

N-channel 600 V, 0.13  $\Omega$  typ., 23 A FDmesh™ II Power MOSFETs  
in D<sup>2</sup>PAK, TO-220FP, TO-220 and TO-247 packages

Datasheet - production data

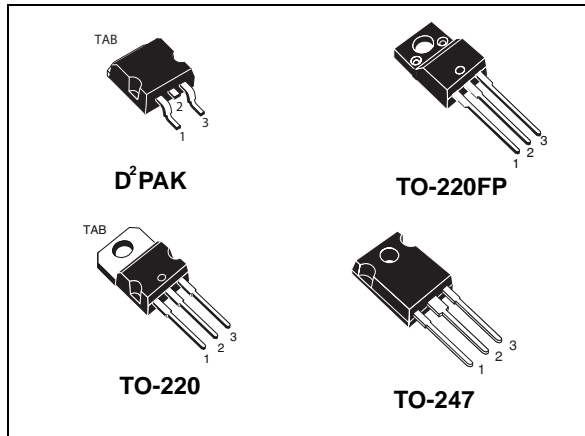
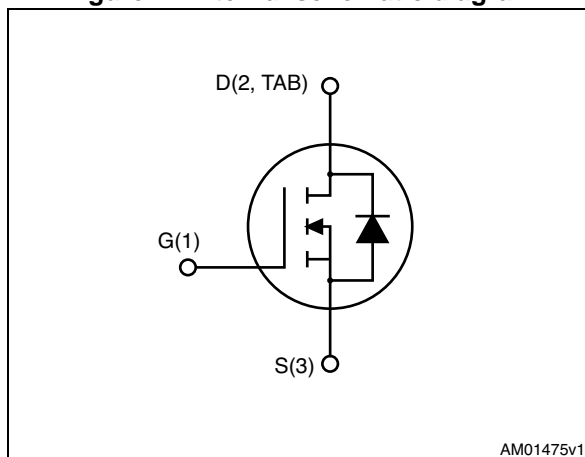


Figure 1. Internal schematic diagram



## Features

Order codes	$V_{DS}$ @ $T_J$ max.	$R_{DS(on)}$ max	$I_D$
STB28NM60ND	650 V	0.150 $\Omega$	23 A
STF28NM60ND			
STP28NM60ND			
STW28NM60ND			

- Intrinsic fast-recovery body diode
- 100% avalanche tested
- Low input capacitance and gate charge
- Low gate input resistance
- Extremely 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.

Table 1. Device summary

Order codes	Marking	Packages	Packaging
STB28NM60ND	28NM60ND	D <sup>2</sup> PAK	Tape and reel
STF28NM60ND		TO-220FP	Tube
STP28NM60ND		TO-220	
STW28NM60ND		TO-247	

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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	23	23 <sup>(1)</sup>	A
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 100 °C	14.5	14.5 <sup>(1)</sup>	A
I <sub>DM</sub> <sup>(2)</sup>	Drain current (pulsed)	92	92(1)	A
P <sub>TOT</sub>	Total dissipation at T <sub>C</sub> = 25 °C	190	35	W
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<sub>SD</sub> ≤ 23 A, di/dt ≤ 600 A/μs, V<sub>DD</sub> = 80% V<sub>(BR)DSS</sub>

**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	0.66	3.6	0.66		°C/W
R <sub>thj-amb</sub>	Thermal resistance junction-ambient max		62.5		50	°C/W
R <sub>thj-pcb</sub> <sup>(1)</sup>	Thermal resistance junction-pcb max	30				°C/W

- When mounted on 1inch<sup>2</sup> FR-4 board, 2 oz Cu

**Table 4. Avalanche characteristics**

Symbol	Parameter	Max value	Unit
I <sub>AR</sub>	Avalanche current, repetitive or not-repetitive (pulse width limited by T <sub>J</sub> max)	5	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)	450	mJ

## 2 Electrical characteristics

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

**Table 5. On/off states**

Symbol	Parameter	Test conditions	Value			Unit
			Min.	Typ.	Max.	
$V_{(BR)DSS}$	Drain-source breakdown voltage	$I_D = 1\text{ mA}, V_{GS} = 0$	600			V
$dv/dt^{(1)}$	Drain source voltage slope	$V_{DD} = 480\text{ V}, I_D = 23\text{ A}, V_{GS} = 10\text{ V}$	45			V/ns
$I_{DSS}$	Zero gate voltage drain current ( $V_{GS} = 0$ )	$V_{DS} = 600\text{ V}$			1	$\mu\text{A}$
		$V_{DS} = 600\text{ V}, T_C = 125\text{ °C}$			100	$\mu\text{A}$
$I_{GSS}$	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	$V_{GS} = 10\text{ V}, I_D = 11.5\text{ A}$		0.13	0.15	$\Omega$

1. Characteristic value at turn off on inductive load.

**Table 6. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$C_{iss}$	Input capacitance	$V_{DS} = 100\text{ V}, f = 1\text{ MHz}, V_{GS} = 0$	-	2090	-	pF
$C_{oss}$	Output capacitance		-	90	-	pF
$C_{riss}$	Reverse transfer capacitance		-	5.5	-	pF
$C_{oss\text{ eq.}}^{(1)}$	Equivalent output capacitance	$V_{GS} = 0, V_{DS} = 0\text{ to }480\text{ V}$	-	312	-	pF
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 300\text{ V}, I_D = 11.5\text{ A}, R_G = 4.7\text{ }\Omega, V_{GS} = 10\text{ V}$ (see Figure 18), (see Figure 20)	-	23.5	-	ns
$t_r$	Rise time		-	21.5	-	ns
$t_{d(off)}$	Turn-off delay time		-	92	-	ns
$t_f$	Fall time		-	27	-	ns
$Q_g$	Total gate charge	$V_{DD} = 480\text{ V}, I_D = 23\text{ A}, V_{GS} = 10\text{ V},$ (see Figure 10)	-	62.5	-	nC
$Q_{gs}$	Gate-source charge		-	11	-	nC
$Q_{gd}$	Gate-drain charge		-	38	-	nC
$R_g$	Gate input resistance	$f = 1\text{ MHz},$ test signal level = 20 mV, $I_D = 0$	-	4.7	-	$\Omega$

