

N-channel 600 V, 0.108  $\Omega$  typ., 26 A MDmesh II Plus™ low  $Q_g$  Power MOSFETs in TO-220FP, I<sup>2</sup>PAK, TO-220 and TO-247 packages

Datasheet - production data

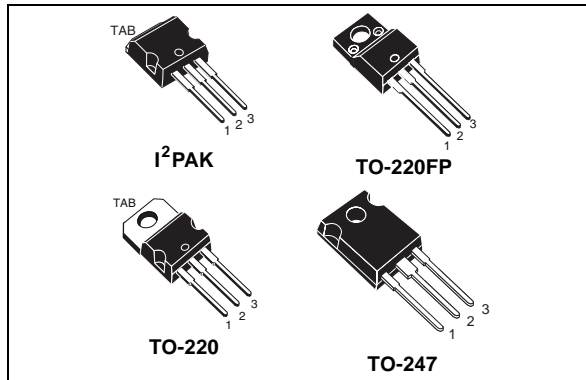
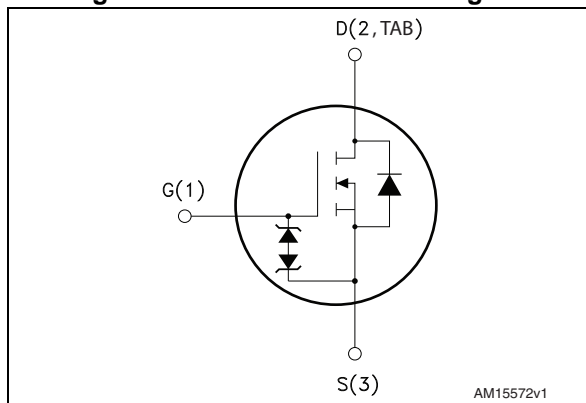


Figure 1. Internal schematic diagram



## Features

Order codes	$V_{DS} @ T_{Jmax}$	$R_{DS(on) max}$	$I_D$
STF33N60M2	650 V	0.125 $\Omega$	26 A <sup>(1)</sup>
STI33N60M2			26 A
STP33N60M2			
STW33N60M2			

1. Limited by maximum junction temperature.

- Extremely low gate charge
- Lower  $R_{DS(on)}$  x area vs previous generation
- MDmesh™ II technology
- Low gate input resistance
- 100% avalanche tested
- Zener-protected

## Applications

- Switching applications
- LCC converters, resonant converters

## Description

These devices are N-channel Power MOSFETs developed using a new generation of MDmesh™ technology: MDmesh II Plus™ low  $Q_g$ . These revolutionary Power MOSFETs associate a vertical structure to the company's strip layout to yield one of the world's lowest on-resistance and gate charge. They are therefore suitable for the most demanding high efficiency converters.

Table 1. Device summary

Order codes	Marking	Package	Packaging
STF33N60M2	33N60M2	TO-220FP	Tube
STI33N60M2		I <sup>2</sup> PAK	
STP33N60M2		TO-220	
STW33N60M2		TO-247	

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value		Unit
		I <sup>2</sup> PAK, TO-220 TO-247	TO-220FP	
V <sub>GS</sub>	Gate-source voltage	± 25		V
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 25 °C	26	26 <sup>(1)</sup>	A
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 100 °C	16	16 <sup>(1)</sup>	A
I <sub>DM</sub> <sup>(2)</sup>	Drain current (pulsed)	104	104 <sup>(1)</sup>	A
P <sub>TOT</sub>	Total dissipation at T <sub>C</sub> = 25 °C	190	35	W
dv/dt <sup>(3)</sup>	Peak diode recovery voltage slope	15		V/ns
dv/dt <sup>(4)</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			

- Limited by maximum junction temperature.
- Pulse width limited by safe operating area.
- I<sub>SD</sub> ≤ 26 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
		TO-220FP	I <sup>2</sup> PAK, TO-220	TO-247	
R <sub>thj-case</sub>	Thermal resistance junction-case max	3.6	0.66		°C/W
R <sub>thj-amb</sub>	Thermal resistance junction-ambient max	62.5		50	°C/W

**Table 4. Avalanche characteristics**

Symbol	Parameter	Value	Unit
I <sub>AR</sub>	Avalanche current, repetitive or not repetitive (pulse width limited by T <sub>jmax</sub> )	5	A
E <sub>AS</sub>	Single pulse avalanche energy (starting T <sub>j</sub> = 25 °C, I <sub>D</sub> = I <sub>AR</sub> ; V <sub>DD</sub> = 50)	2300	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	$I_D = 1\text{ mA}$ , $V_{GS} = 0$	600			V
$I_{DSS}$	Zero gate voltage drain current ( $V_{GS} = 0$ )	$V_{DS} = 600\text{ V}$ $V_{DS} = 600\text{ V}$ , $T_C = 125\text{ °C}$			1 100	$\mu\text{A}$ $\mu\text{A}$
$I_{GSS}$	Gate-body leakage current ( $V_{DS} = 0$ )	$V_{GS} = \pm 25\text{ V}$			$\pm 10$	$\mu\text{A}$
$V_{GS(th)}$	Gate threshold voltage	$V_{DS} = V_{GS}$ , $I_D = 250\text{ }\mu\text{A}$	2	3	4	V
$R_{DS(on)}$	Static drain-source on-resistance	$V_{GS} = 10\text{ V}$ , $I_D = 13\text{ A}$		0.108	0.125	$\Omega$

