



# STB31N65M5, STF31N65M5, STFI31N65M5, STP31N65M5, STW31N65M5

life.augmented

N-channel 650 V, 0.124  $\Omega$  typ., 22 A MDmesh™ V Power MOSFET in D<sup>2</sup>PAK, TO-220FP, I<sup>2</sup>PakFP, TO-220 and TO-247 packages

Datasheet – production data

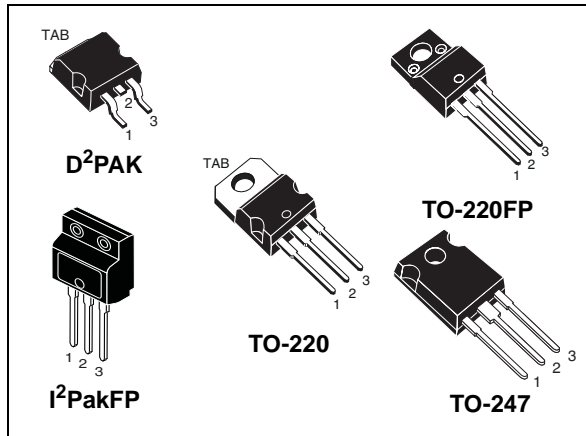
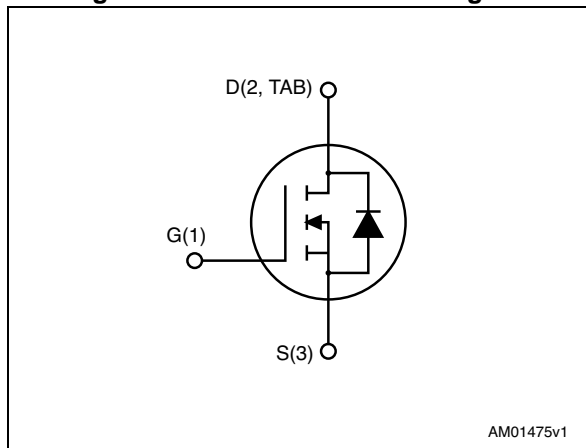


Figure 1. Internal schematic diagram



## Features

Order codes	V <sub>DSS</sub> @ T <sub>Jmax</sub>	R <sub>DS(on)</sub> max	I <sub>D</sub>
STB31N65M5	710 V	< 0.148 $\Omega$	22 A
STF31N65M5			
STFI31N65M5			
STP31N65M5			
STW31N65M5			

- Worldwide best R<sub>DS(on)</sub> \* area
- Higher V<sub>DSS</sub> rating and high dv/dt capability
- Excellent switching performance
- 100% avalanche tested

## Applications

- Switching applications

## Description

These devices are N-channel MDmesh™ V Power MOSFETs based on an innovative proprietary vertical process technology, which is combined with STMicroelectronics' well-known PowerMESH™ horizontal layout structure. The resulting product has extremely low on-resistance, which is unmatched among silicon-based Power MOSFETs, making it especially suitable for applications which require superior power density and outstanding efficiency.

Table 1. Device summary

Order code	Marking	Package	Packaging
STB31N65M5	31N65M5	D <sup>2</sup> PAK	Tape and reel
STF31N65M5		TO-220FP	Tube
STFI31N65M5		I <sup>2</sup> PakFP	
STP31N65M5		TO-220	
STW31N65M5		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 I <sup>2</sup> PakFP	
V <sub>GS</sub>	Gate-source voltage	± 25		V
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 25 °C	22	22 <sup>(1)</sup>	A
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 100 °C	13.9	13.9 <sup>(1)</sup>	A
I <sub>DM</sub> <sup>(1)</sup>	Drain current (pulsed)	88	88 <sup>(1)</sup>	A
P <sub>TOT</sub>	Total dissipation at T <sub>C</sub> = 25 °C	150	30	W
dv/dt <sup>(2)</sup>	Peak diode recovery voltage slope	15		V/ns
dv/dt <sup>(3)</sup>	MOSFET dv/dt ruggedness	50		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.
- I<sub>SD</sub> ≤ 22 A, di/dt ≤ 400 A/μs; V<sub>DS peak</sub> < V<sub>(BR)DSS</sub>; V<sub>DD</sub>=400 V
- V<sub>DS</sub> ≤ 480 V

**Table 3. Thermal data**

Symbol	Parameter	Value				Unit
		D <sup>2</sup> PAK	TO-220FP I <sup>2</sup> PakFP	TO-220	TO-247	
R <sub>thj-case</sub>	Thermal resistance junction-case max	0.83	4.17	0.83		°C/W
R <sub>thj-pcb</sub> <sup>(1)</sup>	Thermal resistance junction-pcb max	30				°C/W
R <sub>thj-amb</sub>	Thermal resistance junction-ambient max		62.5		50	°C/W

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

Table 4. Avalanche characteristics

Symbol	Parameter	Value	Unit
$I_{AR}$	Avalanche current, repetitive or not repetitive (pulse width limited by $T_{jmax}$ )	5	A
$E_{AS}$	Single pulse avalanche energy (starting $t_j=25^\circ\text{C}$ , $I_d=I_{AR}$ ; $V_{dd}=50$ )	410	mJ

## 2 Electrical characteristics

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

**Table 5. On /off states**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source breakdown voltage	$I_D = 1\text{ mA}, V_{GS} = 0$	650			V
$I_{DSS}$	Zero gate voltage drain current ( $V_{GS} = 0$ )	$V_{DS} = 650\text{ V}$ $V_{DS} = 650\text{ V}, T_C = 125\text{ °C}$			1 100	$\mu\text{A}$ $\mu\text{A}$
$I_{GSS}$	Gate-body leakage current ( $V_{DS} = 0$ )	$V_{GS} = \pm 25\text{ V}$			$\pm 100$	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	$V_{GS} = 10\text{ V}, I_D = 11\text{ A}$		0.124	0.148	$\Omega$

**Table 6. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$C_{iss}$	Input capacitance	$V_{DS} = 100\text{ V}, f = 1\text{ MHz},$ $V_{GS} = 0$	-	1865	-	pF
$C_{oss}$	Output capacitance			45		pF
$C_{rss}$	Reverse transfer capacitance			4.2		pF
$C_{o(tr)}^{(1)}$	Equivalent capacitance time related	$V_{DS} = 0\text{ to }520\text{ V}, V_{GS} = 0$	-	146	-	pF
$C_{o(er)}^{(2)}$	Equivalent capacitance energy related			43		pF
$R_G$	Intrinsic gate resistance	$f = 1\text{ MHz open drain}$	-	2.8	-	$\Omega$
$Q_g$	Total gate charge	$V_{DD} = 520\text{ V}, I_D = 11\text{ A},$ $V_{GS} = 10\text{ V}$ (see <a href="#">Figure 20</a> )	-	45	-	nC
$Q_{gs}$	Gate-source charge			11.5		nC
$Q_{gd}$	Gate-drain charge			20		nC

1. Time related is defined as a constant equivalent capacitance giving the same charging time as  $C_{oss}$  when  $V_{DS}$  increases from 0 to 80%  $V_{DSS}$
2. Energy related is defined as a constant equivalent capacitance giving the same stored energy as  $C_{oss}$  when  $V_{DS}$  increases from 0 to 80%  $V_{DSS}$

