



# STB10NK60Z, STP10NK60Z, STP10NK60ZFP, STW10NK60Z

N-channel 600 V, 0.65  $\Omega$  typ., 10 A SuperMESH™ Power MOSFET  
in I<sup>2</sup>PAK, D<sup>2</sup>PAK, TO-220, TO-220FP, TO-247 packages

Datasheet – production data

## Features

Type	V <sub>DSS</sub>	R <sub>DS(on) max</sub>	I <sub>D</sub>	P <sub>w</sub>
STB10NK60Z-1	600 V	< 0.75 $\Omega$	10 A	115 W
STB10NK60ZT4	600 V	< 0.75 $\Omega$	10 A	115 W
STP10NK60Z	600 V	< 0.75 $\Omega$	10 A	115 W
STP10NK60ZFP	600 V	< 0.75 $\Omega$	10 A	35 W
STW10NK60Z	600 V	< 0.75 $\Omega$	10 A	156 W

- Extremely high dv/dt capability
- 100% avalanche tested
- Gate charge minimized
- Zener-protected

## Applications

- Switching applications

## Description

These devices are N-channel Zener-protected Power MOSFET developed using STMicroelectronics' SuperMESH™ technology, achieved through optimization of ST's well-established strip-based PowerMESH™ layout. In addition to a significant reduction in on-resistance, this device is designed to ensure a high level of dv/dt capability for the most demanding applications.

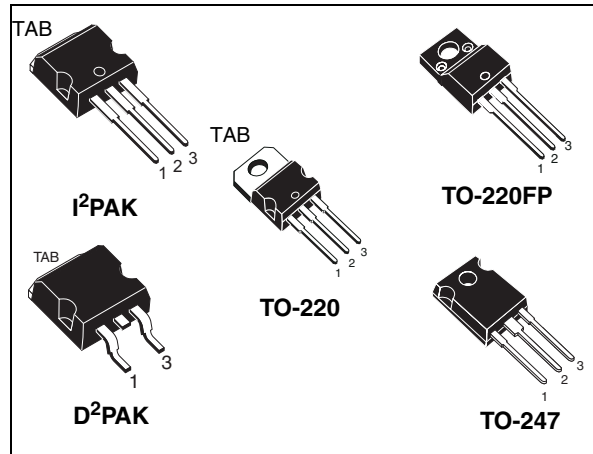


Figure 1. Internal schematic diagram

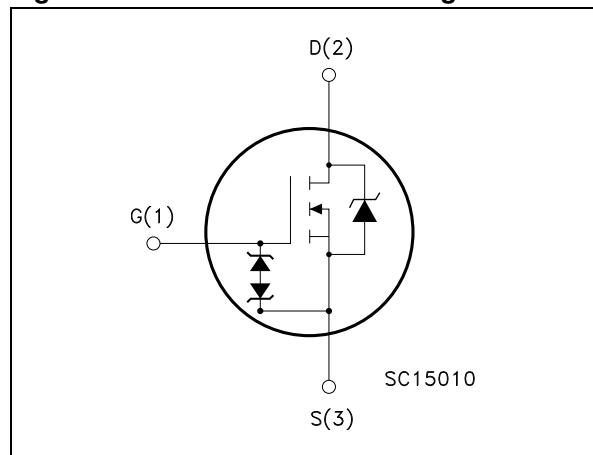


Table 1. Device summary

Order codes	Marking	Package	Packaging
STB10NK60Z-1	B10NK60Z	I <sup>2</sup> PAK	Tube
STB10NK60ZT4	B10NK60Z	D <sup>2</sup> PAK	Tape and reel
STP10NK60Z	P10NK60Z	TO-220	Tube
STP10NK60ZFP	P10NK60ZFP	TO-220FP	Tube
STW10NK60Z	W10NK60Z	TO-247	Tube

# Contents

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value			Unit
		I <sup>2</sup> PAK D <sup>2</sup> PAK TO-220	TO-220FP	TO-247	
V <sub>DS</sub>	Drain-source voltage	600			V
V <sub>GS</sub>	Gate-source voltage	± 30			V
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 25 °C	10	10 <sup>(1)</sup>	10	A
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 100 °C	5.7	5.7 <sup>(1)</sup>	5.7	A
I <sub>DM</sub> <sup>(2)</sup>	Drain current (pulsed)	36	36 <sup>(1)</sup>	36	A
P <sub>TOT</sub>	Total dissipation at T <sub>C</sub> = 25 °C	115	35	156	W
	Derating factor	0.92	0.28	1.25	W/°C
ESD	Gate-source human body model (R = 1,5 kΩ, C = 100 pF)	4			kV
dv/dt <sup>(3)</sup>	Peak diode recovery voltage slope	4.5			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>j</sub> T <sub>stg</sub>	Operating junction temperature Storage temperature	-55 to 150			°C

1. Limited by maximum junction temperature
2. Pulse width limited by safe operating area
3. I<sub>SD</sub> < 10A, di/dt < 200A/μs, V<sub>DD</sub> = 80% V<sub>(BR)DSS</sub>

**Table 3. Thermal data**

Symbol	Parameter	Value				Unit
		I <sup>2</sup> PAK D <sup>2</sup> PAK	TO-220	TO-220FP	TO-247	
R <sub>thj-case</sub>	Thermal resistance junction-case max	1.09		3.6	0.8	°C/W
R <sub>thj-pcb</sub>	Thermal resistance junction-pcb max (when mounted on minimum footprint)	35				°C/W
R <sub>thj-amb</sub>	Thermal resistance junction-amb max	62.5			50	°C/W

**Table 4. Avalanche characteristics**

Symbol	Parameter	Max value	Unit
$I_{AR}$	Avalanche current, repetitive or not-repetitive (pulse width limited by $T_j$ max)	9	A
$E_{AS}$	Single pulse avalanche energy (starting $T_j=25\text{ °C}$ , $I_D=I_{AR}$ , $V_{DD}=50\text{ V}$ )	300	mJ
$E_{AR}$	Repetitive avalanche energy (pulse width limited by $T_j$ max)	3.5	mJ

## 2 Electrical characteristics

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

**Table 5. On /off states**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V <sub>(BR)DSS</sub>	Drain-source breakdown voltage	I <sub>D</sub> = 250 μA, V <sub>GS</sub> = 0	600			V
I <sub>DSS</sub>	Zero gate voltage drain current (V <sub>GS</sub> = 0)	V <sub>DS</sub> = 600 V, V <sub>DS</sub> = 600 V, T <sub>C</sub> = 125 °C			1 50	μA μA
I <sub>GSS</sub>	Gate body leakage current (V <sub>DS</sub> = 0)	V <sub>GS</sub> = ± 20 V			±10	μA
V <sub>GS(th)</sub>	Gate threshold voltage	V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250 μA	3	3.75	4.5	V
R <sub>DS(on)</sub>	Static drain-source on-resistance	V <sub>GS</sub> = 10 V, I <sub>D</sub> = 4.5 A		0.65	0.75	Ω

