



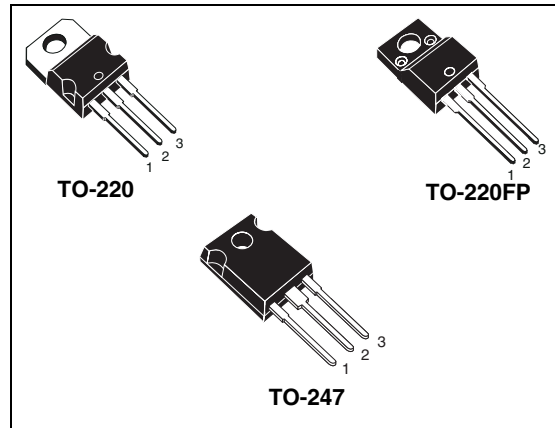
# STF13N95K3 STP13N95K3, STW13N95K3

N-channel 950 V, 0.68  $\Omega$ , 10 A TO-220, TO-220FP, TO-247  
Zener-protected SuperMESH3™ Power MOSFET

## Features

Order codes	V <sub>DSS</sub>	R <sub>DS(on)</sub> max	I <sub>D</sub>	P <sub>W</sub>
STF13N95K3	950 V	< 0.85 $\Omega$	10 A	40 W
STP13N95K3				190 W
STW13N95K3				

- Gate charge minimized
- Extremely large avalanche performance
- 100% avalanche tested
- Very low intrinsic capacitance
- Zener-protected



## Application

Switching applications

## Description

These devices are made using the SuperMESH3™ Power MOSFET technology that is obtained via improvements applied to STMicroelectronics' SuperMESH™ technology combined with a new optimized vertical structure. The resulting product has an extremely low on resistance, superior dynamic performance and high avalanche capability, making it especially suitable for the most demanding applications.

Figure 1. Internal schematic diagram

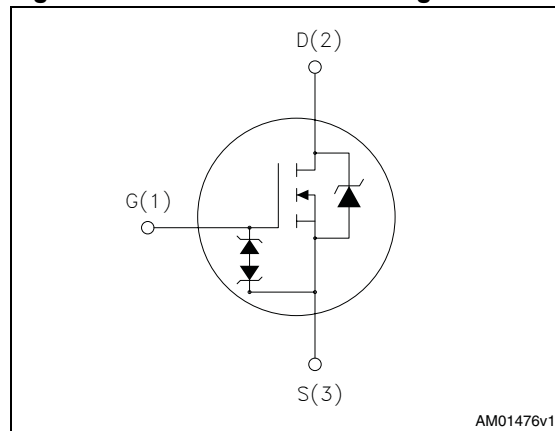


Table 1. Device summary

Order codes	Marking	Package	Packaging
STF13N95K3	13N95K3	TO-220FP	Tube
STP13N95K3		TO-220	
STW13N95K3		TO-247	

## Contents

<b>1</b>	<b>Electrical ratings</b> .....	<b>3</b>
<b>2</b>	<b>Electrical characteristics</b> .....	<b>4</b>
	2.1 Electrical characteristics (curves) .....	6
<b>3</b>	<b>Test circuits</b> .....	<b>9</b>
<b>4</b>	<b>Package mechanical data</b> .....	<b>10</b>
<b>5</b>	<b>Revision history</b> .....	<b>14</b>

# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value		Unit
		TO-220, TO-247	TO-220FP	
$V_{DS}$	Drain source voltage	950		V
$V_{GS}$	Gate- source voltage	$\pm 30$		V
$I_D$	Drain current (continuous) at $T_C = 25\text{ }^\circ\text{C}$	10	10 <sup>(1)</sup>	A
$I_D$	Drain current (continuous) at $T_C = 100\text{ }^\circ\text{C}$	6	6 <sup>(1)</sup>	A
$I_{DM}^{(2)}$	Drain current (pulsed)	40	40 <sup>(1)</sup>	A
$P_{TOT}$	Total dissipation at $T_C = 25\text{ }^\circ\text{C}$	190	40	W
$I_{AR}$	Max current during repetitive or single pulse avalanche (pulse width limited by $T_{jmax}$ )	13		A
$E_{AS}$	Single pulse avalanche energy (starting $T_J = 25\text{ }^\circ\text{C}$ , $I_D = I_{AS}$ , $V_{DD} = 50\text{ V}$ )	400		mJ
$dv/dt^{(3)}$	Peak diode recovery voltage slope	9		V/ns
$T_j$ $T_{stg}$	Operating junction temperature Storage temperature	- 55 to 150		$^\circ\text{C}$

- Limited only by maximum temperature allowed
- Pulse width limited by safe operating area.
- $I_{SD} \leq 10\text{ A}$ ,  $di/dt \leq 400\text{ A}/\mu\text{s}$ ,  $V_{Peak} \leq V_{(BR)DSS}$