**Table 7. Switching times**

Symbol	Parameter	Test conditions	Min.	Typ.	Max	Unit
$t_d$ (v)	Voltage delay time	$V_{DD} = 400\text{ V}$ , $I_D = 14\text{ A}$ ,		46		ns
$t_r$ (v)	Voltage rise time	$R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$	-	8	-	ns
$t_f$ (i)	Current fall time	(see <a href="#">Figure 21</a> and		8.5		ns
$t_{c(off)}$	Crossing time	<a href="#">Figure 24</a> )		11		ns

**Table 8. Source drain diode**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{SD}$	Source-drain current		-		22	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)		-		88	A
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 22\text{ A}$ , $V_{GS} = 0$	-		1.5	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 22\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$	-	336		ns
$Q_{rr}$	Reverse recovery charge	$V_{DD} = 100\text{ V}$ (see <a href="#">Figure 21</a> )		5		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current			30		A
$t_{rr}$	Reverse recovery time	$I_{SD} = 22\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$	-	406		ns
$Q_{rr}$	Reverse recovery charge	$V_{DD} = 100\text{ V}$ , $T_j = 150\text{ }^\circ\text{C}$		6		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current	(see <a href="#">Figure 21</a> )		31		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 TO220

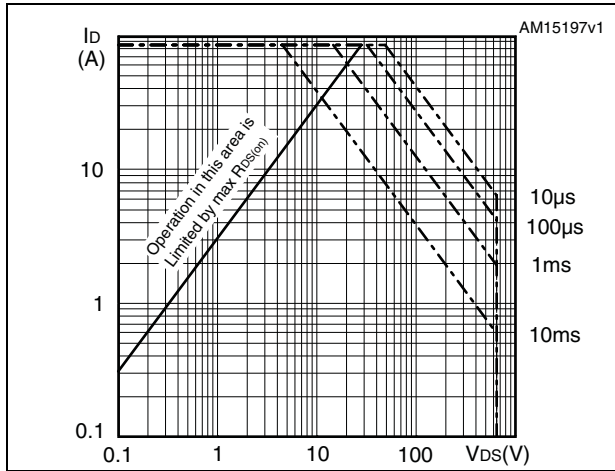


Figure 3. Thermal impedance for D<sup>2</sup>PAK and TO-220

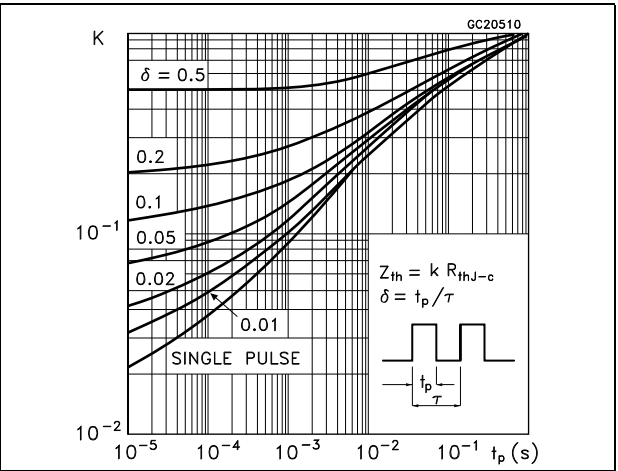


Figure 4. Safe operating area for TO-220FP and I<sup>2</sup>PakFP

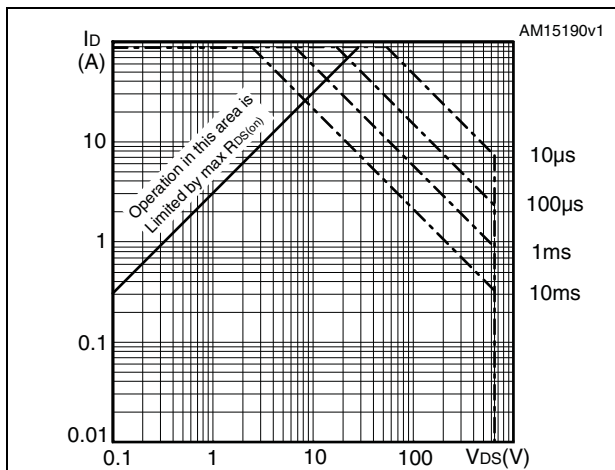


Figure 5. Thermal impedance for TO-220FP and I<sup>2</sup>PakFP

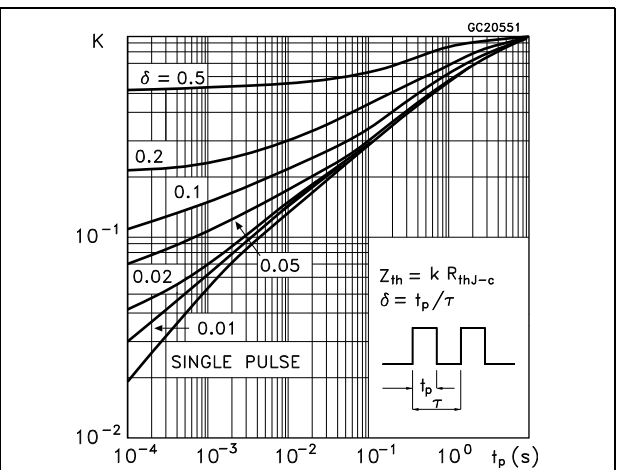


Figure 6. Safe operating area for TO-247

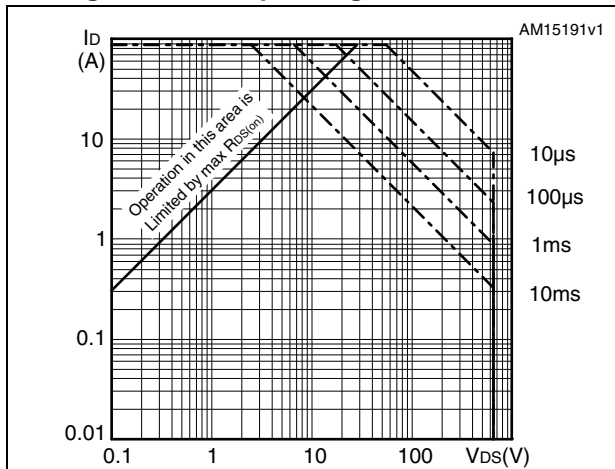


Figure 7. Thermal impedance for TO-247

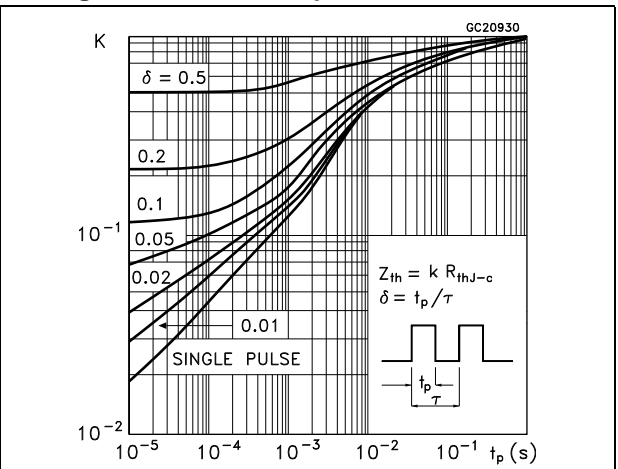