**Table 6. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$C_{iss}$	Input capacitance	$V_{DS} = 100\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GS} = 0$	-	1781	-	pF
$C_{oss}$	Output capacitance		-	85	-	pF
$C_{rss}$	Reverse transfer capacitance		-	2.5	-	pF
$C_{oss\text{ eq.}}^{(1)}$	Equivalent output capacitance	$V_{DS} = 0\text{ to }480\text{ V}$ , $V_{GS} = 0$	-	135	-	pF
$R_G$	Intrinsic gate resistance	$f = 1\text{ MHz}$ open drain	-	5.2	-	$\Omega$
$Q_g$	Total gate charge	$V_{DD} = 480\text{ V}$ , $I_D = 26\text{ A}$ , $V_{GS} = 10\text{ V}$ (see <a href="#">Figure 19</a> )	-	45.5	-	nC
$Q_{gs}$	Gate-source charge		-	9.9	-	nC
$Q_{gd}$	Gate-drain charge		-	18.5	-	nC

1.  $C_{oss\text{ eq.}}$  is defined as a constant equivalent capacitance giving the same charging time as  $C_{oss}$  when  $V_{DS}$  increases from 0 to 80%  $V_{DSS}$

**Table 7. Switching times**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_d(on)$	Turn-on delay time	$V_{DD} = 300\text{ V}$ , $I_D = 13\text{ A}$ , $R_G = 4.7\text{ }\Omega$ , $V_{GS} = 10\text{ V}$ (see <a href="#">Figure 18</a> and <a href="#">Figure 23</a> )	-	16	-	ns
$t_r(v)$	Voltage rise time		-	9.6	-	ns
$t_d(off)$	Turn-off-delay time		-	109	-	ns
$t_f(i)$	Fall time		-	9	-	ns

Table 8. Source drain diode

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{SD}$	Source-drain current		-		26	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)		-		104	A
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 26 \text{ A}$ , $V_{GS} = 0$	-		1.6	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 26 \text{ A}$ , $di/dt = 100 \text{ A}/\mu\text{s}$ $V_{DD} = 60 \text{ V}$ (see <a href="#">Figure 23</a> )	-	375		ns
$Q_{rr}$	Reverse recovery charge		-	5.6		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current		-	30		A
$t_{rr}$	Reverse recovery time	$I_{SD} = 26 \text{ A}$ , $di/dt = 100 \text{ A}/\mu\text{s}$ $V_{DD} = 60 \text{ V}$ , $T_j = 150 \text{ }^\circ\text{C}$ (see <a href="#">Figure 23</a> )	-	478		ns
$Q_{rr}$	Reverse recovery charge		-	7.7		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current		-	32.5		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 TO-220FP

