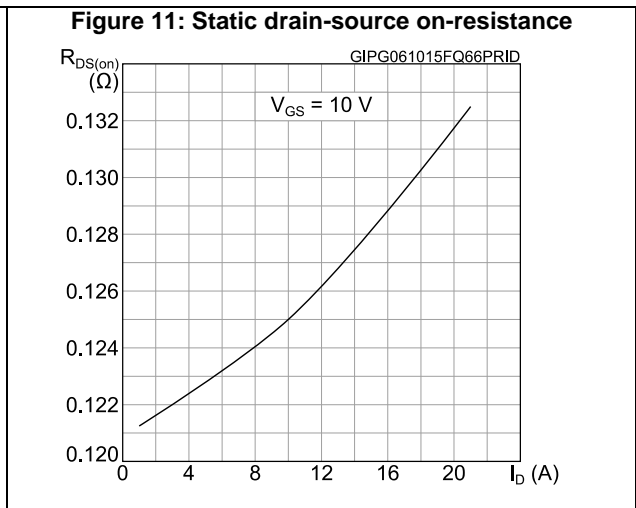
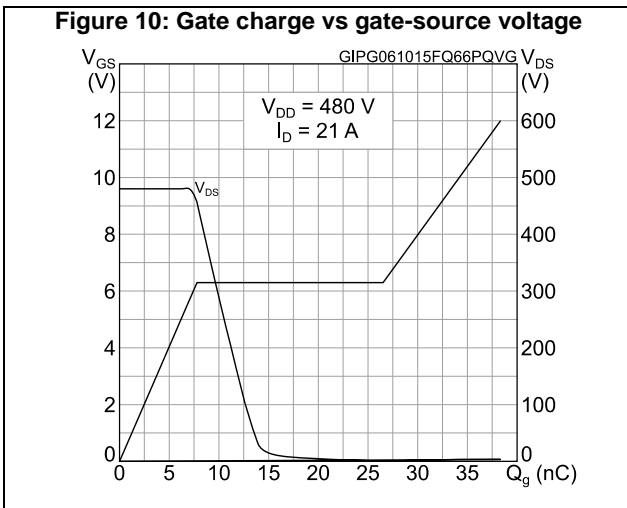
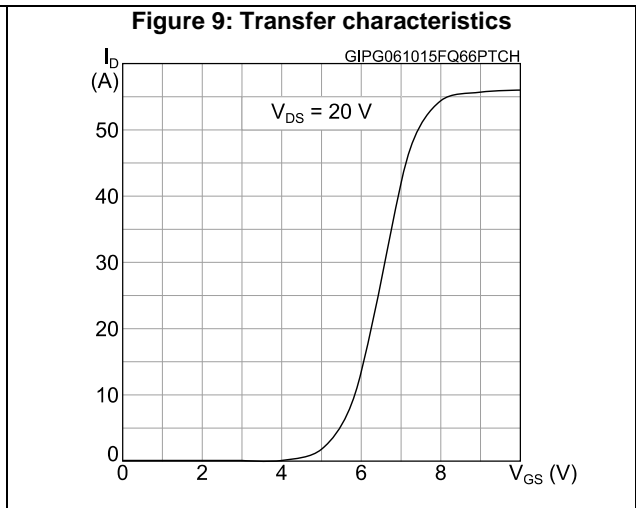
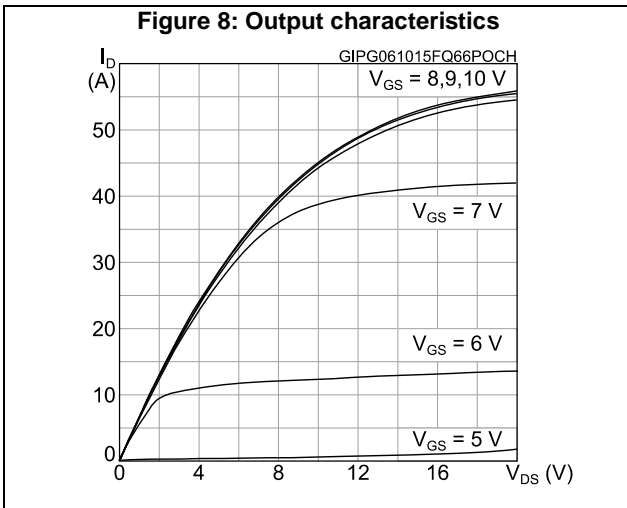