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 7. Source drain diode

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{SD}$	Source-drain current		-		23	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)		-		92	A
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 23 \text{ A}, V_{GS} = 0$	-		1.6	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 23 \text{ A}, V_{DD} = 60 \text{ V}$ $di/dt = 100 \text{ A}/\mu\text{s}$ (see Figure 17)	-	170		ns
$Q_{rr}$	Reverse recovery charge		-	1160		nC
$I_{RRM}$	Reverse recovery current		-	14		A
$t_{rr}$	Reverse recovery time	$I_{SD} = 23 \text{ A}, V_{DD} = 60 \text{ V}$ $di/dt = 100 \text{ A}/\mu\text{s},$ $T_J = 150 \text{ }^\circ\text{C}$ (see Figure 17)	-	237		ns
$Q_{rr}$	Reverse recovery charge		-	2090		nC
$I_{RRM}$	Reverse recovery current		-	18		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

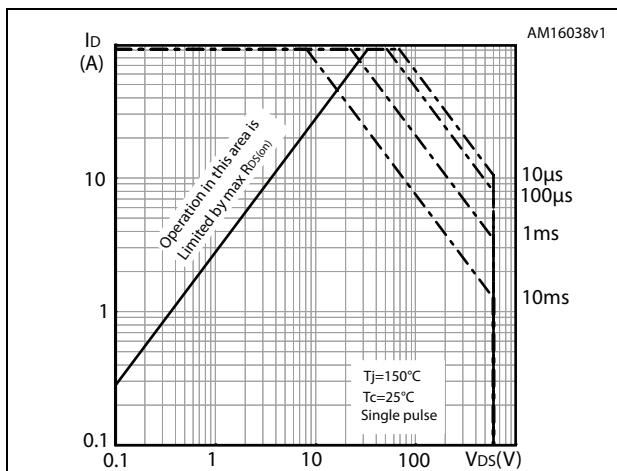


Figure 3. Thermal impedance for D<sup>2</sup>PAK and TO-220

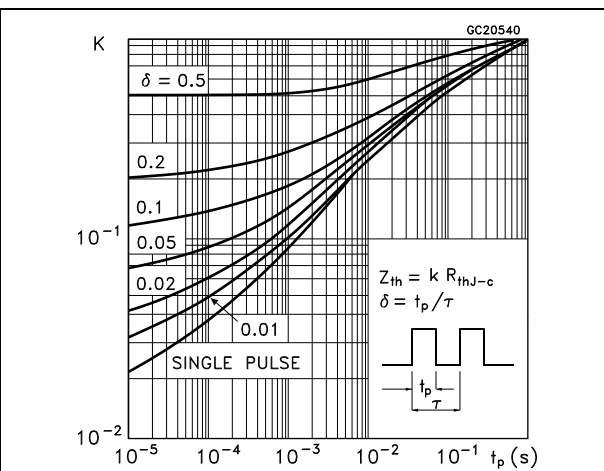


Figure 4. Safe operating area for TO-220FP

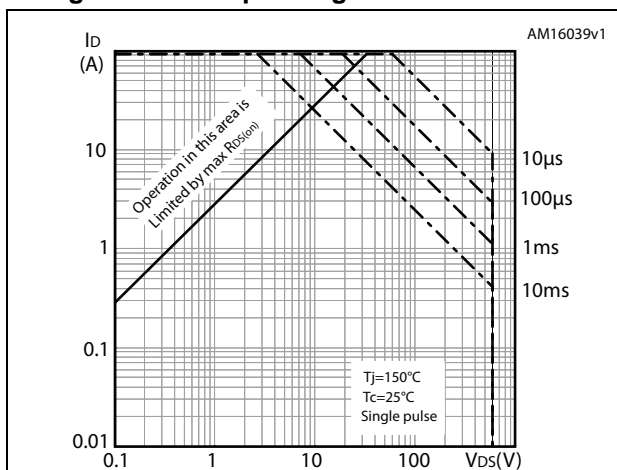


Figure 5. Thermal impedance for TO-220FP

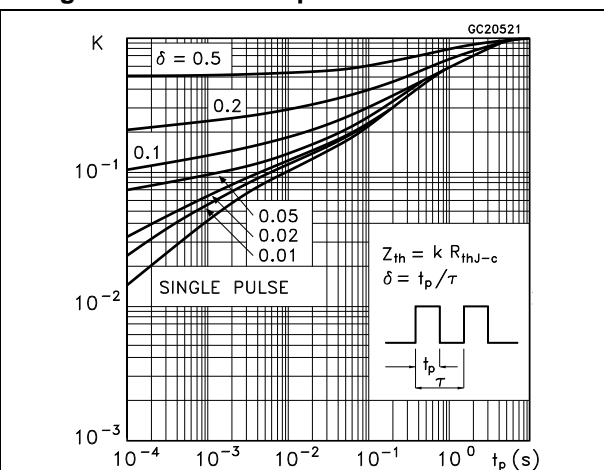


Figure 6. Safe operating area for TO-247

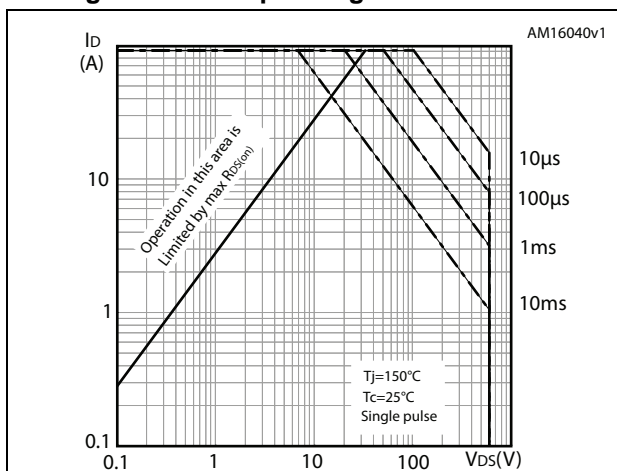


Figure 7. Thermal impedance for TO-247

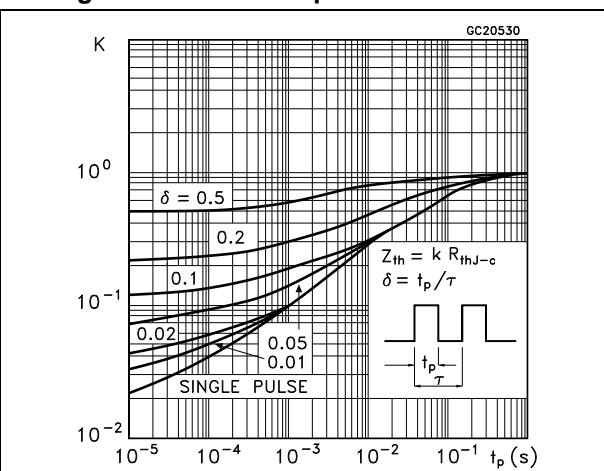


Figure 8. Output characteristics

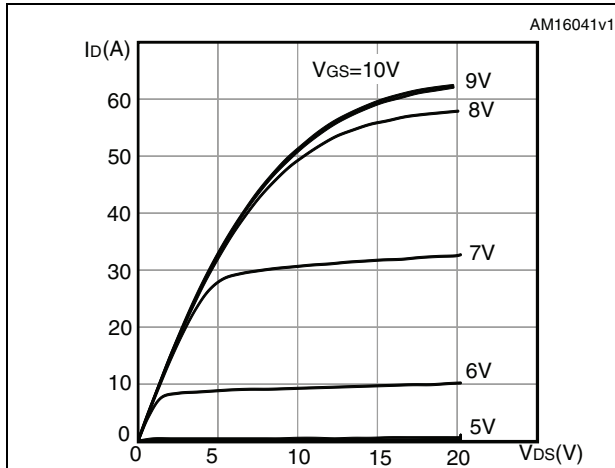


Figure 9. Transfer characteristics

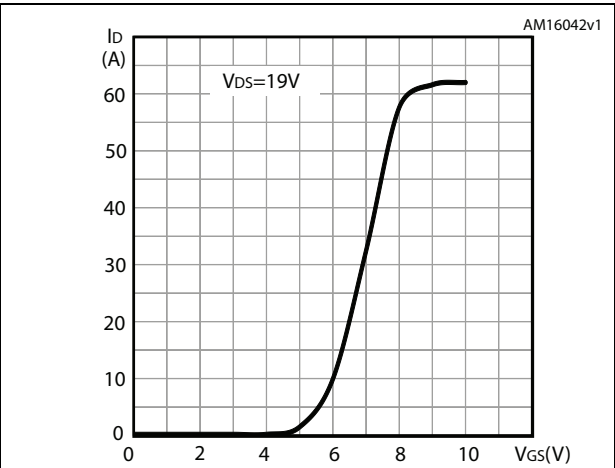


Figure 10. Gate charge vs gate-source voltage

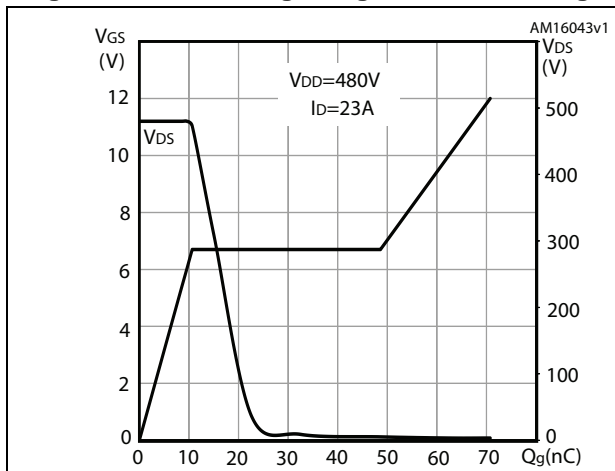


Figure 11. Static drain-source on-resistance

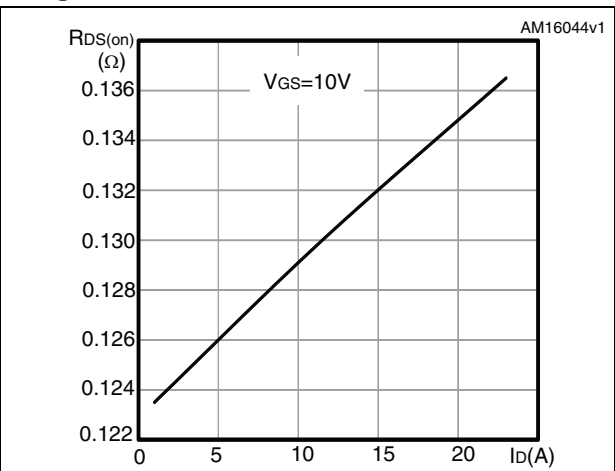


Figure 12. Capacitance variations

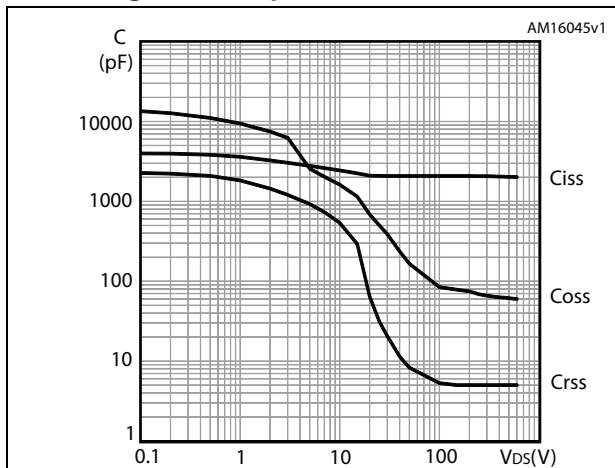