**Table 6. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
g <sub>fs</sub> <sup>(1)</sup>	Forward transconductance	V <sub>DS</sub> = 15 V, I <sub>D</sub> = 4.5 A		7.8		S
C <sub>iss</sub> C <sub>oss</sub> C <sub>rss</sub>	Input capacitance Output capacitance Reverse transfer capacitance	V <sub>DS</sub> = 25 V, f = 1 MHz, V <sub>GS</sub> = 0		1370 156 37		pF pF pF
C <sub>oss eq</sub> <sup>(2)</sup>	Equivalent output capacitance	V <sub>GS</sub> = 0, V <sub>DS</sub> = 0 to 480 V		90		pF
Q <sub>g</sub> Q <sub>gs</sub> Q <sub>gd</sub>	Total gate charge Gate-source charge Gate-drain charge	V <sub>DD</sub> = 480 V, I <sub>D</sub> = 8 A V <sub>GS</sub> = 10 V (see Figure 20)		50 10 25	70	nC nC nC

1. Pulsed: pulse duration = 300 μs, duty cycle 1.5%

2. C<sub>oss eq</sub> is defined as a constant equivalent capacitance giving the same charging time as C<sub>oss</sub> when V<sub>DS</sub> increases from 0 to 80%

**Table 7. Switching times**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ $t_r$	Turn-on delay time Rise time	$V_{DD}=300\text{ V}$ , $I_D=4\text{ A}$ , $R_G=4.7\ \Omega$ , $V_{GS}=10\text{ V}$ (see Figure 19)	-	20 20	-	ns ns
$t_{d(off)}$ $t_f$	Turn-off delay time Fall time	$V_{DD}=300\text{ V}$ , $I_D=4\text{ A}$ , $R_G=4.7\ \Omega$ , $V_{GS}=10\text{ V}$ (see Figure 19)	-	55 30	-	ns ns

**Table 8. Source drain diode**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{SD}$	Source-drain current		-		10	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)		-		36	A
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD}=10\text{ A}$ , $V_{GS}=0$	-		1.6	V
$t_{rr}$	Reverse recovery time	$I_{SD}=8\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ , $V_{DD}=40\text{ V}$ , $T_j=150\text{ }^\circ\text{C}$	-	570		ns
$Q_{rr}$	Reverse recovery charge			4.3		$\mu\text{C}$
$I_{RRM}$	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%

**Table 9. 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 specifically been designed to enhance not only the device's ESD capability, but also to make them safely absorb possible voltage transients that may occasionally be applied from gate to source. In this respect the Zener voltage is appropriate to achieve an efficient and cost-effective intervention to protect the device's integrity. These integrated Zener diodes thus avoid the usage of external components