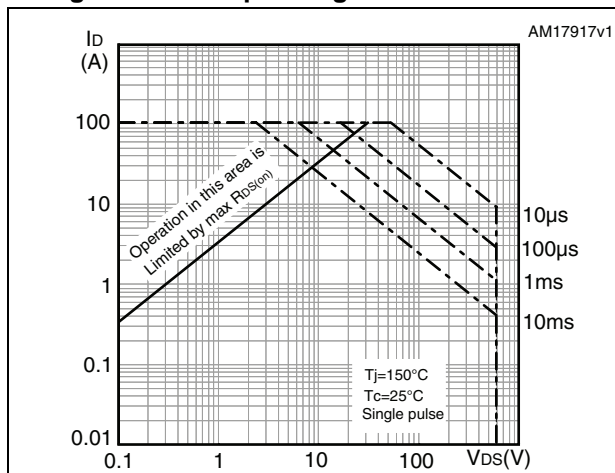


Figure 3. Thermal impedance for TO-220FP

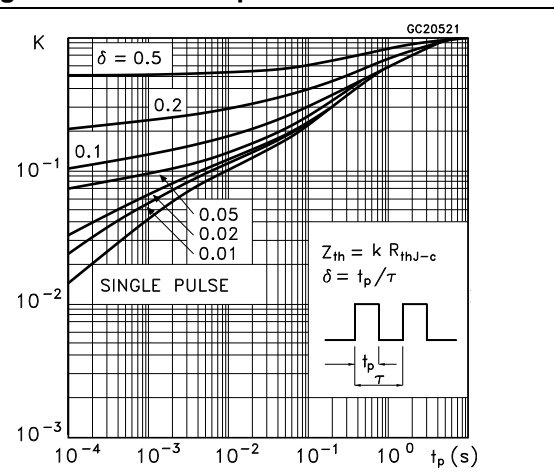


Figure 4. Safe operating area for I<sup>2</sup>PAK and TO-220

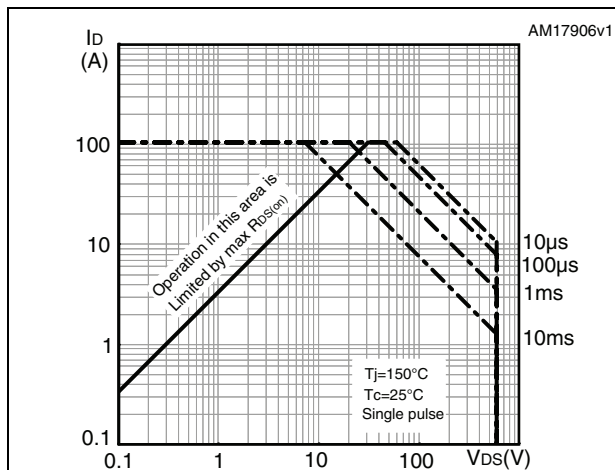


Figure 5. Thermal impedance for I<sup>2</sup>PAK and TO-220

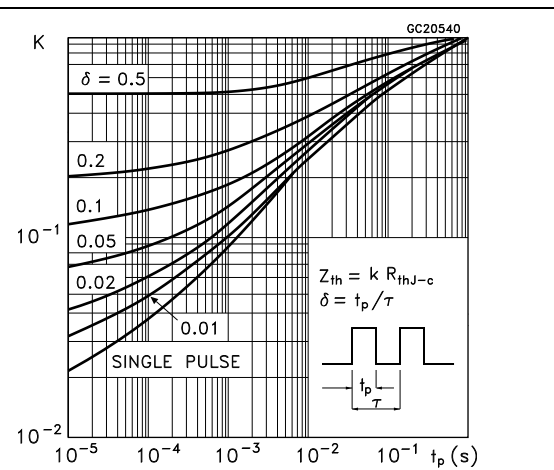


Figure 6. Safe operating area for TO-247

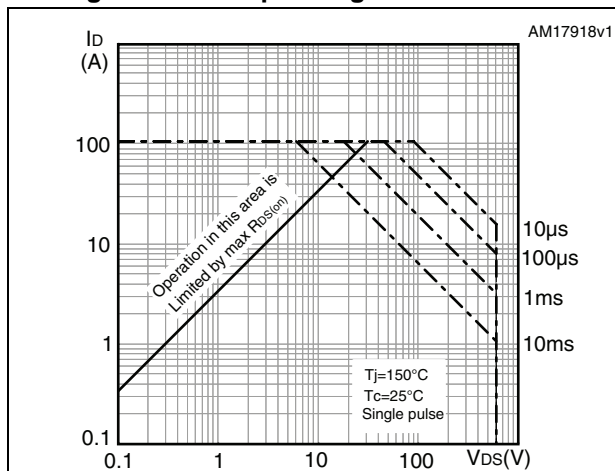


Figure 7. Thermal impedance for TO-247