**Table 3. Thermal data**

Symbol	Parameter	Value			Unit
		TO-220	TO-247	TO-220FP	
Rthj-case	Thermal resistance junction-case max	0.66		3.13	$^\circ\text{C}/\text{W}$
Rthj-amb	Thermal resistance junction-amb max	62.5	50	62.5	$^\circ\text{C}/\text{W}$
$T_l$	Maximum lead temperature for soldering purpose	300			$^\circ\text{C}$

## 2 Electrical characteristics

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

**Table 4. On/off states**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source breakdown voltage	$I_D = 1\text{ mA}$ , $V_{GS} = 0$	950			V
$I_{DSS}$	Zero gate voltage drain current ( $V_{GS} = 0$ )	$V_{DS} = \text{max rating}$ , $V_{DS} = \text{max rating}$ , $T_c = 125\text{ °C}$			1 50	$\mu\text{A}$ $\mu\text{A}$
$I_{GSS}$	Gate body leakage current ( $V_{DS} = 0$ )	$V_{GS} = \pm 20\text{ V}$			$\pm 10$	$\mu\text{A}$
$V_{GS(th)}$	Gate threshold voltage	$V_{DS} = V_{GS}$ , $I_D = 100\text{ }\mu\text{A}$	3	4	5	V
$R_{DS(on)}$	Static drain-source on resistance	$V_{GS} = 10\text{ V}$ , $I_D = 5\text{ A}$		0.68	0.85	$\Omega$

**Table 5. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$C_{iss}$	Input capacitance			1620		pF
$C_{oss}$	Output capacitance	$V_{DS} = 100\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GS} = 0$	-	117	-	pF
$C_{rss}$	Reverse transfer capacitance			1.2		pF
$C_{o(tr)}^{(1)}$	Equivalent capacitance time related	$V_{GS} = 0$ , $V_{DS} = 0\text{ to }760\text{ V}$	-	115	-	pF
$C_{o(er)}^{(2)}$	Equivalent capacitance energy related			-	131	-
$R_G$	Intrinsic gate resistance	$f = 1\text{ MHz}$ open drain	-	2.3	-	$\Omega$
$Q_g$	Total gate charge	$V_{DD} = 760\text{ V}$ , $I_D = 10\text{ A}$		51		nC
$Q_{gs}$	Gate-source charge	$V_{GS} = 10\text{ V}$	-	10	-	nC
$Q_{gd}$	Gate-drain charge	(see <a href="#">Figure 20</a> )		30		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 6. Switching times**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 475 \text{ V}$ , $I_D = 5 \text{ A}$ , $R_G = 4.7 \Omega$ , $V_{GS} = 10 \text{ V}$ (see <a href="#">Figure 22</a> )	-	18	-	ns
$t_r$	Rise time			16		ns
$t_{d(off)}$	Turn-off delay time			50		ns
$t_f$	Fall time			21		ns

**Table 7. Source drain diode**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{SD}$	Source-drain current		-		10	mA
$I_{SDM}$	Source-drain current (pulsed)			40	A	
$V_{SD}^{(1)}$	Forward on voltage	$I_{SD} = 10 \text{ A}$ , $V_{GS} = 0$	-		1.6	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 10 \text{ A}$ , $V_{DD} = 60 \text{ V}$ $di/dt = 100 \text{ A}/\mu\text{s}$ , (see <a href="#">Figure 21</a> )	-	500		ns
$Q_{rr}$	Reverse recovery charge			9	$\mu\text{C}$	
$I_{RRM}$	Reverse recovery current			36	A	
$t_{rr}$	Reverse recovery time	$I_{SD} = 10 \text{ A}$ , $V_{DD} = 60 \text{ V}$ $di/dt = 100 \text{ A}/\mu\text{s}$ , $T_j = 150 \text{ }^\circ\text{C}$ (see <a href="#">Figure 21</a> )	-	624		ns
$Q_{rr}$	Reverse recovery charge			11	$\mu\text{C}$	
$I_{RRM}$	Reverse recovery current			37	A	

1. 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
$BV_{GSO}$	Gate-source breakdown voltage	$I_{gs} \pm 1 \text{ mA}$ , (open drain)	30	-		V

