



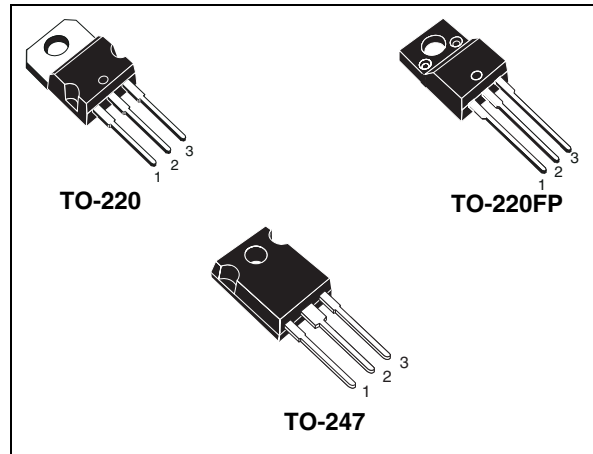
# STF13N95K3 STP13N95K3, STW13N95K3

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	< 0.68 $\Omega$	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

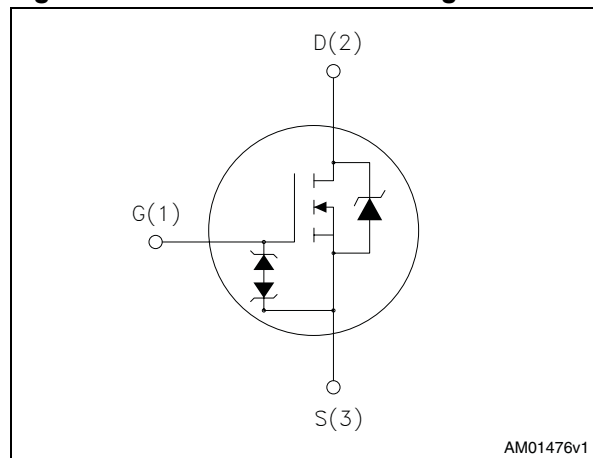


Table 1. Device summary

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

# Contents

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# 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		$^\circ\text{C}$

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

**Table 3. Thermal data**

Symbol	Parameter	Value			Unit
		TO-220	TO-247	TO-220FP	
$R_{thj-case}$	Thermal resistance junction-case max	0.66		3.13	$^\circ\text{C}/\text{W}$
$R_{thj-amb}$	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			pF
$R_G$	Intrinsic gate resistance	$f = 1\text{ MHz open drain}$	-	2.3	-	$\Omega$	
$Q_g$	Total gate charge	$V_{DD} = 760\text{ V}, I_D = 10\text{ A}$ $V_{GS} = 10\text{ V}$ (see <a href="#">Figure 20</a> )	-	51	-	nC	
$Q_{gs}$	Gate-source charge			10			nC
$Q_{gd}$	Gate-drain charge			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	$V_{DD} = 475 \text{ V}$ , $I_D = 5 \text{ A}$ , $R_G = 4.7 \text{ } \Omega$ , $V_{GS} = 10 \text{ V}$ (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