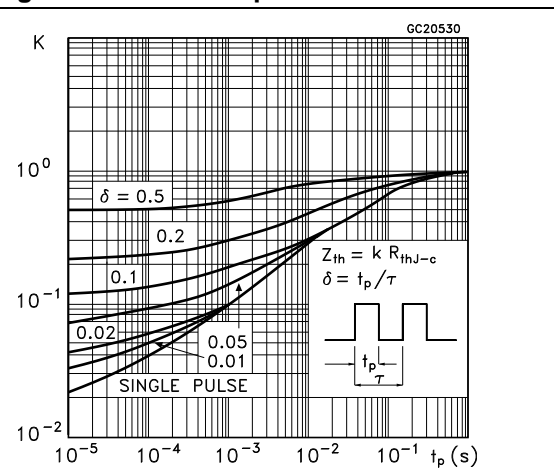


Figure 8. Output characteristics

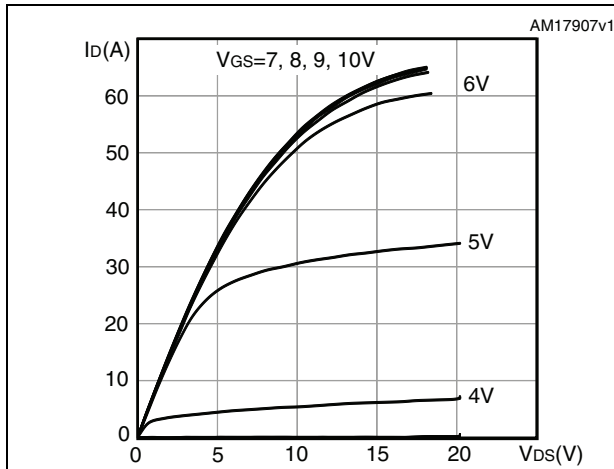


Figure 9. Transfer characteristics

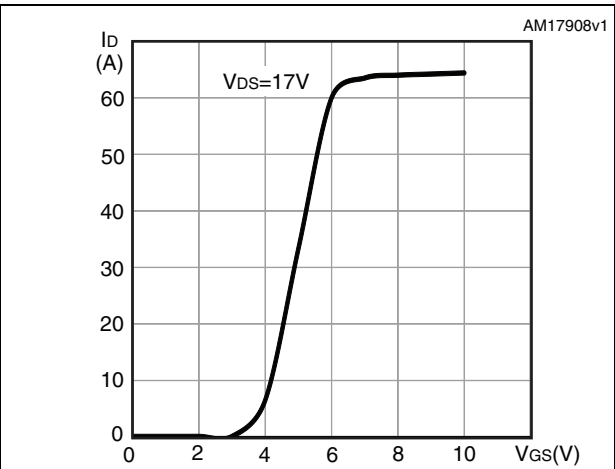


Figure 10. Gate charge vs gate-source voltage

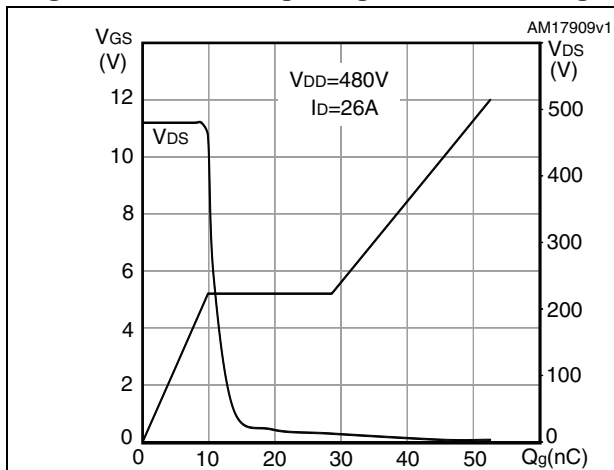


Figure 11. Static drain-source on-resistance

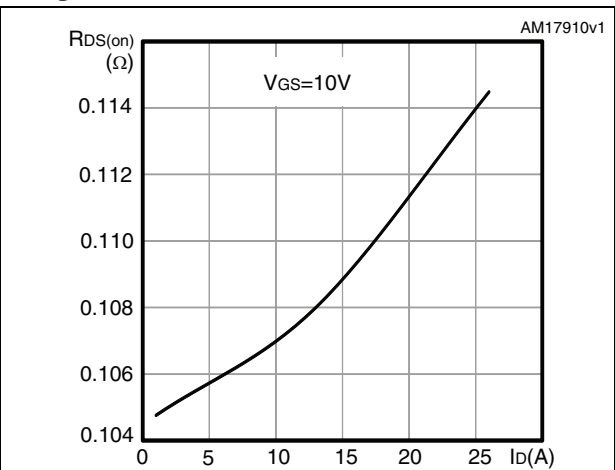


Figure 12. Capacitance variations

