

## N-channel 950 V, 0.41 $\Omega$ typ., 12 A SuperMESH™ 5 Power MOSFETs in TO-220FP, TO-220 and TO-247 packages

Datasheet - production data

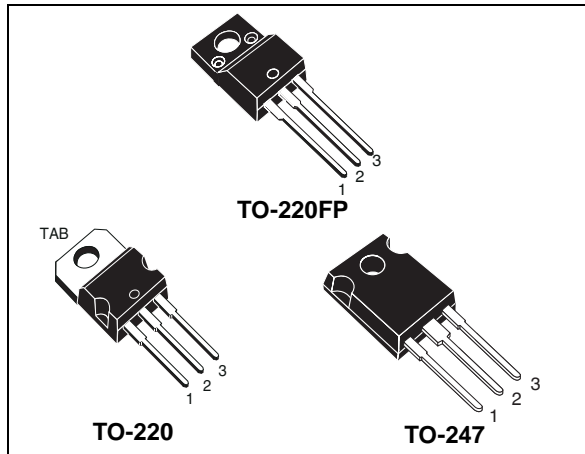
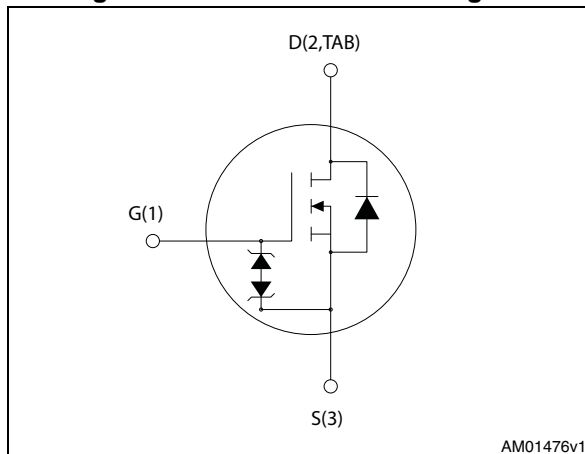


Figure 1. Internal schematic diagram



### Features

Order codes	$V_{DS}$	$R_{DS(on)max}$	$I_D$	$P_{TOT}$
STF15N95K5	950 V	0.5 $\Omega$	12 A	30 W
STP15N95K5				170 W
STW15N95K5				170 W

- TO-220 worldwide best  $R_{DS(on)}$
- Worldwide best FOM (figure of merit)
- Ultra low gate charge
- 100% avalanche tested
- Zener-protected

### Applications

- Switching applications

### Description

These devices are N-channel Power MOSFETs developed using SuperMESH™ 5 technology. This revolutionary, avalanche-rugged, high voltage Power MOSFET technology is based on an innovative proprietary vertical structure. The result is a drastic reduction in on-resistance and ultra low gate charge for applications which require superior power density and high efficiency.

Table 1. Device summary

Order codes	Marking	Package	Packaging
STF15N95K5	15N95K5	TO-220FP	Tube
STP15N95K5	15N95K5	TO-220	
STW15N95K5	15N95K5	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	
$V_{GS}$	Gate- source voltage	$\pm 30$		V
$I_D$	Drain current (continuous) at $T_C = 25\text{ }^\circ\text{C}$	12	12 <sup>(1)</sup>	A
$I_D$	Drain current (continuous) at $T_C = 100\text{ }^\circ\text{C}$	7.6	7.6 <sup>(1)</sup>	A
$I_{DM}^{(2)}$	Drain current (pulsed)	48	48 <sup>(1)</sup>	A
$P_{TOT}$	Total dissipation at $T_C = 25\text{ }^\circ\text{C}$	170	30	W
$I_{AR}$	Max current during repetitive or single pulse avalanche (pulse width limited by $T_{jmax}$ )	4		A
$E_{AS}$	Single pulse avalanche energy (starting $T_J = 25\text{ }^\circ\text{C}$ , $I_D = I_{AS}$ , $V_{DD} = 50\text{ V}$ )	124		mJ
ESD	Gate-source human body model (R= 1,5 k $\Omega$ , C = 100 pF)	2		kV
$V_{ISO}$	Insulation withstand voltage (RMS) from all three leads to external heat sink (t=1 s; $T_C = 25\text{ }^\circ\text{C}$ )	2500		V
dv/dt <sup>(3)</sup>	Peak diode recovery voltage slope	4.5		V/ns
dv/dt <sup>(4)</sup>	MOSFET dv/dt ruggedness	50		V/ns
$T_J$ $T_{stg}$	Operating junction temperature Storage temperature	-55 to 150		$^\circ\text{C}$

1. Limited by maximum junction temperature.
2. Pulse width limited by safe operating area.
3.  $I_{SD} \leq 12$ ,  $di/dt \leq 100\text{ A}/\mu\text{s}$ ,  $V_{DS(peak)} \leq V_{(BR)DSS}$
4.  $V_{DS} \leq 760\text{ V}$

**Table 3. Thermal data**

Symbol	Parameter	Value			Unit
		TO-220	TO-247	TO-220FP	
$R_{thj-case}$	Thermal resistance junction-case max	0.74		4.2	$^\circ\text{C}/\text{W}$
$R_{thj-amb}$	Thermal resistance junction-amb max	62.5	50	62.5	$^\circ\text{C}/\text{W}$