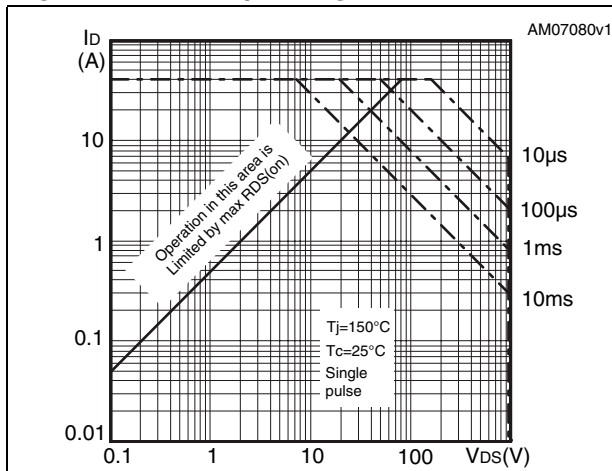


Figure 3. Thermal impedance for TO-220FP

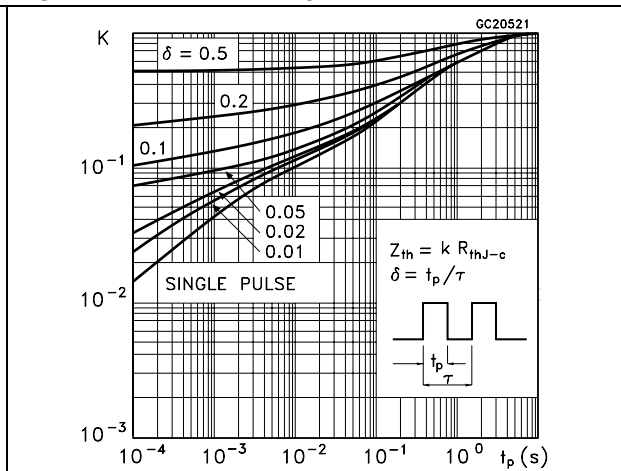


Figure 4. Safe operating area for TO-220

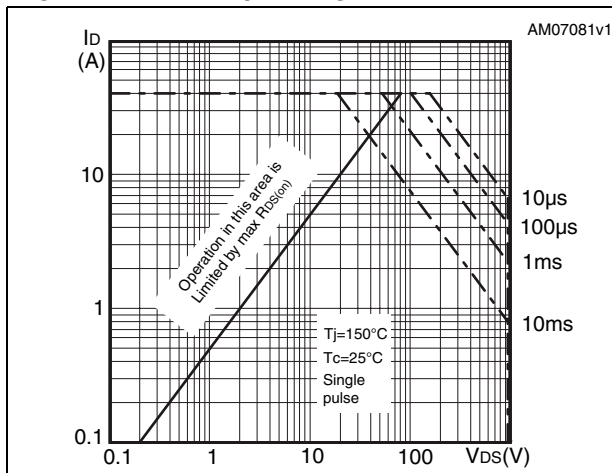


Figure 5. Thermal impedance for TO-220

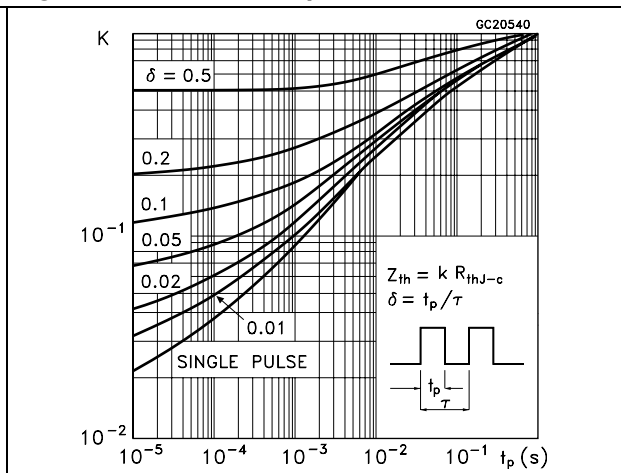


Figure 6. Safe operating area for TO-247

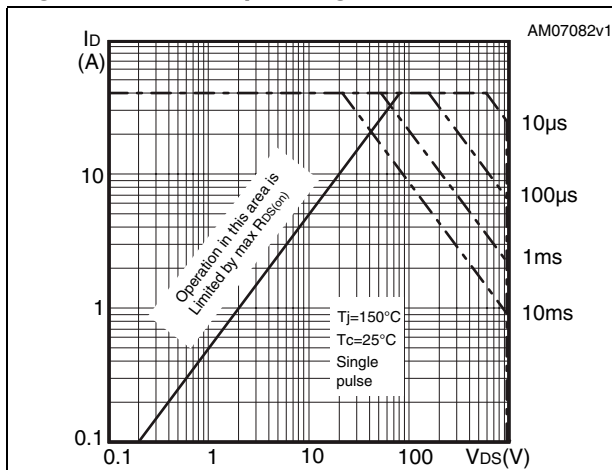


