

N-channel 650 V, 1.1  $\Omega$  typ., 6.0 A Power MOSFET  
in DPAK, I<sup>2</sup>PAKFP, TO-220 and IPAK packages

Datasheet – preliminary data

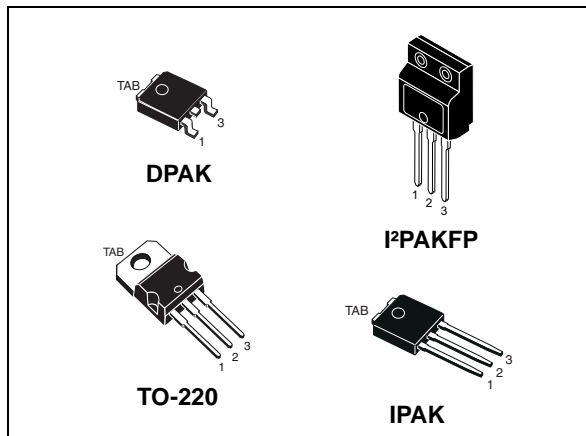
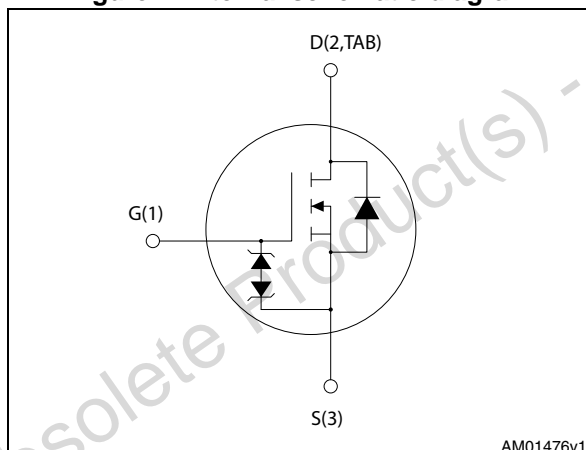


Figure 1. Internal schematic diagram



## Features

Order codes	V <sub>DS</sub>	R <sub>DS(on)</sub> max	I <sub>D</sub>	P <sub>TOT</sub>
STDLED656	650 V	1.3 $\Omega$	6.0 A	70 W
STFILED656				25 W
STPLED656				70 W
STULED656				70 W

- 100% avalanche tested
- Extremely high dv/dt capability
- Gate charge minimized
- Very low intrinsic capacitance
- Improved diode reverse recovery characteristics
- Zener-protected

## Applications

- LED lighting applications

## Description

These Power MOSFETs boast extremely low on-resistance and very good dv/dt capability, rendering them suitable for buck-boost and flyback topologies.

Table 1. Device summary

Order codes	Marking	Package	Packaging
STDLED656	LED656	DPAK	Tape and reel
STFILED656		I <sup>2</sup> PAKFP (TO-281)	Tube
STPLED656		TO-220	
STULED656		IPAK	

# Contents

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value		Unit
		DPAK, TO-220 IPAK	I <sup>2</sup> PAKFP	
V <sub>DS</sub>	Drain- source voltage	650		V
V <sub>GS</sub>	Gate- source voltage	±30		V
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 25 °C	6.0	6.0 <sup>(1)</sup>	A
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 100 °C	3.3	3.3 <sup>(1)</sup>	A
I <sub>DM</sub> <sup>(2)</sup>	Drain current (pulsed)	24.0	24.0 <sup>(1)</sup>	A
P <sub>TOT</sub>	Total dissipation at T <sub>C</sub> = 25 °C	30	110	W
I <sub>AR</sub>	Avalanche current, repetitive or not-repetitive (pulse width limited by T <sub>J</sub> max)	5.4		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)	2.5		kV
ESD	Gate-source human body model (C=100 pF, R=1.5 kΩ)			
dv/dt <sup>(3)</sup>	Peak diode recovery voltage slope	12		V/ns
V <sub>ISO</sub>	Insulation withstand voltage (AC)		2500	V
T <sub>stg</sub>	Storage temperature	- 55 to 150		°C
T <sub>J</sub>	Operating junction temperature	150		°C

1. Limited only by maximum temperature allowed
2. Pulse width limited by safe operating area
3. I<sub>SD</sub> ≤ 5.4 A, di/dt ≤ 400 A/μs, V<sub>DD</sub> = 80% V<sub>(BR)DSS</sub>.

**Table 3. Thermal data**

Symbol	Parameter	Value				Unit
		DPAK	I <sup>2</sup> PAKFP	TO-220	IPAK	
R <sub>thj-case</sub>	Thermal resistance junction-case max.		4.17	-	1.14	°C/W
R <sub>thj-amb</sub>	Thermal resistance junction-ambient max		62.5	-	100	°C/W
R <sub>thj-pcb</sub>	Thermal resistance junction-pcb max.	50		-		°C/W

## 2 Electrical characteristics

(T<sub>case</sub> = 25 °C unless otherwise specified)

**Table 4. On /off states**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V <sub>(BR)DSS</sub>	Drain-source breakdown voltage	I <sub>D</sub> = 1 mA, V <sub>GS</sub> = 0	650			V
I <sub>DSS</sub>	Zero gate voltage drain current (V <sub>GS</sub> = 0)	V <sub>DS</sub> = 650 V V <sub>DS</sub> = 650 V, T <sub>C</sub> = 125 °C			0.8 50	μA μA
I <sub>GSS</sub>	Gate-body leakage current (V <sub>DS</sub> = 0)	V <sub>GS</sub> = ± 20 V; V <sub>DS</sub> = 0			±9	μA
V <sub>GS(th)</sub>	Gate threshold voltage	V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 50 μA	3	3.6	4.5	V
R <sub>DS(on)</sub>	Static drain-source on resistance	V <sub>GS</sub> = 10 V, I <sub>D</sub> = 2.7 A		1.1	1.3	Ω