Figure 14: Normalized on-resistance vs temperature

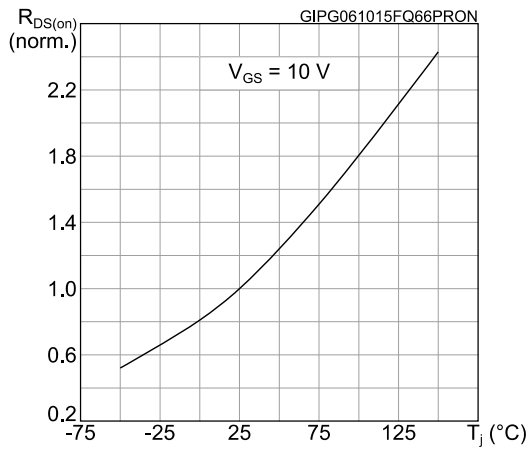


Figure 15: Normalized  $V_{(BR)DSS}$  vs temperature

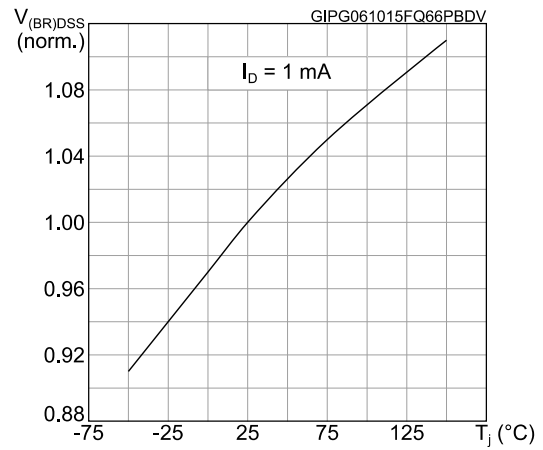


Figure 16: Output capacitance stored energy

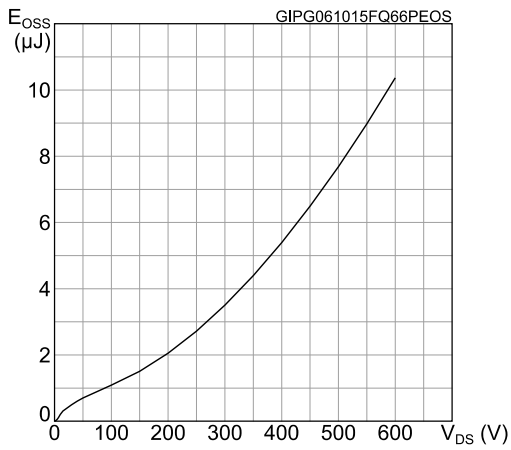
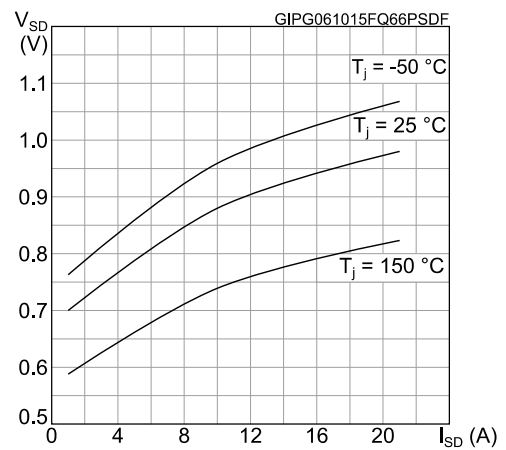


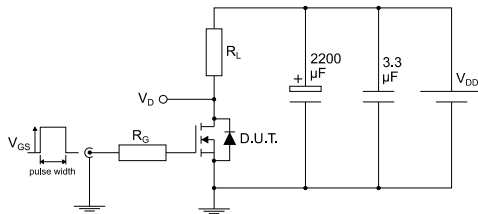
Figure 17: Source-drain diode forward characteristics