Figure 13. Output capacitance stored energy

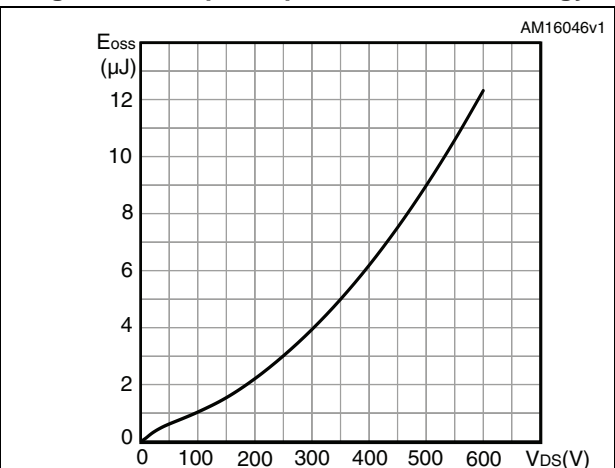


Figure 14. Normalized gate threshold voltage vs temperature

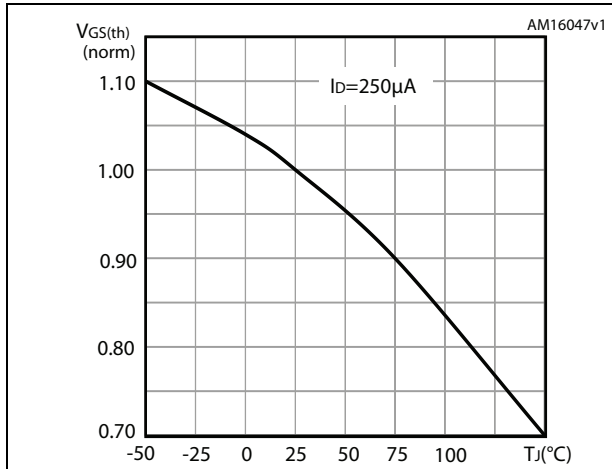


Figure 15. Normalized on-resistance vs temperature

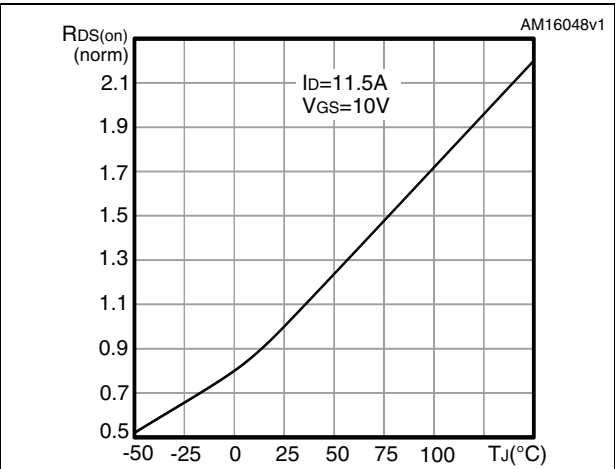


Figure 16. Source-drain diode forward characteristics

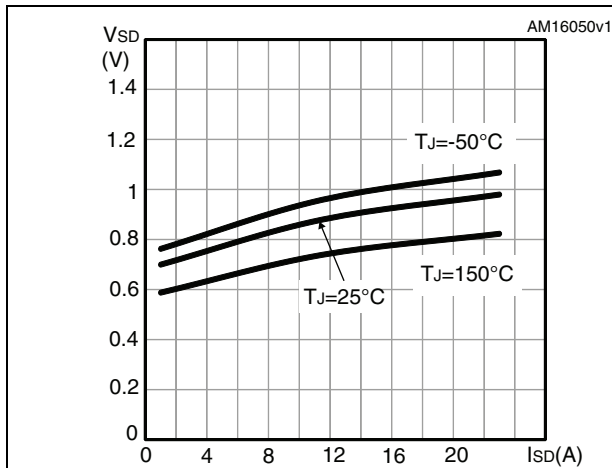
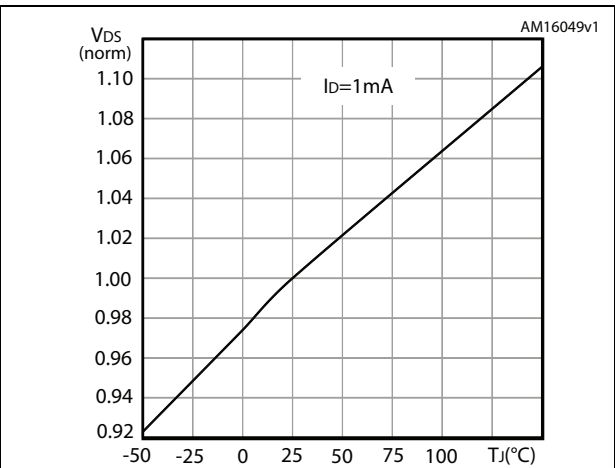


Figure 17. Normalized V<sub>DS</sub> vs temperature



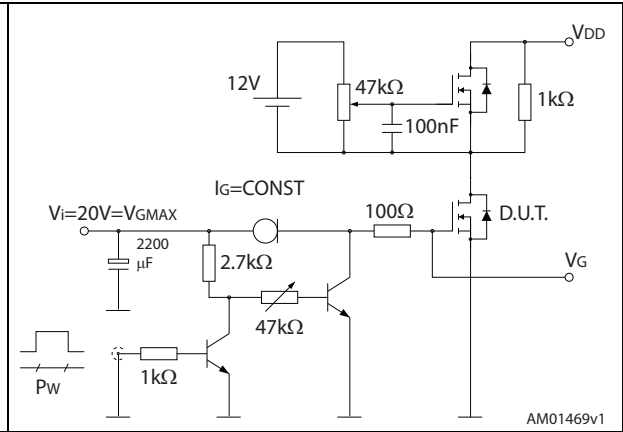


### 3 Test circuits

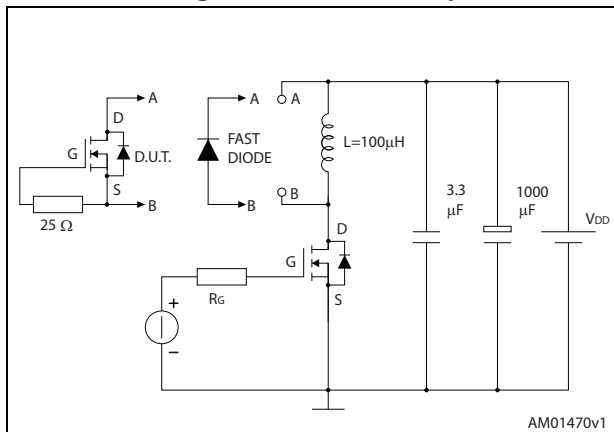
**Figure 18. Switching times test circuit for resistive load**



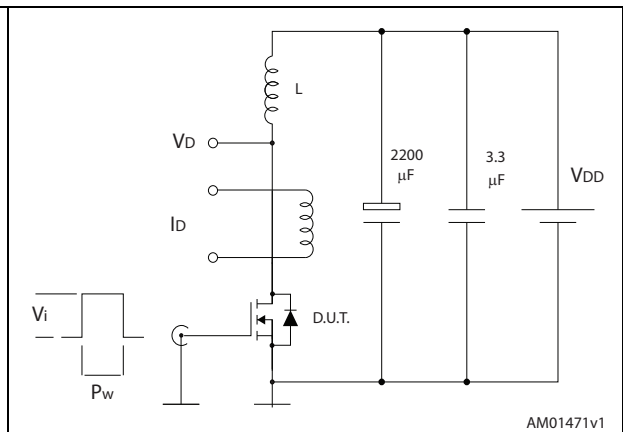
**Figure 19. Gate charge test circuit**



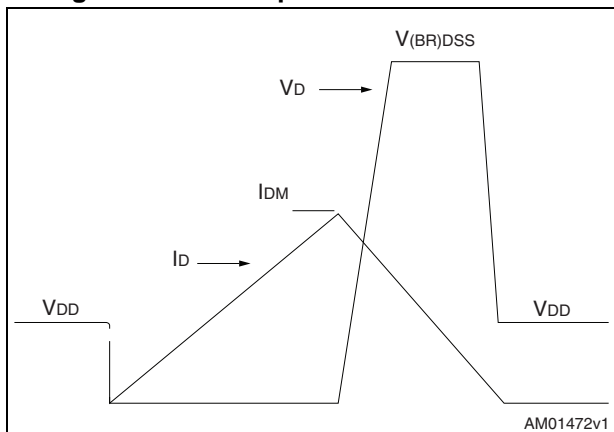
**Figure 20. Test circuit for inductive load switching and diode recovery times**