## 2.1 Electrical characteristics (curves)

Figure 2. Safe operating area for I<sup>2</sup>PAK, D<sup>2</sup>PAK and TO-220

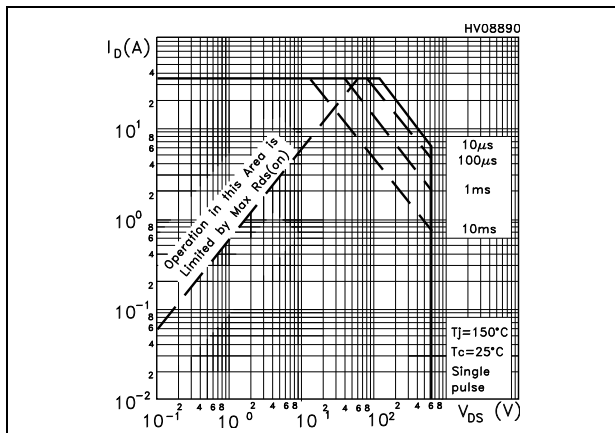


Figure 3. Thermal impedance for I<sup>2</sup>PAK, D<sup>2</sup>PAK and TO-220

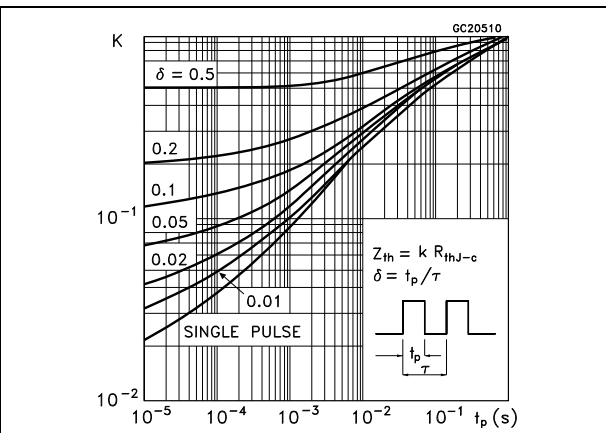


Figure 4. Safe operating area for TO-220FP

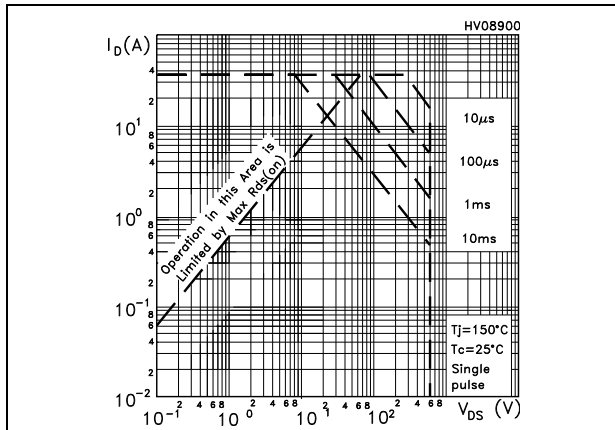


Figure 5. Thermal impedance for TO-220FP

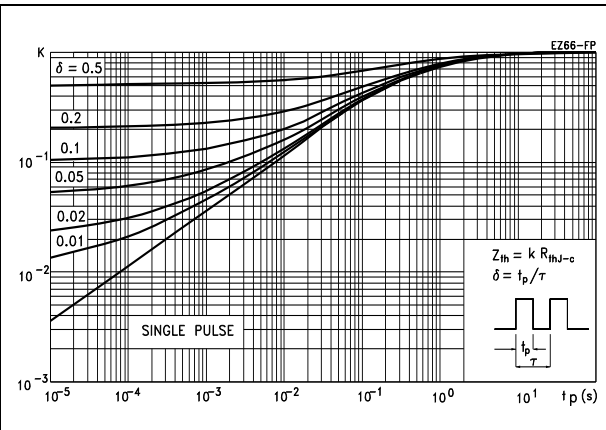


Figure 6. Safe operating area for TO-247

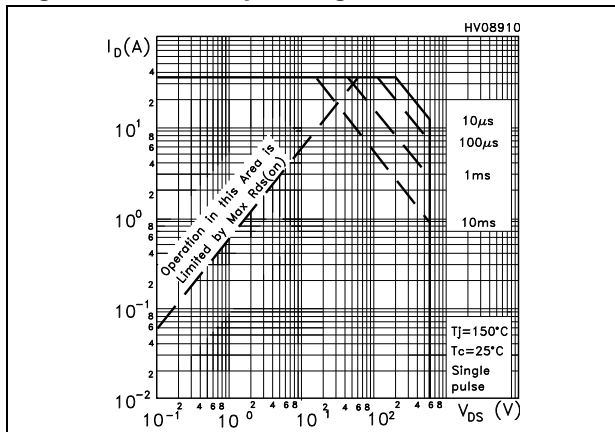


Figure 7. Thermal impedance for TO-247

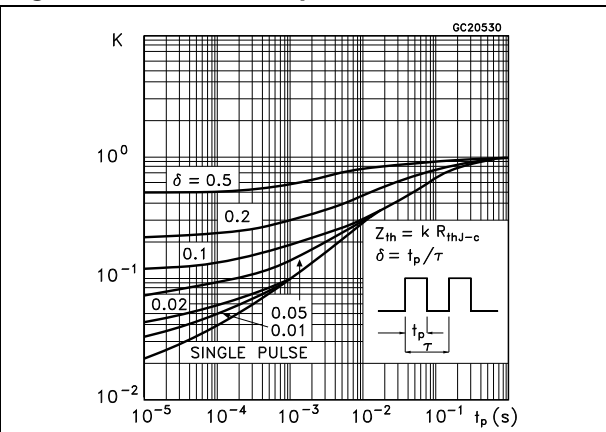


Figure 8. Output characteristics

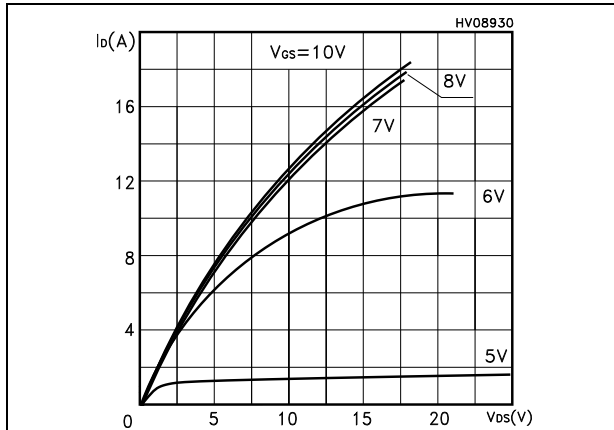


Figure 9. Transfer characteristics

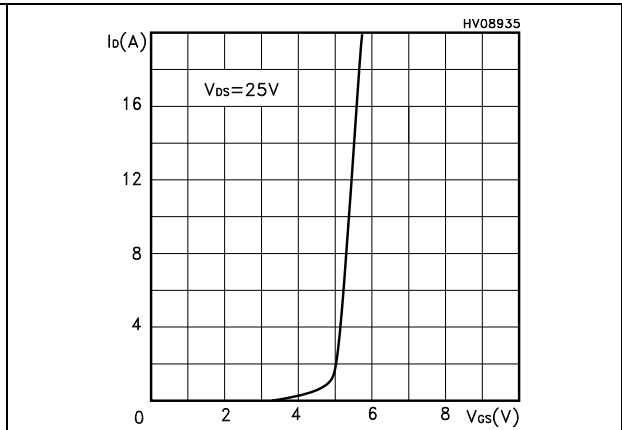


Figure 10. Transconductance

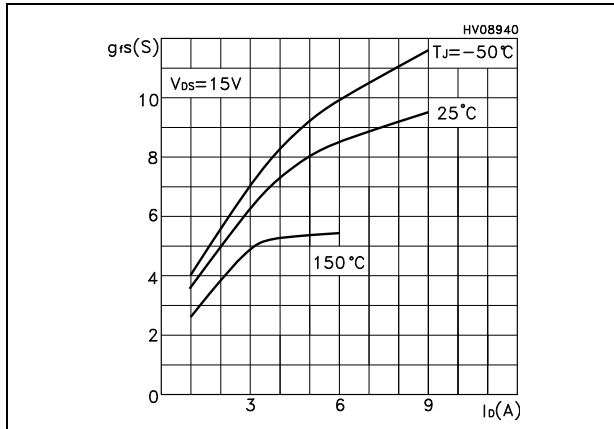


Figure 11. Static drain-source on-resistance

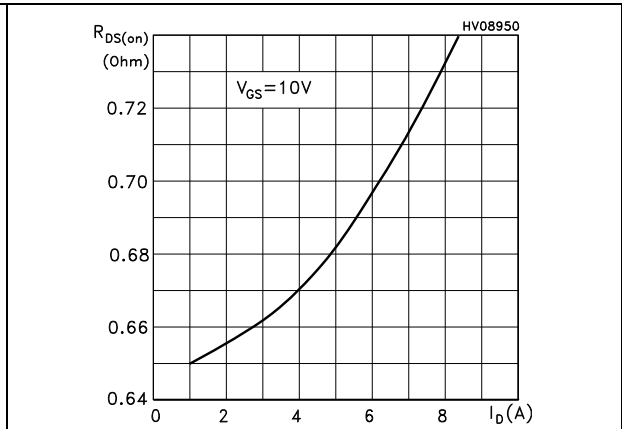


Figure 12. Gate charge vs gate-source voltage Figure 13. Capacitance variations

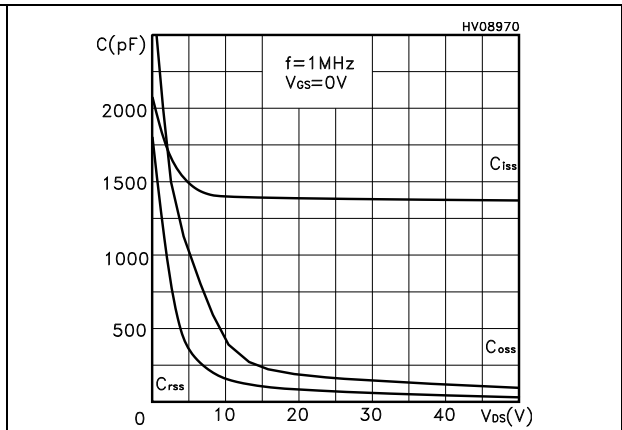
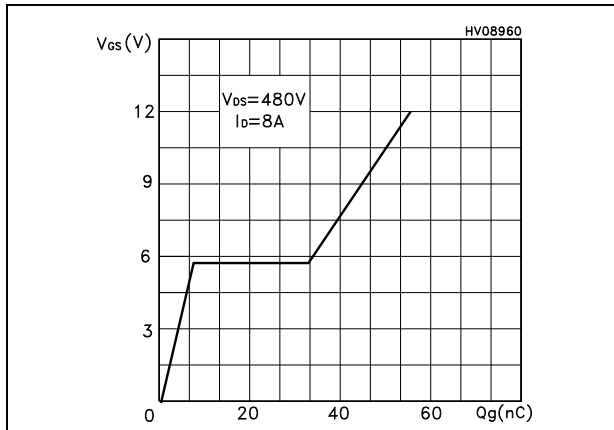