## 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 ( $V_{GS} = 0$ )	$V_{DS} = 950\text{ V},$			1	$\mu\text{A}$
		$V_{DS} = 950\text{ V}, T_c = 125\text{ °C}$			50	$\mu\text{A}$
$I_{GSS}$	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	$V_{GS} = 10\text{ V}, I_D = 6\text{ A}$		0.41	0.50	$\Omega$

**Table 5. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$C_{iss}$	Input capacitance	$V_{DS} = 100\text{ V}, f = 1\text{ MHz}, V_{GS} = 0$	-	855	-	pF
$C_{oss}$	Output capacitance		-	65		pF
$C_{rss}$	Reverse transfer capacitance		-	1		pF
$C_{o(tr)}^{(1)}$	Equivalent capacitance time related	$V_{GS} = 0, V_{DS} = 0\text{ to }760\text{ V}$	-	104	-	pF
$C_{o(er)}^{(2)}$	Equivalent capacitance energy related		-	38	-	pF
$R_G$	Intrinsic gate resistance	$f = 1\text{ MHz open drain}$	-	6	-	$\Omega$
$Q_g$	Total gate charge	$V_{DD} = 760\text{ V}, I_D = 12\text{ A}$ $V_{GS} = 10\text{ V}$ (see <a href="#">Figure 20</a> )	-	30	-	nC
$Q_{gs}$	Gate-source charge		-	5	-	nC
$Q_{gd}$	Gate-drain charge		-	22	-	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
$t_{d(v)}$	Voltage delay time	$V_{DD} = 475 \text{ V}$ , $I_D = 6 \text{ A}$ , $R_G = 4.7 \text{ } \Omega$ , $V_{GS} = 10 \text{ V}$ (see <a href="#">Figure 22</a> )	-	23	-	ns
$t_{r(v)}$	Voltage rise time		-	20	-	ns
$t_{f(i)}$	Current fall time		-	62	-	ns
$t_{c(off)}$	Crossing time		-	11	-	ns

Table 7. Source drain diode

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{SD}$	Source-drain current		-		12	A
$I_{SDM}$	Source-drain current (pulsed)		48	A		
$V_{SD}^{(1)}$	Forward on voltage	$I_{SD} = 12 \text{ A}$ , $V_{GS} = 0$	-		1.5	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 12 \text{ A}$ , $V_{DD} = 60 \text{ V}$ $di/dt = 100 \text{ A}/\mu\text{s}$ , (see <a href="#">Figure 21</a> )	-	444		ns
$Q_{rr}$	Reverse recovery charge		-	7		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current		-	32		A
$t_{rr}$	Reverse recovery time	$I_{SD} = 12 \text{ A}$ , $V_{DD} = 60 \text{ V}$ $di/dt = 100 \text{ A}/\mu\text{s}$ , $T_j = 150 \text{ } ^\circ\text{C}$ (see <a href="#">Figure 21</a> )	-	630		ns
$Q_{rr}$	Reverse recovery charge		-	9.2		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current		-	29		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
$V_{(BR)GSO}$	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 TO-220FP