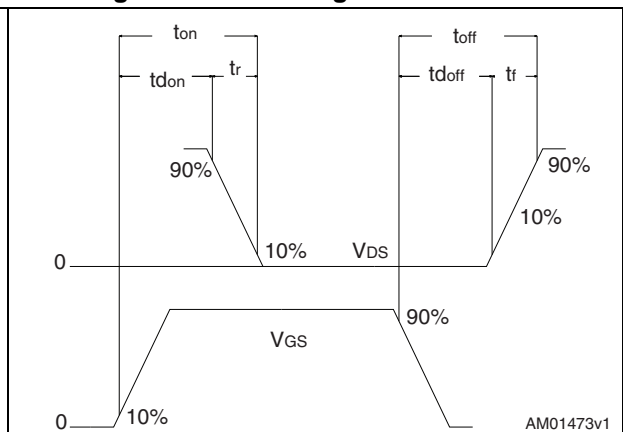
**Figure 21. Unclamped inductive load test circuit**



**Figure 22. Unclamped inductive waveform**



**Figure 23. Switching time waveform**



## 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.

### 4.1 D<sup>2</sup>PAK, STB28NM60ND

Figure 24. D<sup>2</sup>PAK (TO-263) drawing

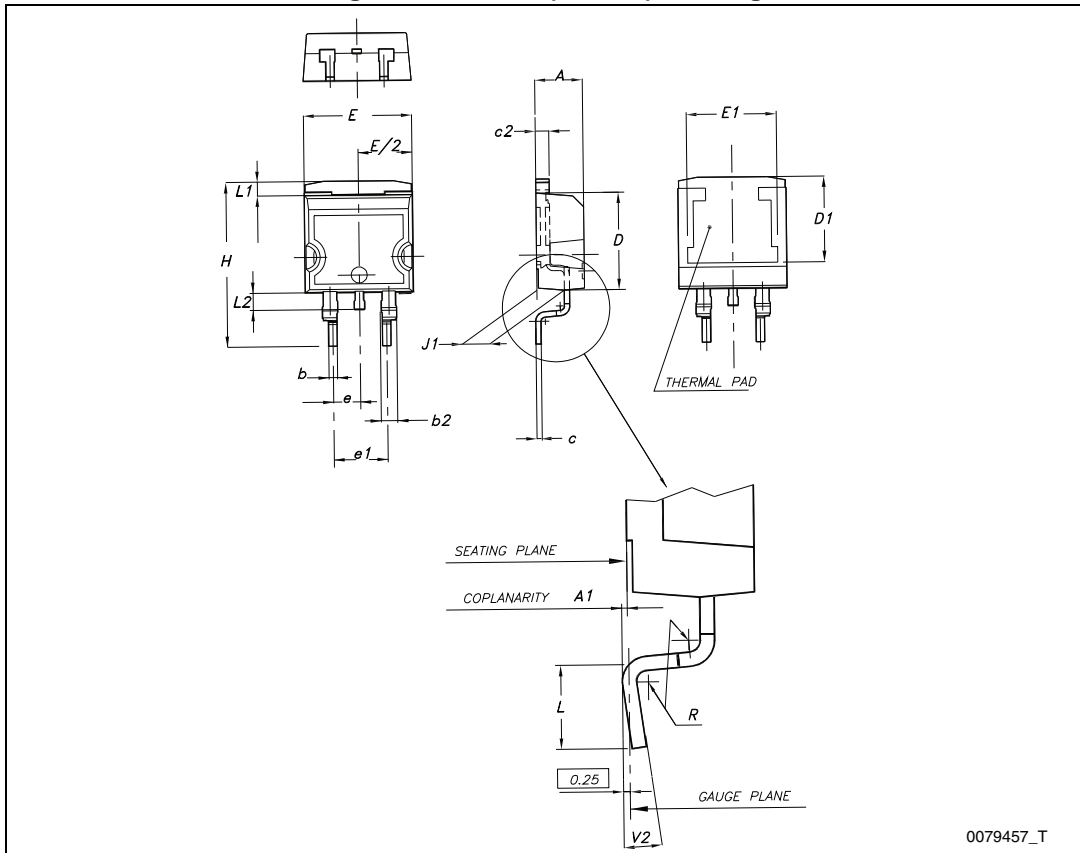
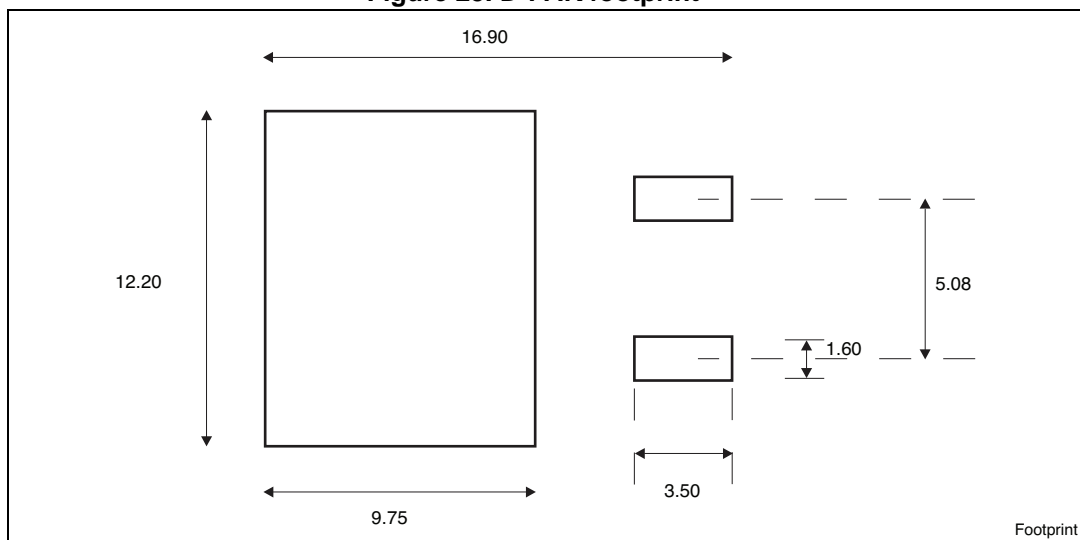