The built-in-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 TO-220FP

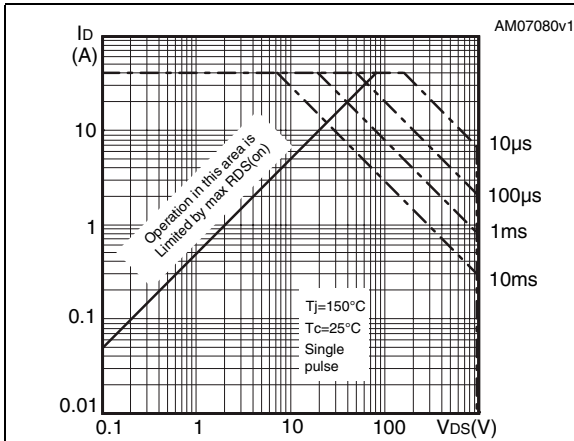


Figure 3. Thermal impedance for TO-220FP

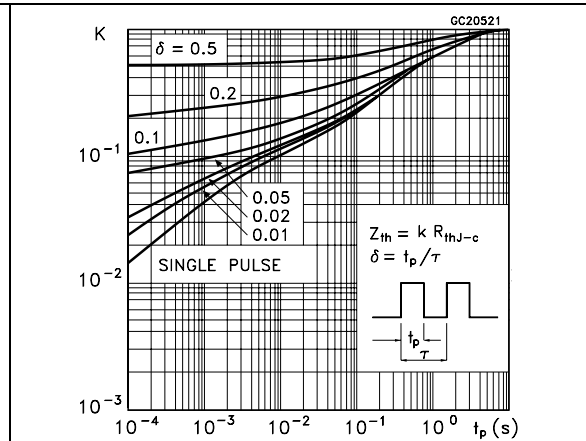


Figure 4. Safe operating area for TO-220

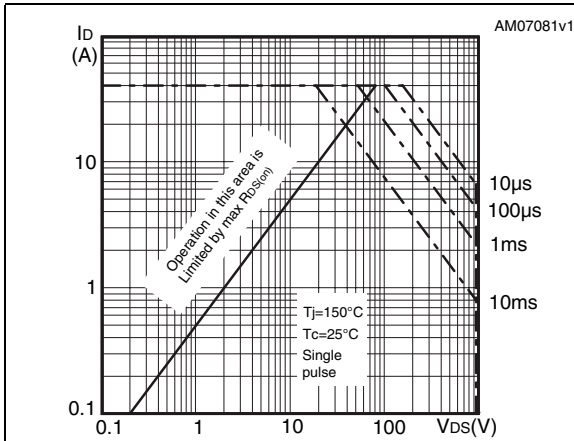


Figure 5. Thermal impedance for TO-220

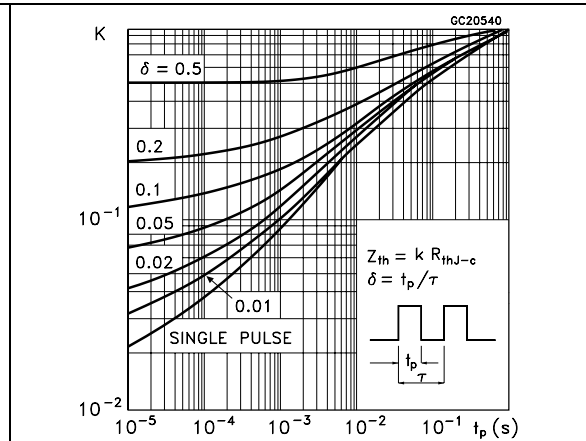


Figure 6. Safe operating area for TO-247