Figure 8. Output characteristics

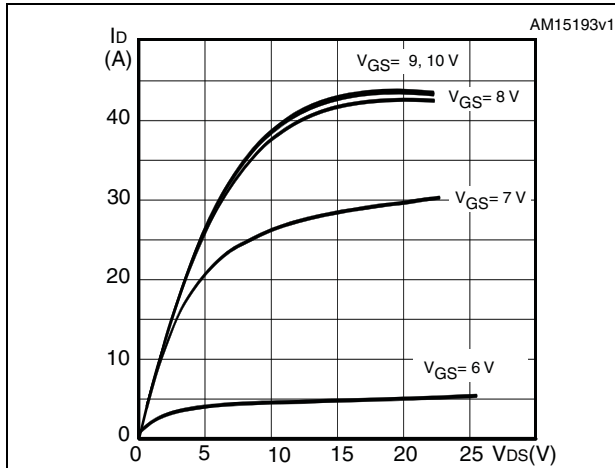


Figure 9. Transfer characteristics

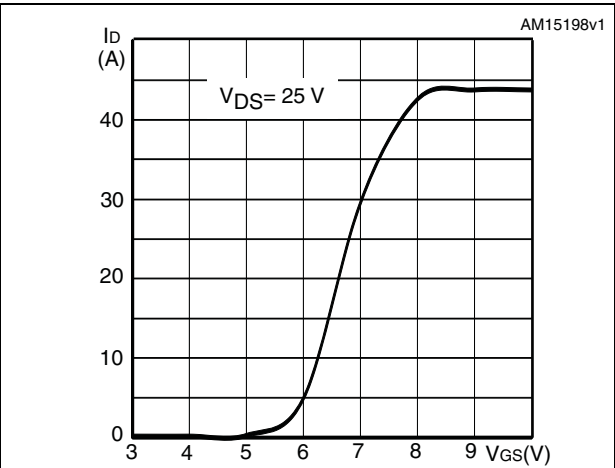


Figure 10. Gate charge vs gate-source voltage

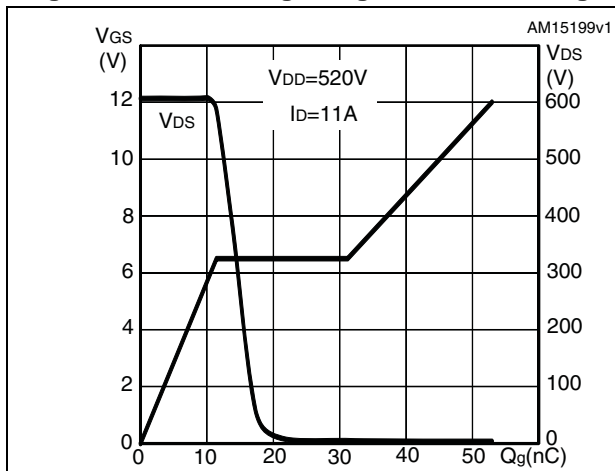


Figure 11. Static drain-source on-resistance

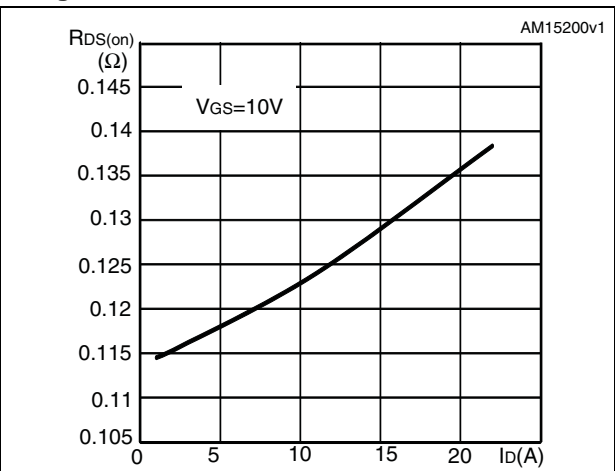


Figure 12. Capacitance variations

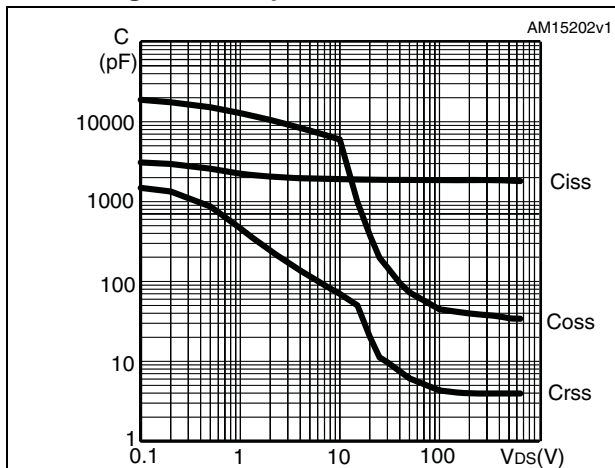


Figure 13. Output capacitance stored energy

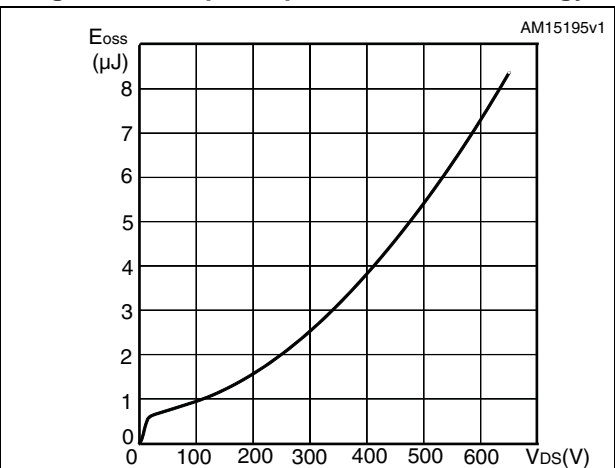




Figure 14. Normalized gate threshold voltage vs temperature

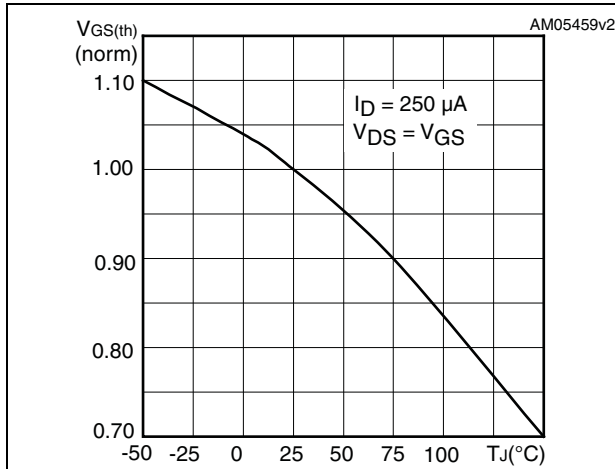


Figure 15. Normalized on-resistance vs temperature

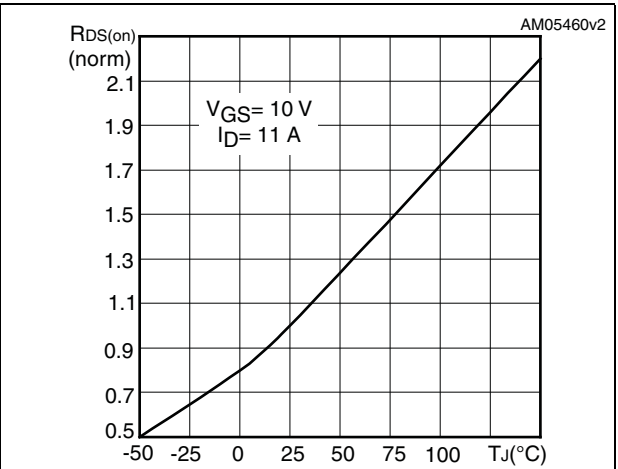


Figure 16. Source-drain diode forward characteristics

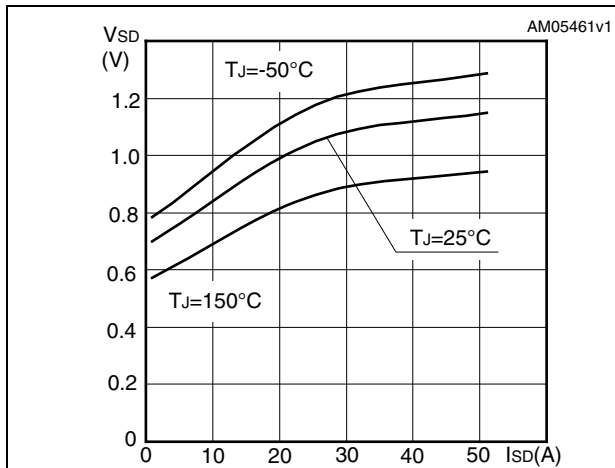


Figure 17. Normalized BV<sub>DSS</sub> vs temperature

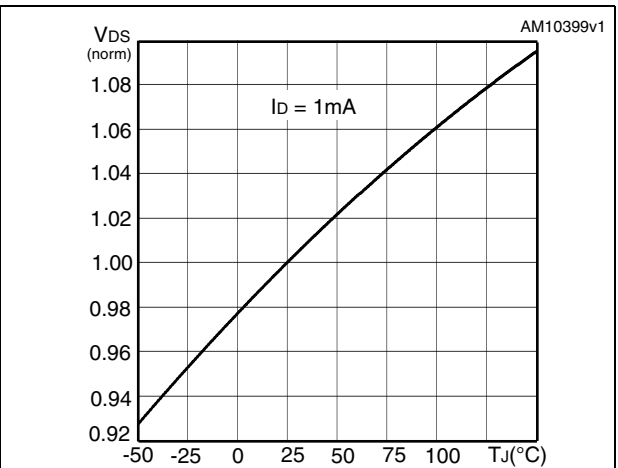
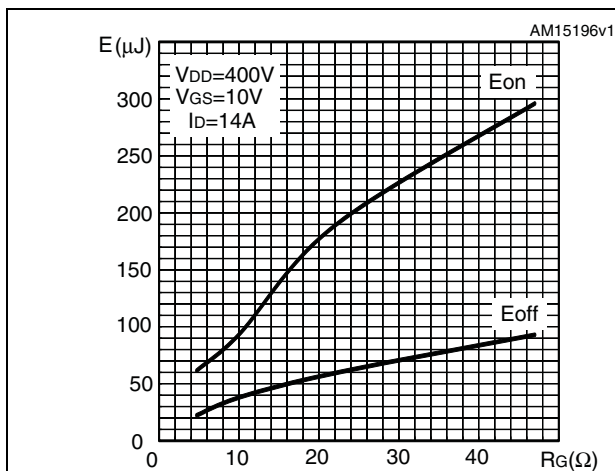