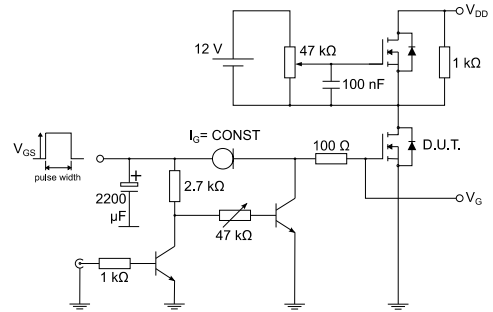
### 3 Test circuits

**Figure 18: Test circuit for resistive load switching times**



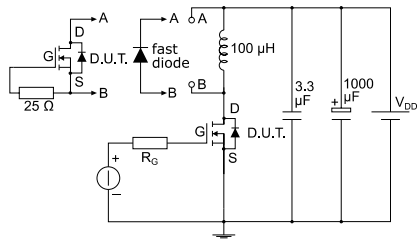
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**Figure 19: Test circuit for gate charge behavior**



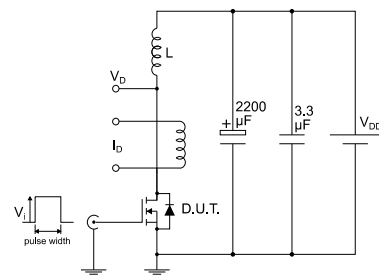
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**Figure 20: Test circuit for inductive load switching and diode recovery times**



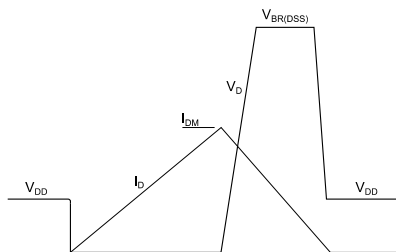
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**Figure 21: Unclamped inductive load test circuit**



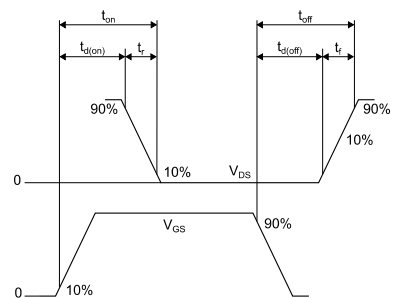
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**Figure 22: Unclamped inductive waveform**