**Table 5. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
C <sub>iss</sub>	Input capacitance	V <sub>DS</sub> = 100 V, f = 1 MHz, V <sub>GS</sub> = 0	-	895	-	pF
C <sub>OSS</sub>	Output capacitance			67		pF
C <sub>rss</sub>	Reverse transfer capacitance			12.5		pF
C <sub>OSS eq.</sub> <sup>(1)</sup>	Equivalent capacitance energy related	V <sub>DS</sub> = 0 to 520 V, V <sub>GS</sub> = 0	-	27	-	pF
R <sub>g</sub>	Gate input resistance	f = 1 MHz open drain	-	3.5	-	Ω
Q <sub>g</sub>	Total gate charge	V <sub>DD</sub> = 500 V, I <sub>D</sub> = 5.4 A,	-	34	-	nC
Q <sub>gs</sub>	Gate-source charge	V <sub>GS</sub> = 10 V		4		nC
Q <sub>gd</sub>	Gate-drain charge	(see Figure 17)		21		nC

1. C<sub>OSS eq.</sub> energy related is defined as a constant equivalent capacitance giving the same stored energy as C<sub>OSS</sub> when V<sub>DS</sub> increases from 0 to 80% V<sub>DSS</sub>

**Table 6. Switching times**

Symbol	Parameter	Test conditions	Min.	Typ.	Max	Unit
t <sub>d(on)</sub>	Turn-on delay time	V <sub>DD</sub> = 325 V, I <sub>D</sub> = 2.7 A, R <sub>G</sub> = 4.7 Ω, V <sub>GS</sub> = 10 V (see Figure 17)	-	14	-	ns
t <sub>r</sub>	Rise time			10		ns
t <sub>d(off)</sub>	Turn-off-delay time			44		ns
t <sub>f</sub>	Fall time			24		ns

**Table 7. Source drain diode**

Symbol	Parameter	Test conditions	Min.	Typ.	Max	Unit
$I_{SD}$	Source-drain current		-		5.4	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)		-		21.6	A
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 5.4 \text{ A}, V_{GS} = 0$	-		1.5	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 5.4 \text{ A}, di/dt = 100 \text{ A}/\mu\text{s}$	-	285		ns
$Q_{rr}$	Reverse recovery charge	$V_{DD} = 60 \text{ V}$	-	5100		nC
$I_{RRM}$	Reverse recovery current	(see Figure 21)		14		A
$t_{rr}$	Reverse recovery time	$I_{SD} = 5.4 \text{ A}, di/dt = 100 \text{ A}/\mu\text{s}$	-	330		ns
$Q_{rr}$	Reverse recovery charge	$V_{DD} = 60 \text{ V } T_J = 150 \text{ }^\circ\text{C}$	-	2500		nC
$I_{RRM}$	Reverse recovery current	(see Figure 21)		15.5		A

1. Pulse width limited by safe operating area

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

**Table 8. Gate-source Zener diode**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)GSO}$	Gate-source breakdown voltage	$I_{GS} = \pm 1 \text{ mA}, I_D = 0$	30	-	-	V

The built-in back-to-back Zener diodes have been specifically designed to enhance not only the device's ESD capability, but also to make them capable of safely absorbing any voltage transients that may occasionally be applied from gate to source. In this respect, the Zener voltage is appropriate to achieve efficient and cost-effective protection of device integrity. The integrated Zener diodes thus eliminate the need for external components.