Figure 18. Switching losses vs gate resistance<sup>(1)</sup>



1. Eon including reverse recovery of a SiC diode

### 3 Test circuits

Figure 19. Switching times test circuit for resistive load

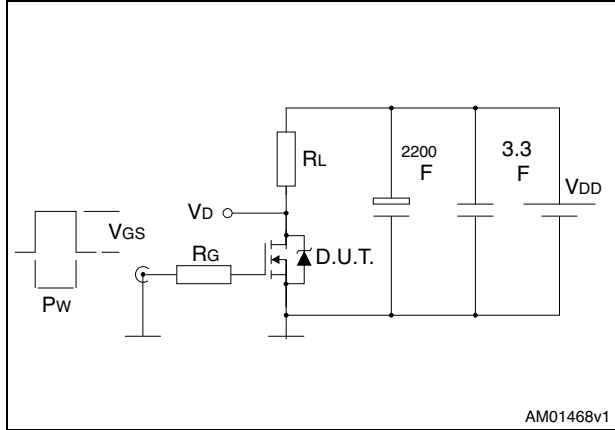


Figure 20. Gate charge test circuit

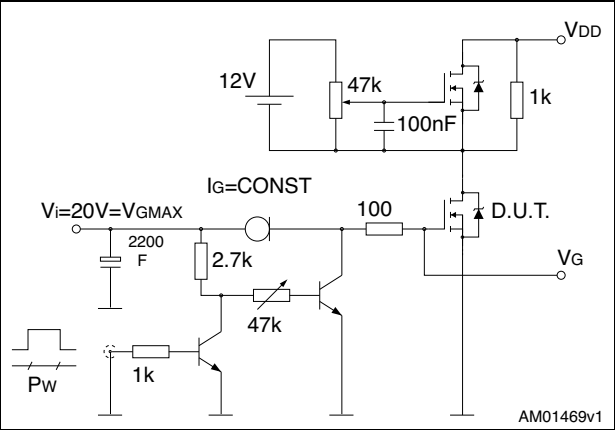


Figure 21. Test circuit for inductive load switching and diode recovery times

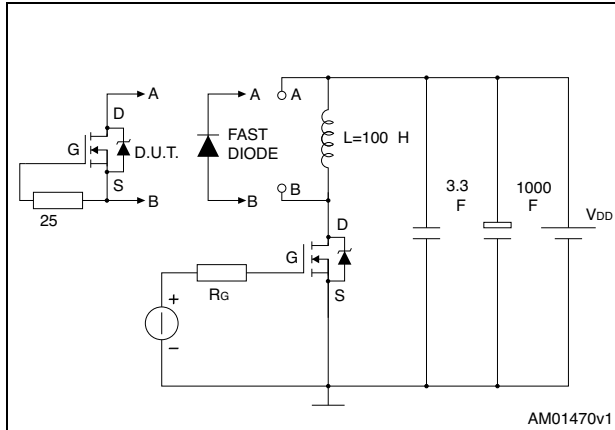


Figure 22. Unclamped inductive load test circuit

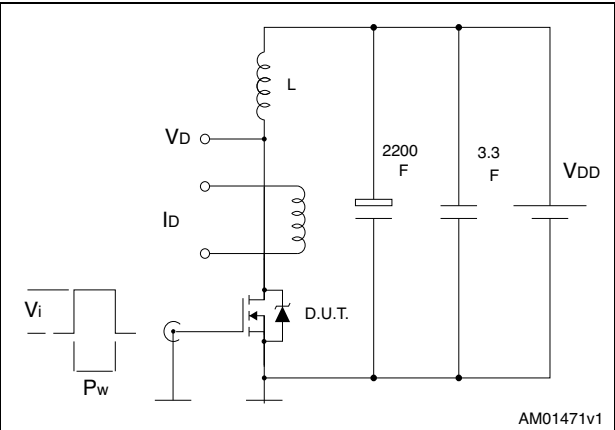


Figure 23. Unclamped inductive waveform

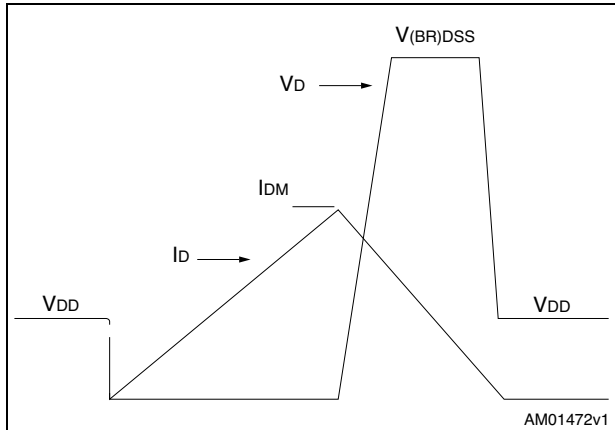
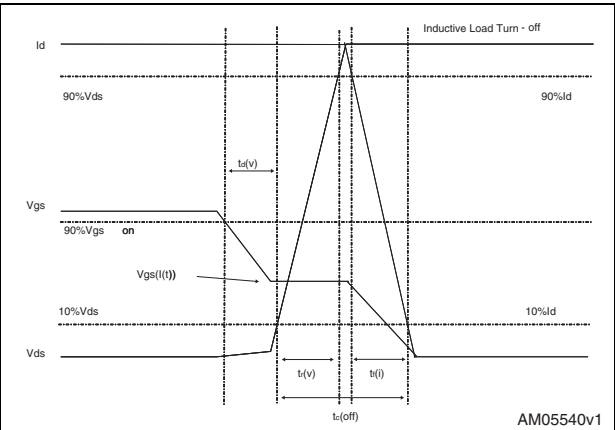


Figure 24. Switching time waveform



## 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.

Table 9. 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 (TO-263) drawing

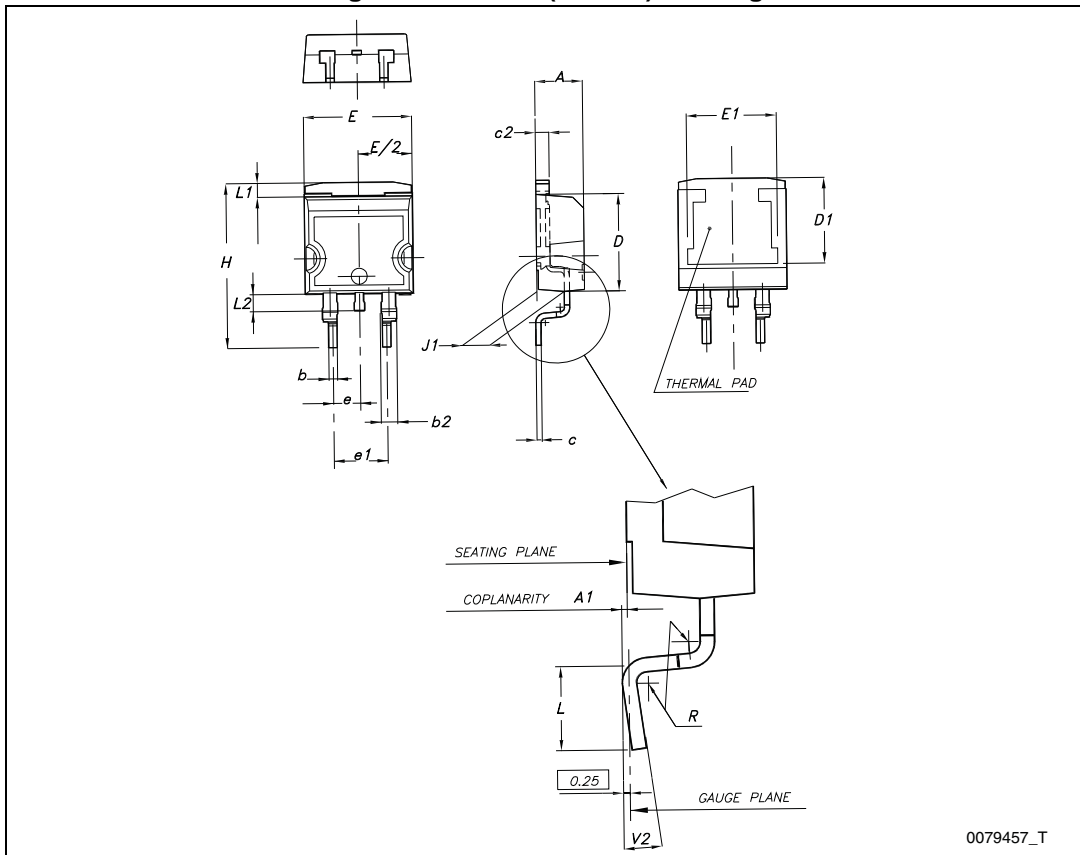
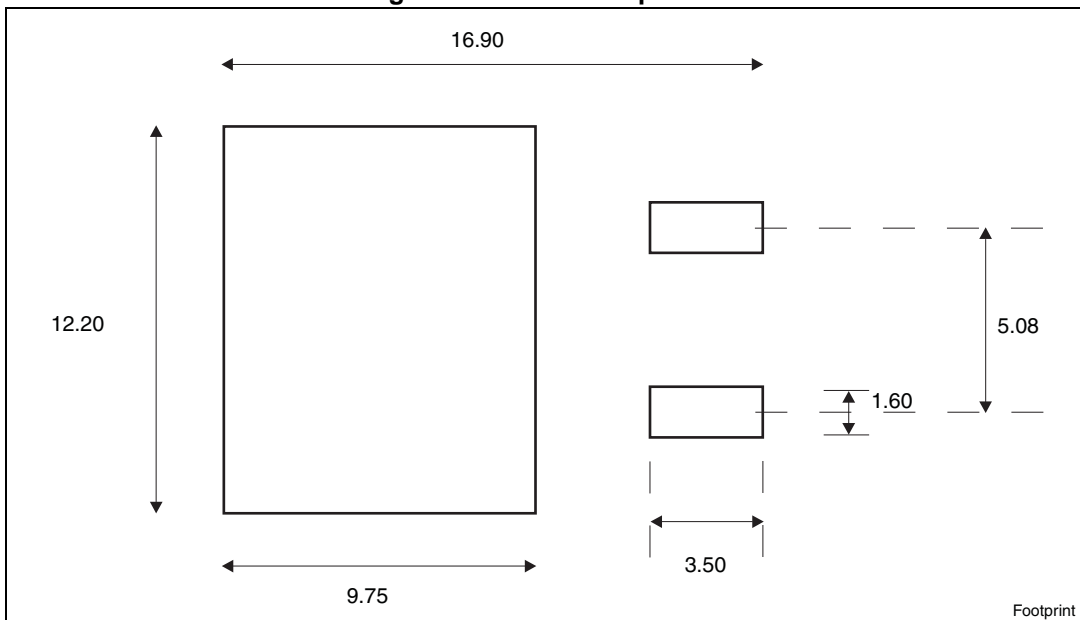