Figure 14. Normalized gate threshold voltage vs temperature

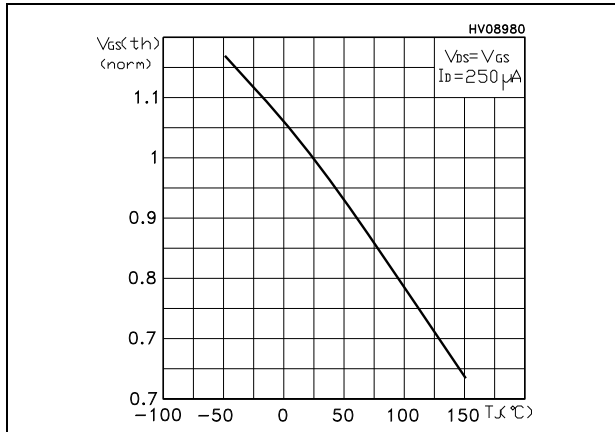


Figure 15. Normalized on-resistance vs temperature

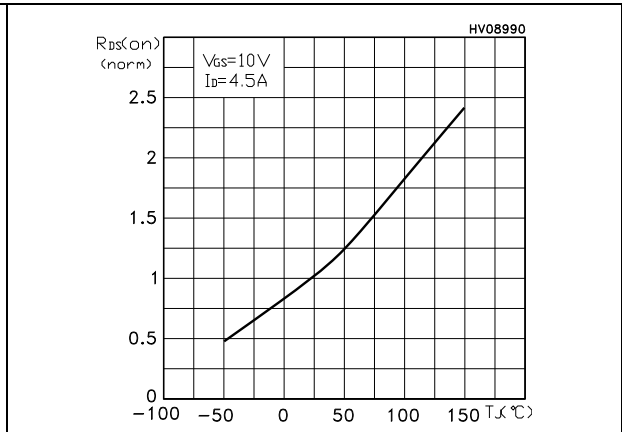


Figure 16. Source-drain diode forward characteristics

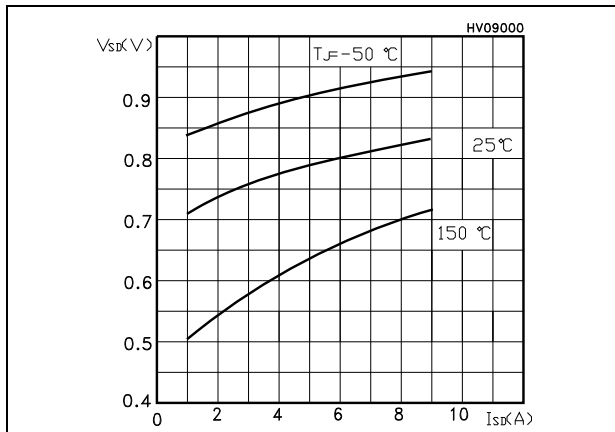


Figure 17. Maximum avalanche energy vs temperature

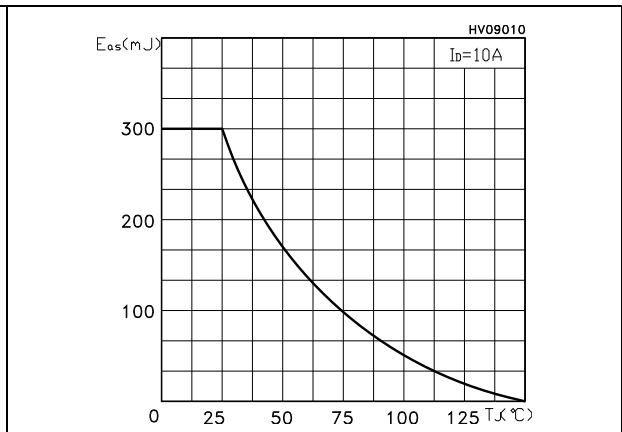
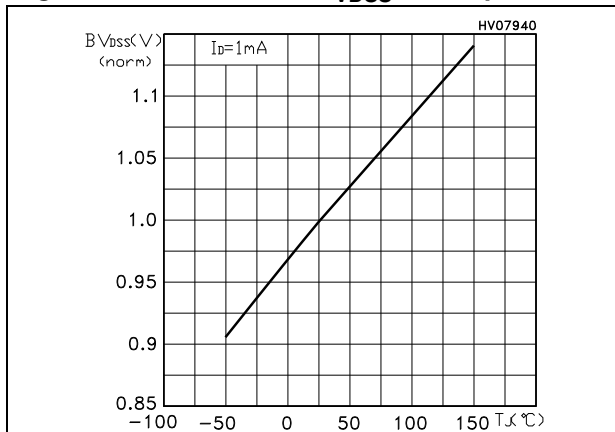
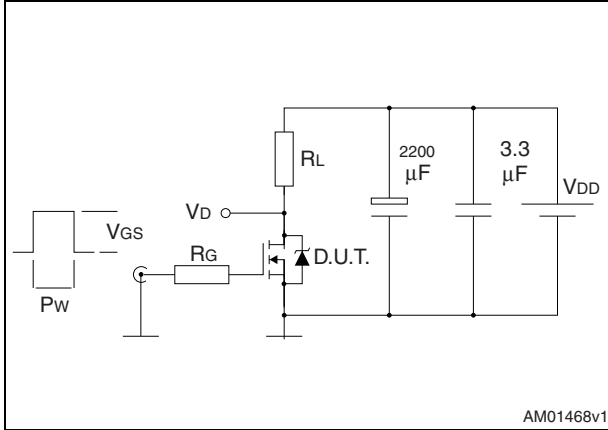


Figure 18. Normalized B<sub>V</sub>DSS vs temperature



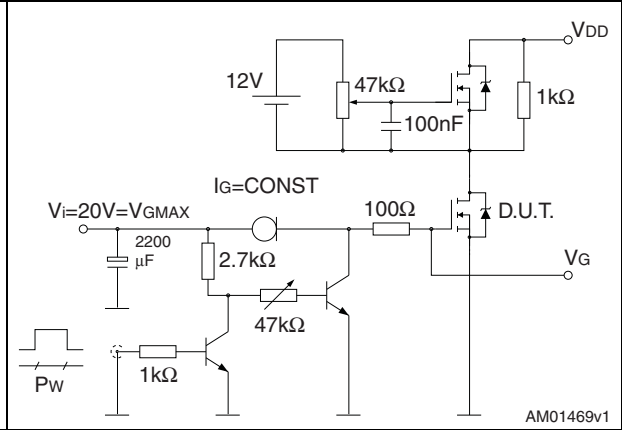
### 3 Test circuits

**Figure 19. Switching times test circuit for resistive load**



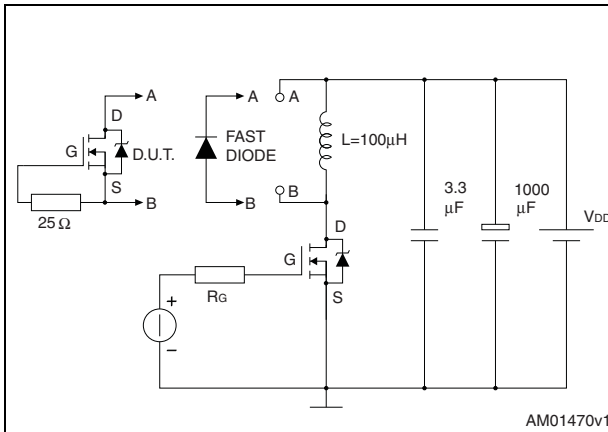
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**Figure 20. Gate charge test circuit**



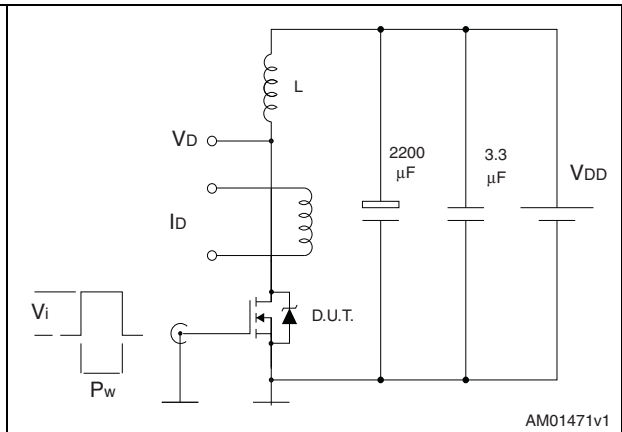
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**Figure 21. Test circuit for inductive load switching and diode recovery times**