AM01472v1

**Figure 23: 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 24: D<sup>2</sup>PAK (TO-263) type A package outline

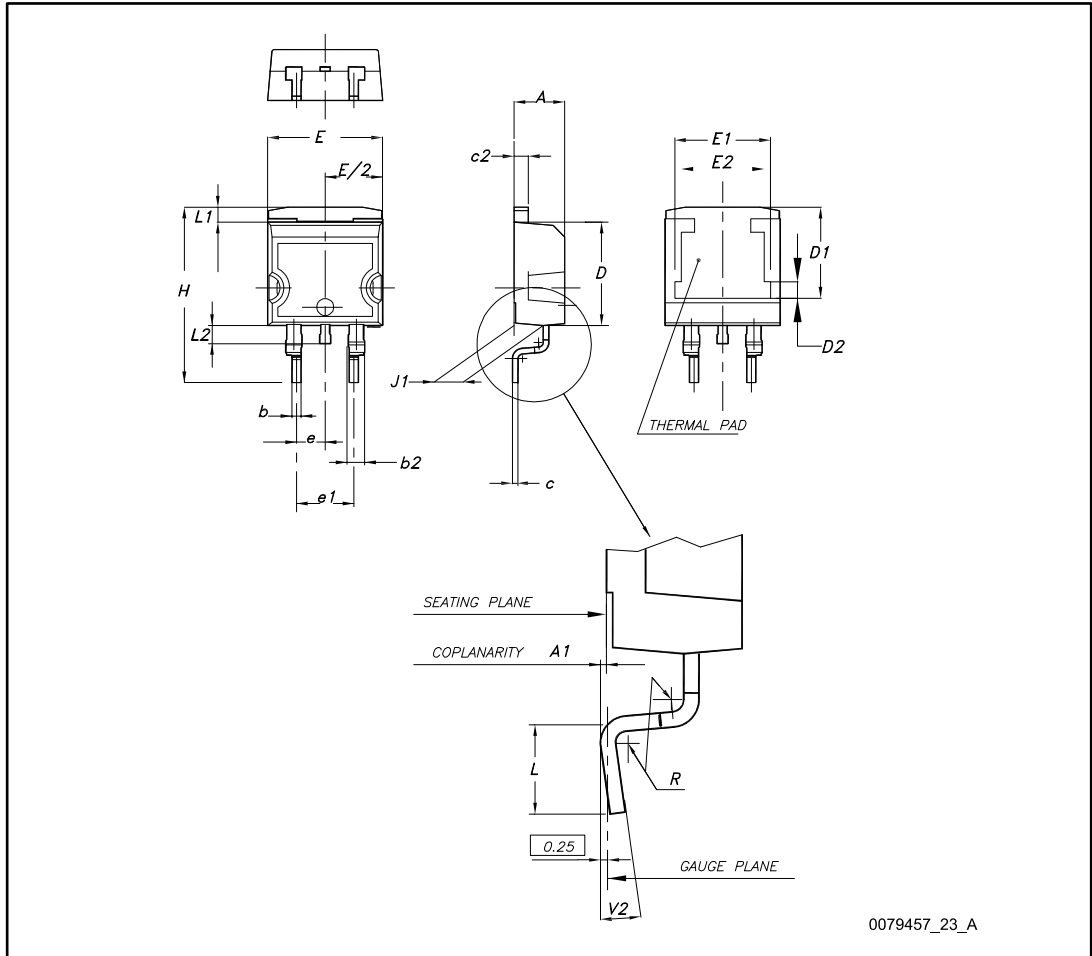
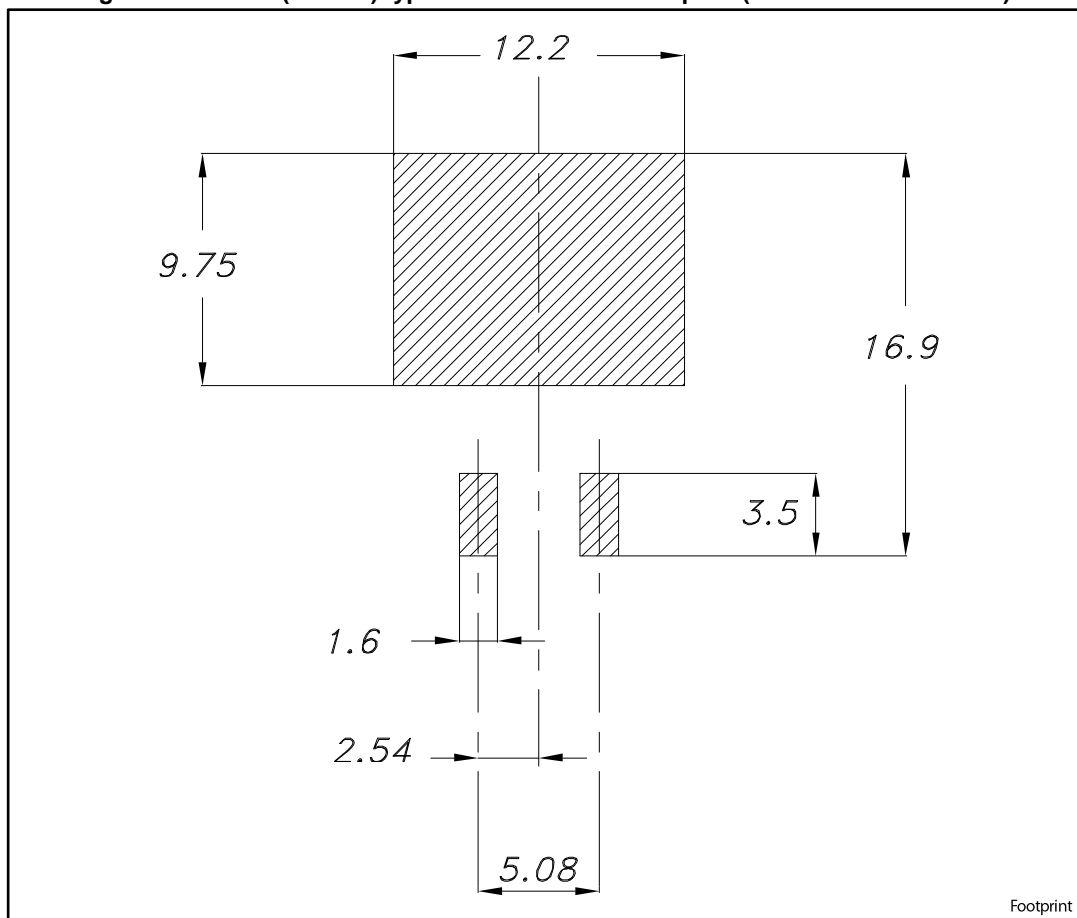