## 2.1 Electrical characteristics (curves)

Figure 2. Safe operating area for DPAK, TO-220 and IPAK

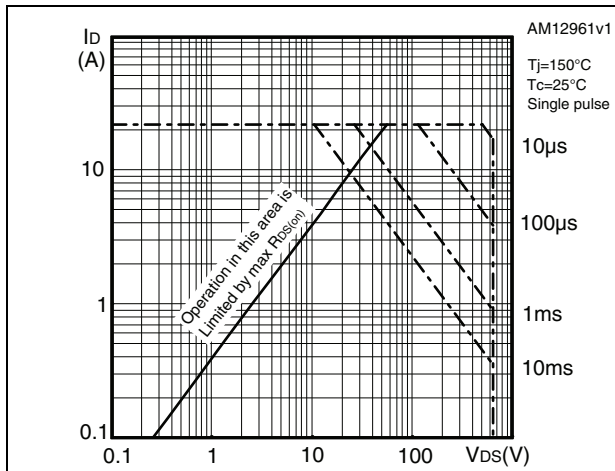


Figure 3. Thermal impedance for DPAK, TO-220 and IPAK

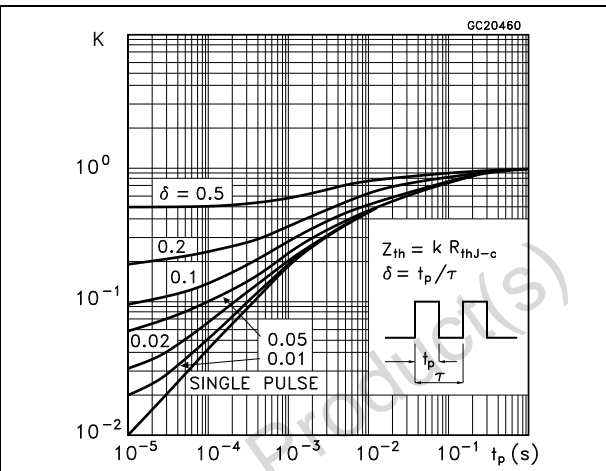


Figure 4. Safe operating area for I<sup>2</sup>PAKFP

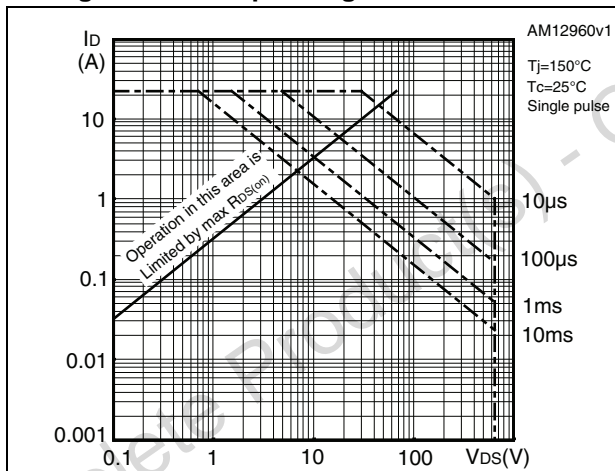


Figure 5. Thermal impedance for I<sup>2</sup>PAKFP

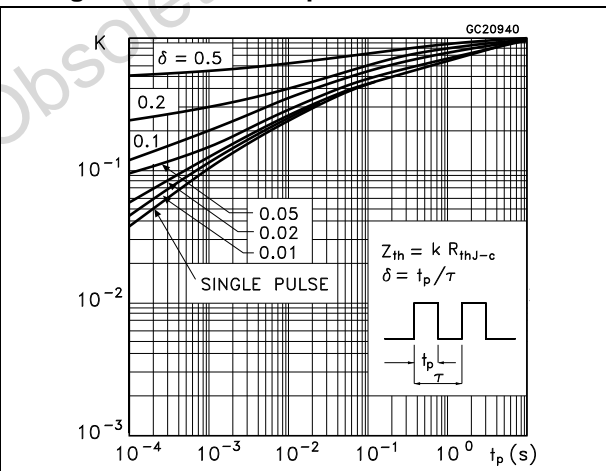


Figure 6. Output characteristics

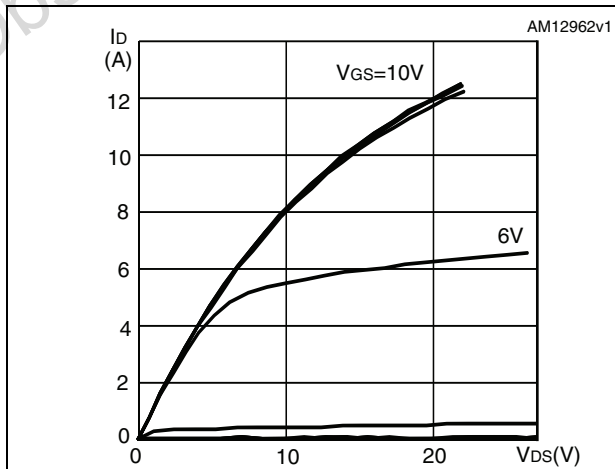


Figure 7. Transfer characteristics

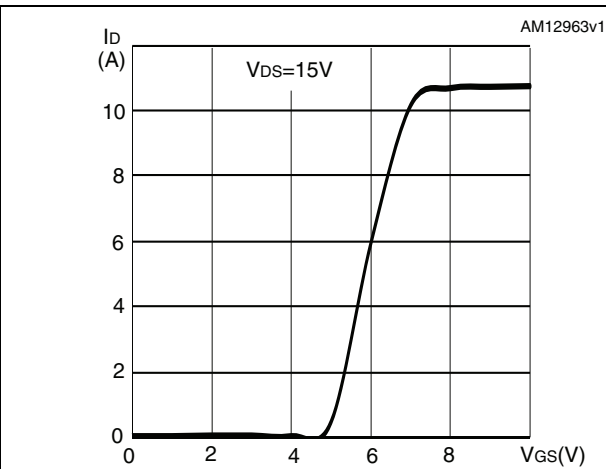


Figure 8. Gate charge vs gate-source voltage

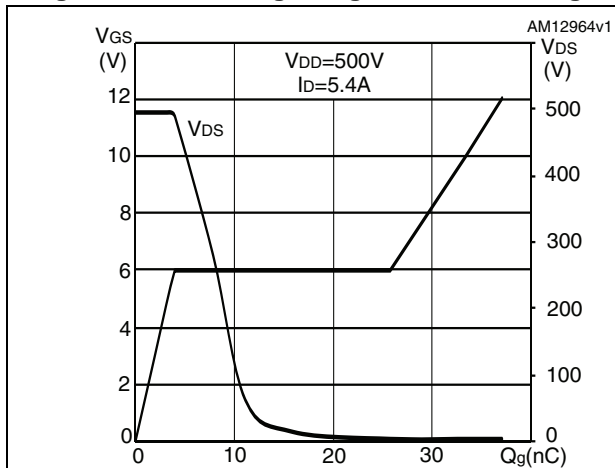