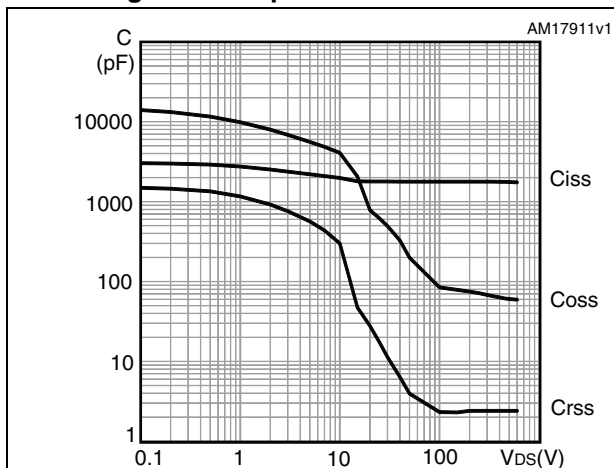


Figure 13. Output capacitance stored energy

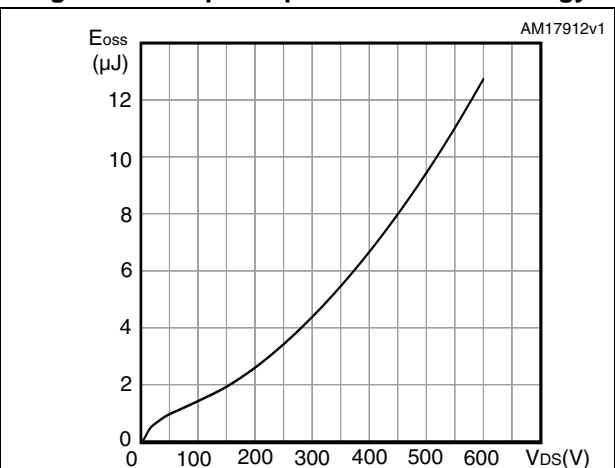


Figure 14. Normalized gate threshold voltage vs temperature

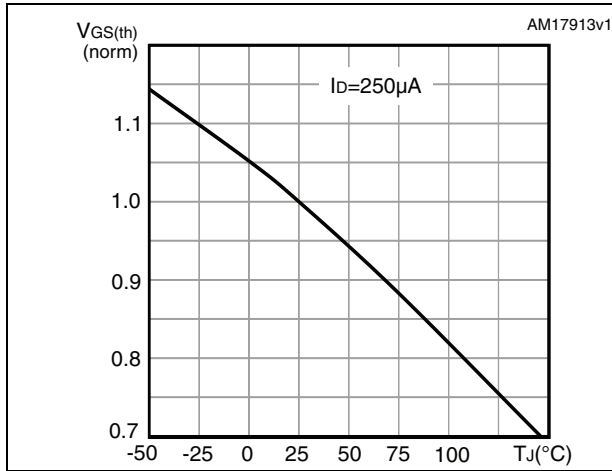


Figure 15. Normalized on-resistance vs temperature

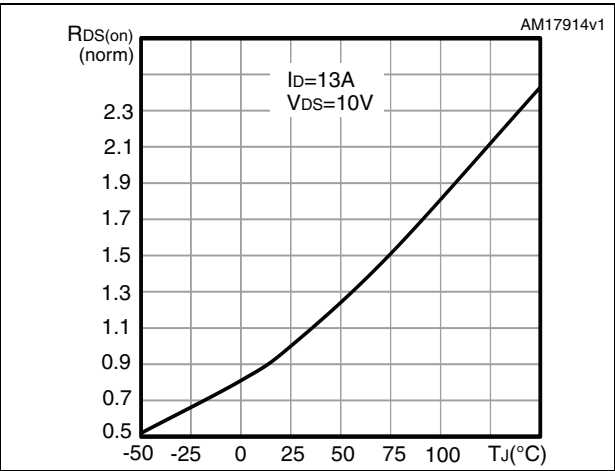


Figure 16. Normalized V<sub>DS</sub> vs temperature

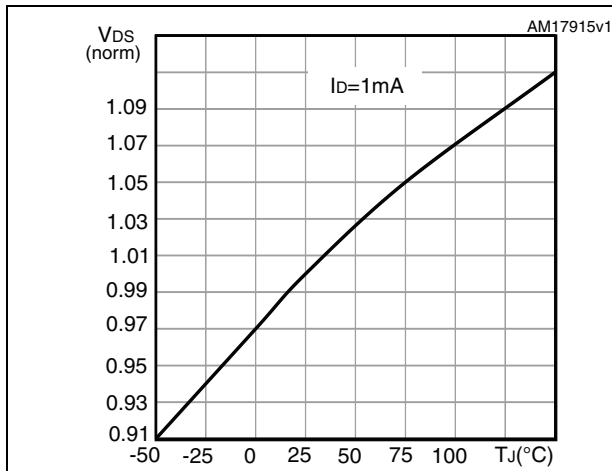
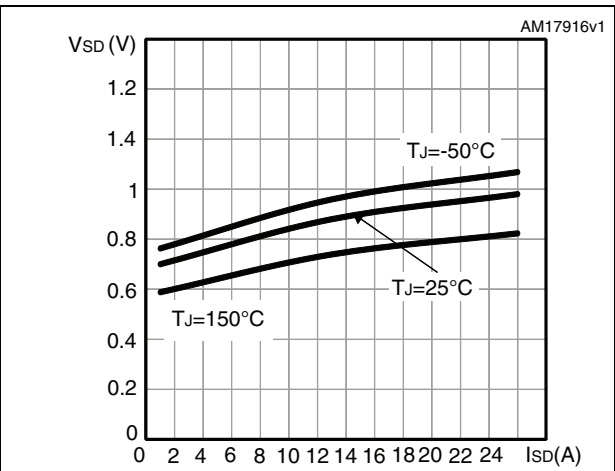