Table 10: D<sup>2</sup>PAK (TO-263) type A package mechanical data

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	8.50	8.70	8.90
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 25: D<sup>2</sup>PAK (TO-263) type A recommended footprint (dimensions are in mm)



4.2 TO-220 type A package information

Figure 26: TO-220 type A package outline

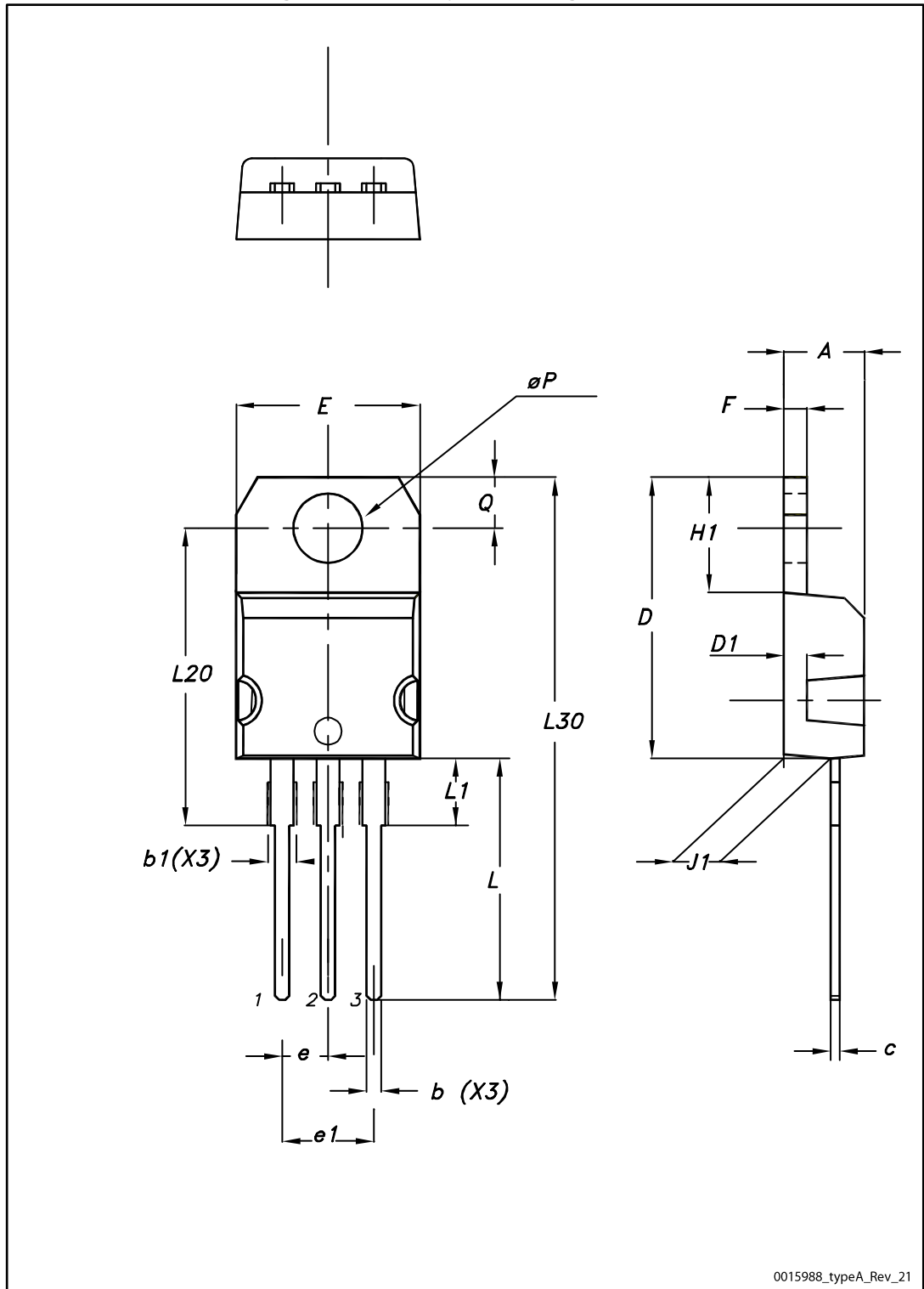


Table 11: TO-220 type A mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	4.40		4.60
b	0.61		0.88
b1	1.14		1.55
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