Figure 9. Static drain-source on-resistance

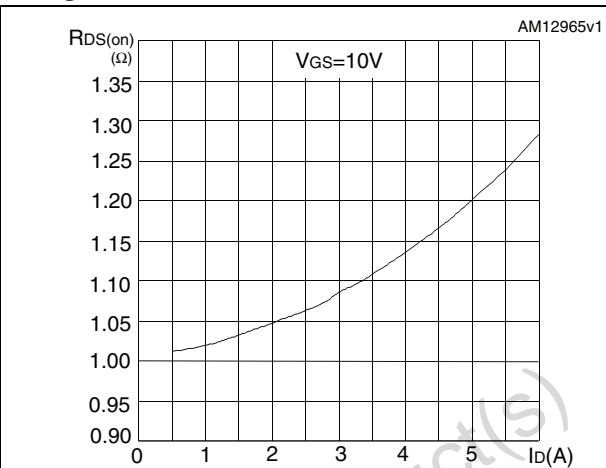


Figure 10. Capacitance variations

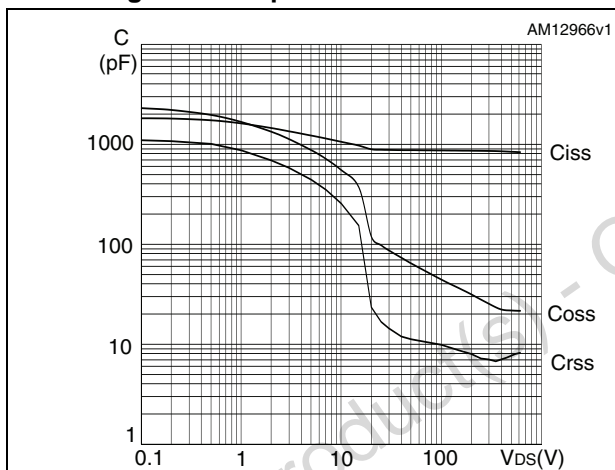


Figure 11. Output capacitance stored energy

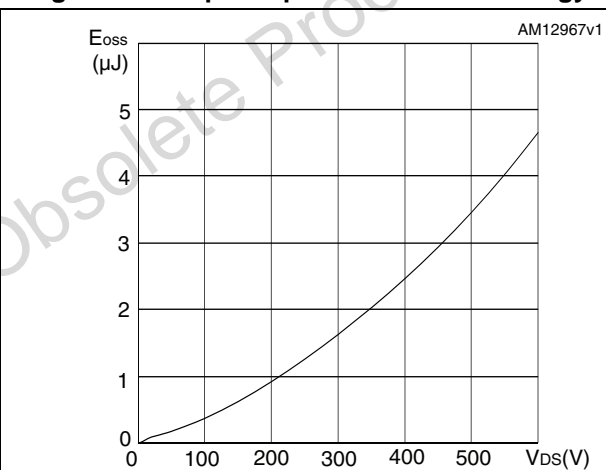


Figure 12. Normalized gate threshold voltage vs temperature

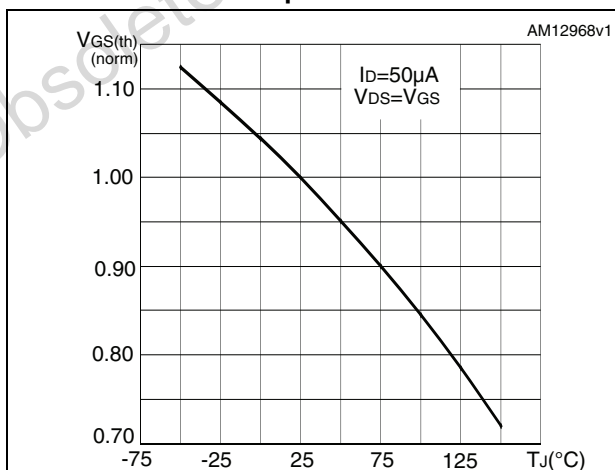


Figure 13. Normalized on-resistance vs temperature

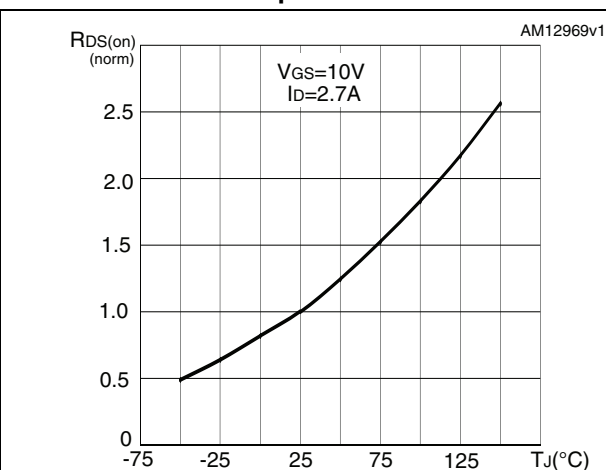


Figure 14. Normalized  $BV_{DSS}$  vs temperature

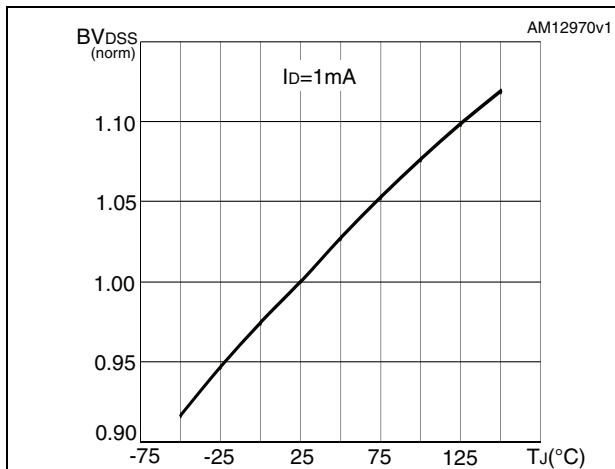


Figure 15. Source-drain diode forward characteristics

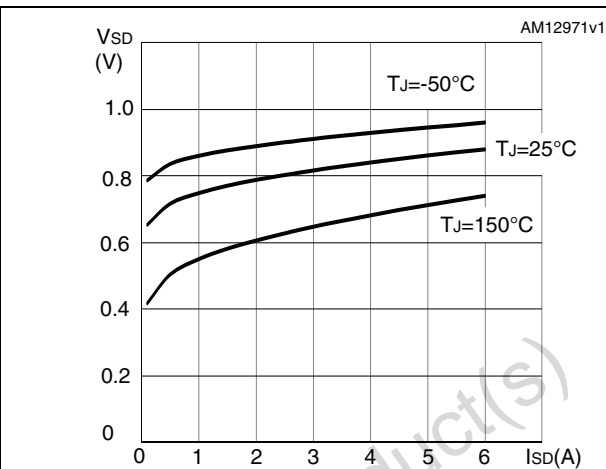
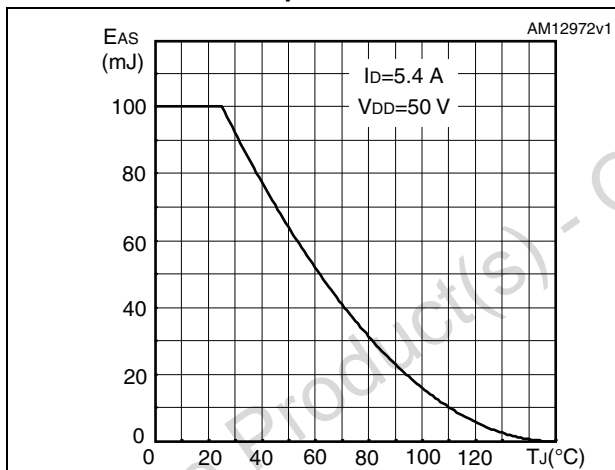