Figure 7. Thermal impedance for TO-247

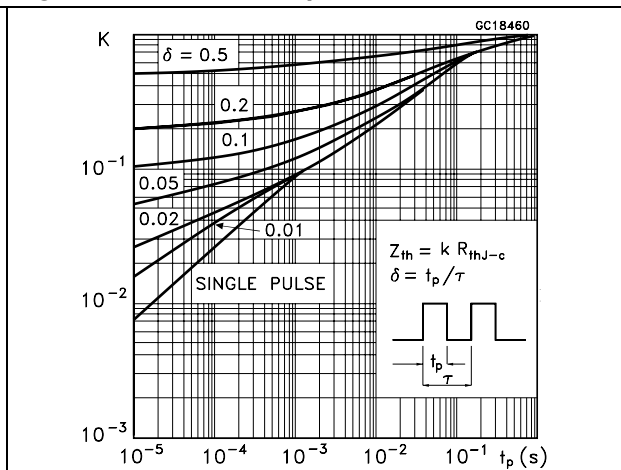


Figure 8. Output characteristics

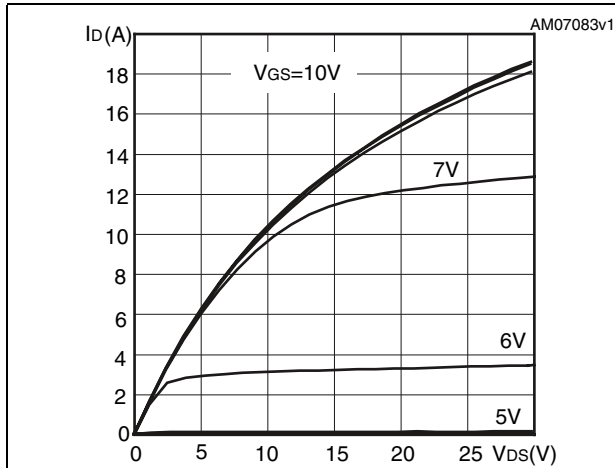


Figure 9. Transfer characteristics

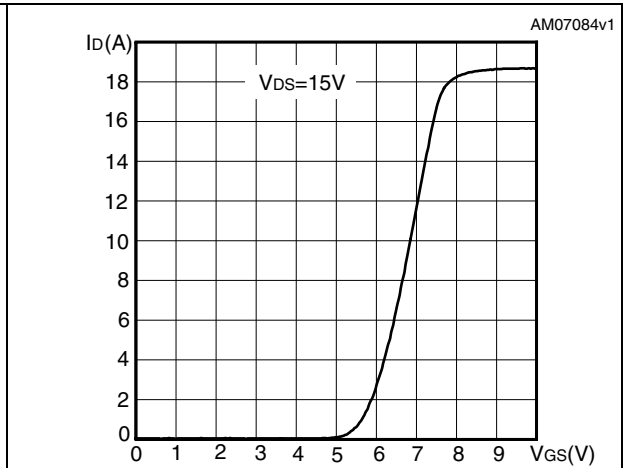


Figure 10. Gate charge vs gate-source voltage Figure 11. Static drain-source on resistance

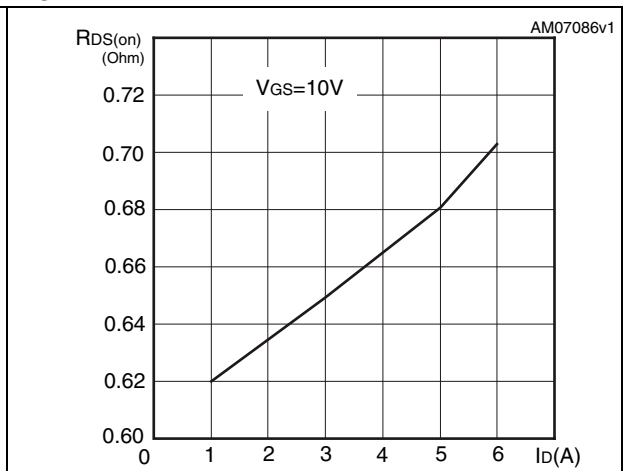
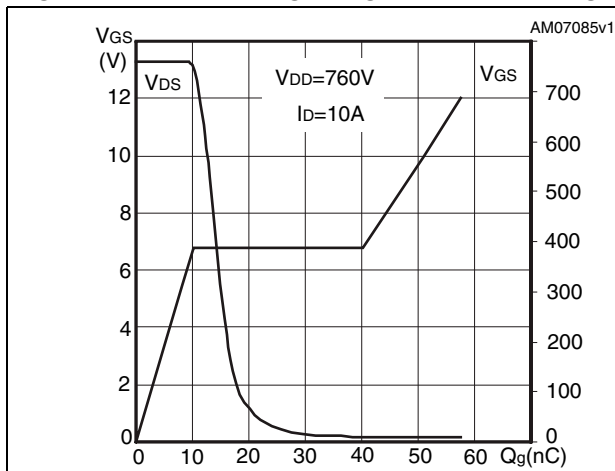