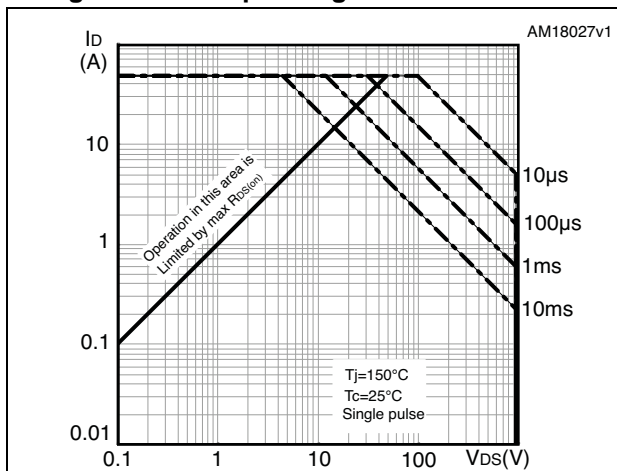


Figure 3. Thermal impedance for TO-220FP

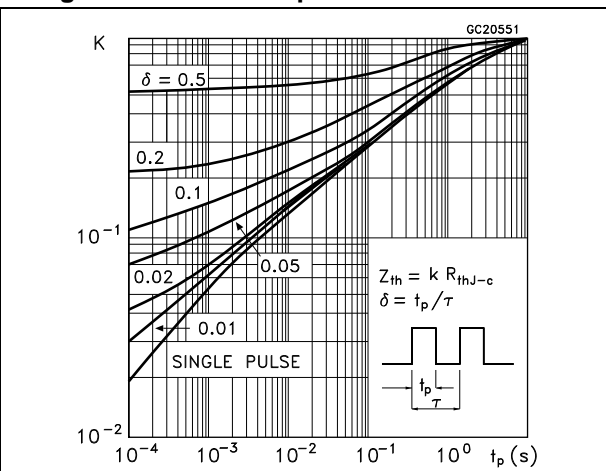


Figure 4. Safe operating area for TO-220

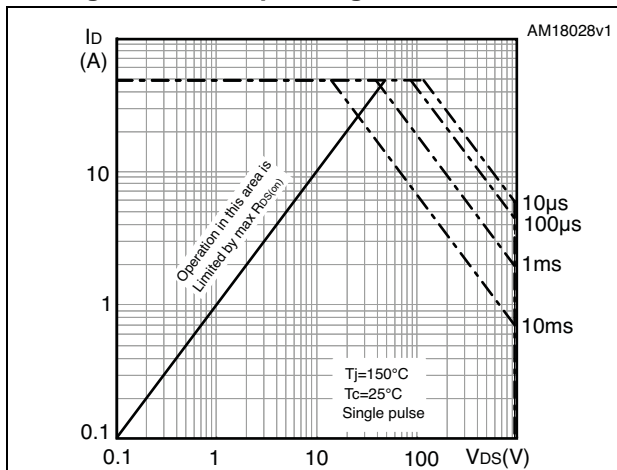


Figure 5. Thermal impedance for TO-220

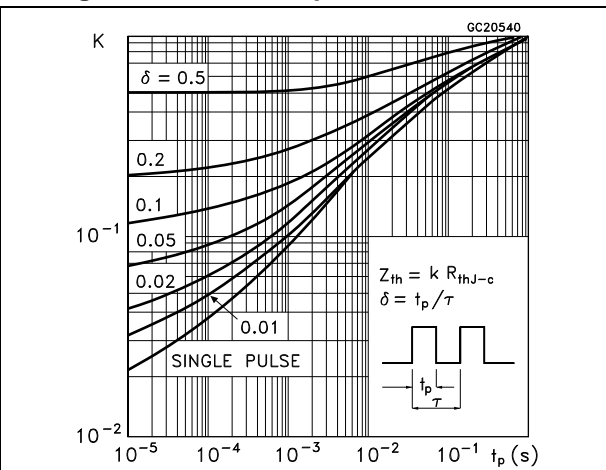


Figure 6. Safe operating area for TO-247

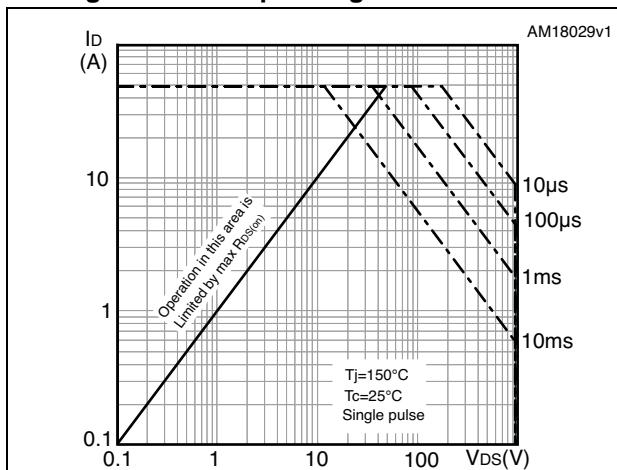


Figure 7. Thermal impedance for TO-247

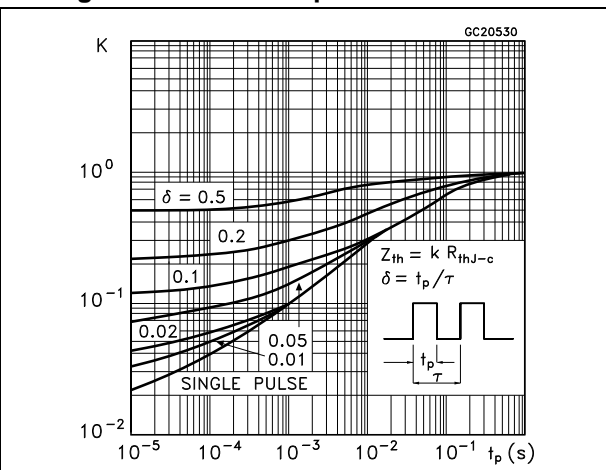