Figure 16. Maximum avalanche energy vs temperature





### 3 Test circuits

Figure 17. Switching times test circuit for resistive load

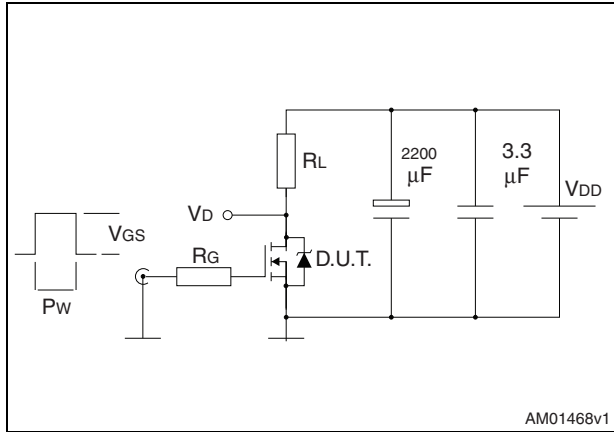


Figure 18. Gate charge test circuit

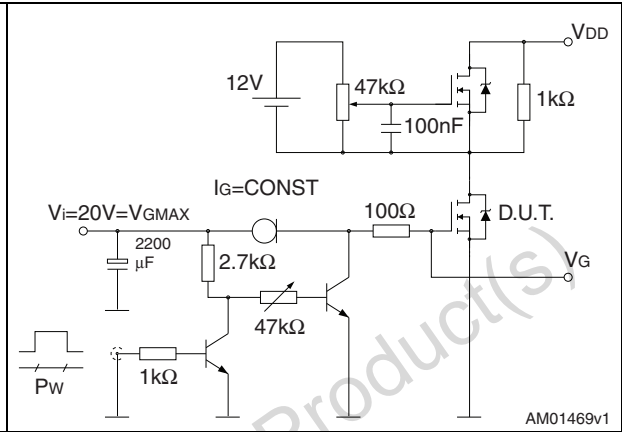


Figure 19. Test circuit for inductive load switching and diode recovery times

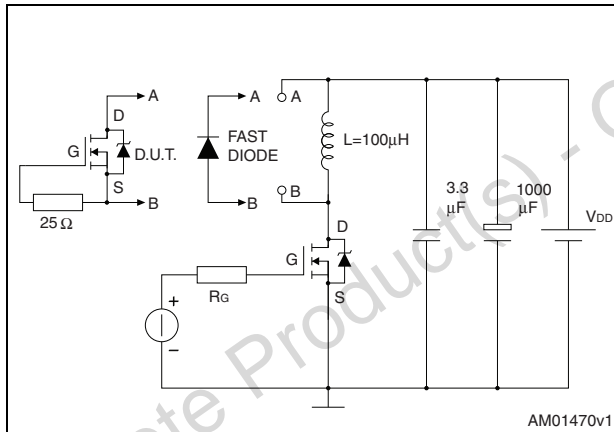


Figure 20. Unclamped inductive load test circuit

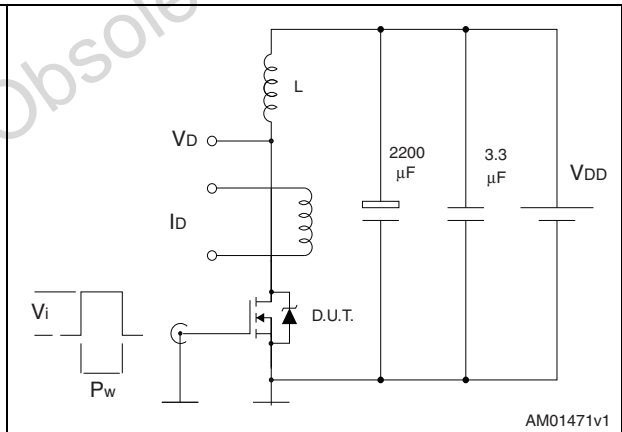


Figure 21. Unclamped inductive waveform

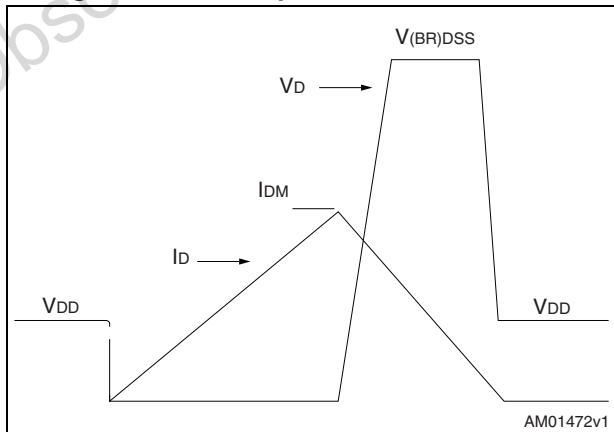


Figure 22. Switching time waveform



## 4 Package mechanical data

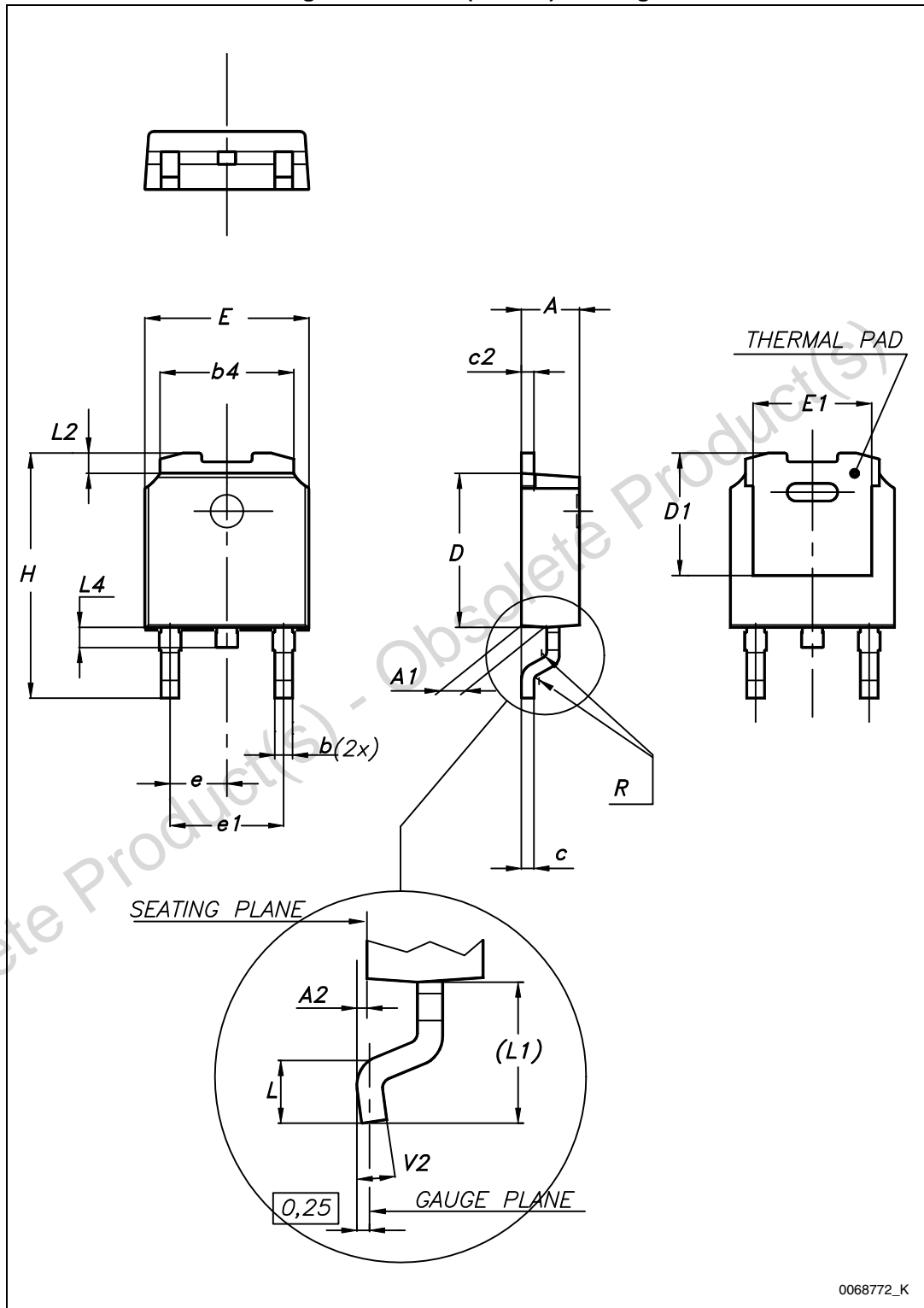
In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK<sup>®</sup> packages, depending on their level of environmental compliance. ECOPACK<sup>®</sup> specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK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