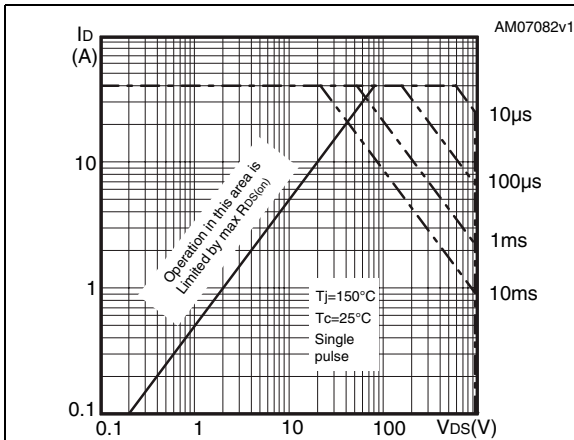


Figure 7. Thermal impedance for TO-247

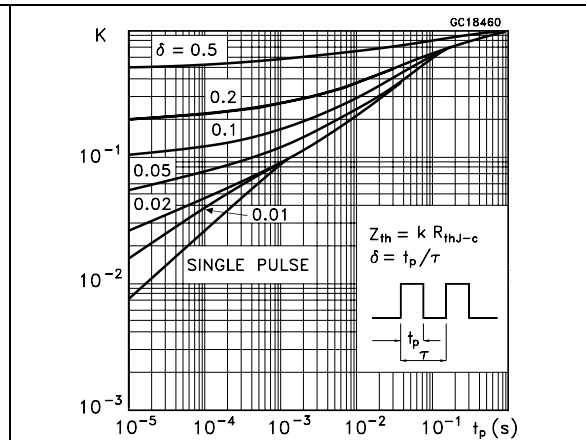


Figure 8. Output characteristics

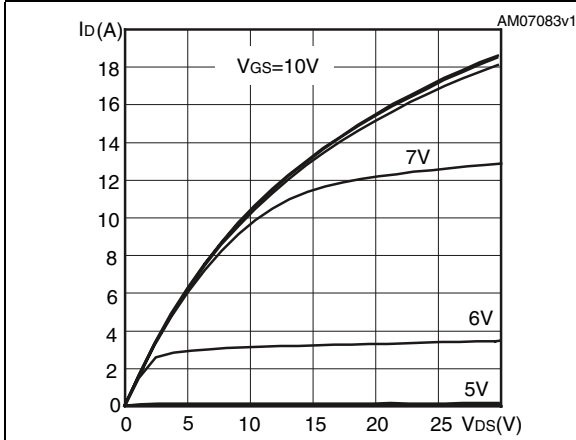


Figure 9. Transfer characteristics

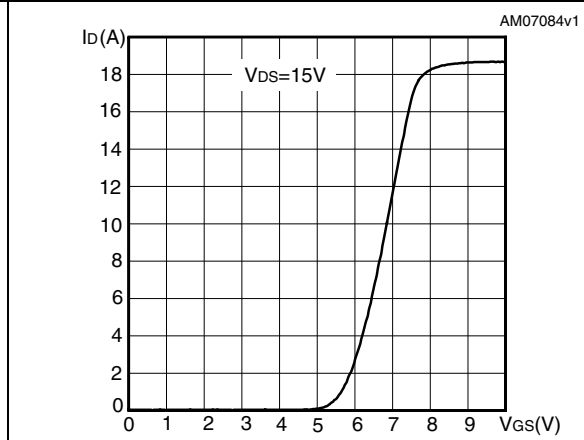


Figure 10. Gate charge vs gate-source voltage Figure 11. Static drain-source on resistance

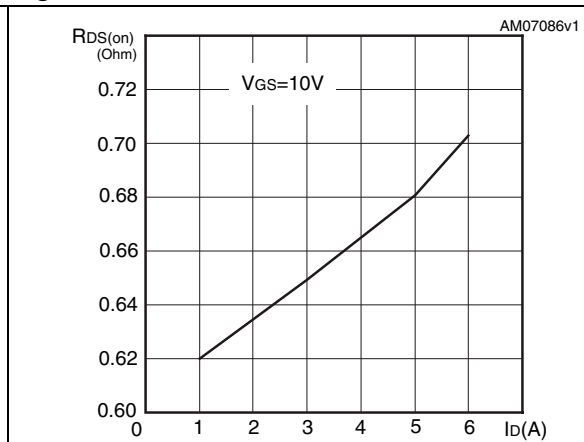
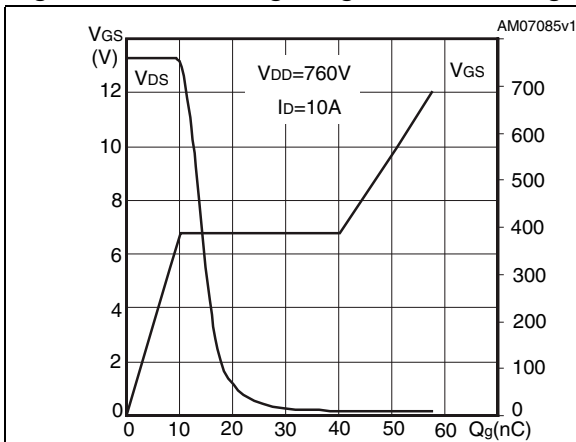