Figure 12. Capacitance variations

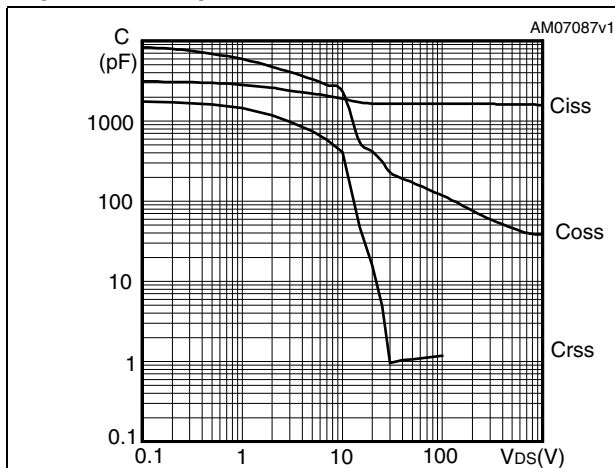


Figure 13. Output capacitance stored energy

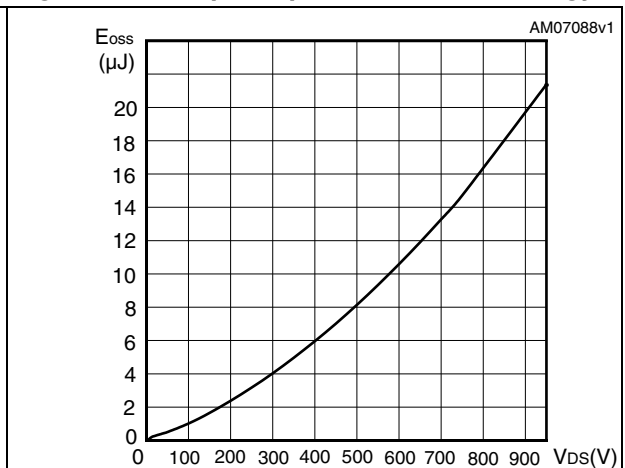


Figure 14. Normalized gate threshold voltage vs temperature

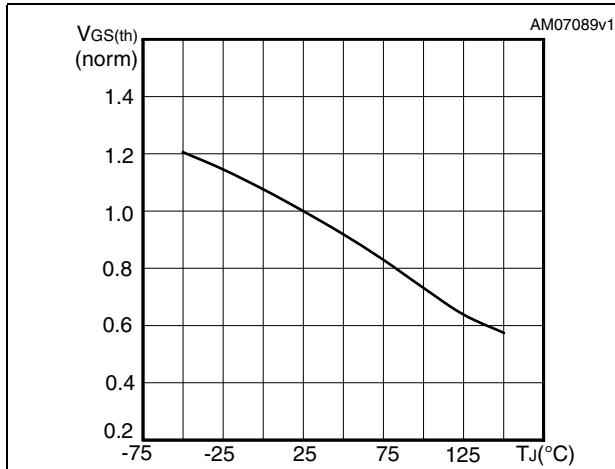


Figure 15. Normalized on resistance vs temperature

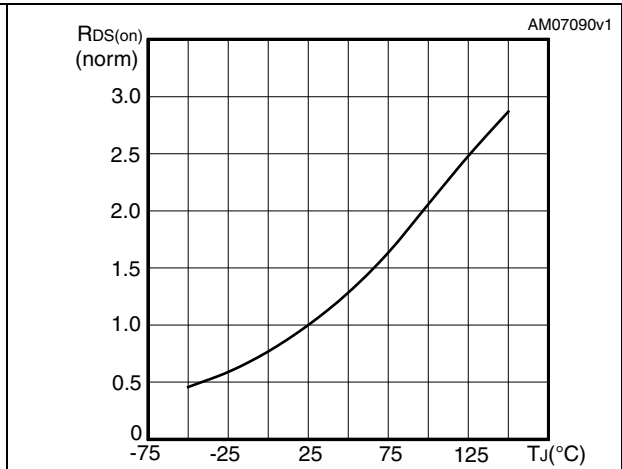