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Table 9. DPAK (TO-252) mechanical data

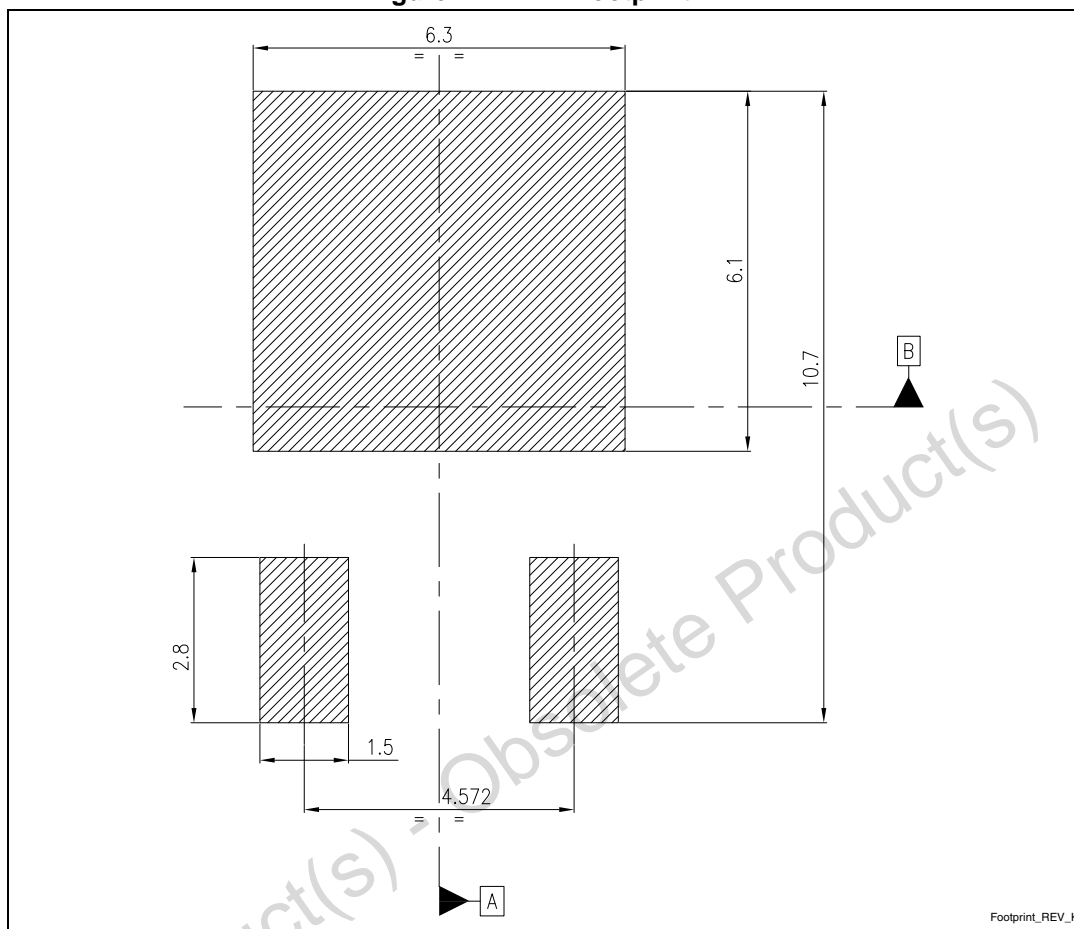
Dim.	mm		
	Min.	Typ.	Max.
A	2.20		2.40
A1	0.90		1.10
A2	0.03		0.23
b	0.64		0.90
b4	5.20		5.40
c	0.45		0.60
c2	0.48		0.60
D	6.00		6.20
D1		5.10	
E	6.40		6.60
E1		4.70	
e		2.28	
e1	4.40		4.60
H	9.35		10.10
L	1.00		1.50
(L1)		2.80	
L2		0.80	
L4	0.60		1.00
R		0.20	
V2	0°		8°

Figure 23. DPAK (TO-252) drawing



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Figure 24. DPAK footprint (a)