Table 8. D<sup>2</sup>PAK (TO-263) mechanical data

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°

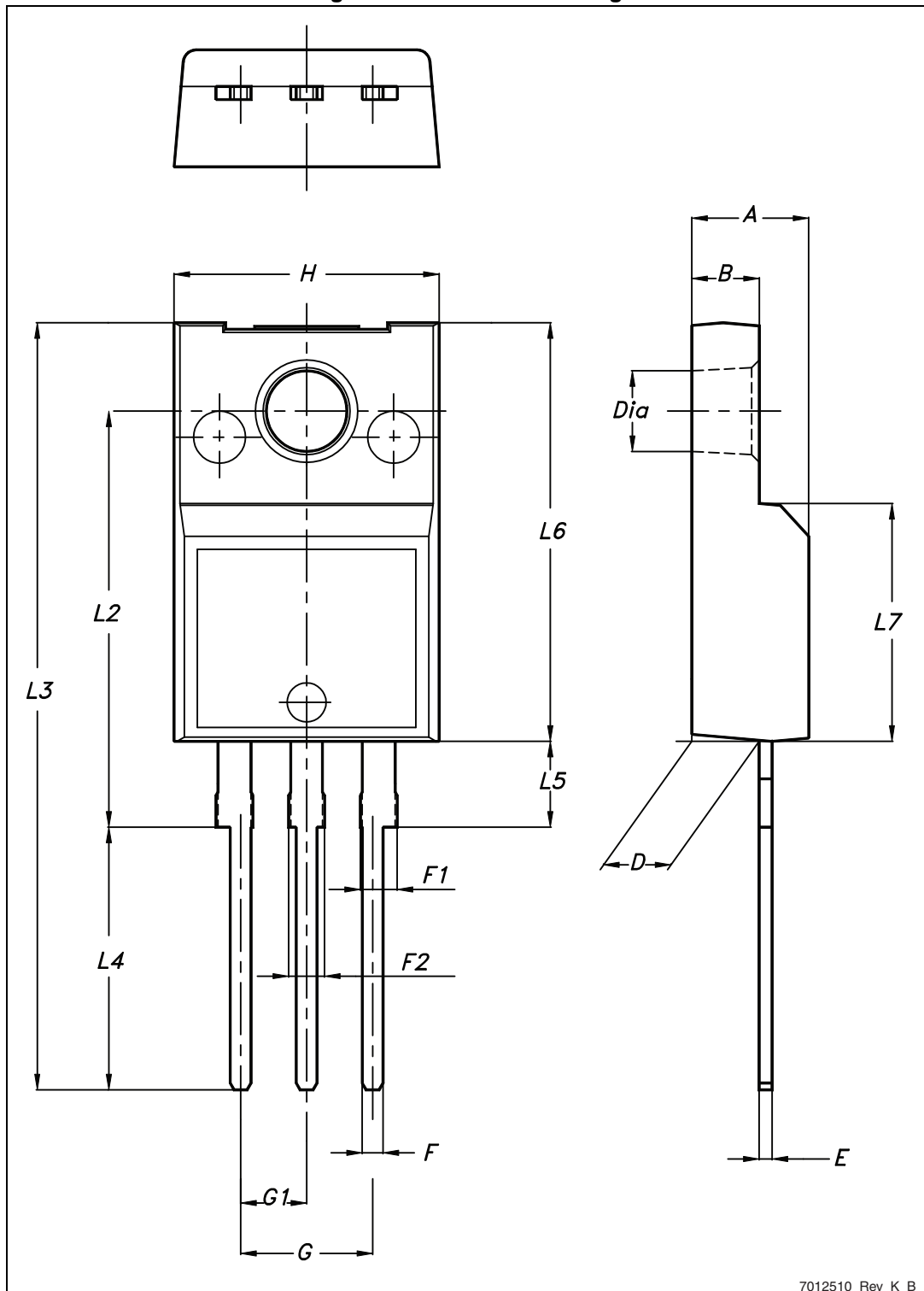
Figure 25. D<sup>2</sup>PAK footprint<sup>(a)</sup>