Figure 17. Source-drain diode forward characteristics





### 3 Test circuits

Figure 18. Switching times test circuit for resistive load



Figure 19. Gate charge test circuit

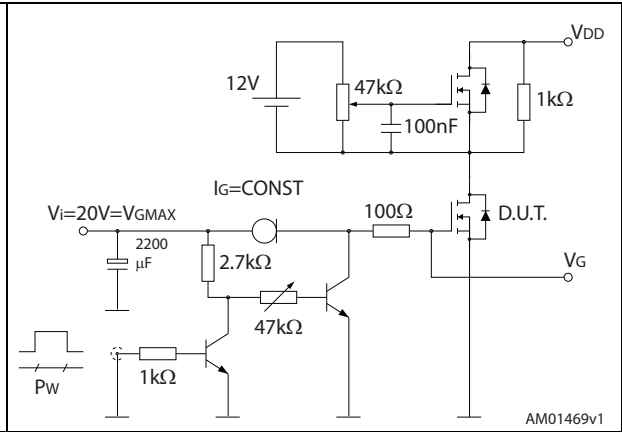


Figure 20. Test circuit for inductive load switching and diode recovery times

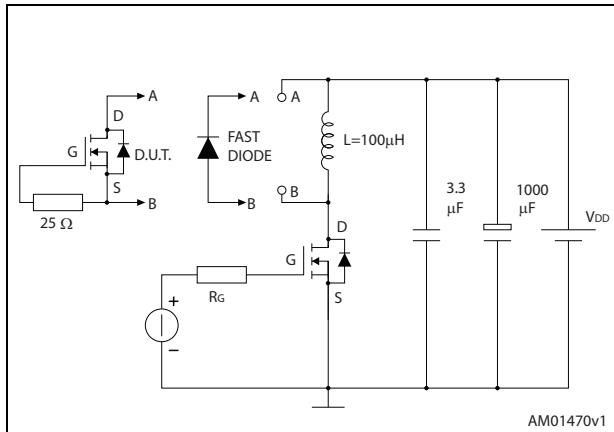


Figure 21. Unclamped inductive load test circuit

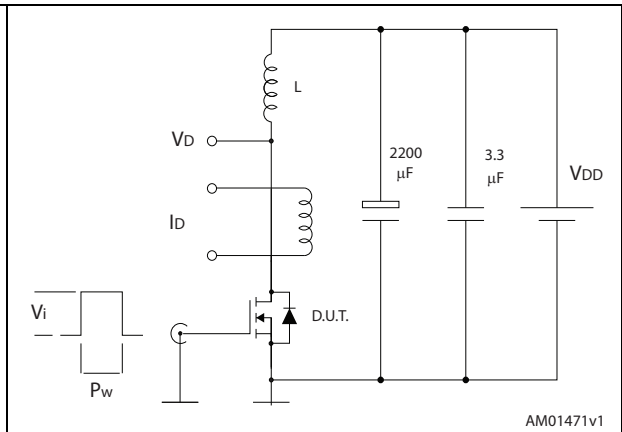


Figure 22. Unclamped inductive waveform

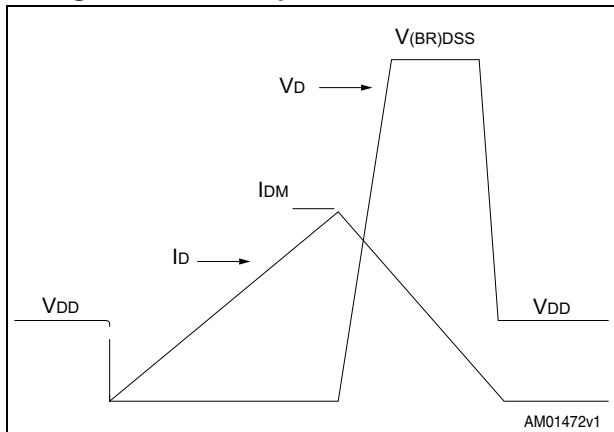
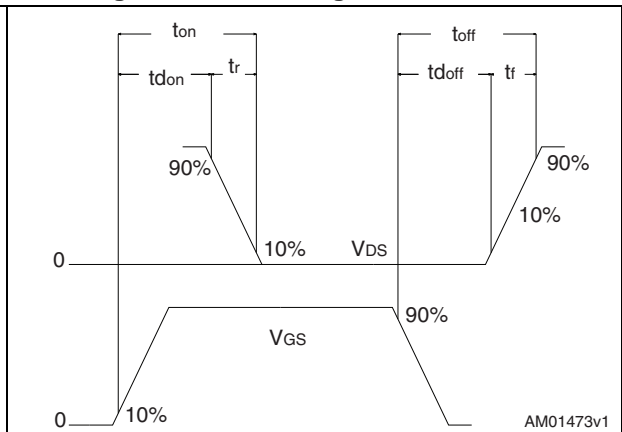