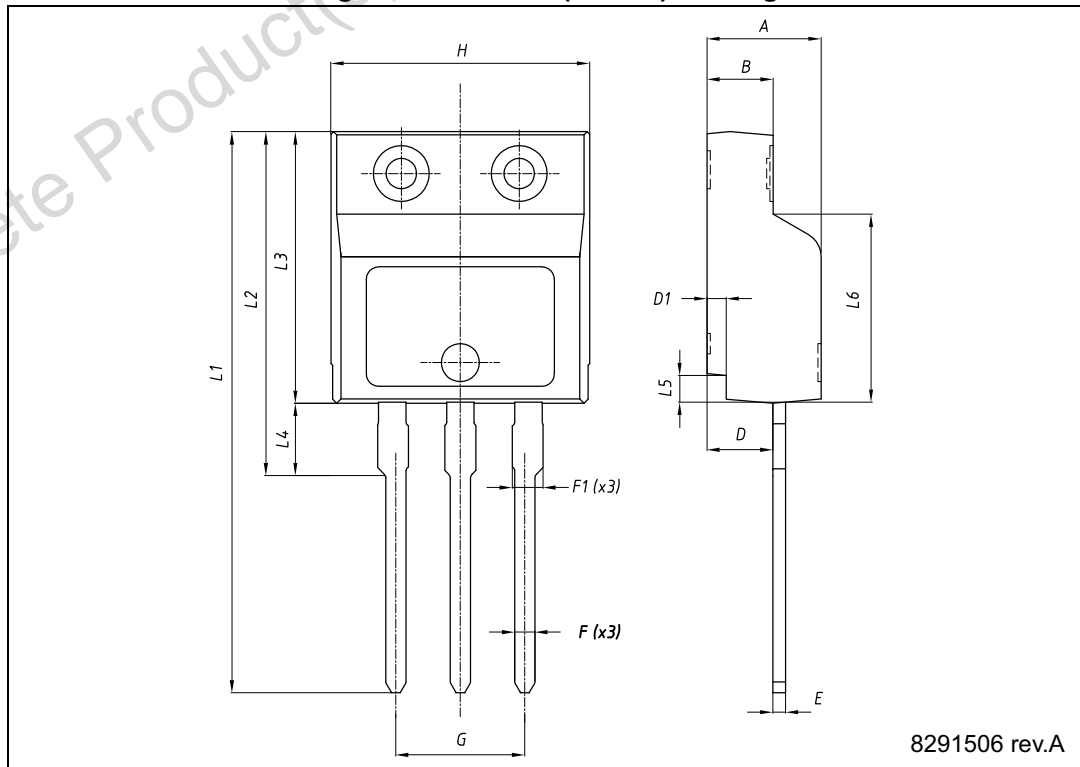


a. All dimensions are in millimeters

Table 10. I<sup>2</sup>PAKFP (TO-281) mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	4.40		4.60
B	2.50		2.70
D	2.50		2.75
D1	0.65		0.85
E	0.45		0.70
F	0.75		1.00
F1			1.20
G	4.95	-	5.20
H	10.00		10.40
L1	21.00		23.00
L2	13.20		14.10
L3	10.55		10.85
L4	2.70		3.20
L5	0.85		1.25
L6	7.30		7.50

Figure 25. I<sup>2</sup>PAKFP (TO-281) drawing



8291506 rev.A

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		1.70
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

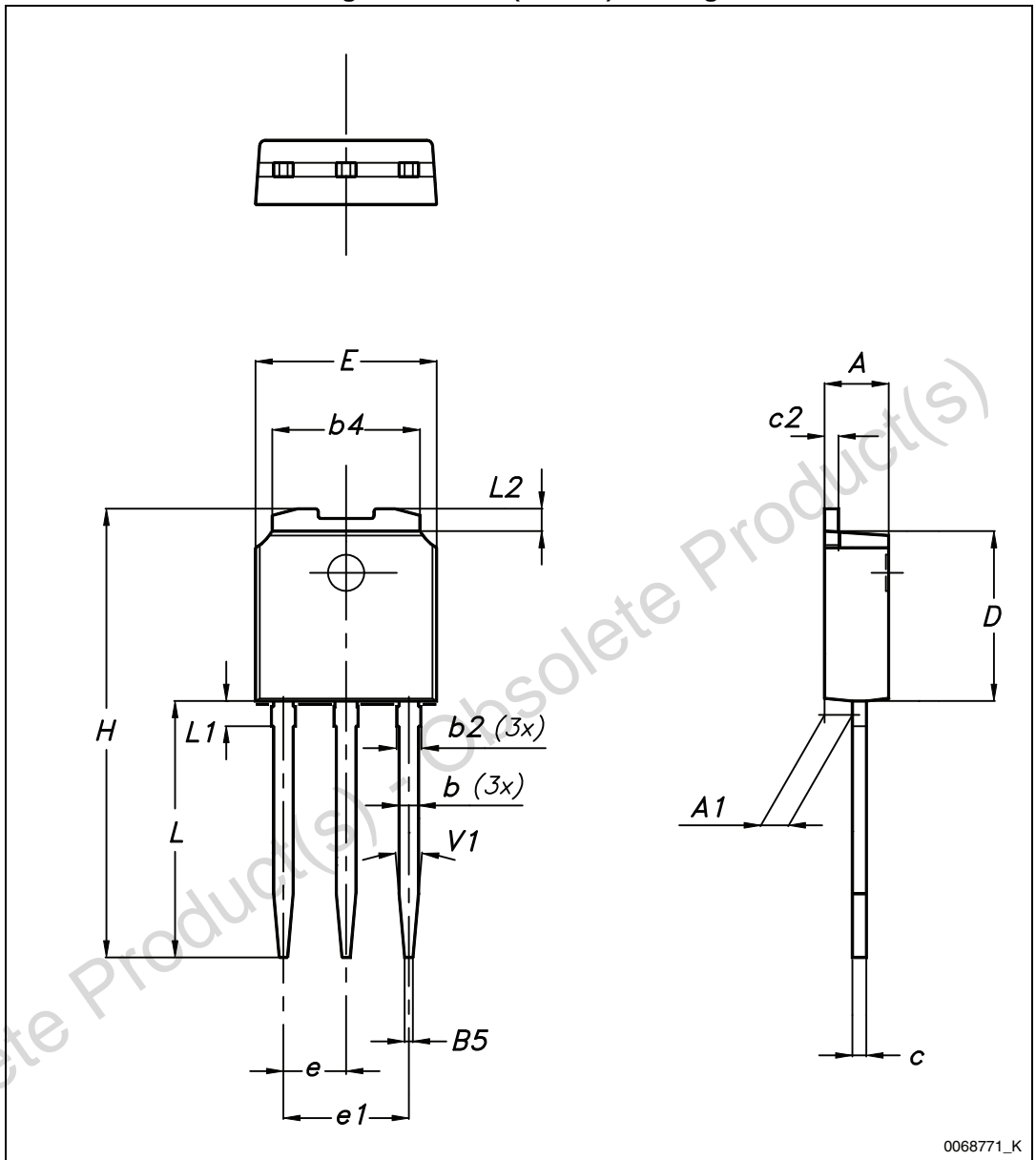




Table 12. IPAK (TO-251) mechanical data

DIM	mm.		
	min.	typ.	max.
A	2.20		2.40
A1	0.90		1.10
b	0.64		0.90
b2			0.95
b4	5.20		5.40
B5		0.30	
c	0.45		0.60
c2	0.48		0.60
D	6.00		6.20
E	6.40		6.60
e		2.28	
e1	4.40		4.60
H		16.10	
L	9.00		9.40
L1	0.80		1.20
L2		0.80	1.00
V1		10°	