Figure 8. Output characteristics

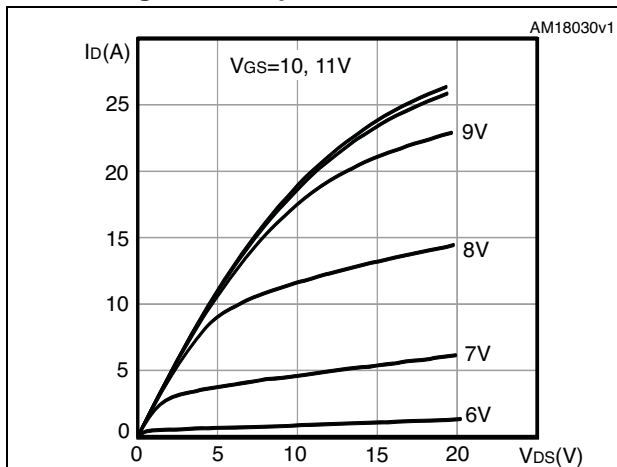


Figure 9. Transfer characteristics

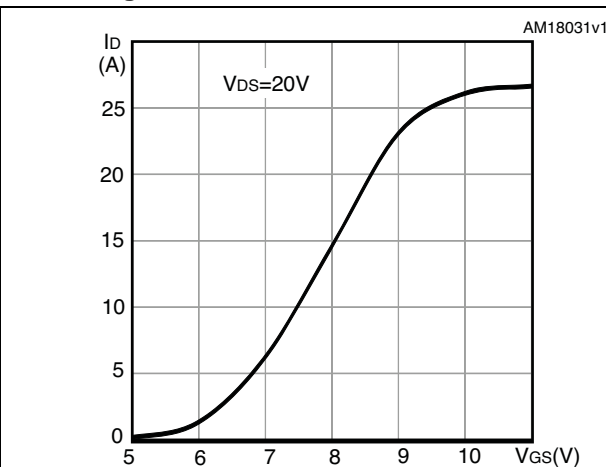


Figure 10. Gate charge vs gate-source voltage

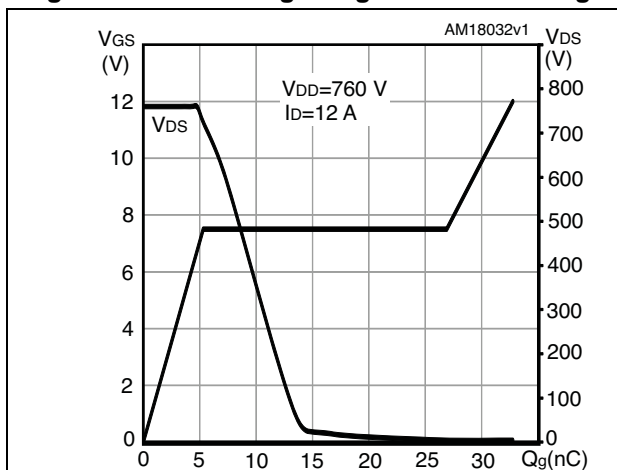


Figure 11. Static drain-source on-resistance

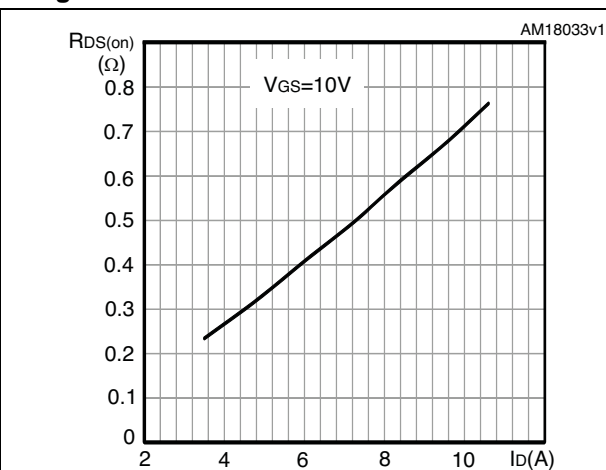


Figure 12. Capacitance variations

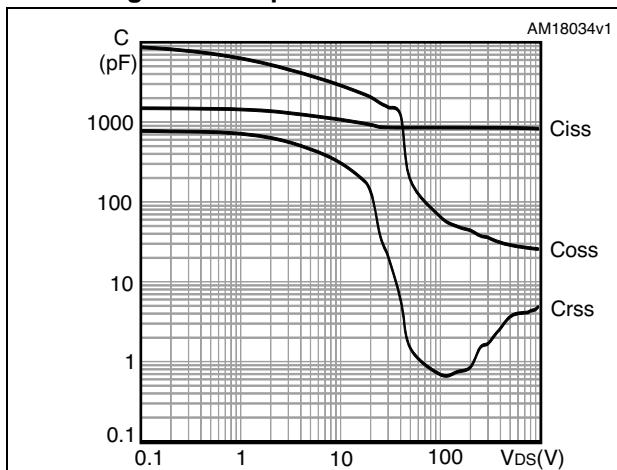


Figure 13. Output capacitance stored energy