Figure 26. D<sup>2</sup>PAK footprint<sup>(a)</sup>



a. All dimension are in millimeters

Table 10. 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 27. TO-220FP drawing

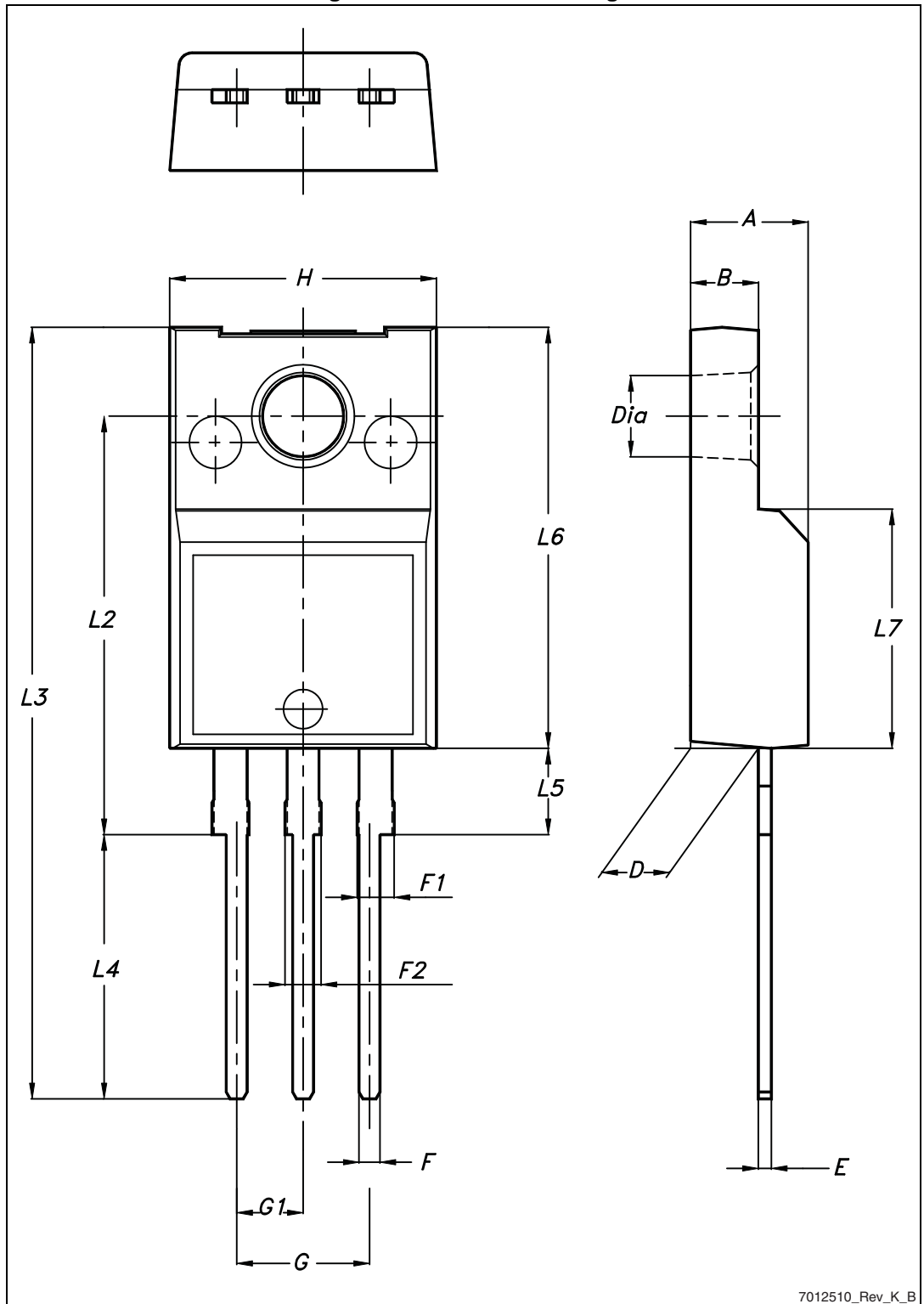


Table 11. I<sup>2</sup>PakFP mechanical data

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 28. I<sup>2</sup>PakFP drawing