Figure 16. Source-drain diode forward characteristics

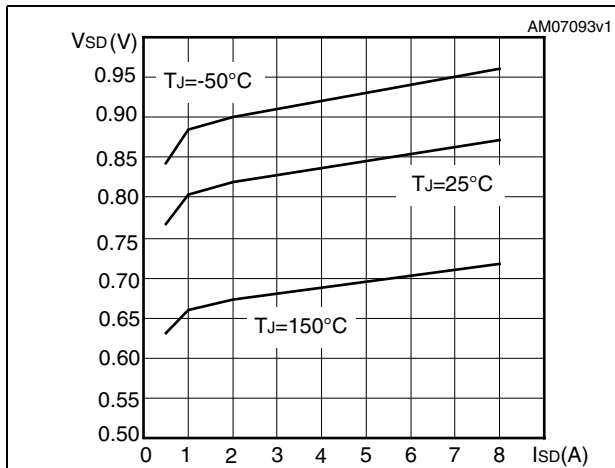


Figure 17. Normalized B<sub>VDSS</sub> vs temperature

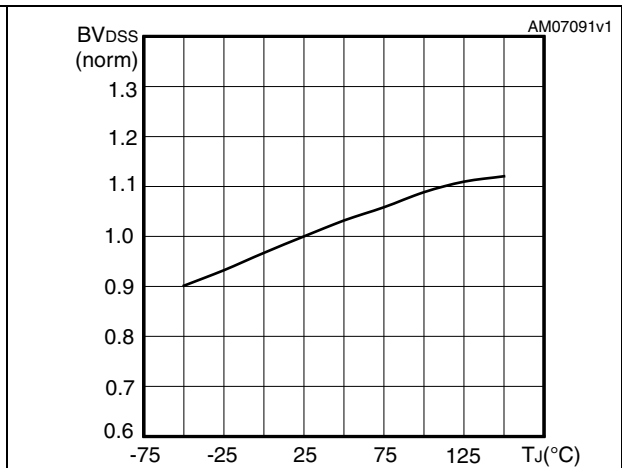
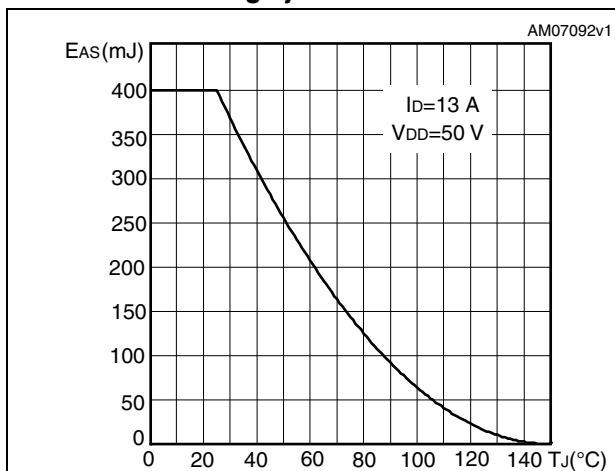


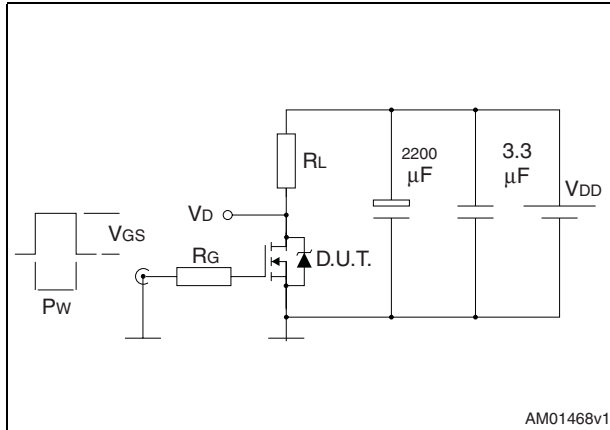
Figure 18. Maximum avalanche energy vs starting Tj