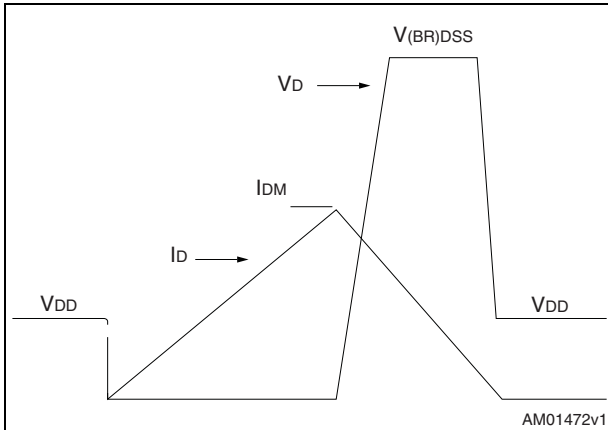
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**Figure 22. Unclamped inductive load test circuit**



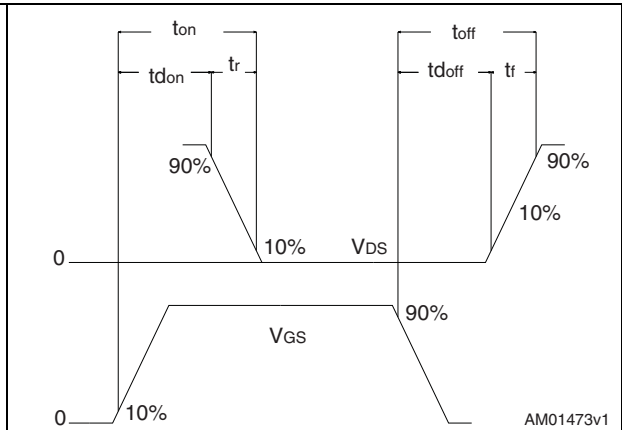
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**Figure 23. Unclamped inductive waveform**



AM01472v1

**Figure 24. Switching time waveform**



AM01473v1

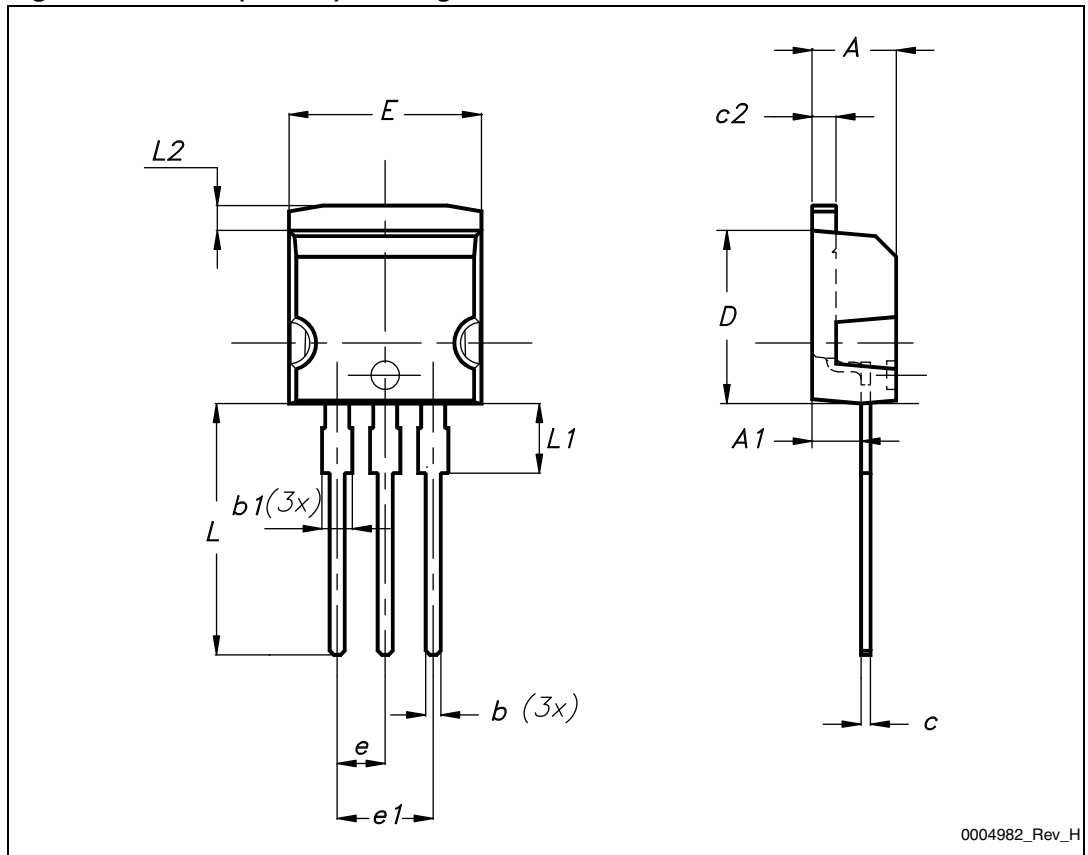
## 4 Package mechanical data

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 10. I<sup>2</sup>PAK (TO-262) mechanical data**

DIM.	mm.		
	min.	typ	max.
A	4.40		4.60
A1	2.40		2.72
b	0.61		0.88
b1	1.14		1.70
c	0.49		0.70
c2	1.23		1.32
D	8.95		9.35
e	2.40		2.70
e1	4.95		5.15
E	10		10.40
L	13		14
L1	3.50		3.93
L2	1.27		1.40

Figure 25. I<sup>2</sup>PAK (TO-262) drawing



0004982\_Rev\_H

Table 11. 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 26. D<sup>2</sup>PAK (TO-263) drawing