Figure 27. IPAK (TO-251) drawing



0068771\_K

## 5 Packaging mechanical data

Table 13. 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			

Figure 28. Tape for DPAK (TO-252)

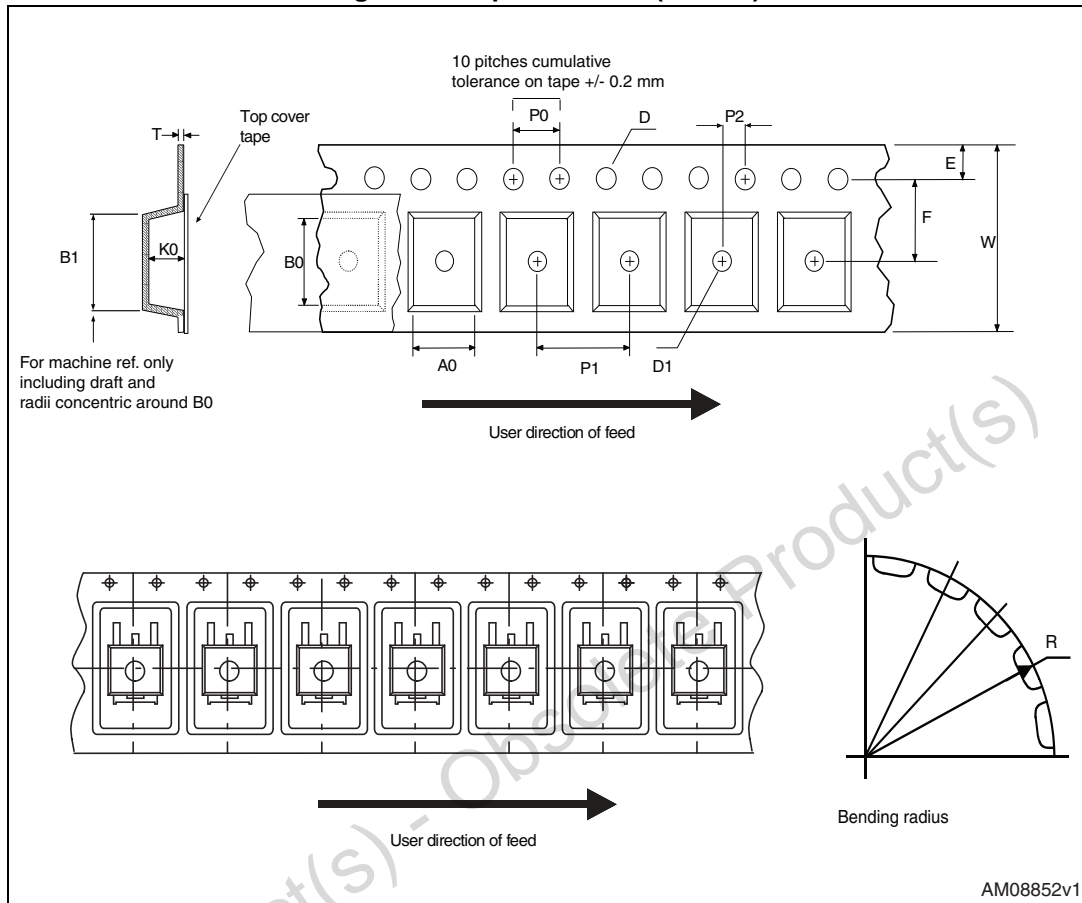
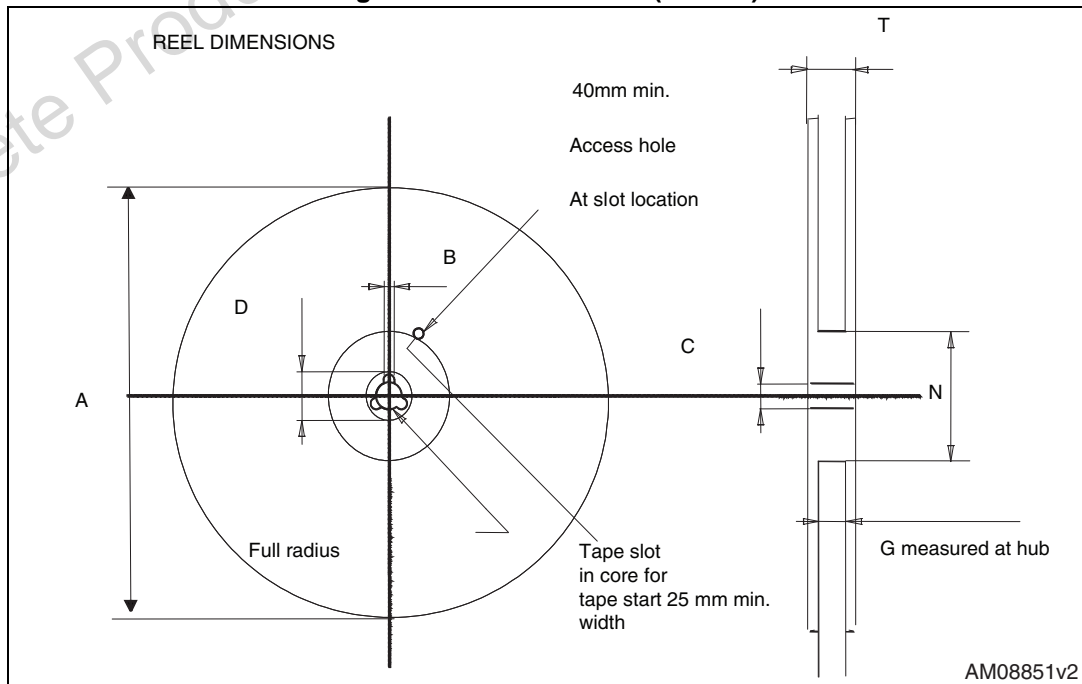


Figure 29. Reel for DPAK (TO-252)



## 6 Revision history

Table 14. Document revision history

Date	Revision	Changes
26-Mar-2013	1	First release.

Obsolete Product(s) - Obsolete Product(s)

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