Figure 23. Switching time waveform



## 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 24. TO-220FP drawing

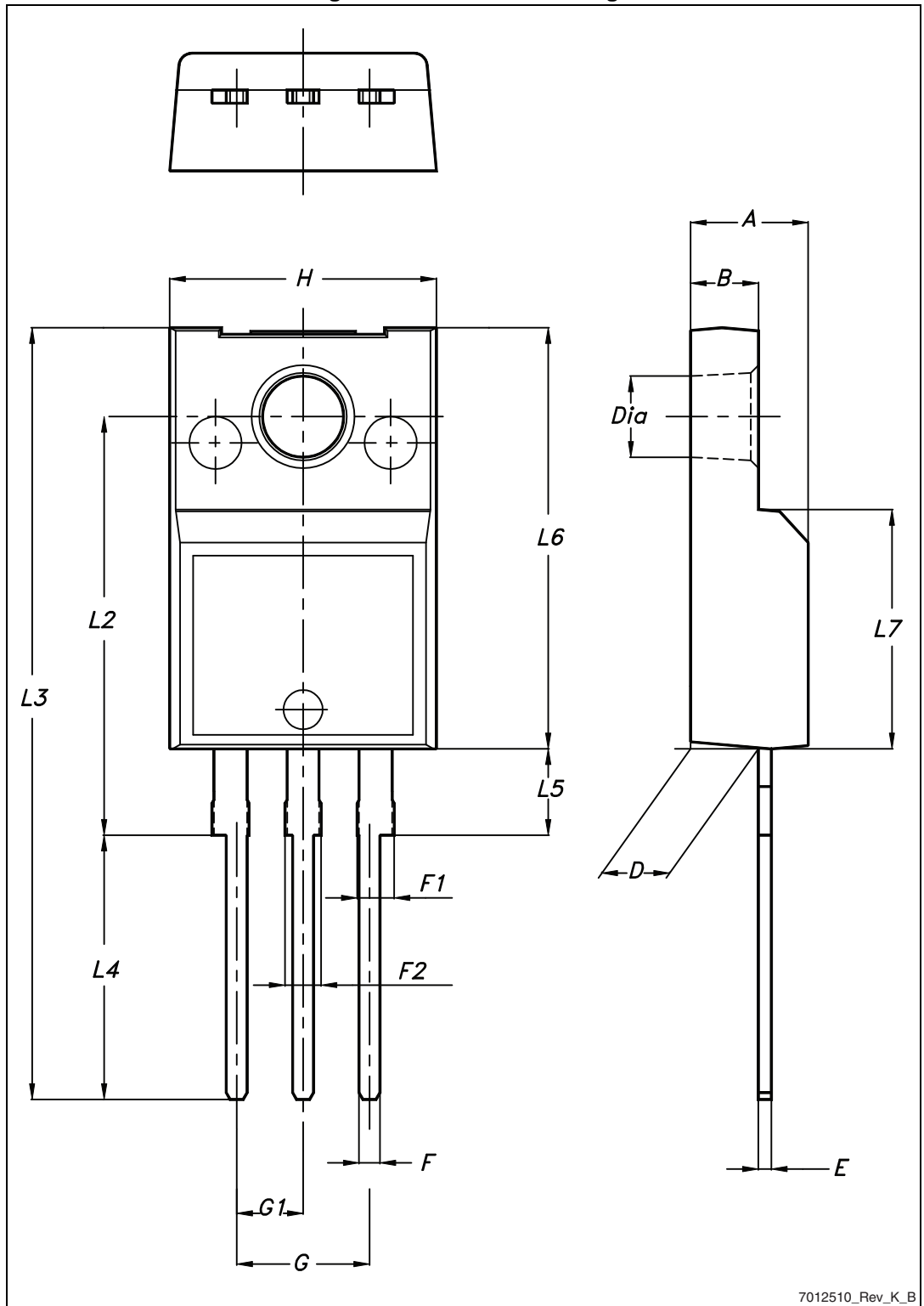
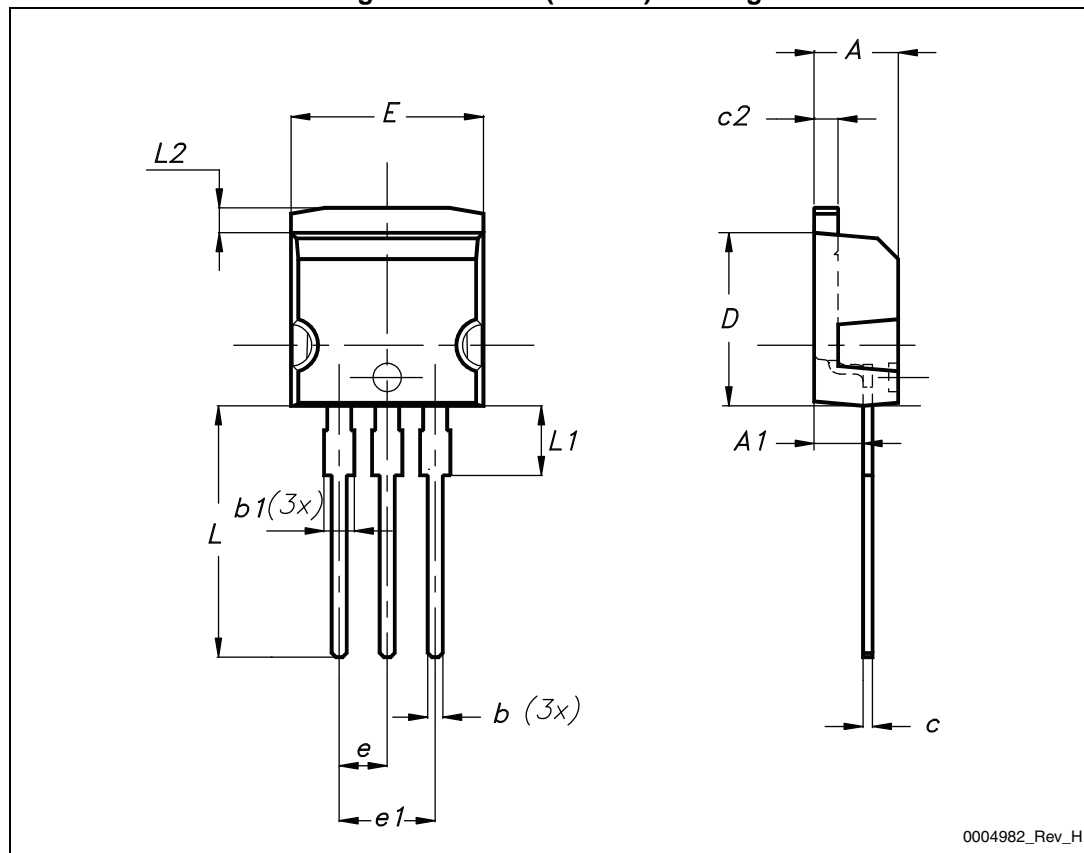