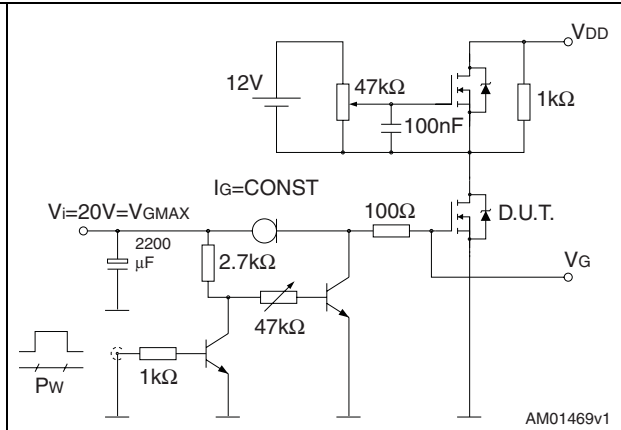
### 3 Test circuits

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



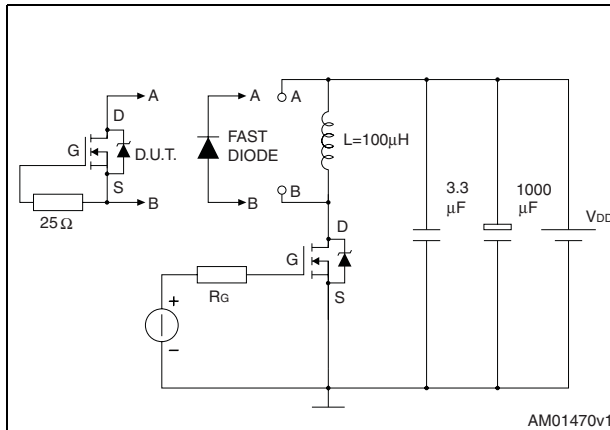
AM01468v1

**Figure 20. Gate charge test circuit**



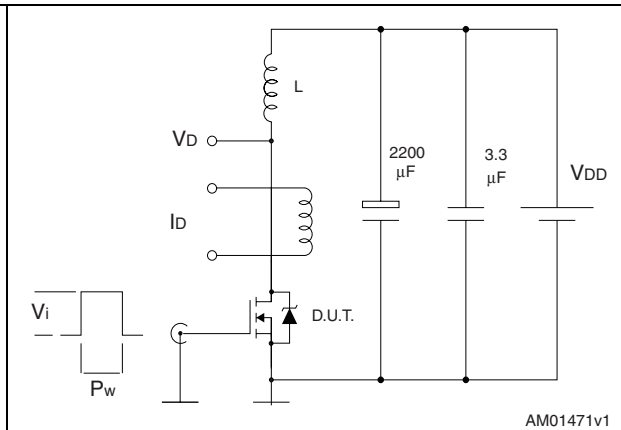
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**Figure 21. Test circuit for inductive load switching and diode recovery times**