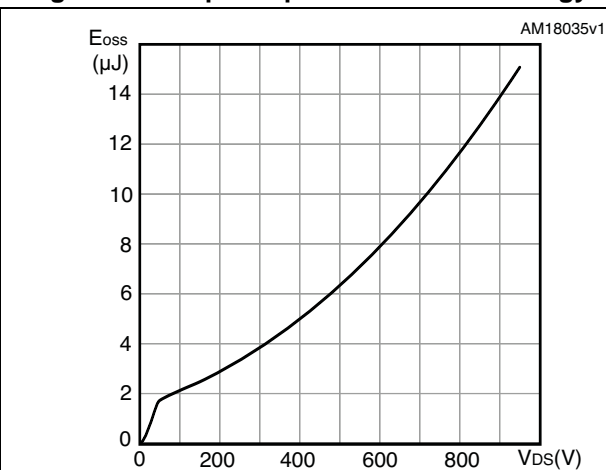


Figure 14. Normalized gate threshold voltage vs temperature

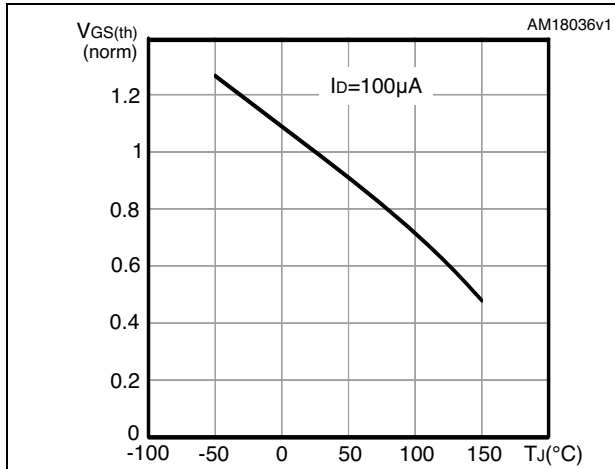


Figure 15. Normalized on-resistance vs temperature

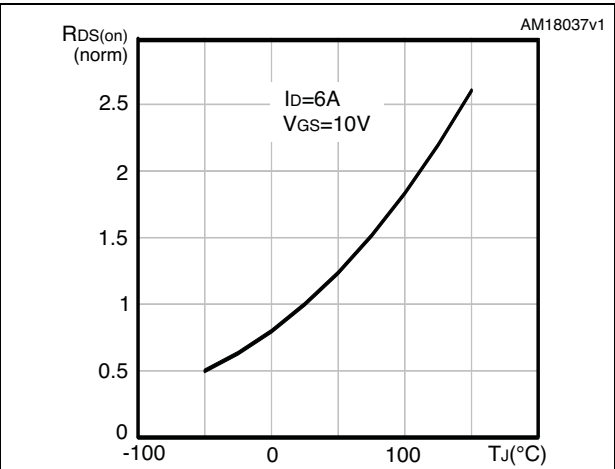


Figure 16. Normalized V<sub>DS</sub> vs temperature

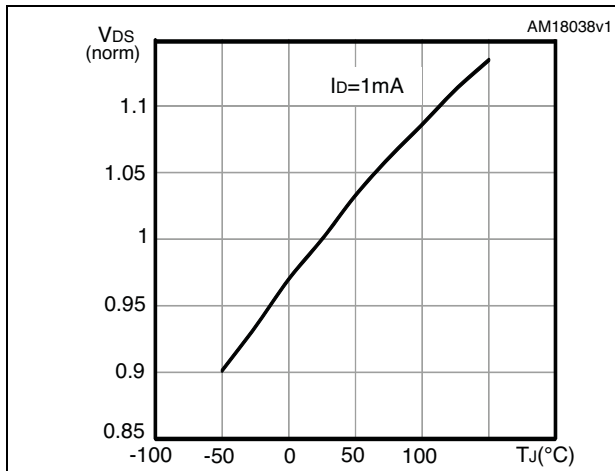


Figure 17. Source-drain diode forward characteristics

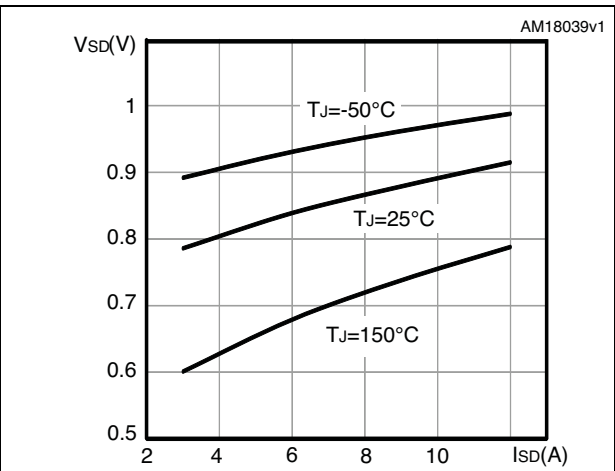
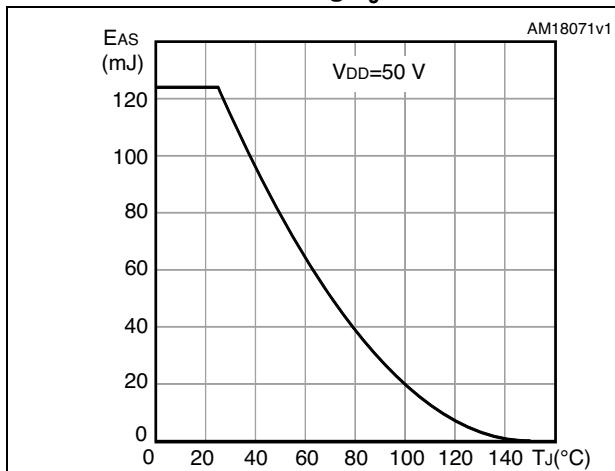