### 4.3 TO-247 package information

Figure 27: TO-247 package outline

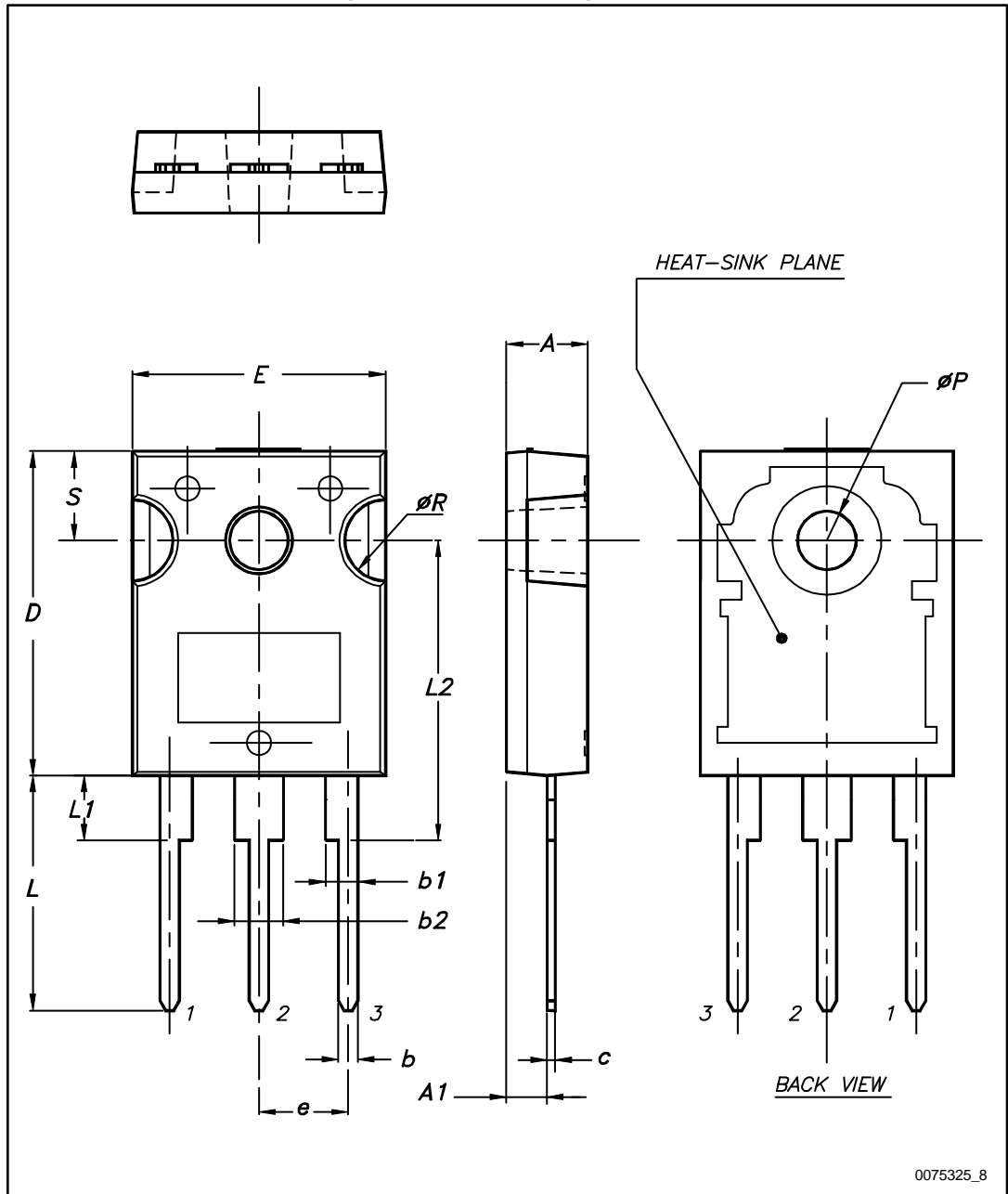


Table 12: TO-247 package mechanical data

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 Packing information

### 5.1 D<sup>2</sup>PAK type A packing information

Figure 28: D<sup>2</sup>PAK type A tape outline

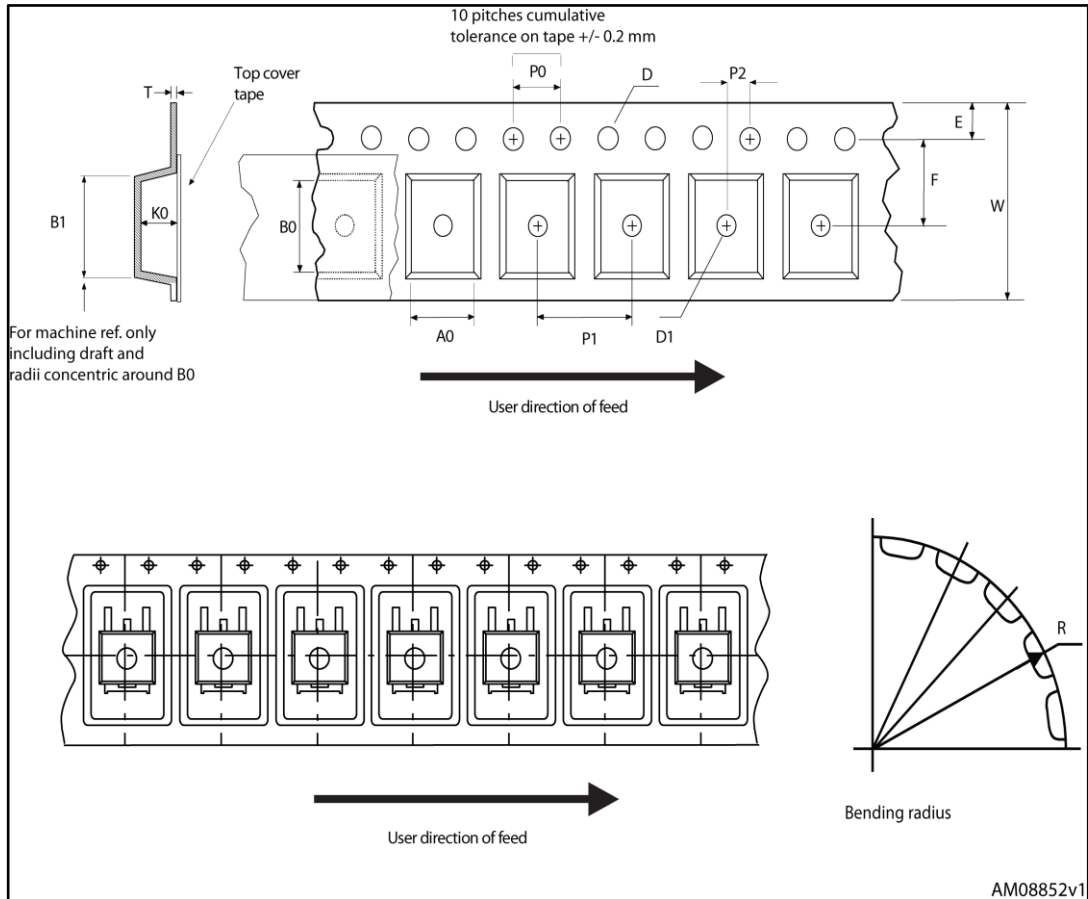


Figure 29: D2PAK type A reel outline

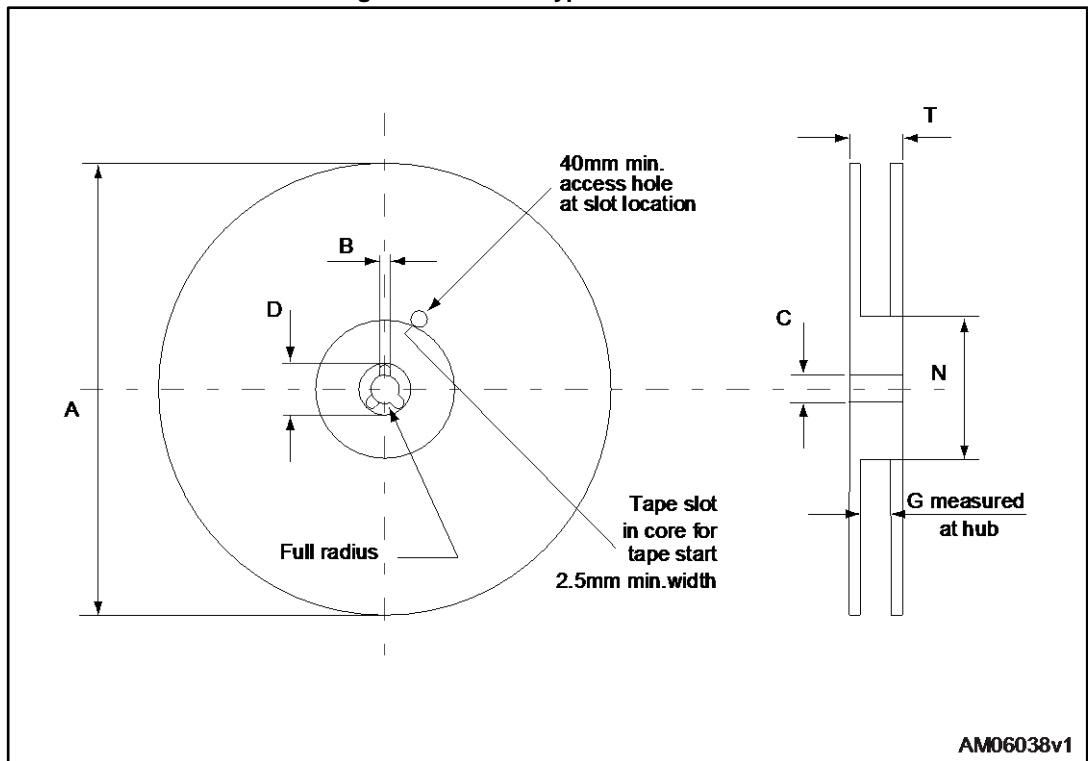


Table 13: D<sup>2</sup>PAK type A tape and reel mechanical data

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 quantity		1000
P2	1.9	2.1	Bulk quantity		1000
R	50				
T	0.25	0.35			
W	23.7	24.3			

## 6 Revision history

Table 14: Document revision history

Date	Revision	Changes
21-Oct-2014	1	First release.
05-Oct-2015	2	Text and formatting changes throughout document On cover page: - updated title and Features table In section Electrical ratings: - updated all table data In section Electrical characteristics: - updated all table data - renamed table Static (was On /off states) - added table Gate-source Zener diode Added section Electrical characteristics (curves) Updated and renamed section Package mechanical data (was Package information) Datasheet promoted from preliminary to production data
30-Oct-2015	3	Minor text changes in <i>Section 2.1: "Electrical characteristics (curves)"</i> .
09-Dec-2015	4	Updated features and <i>Table 1: "Device summary"</i> .
24-Apr-2017	5	Updated features in cover page. Updated <a href="#">Section 4: "Package information"</a> Minor text changes.

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