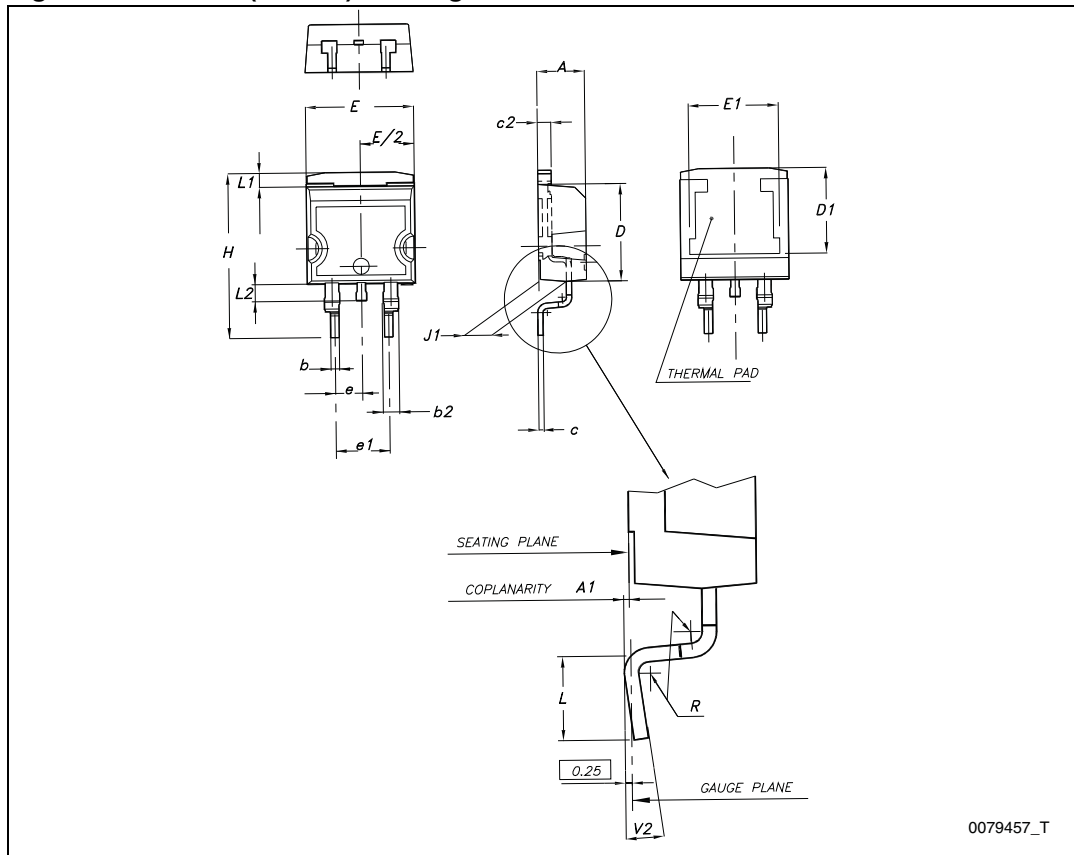
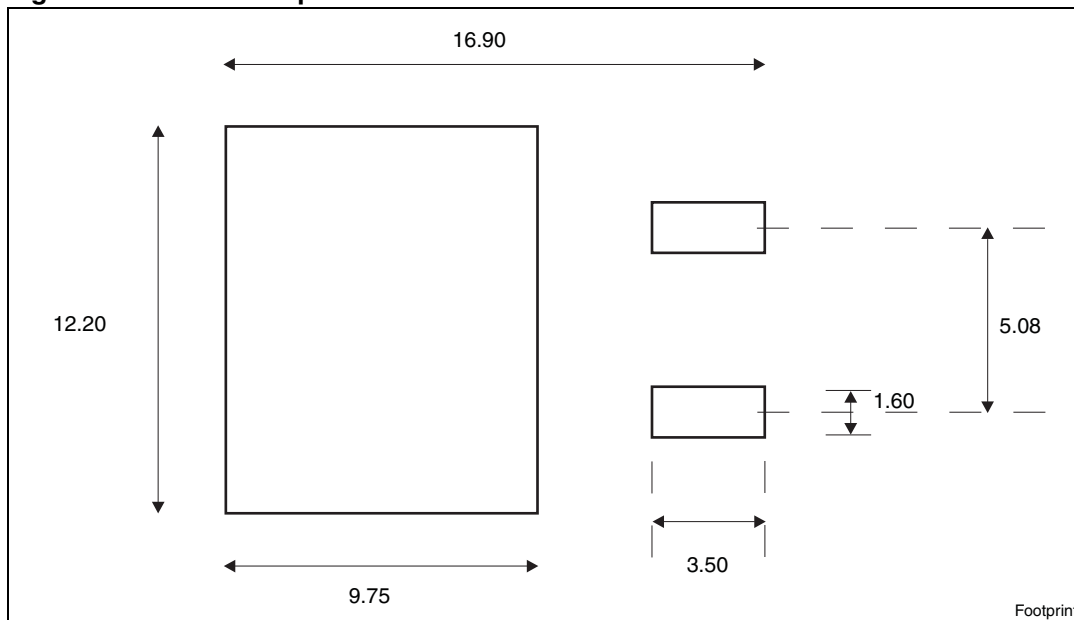


Figure 27. D<sup>2</sup>PAK footprint<sup>(a)</sup>



a. All dimensions are in millimeters

Table 12. 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 28. TO-220 type A drawing