Figure 18. Maximum avalanche energy vs starting T<sub>J</sub>





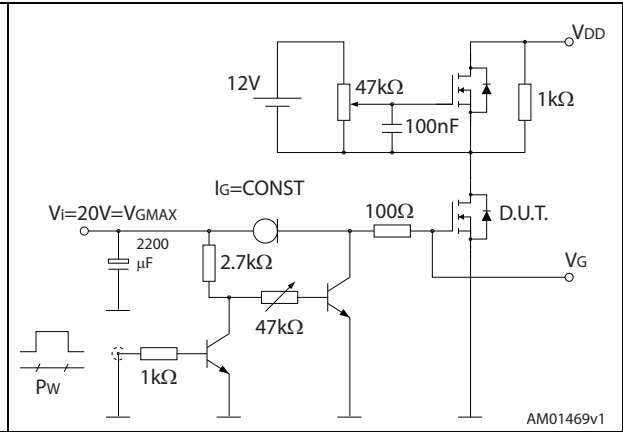
### 3 Test circuits

Figure 19. Switching times test circuit for resistive load



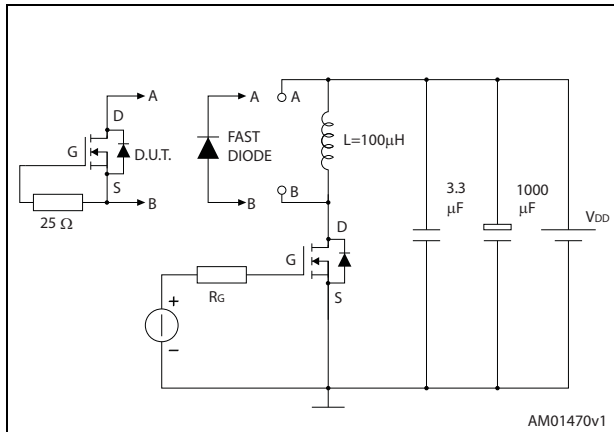
AM01468v1

Figure 20. Gate charge test circuit



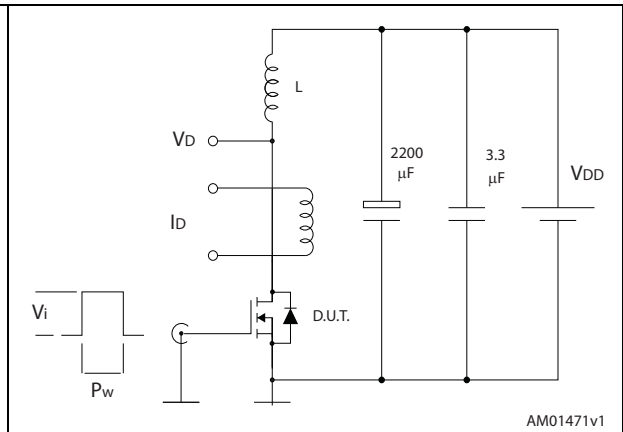
AM01469v1

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



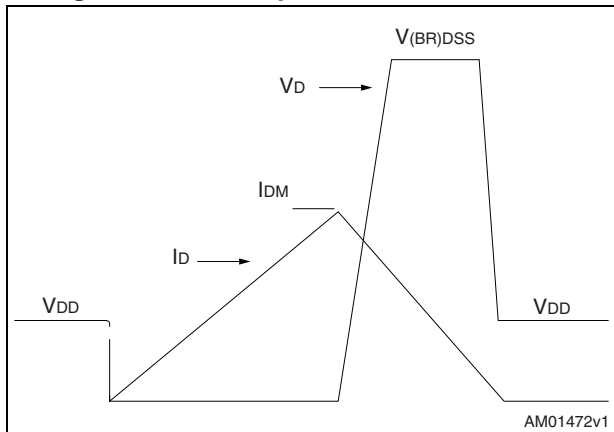
AM01470v1

Figure 22. Unclamped inductive load test circuit



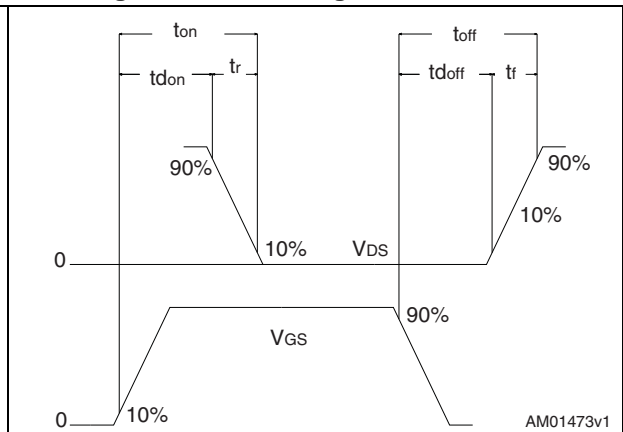
AM01471v1

Figure 23. Unclamped inductive waveform



AM01472v1

Figure 24. Switching time waveform

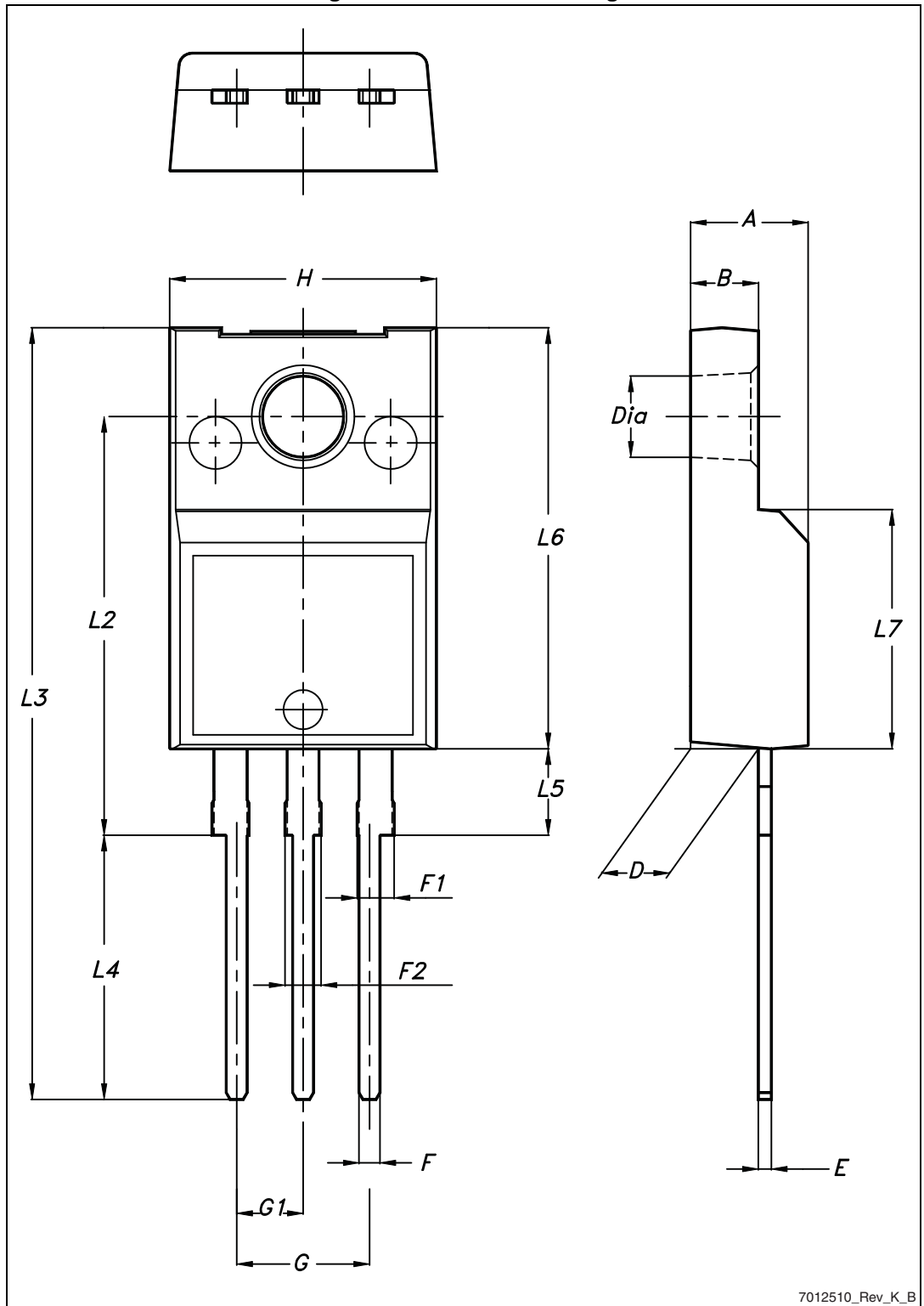


AM01473v1