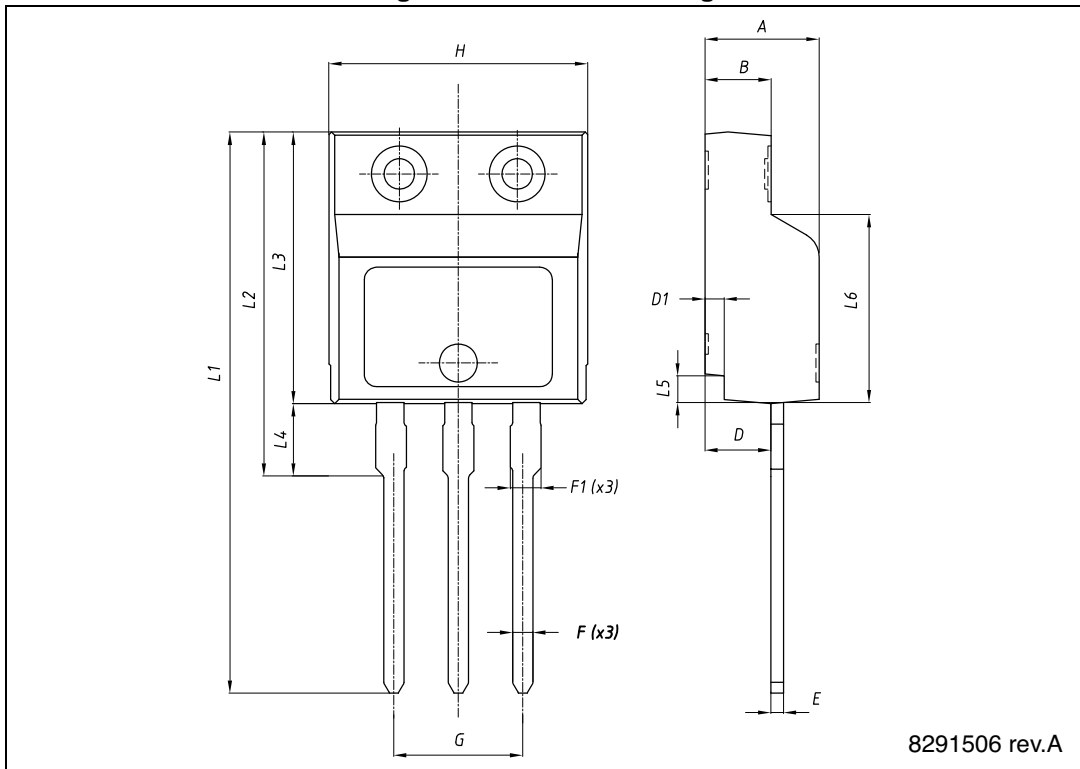


Table 12. TO-220 type A mechanical data

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 29. TO-220 type A drawing

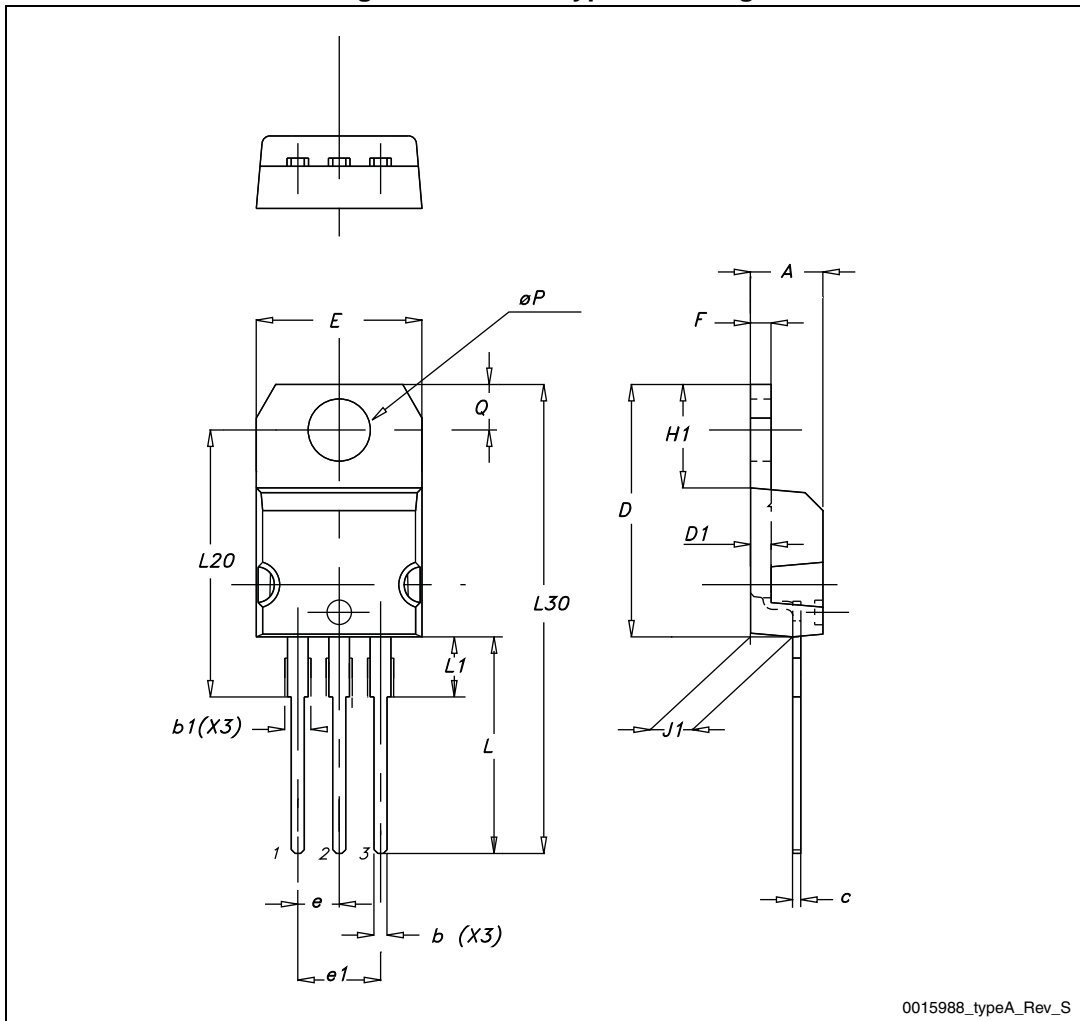
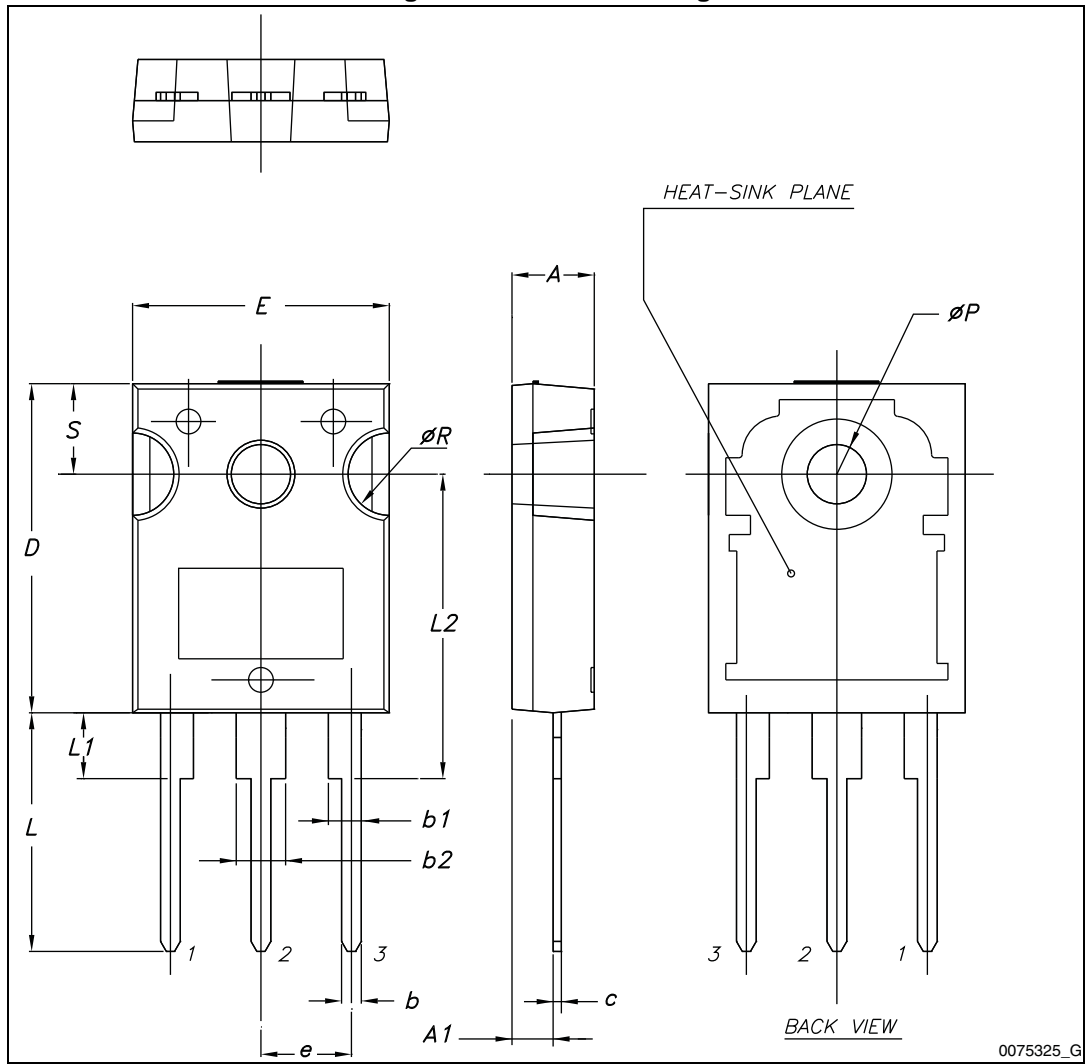