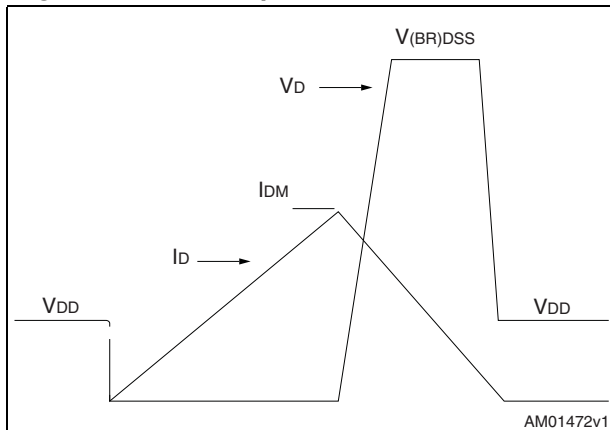
AM01470v1

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



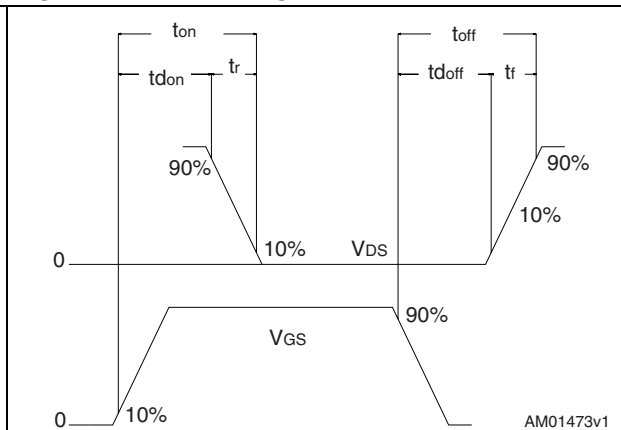
AM01471v1

**Figure 23. Unclamped inductive waveform**



AM01472v1

**Figure 24. Switching time waveform**



AM01473v1

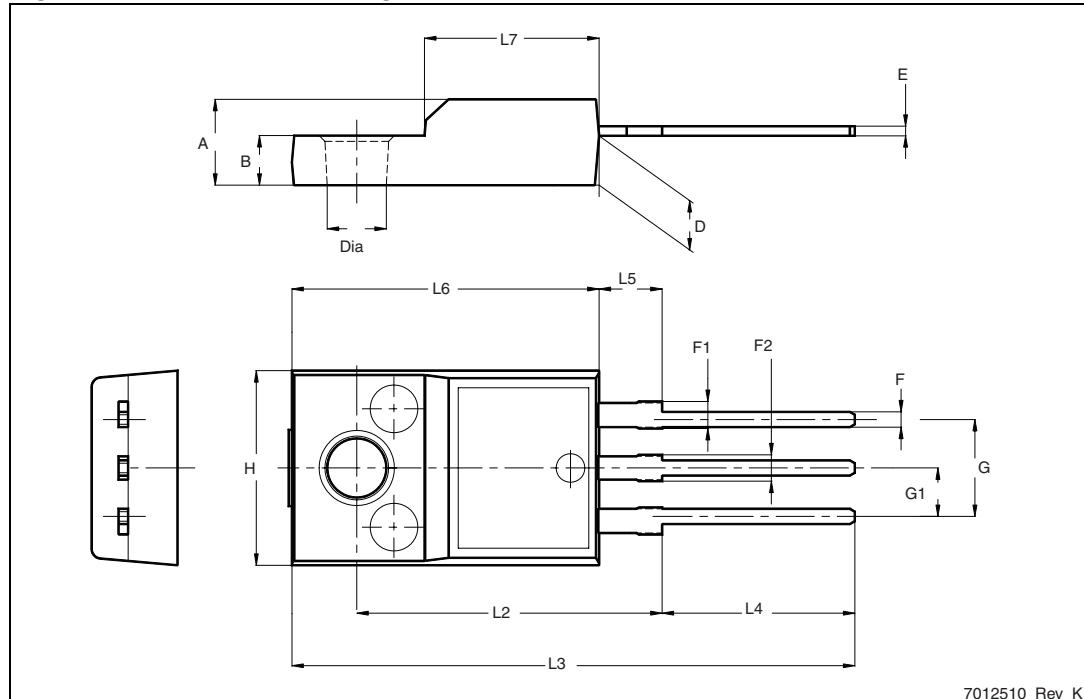
## 4 Package mechanical data

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 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