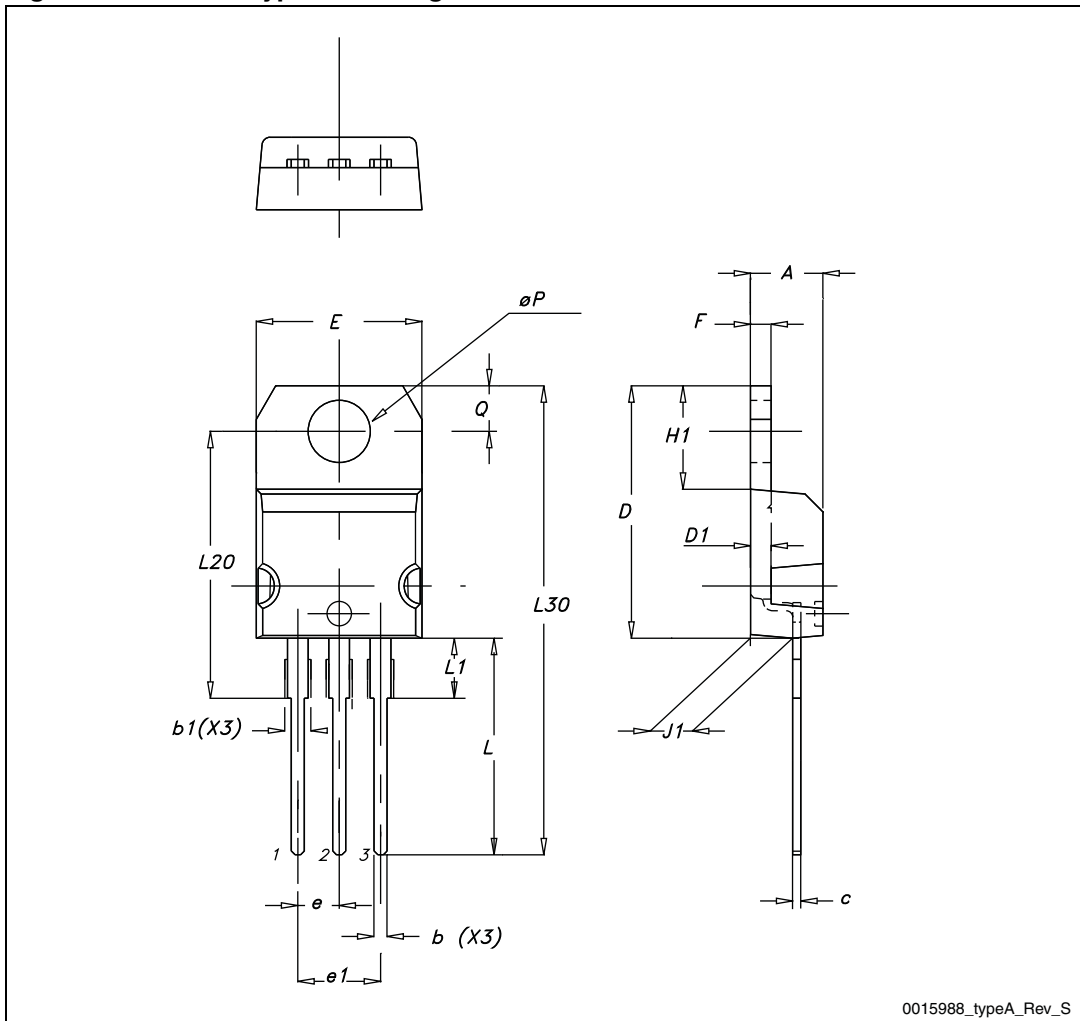




Table 13. TO-220FP mechanical data

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 29. TO-220FP drawing

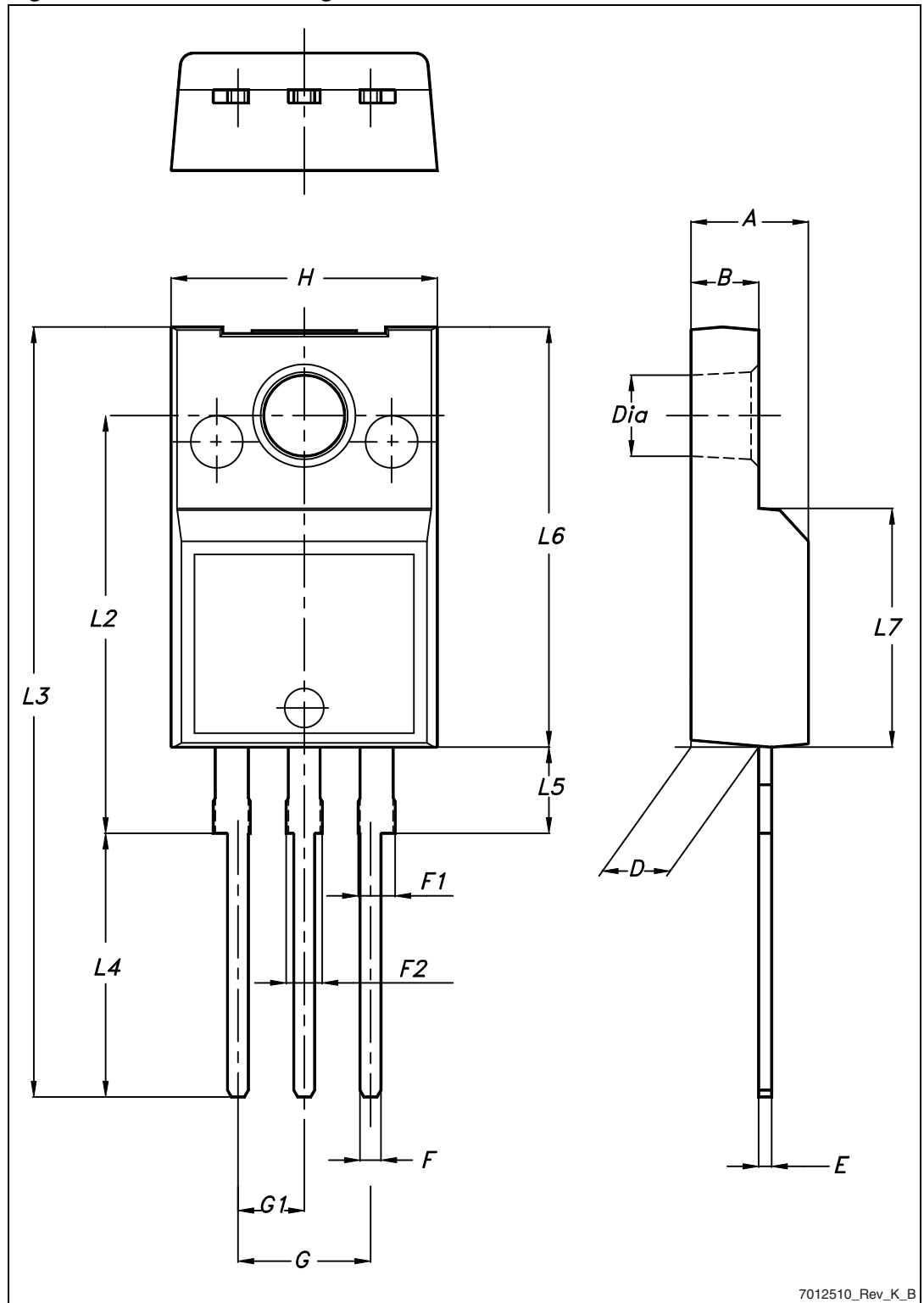
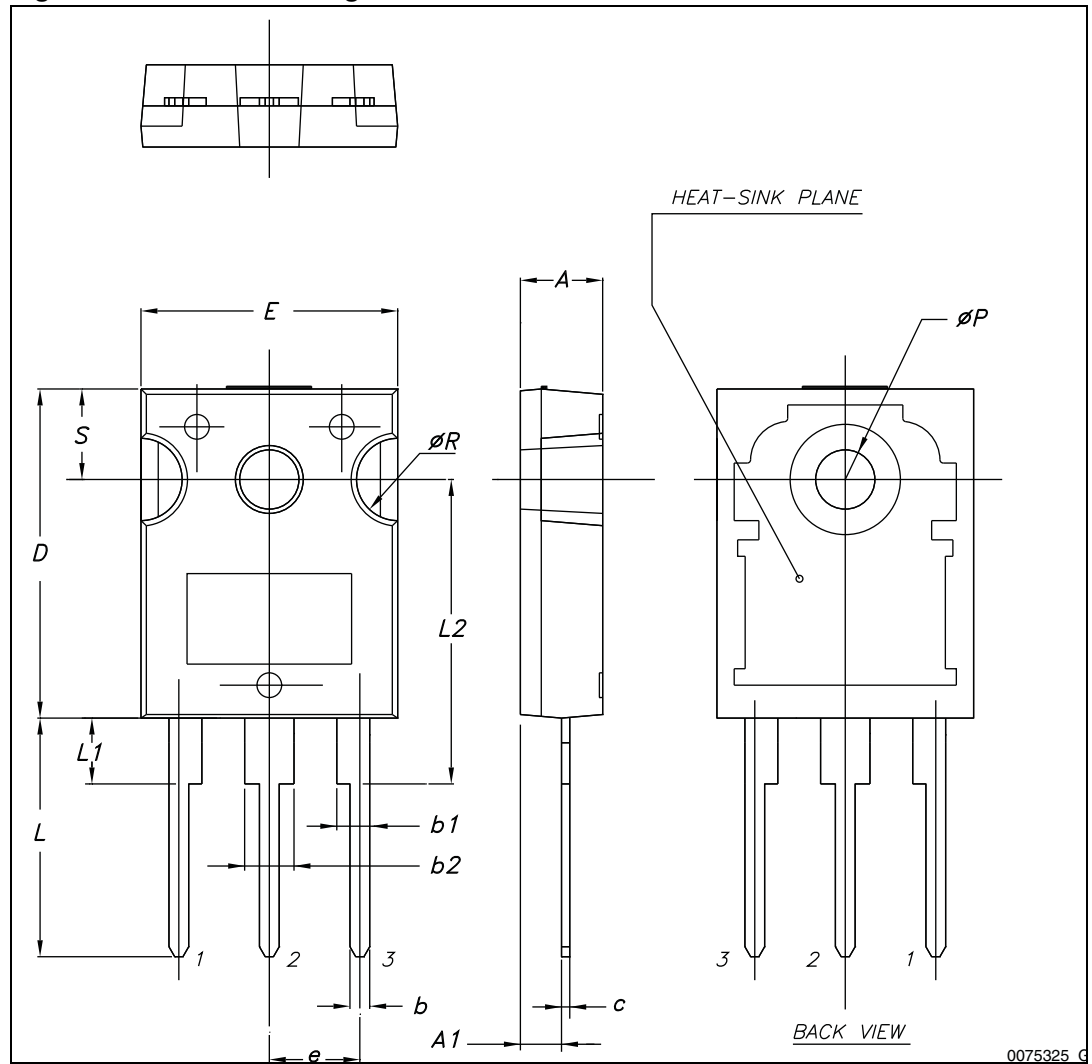