## 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.

Figure 25. TO-220FP drawing



7012510\_Rev\_K\_B

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 26. TO-220 type A drawing

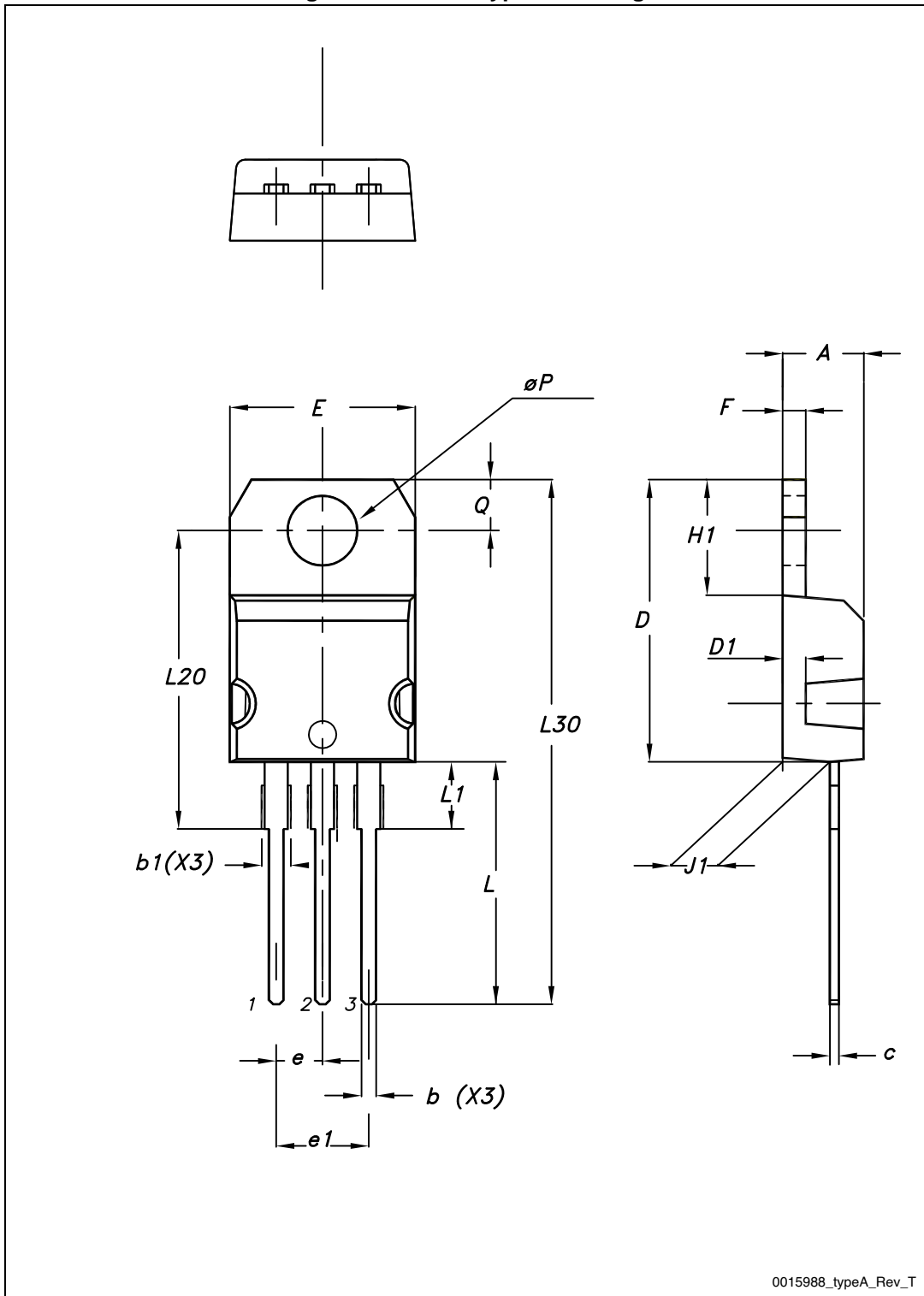
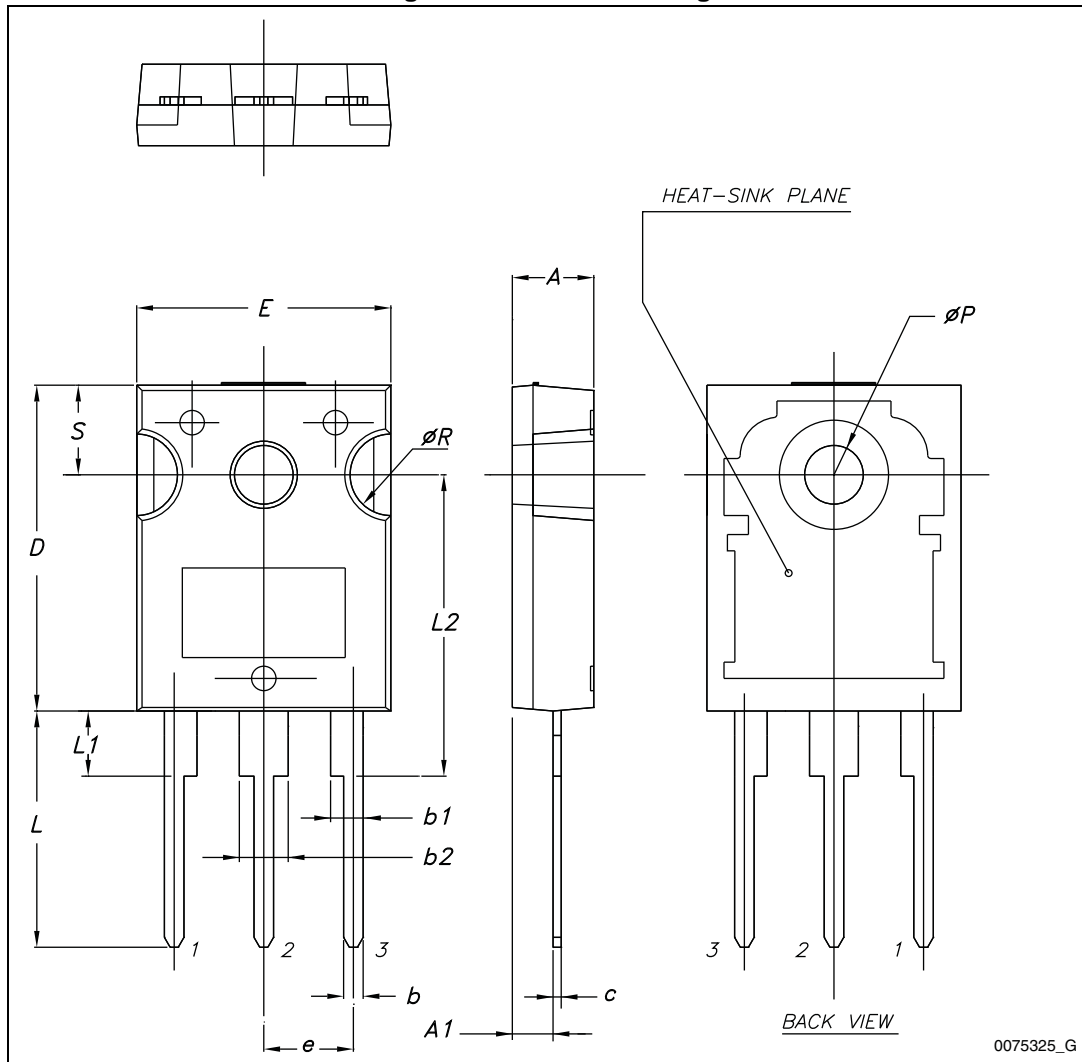


Table 10. TO-220 type A mechanical data

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 27. TO-247 drawing



0075325\_G

Table 11. 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

Table 11. TO-247 mechanical data (continued)

Dim.	mm.		
	Min.	Typ.	Max.
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



## 5 Revision history

Table 12. Document revision history

Date	Revision	Changes
20-Sep-2013	1	First release.
07-Feb-2014	2	<ul style="list-style-type: none"><li>– Modified: <math>I_{AR}</math> and <math>E_{AS}</math> values in <a href="#">Table 2</a></li><li>– Added: <a href="#">note 4</a> in <a href="#">Table 2</a></li><li>– Modified: <math>R_{thj-case}</math> values in <a href="#">Table 3</a></li><li>– Modified: typical values in <a href="#">Table 5</a>, <a href="#">6</a> and <a href="#">7</a></li><li>– Added: <a href="#">Section 2.1: Electrical characteristics (curves)</a></li><li>– Updated: <a href="#">Figure 19</a>, <a href="#">20</a>, <a href="#">21</a> and <a href="#">22</a></li><li>– Minor text changes</li></ul>

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