Figure 12. Capacitance variations

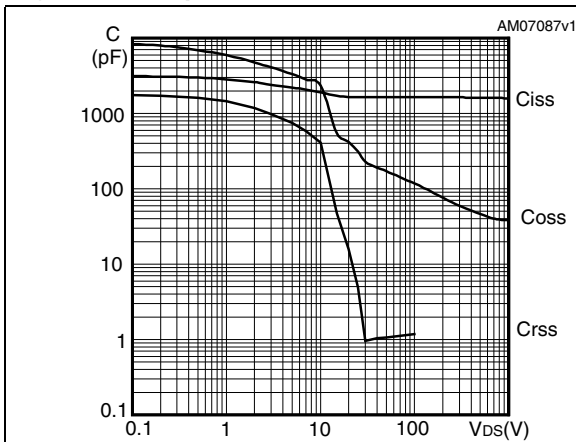


Figure 13. Output capacitance stored energy

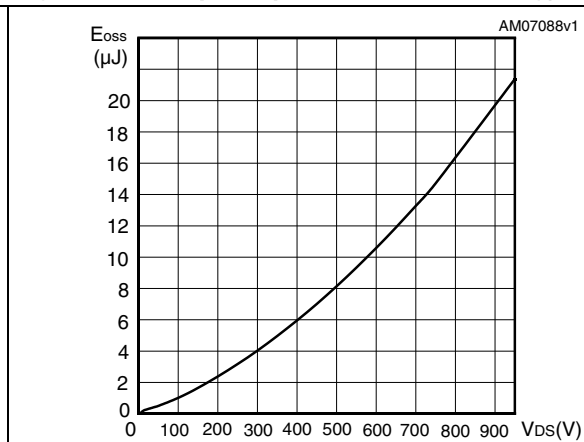


Figure 14. Normalized gate threshold voltage vs temperature

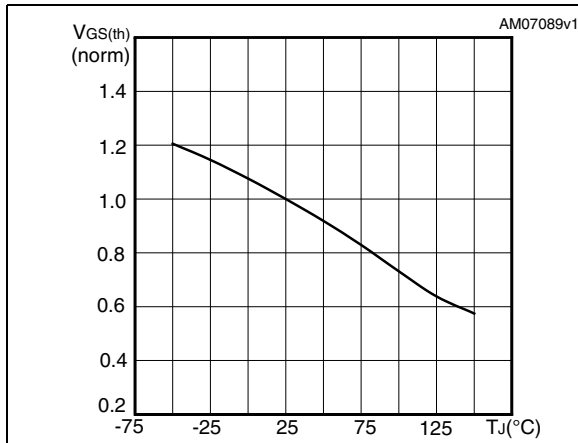


Figure 15. Normalized on resistance vs temperature

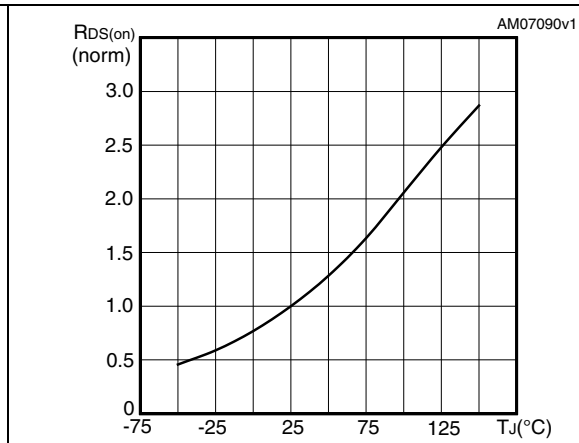


Figure 16. Source-drain diode forward characteristics

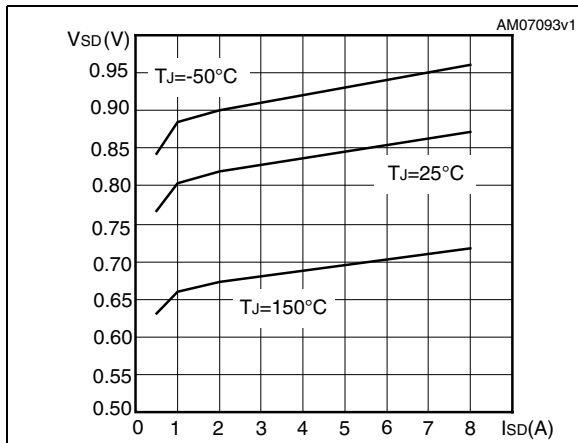


Figure 17. Normalized B<sub>VDSS</sub> vs temperature

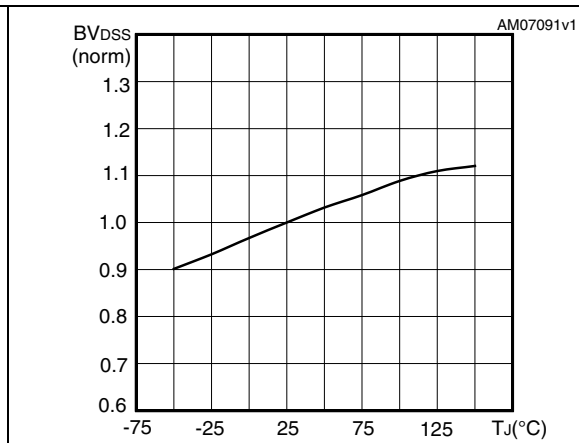
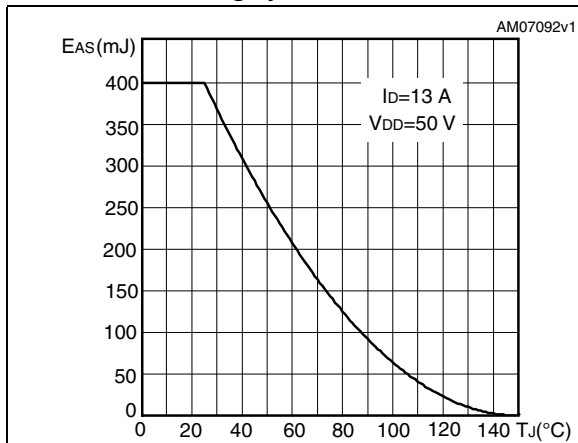