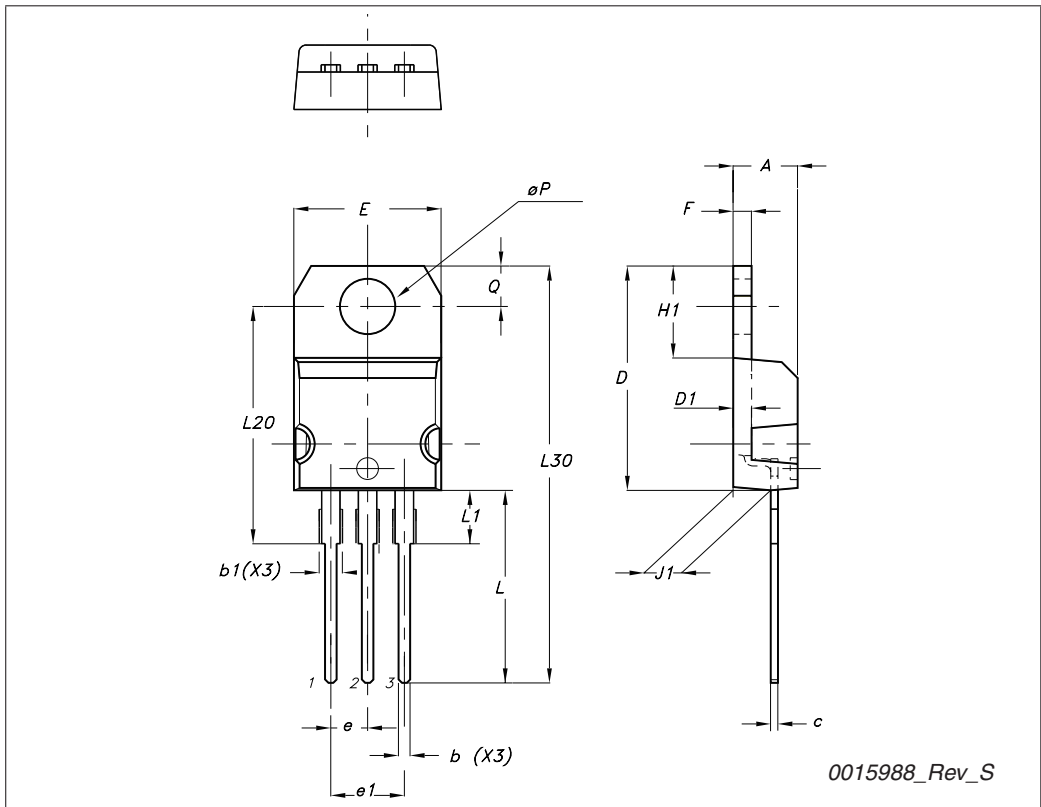
Figure 25. TO-220FP drawing



7012510 Rev. K

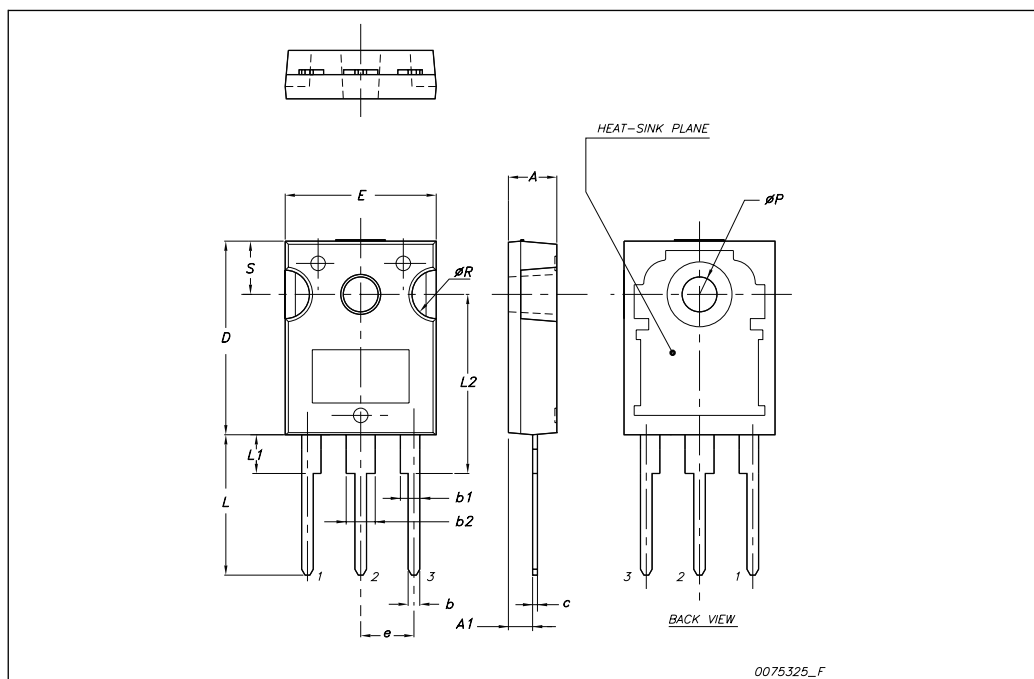
TO-220 type A mechanical data

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.

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