Table 13. TO-247 mechanical data

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 14. 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

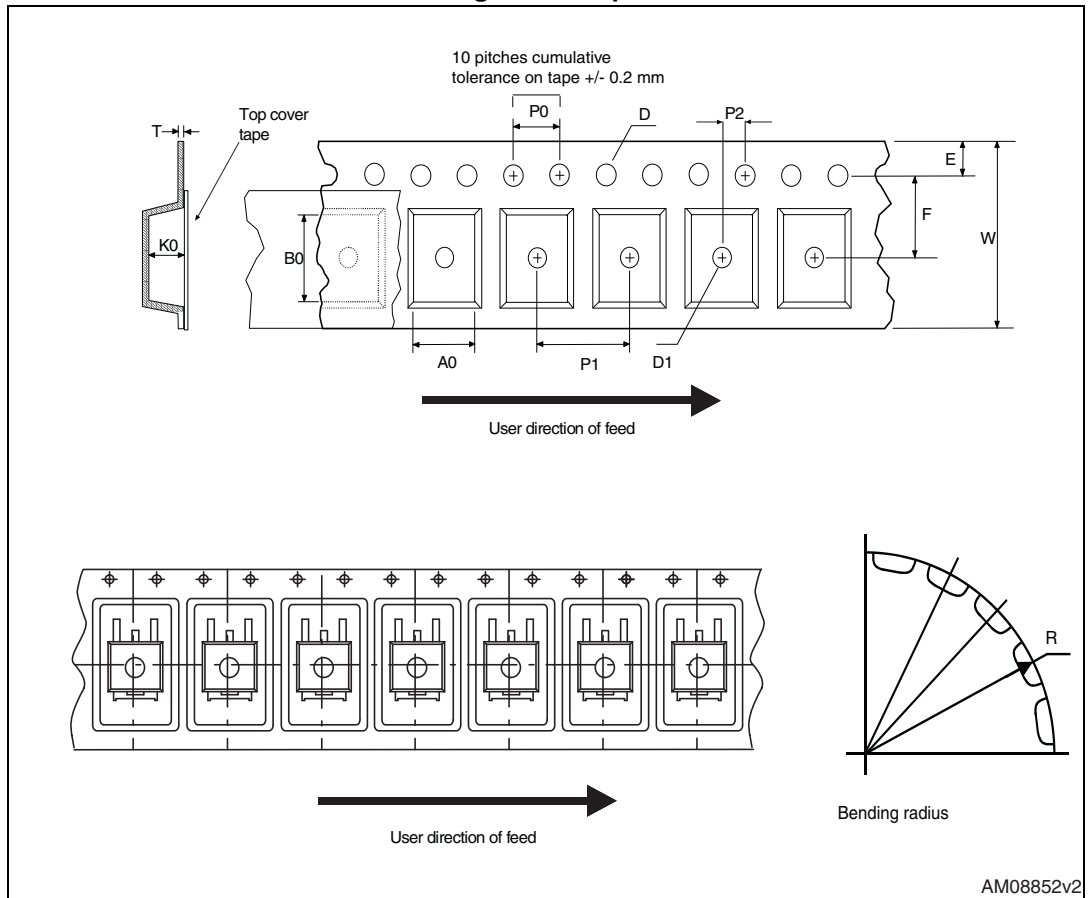
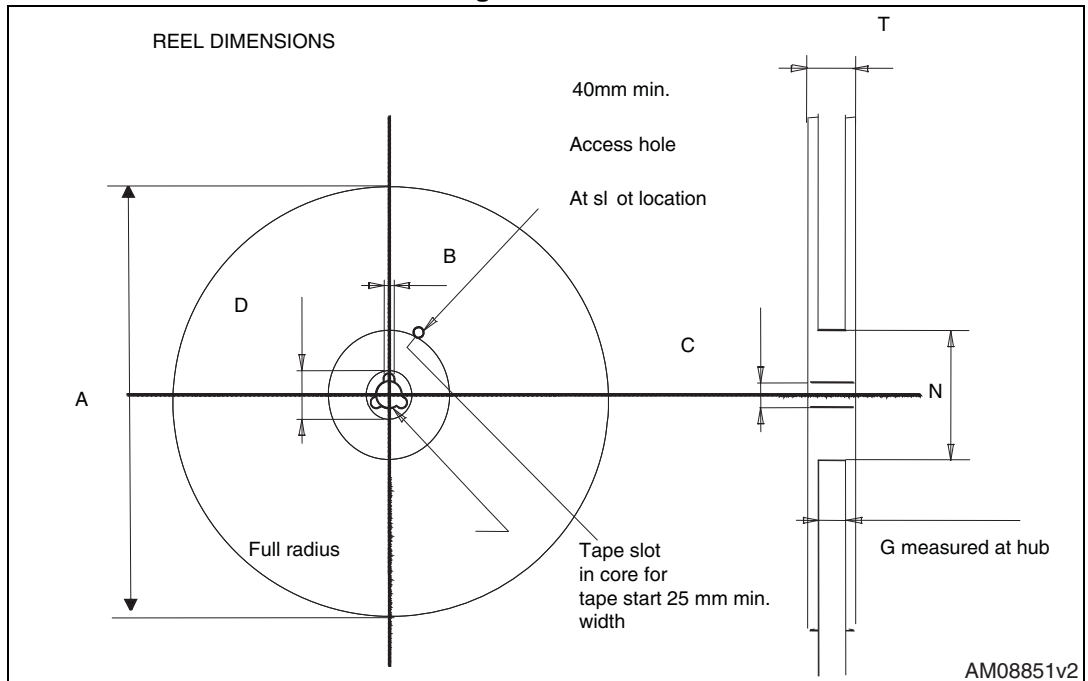


Figure 32. Reel



## 6 Revision history

Table 15. Document revision history

Date	Revision	Changes
23-Feb-2012	1	First release.
10-Sep-2012	2	<ul style="list-style-type: none"><li>– Modified <a href="#">note 2</a> under the <a href="#">Table 2</a>.</li><li>– Updated typical values in <a href="#">Table 4</a>, <a href="#">5</a> and <a href="#">6</a>.</li><li>– Added <a href="#">Section 2.1</a>.</li><li>– Minor text changes on the cover page.</li></ul>
05-Mar-2013	3	Added dv/dt value on <a href="#">Table 2: Absolute maximum ratings</a> .



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