Figure 18. Maximum avalanche energy vs starting T<sub>j</sub>





### 3 Test circuits

Figure 19. Switching times test circuit for resistive load

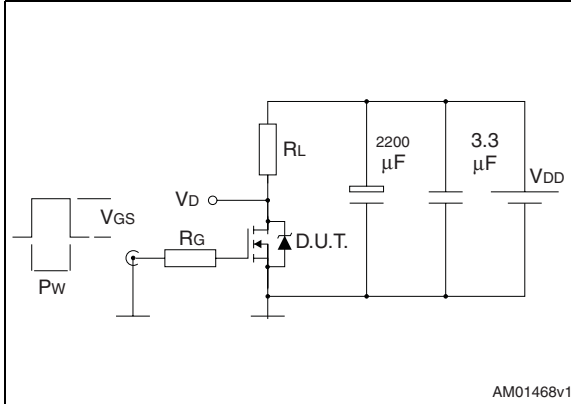


Figure 20. Gate charge test circuit

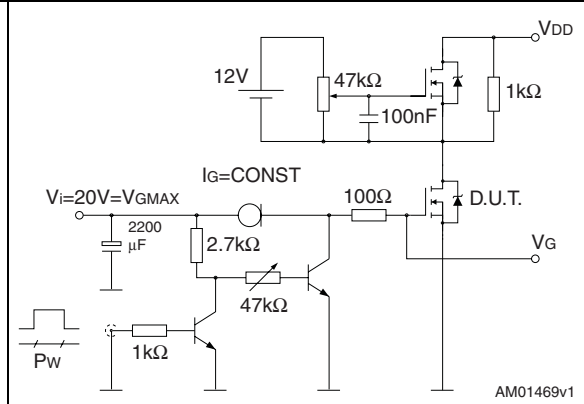


Figure 21. Test circuit for inductive load switching and diode recovery times

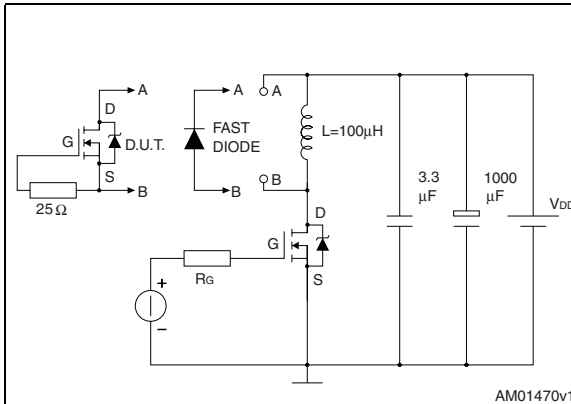


Figure 22. Unclamped inductive load test circuit

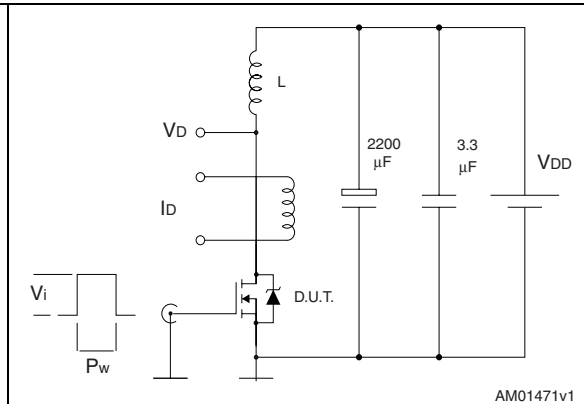


Figure 23. Unclamped inductive waveform

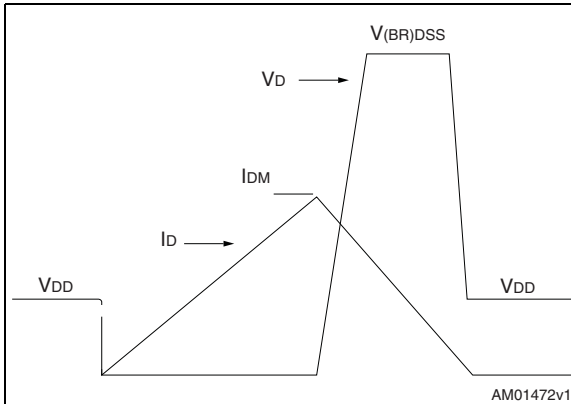
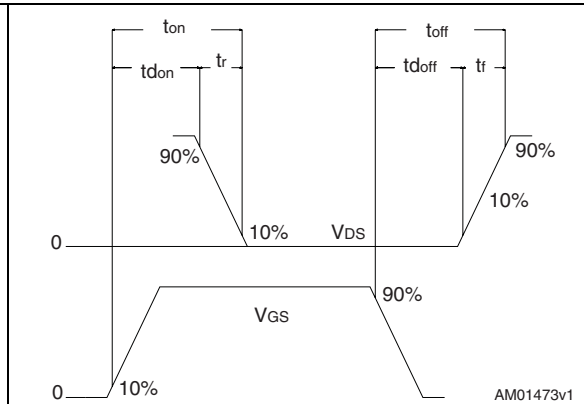