Table 14. TO-247 mechanical data

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 30. TO-247 drawing

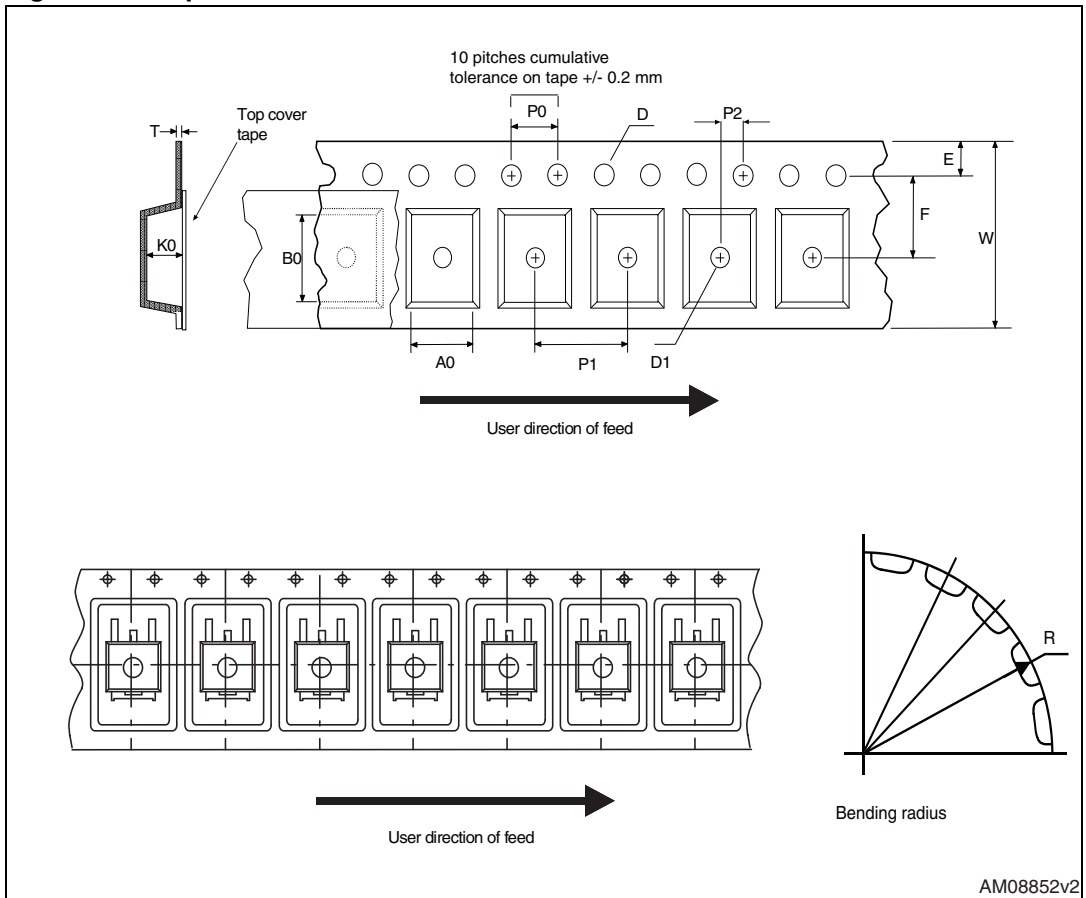


## 5 Packaging mechanical data

Table 15. D<sup>2</sup>PAK (TO-263) tape and reel mechanical data

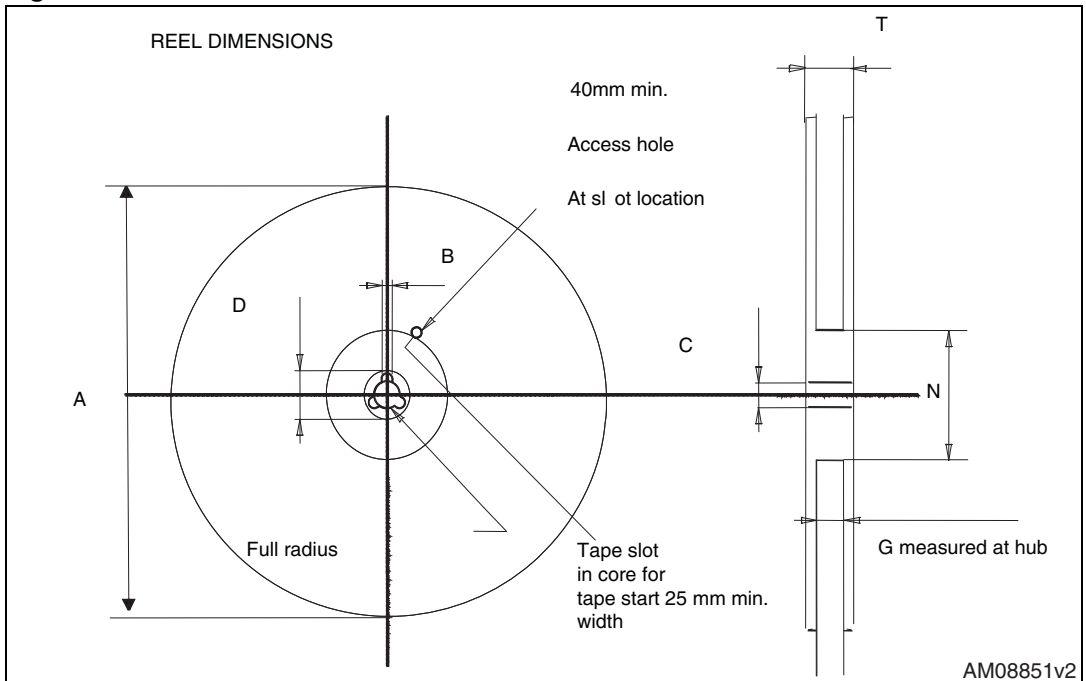
Tape			Reel		
Dim.	mm		Dim.	mm	
	Min.	Max.		Min.	Max.
A0	10.5	10.7	A		330
B0	15.7	15.9	B	1.5	
D	1.5	1.6	C	12.8	13.2
D1	1.59	1.61	D	20.2	
E	1.65	1.85	G	24.4	26.4
F	11.4	11.6	N	100	
K0	4.8	5.0	T		30.4
P0	3.9	4.1			
P1	11.9	12.1		Base qty	1000
P2	1.9	2.1		Bulk qty	1000
R	50				
T	0.25	0.35			
W	23.7	24.3			

Figure 31. Tape



AM08852v2

Figure 32. Reel



AM08851v2

## 6 Revision history

**Table 16. Document revision history**

Date	Revision	Changes
29-Sep-2005	6	Inserted ecopack indication
29-Oct-2005	7	New value inserted in <a href="#">Table 6</a>
11-Apr-2006	8	New template
19-Sep-2006	9	Unit changed in <a href="#">Table 5</a>
17-Nov-2008	10	Updated <a href="#">Section 4: Package mechanical data</a>
15-Nov-2012	11	Updated <a href="#">Table 2: Absolute maximum ratings</a> , <a href="#">Table 3: Thermal data</a> , <a href="#">Table 5: On /off states</a> and <a href="#">Table 9: Gate-source Zener diode</a> . Updated <a href="#">Section 4: Package mechanical data</a> and <a href="#">Section 5: Packaging mechanical data</a> . Minor text changes.

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