a. All dimension are in millimeters

### 4.2 TO-220FP, STF28NM60ND

Figure 26. TO-220FP drawing



7012510\_Rev\_K\_B

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

### 4.3 TO-220, STP28NM60ND

Figure 27. TO-220 type A drawing

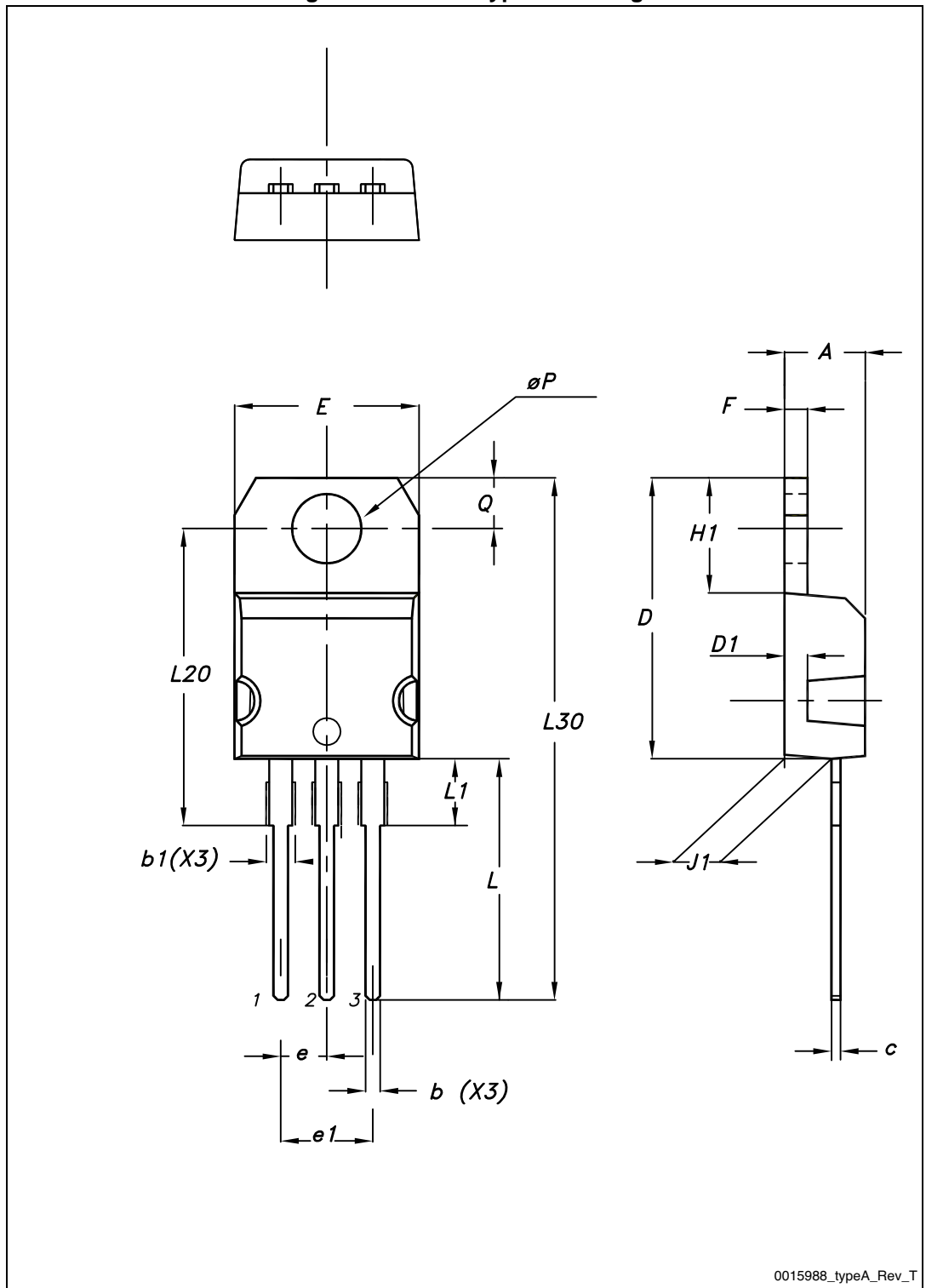


Table 10. TO-220 type A mechanical data

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



### 4.4 TO-247, STW28NM60ND

Figure 28. TO-247 drawing

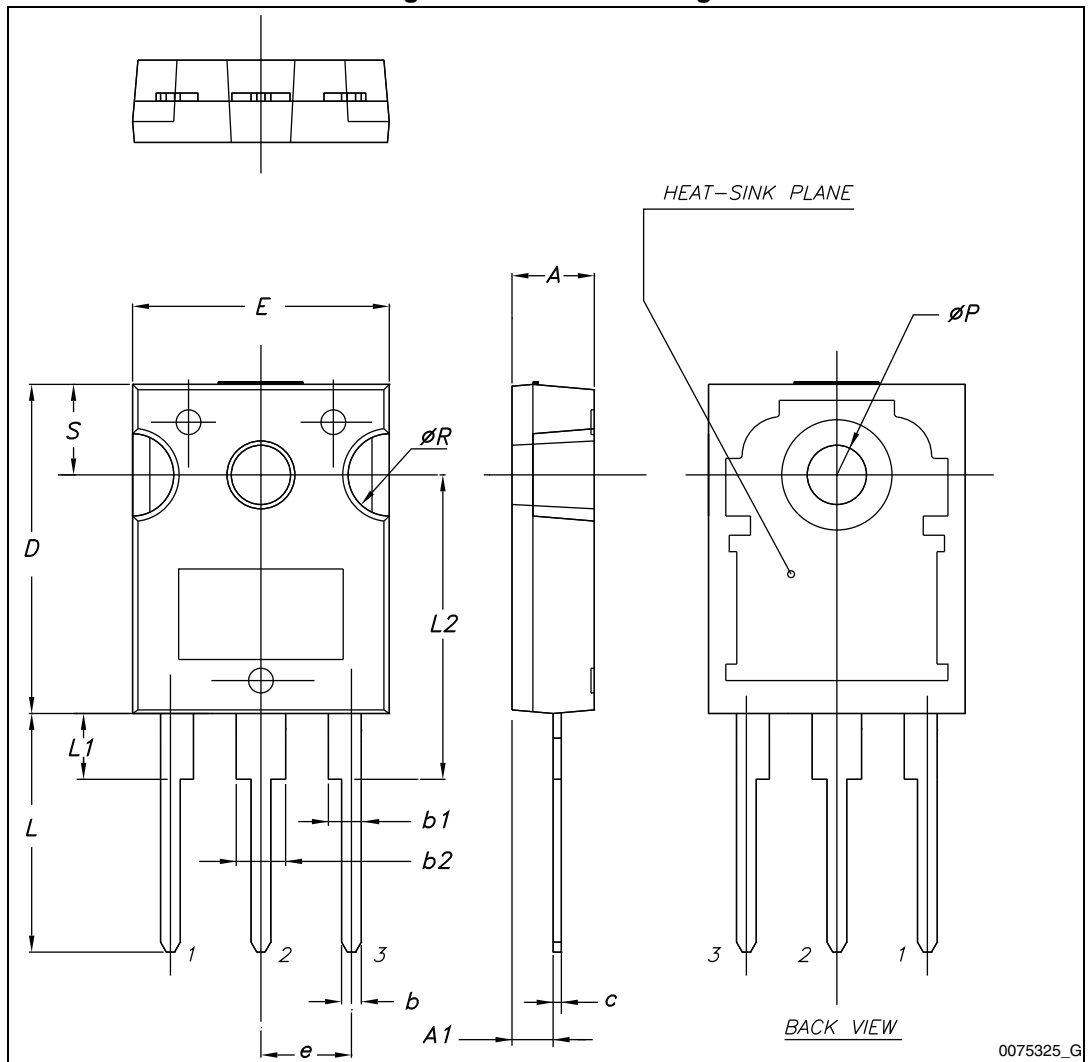


Table 11. TO-247 mechanical data

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

## 5 Packing mechanical data

Figure 29. Tape

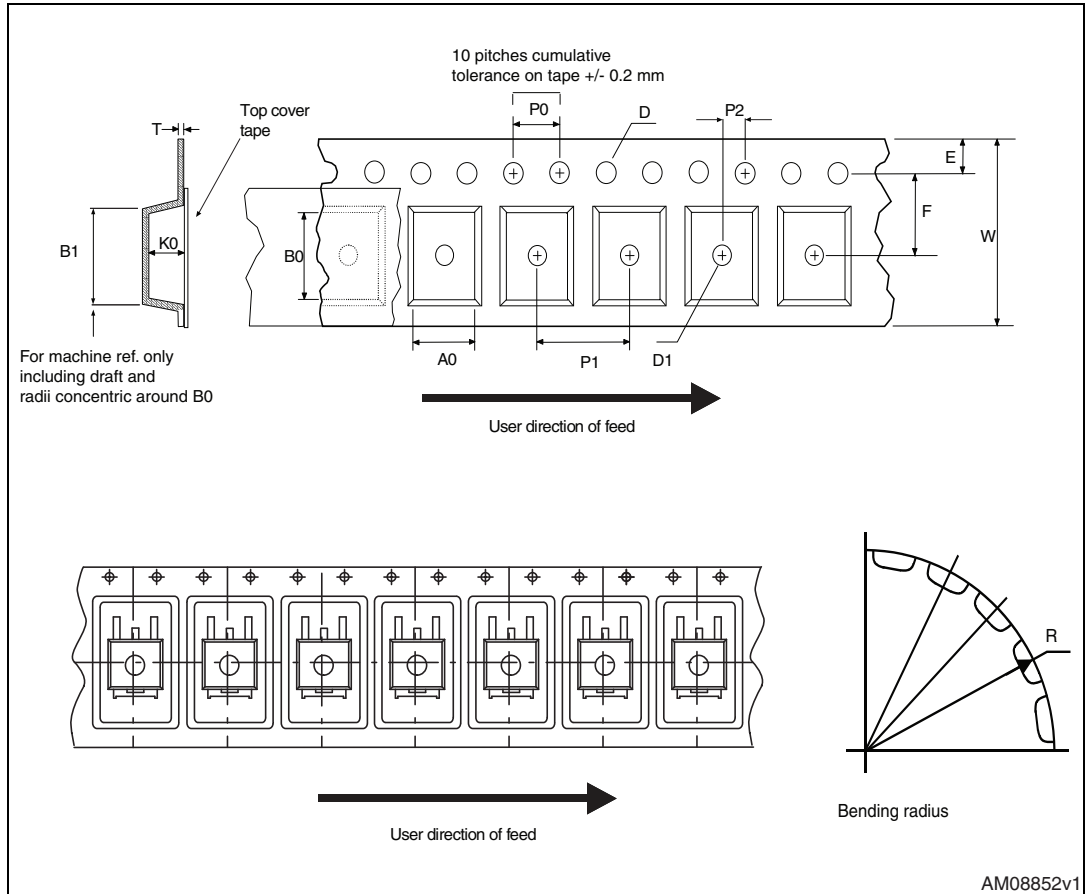
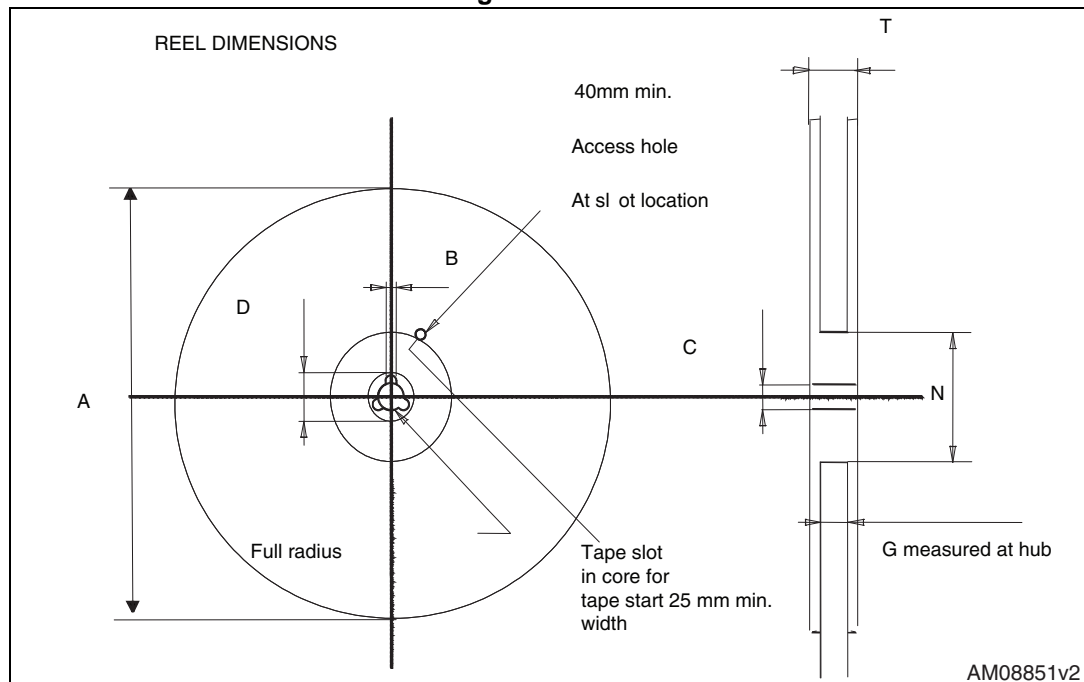


Table 12. D<sup>2</sup>PAK (TO-263) tape and reel mechanical data

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 30. Reel



## 6 Revision history

Table 13. Document revision history

Date	Revision	Changes
15-Apr-2013	1	First release.
25-Nov-2013	2	<ul style="list-style-type: none"><li>– Document status changed from preliminary to production data</li><li>– Modified: typical values in <a href="#">Table 6</a> and <a href="#">7</a></li><li>– Added: <a href="#">Section 2.1: Electrical characteristics (curves)</a></li><li>– Updated: <a href="#">Table 10</a> and <a href="#">Figure 27</a></li><li>– Minor text changes</li></ul>
05-May-2014	3	<ul style="list-style-type: none"><li>– Modified: E<sub>AS</sub> value in <a href="#">Table 4</a></li><li>– Minor text changes</li></ul>

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## Стандарт Электрон Связь

Мы молодая и активно развивающаяся компания в области поставок электронных компонентов. Мы поставляем электронные компоненты отечественного и импортного производства напрямую от производителей и с крупнейших складов мира.

Благодаря сотрудничеству с мировыми поставщиками мы осуществляем комплексные и плановые поставки широчайшего спектра электронных компонентов.

Собственная эффективная логистика и склад в обеспечивает надежную поставку продукции в точно указанные сроки по всей России.

Мы осуществляем техническую поддержку нашим клиентам и предпродажную проверку качества продукции. На все поставляемые продукты мы предоставляем гарантию .

Осуществляем поставки продукции под контролем ВП МО РФ на предприятия военно-промышленного комплекса России , а также работаем в рамках 275 ФЗ с открытием отдельных счетов в уполномоченном банке. Система менеджмента качества компании соответствует требованиям ГОСТ ISO 9001.

Минимальные сроки поставки, гибкие цены, неограниченный ассортимент и индивидуальный подход к клиентам являются основой для выстраивания долгосрочного и эффективного сотрудничества с предприятиями радиоэлектронной промышленности, предприятиями ВПК и научно-исследовательскими институтами России.

С нами вы становитесь еще успешнее!

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