Figure 24. Switching time waveform



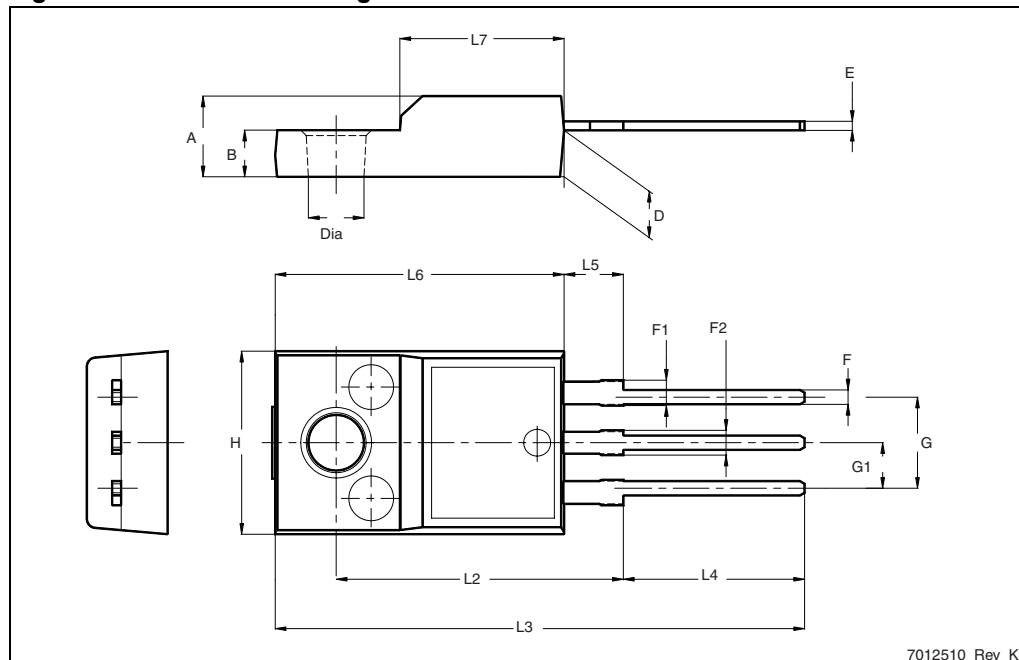
## 4 Package mechanical data

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. TO-220FP mechanical data

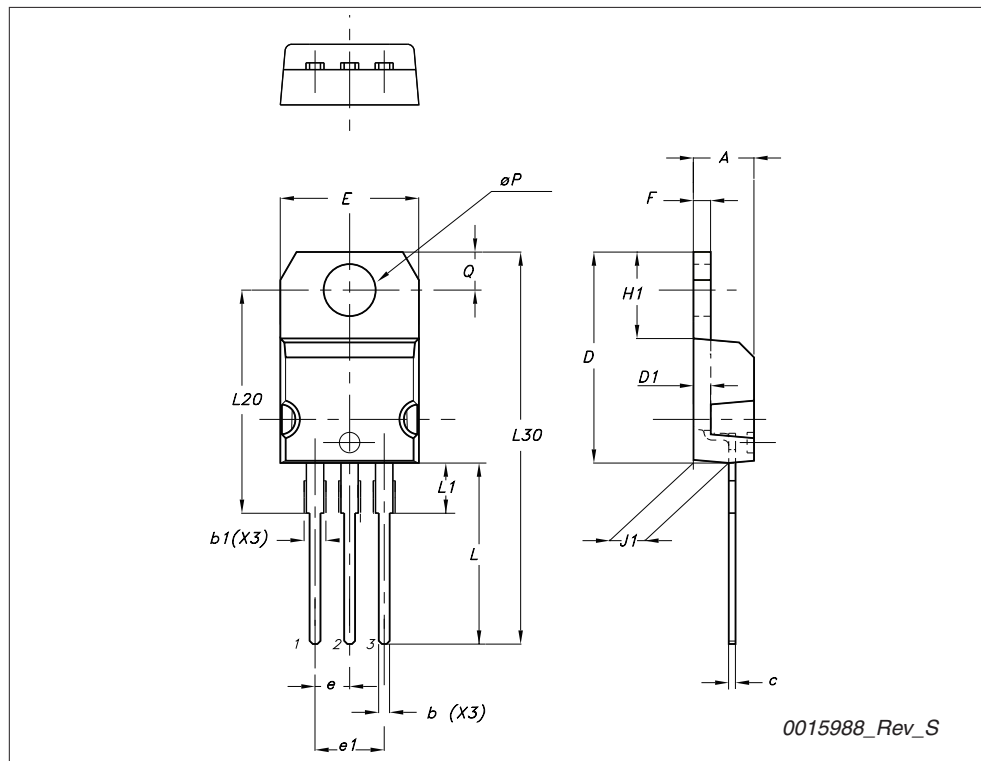
Dim.	mm		
	Min.	Typ.	Max.
A	4.4		4.6
B	2.5		2.7
D	2.5		2.75
E	0.45		0.7
F	0.75		1
F1	1.15		1.70
F2	1.15		1.70
G	4.95		5.2
G1	2.4		2.7
H	10		10.4
L2		16	
L3	28.6		30.6
L4	9.8		10.6
L5	2.9		3.6
L6	15.9		16.4
L7	9		9.3
Dia	3		3.2

Figure 25. TO-220FP drawing



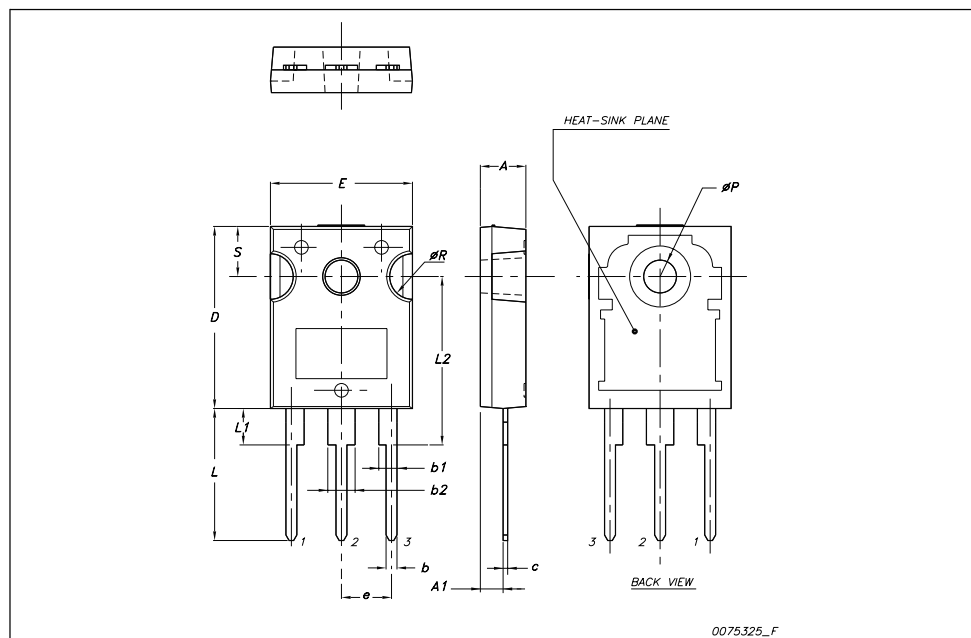
TO-220 type A mechanical data

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	
∅P	3.75		3.85
Q	2.65		2.95



## 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		5.45	
L	14.20		14.80
L1	3.70		4.30
L2		18.50	
øP	3.55		3.65
øR	4.50		5.50
S		5.50	



## 5 Revision history

Table 10. Document revision history

Date	Revision	Changes
15-May-2009	1	First release.
02-Sep-2010	2	Document status promoted from preliminary data to datasheet.

**Please Read Carefully:**

Information in this document is provided solely in connection with ST products. STMicroelectronics NV and its subsidiaries ("ST") reserve the right to make changes, corrections, modifications or improvements, to this document, and the products and services described herein at any time, without notice.

All ST products are sold pursuant to ST's terms and conditions of sale.

Purchasers are solely responsible for the choice, selection and use of the ST products and services described herein, and ST assumes no liability whatsoever relating to the choice, selection or use of the ST products and services described herein.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted under this document. If any part of this document refers to any third party products or services it shall not be deemed a license grant by ST for the use of such third party products or services, or any intellectual property contained therein or considered as a warranty covering the use in any manner whatsoever of such third party products or services or any intellectual property contained therein.

**UNLESS OTHERWISE SET FORTH IN ST'S TERMS AND CONDITIONS OF SALE ST DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY WITH RESPECT TO THE USE AND/OR SALE OF ST PRODUCTS INCLUDING WITHOUT LIMITATION IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION), OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.**

**UNLESS EXPRESSLY APPROVED IN WRITING BY AN AUTHORIZED ST REPRESENTATIVE, ST PRODUCTS ARE NOT RECOMMENDED, AUTHORIZED OR WARRANTED FOR USE IN MILITARY, AIR CRAFT, SPACE, LIFE SAVING, OR LIFE SUSTAINING APPLICATIONS, NOR IN PRODUCTS OR SYSTEMS WHERE FAILURE OR MALFUNCTION MAY RESULT IN PERSONAL INJURY, DEATH, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE. ST PRODUCTS WHICH ARE NOT SPECIFIED AS "AUTOMOTIVE GRADE" MAY ONLY BE USED IN AUTOMOTIVE APPLICATIONS AT USER'S OWN RISK.**

Resale of ST products with provisions different from the statements and/or technical features set forth in this document shall immediately void any warranty granted by ST for the ST product or service described herein and shall not create or extend in any manner whatsoever, any liability of ST.

ST and the ST logo are trademarks or registered trademarks of ST in various countries.

Information in this document supersedes and replaces all information previously supplied.

The ST logo is a registered trademark of STMicroelectronics. All other names are the property of their respective owners.

© 2010 STMicroelectronics - All rights reserved

STMicroelectronics group of companies

Australia - Belgium - Brazil - Canada - China - Czech Republic - Finland - France - Germany - Hong Kong - India - Israel - Italy - Japan - Malaysia - Malta - Morocco - Philippines - Singapore - Spain - Sweden - Switzerland - United Kingdom - United States of America

[www.st.com](http://www.st.com)