Table 10. I<sup>2</sup>PAK (TO-262) mechanical data

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. 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 26. TO-220 type A drawing

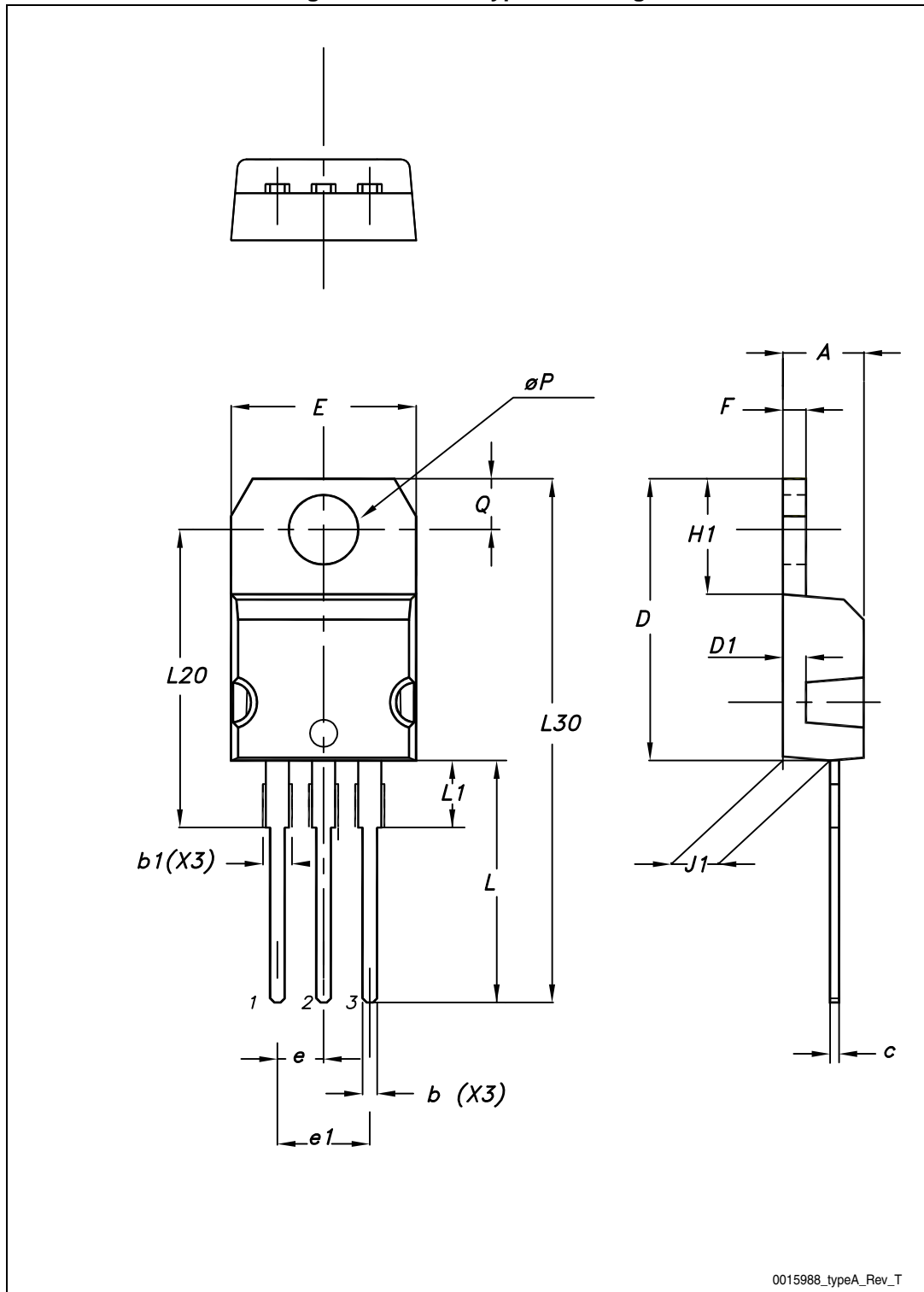
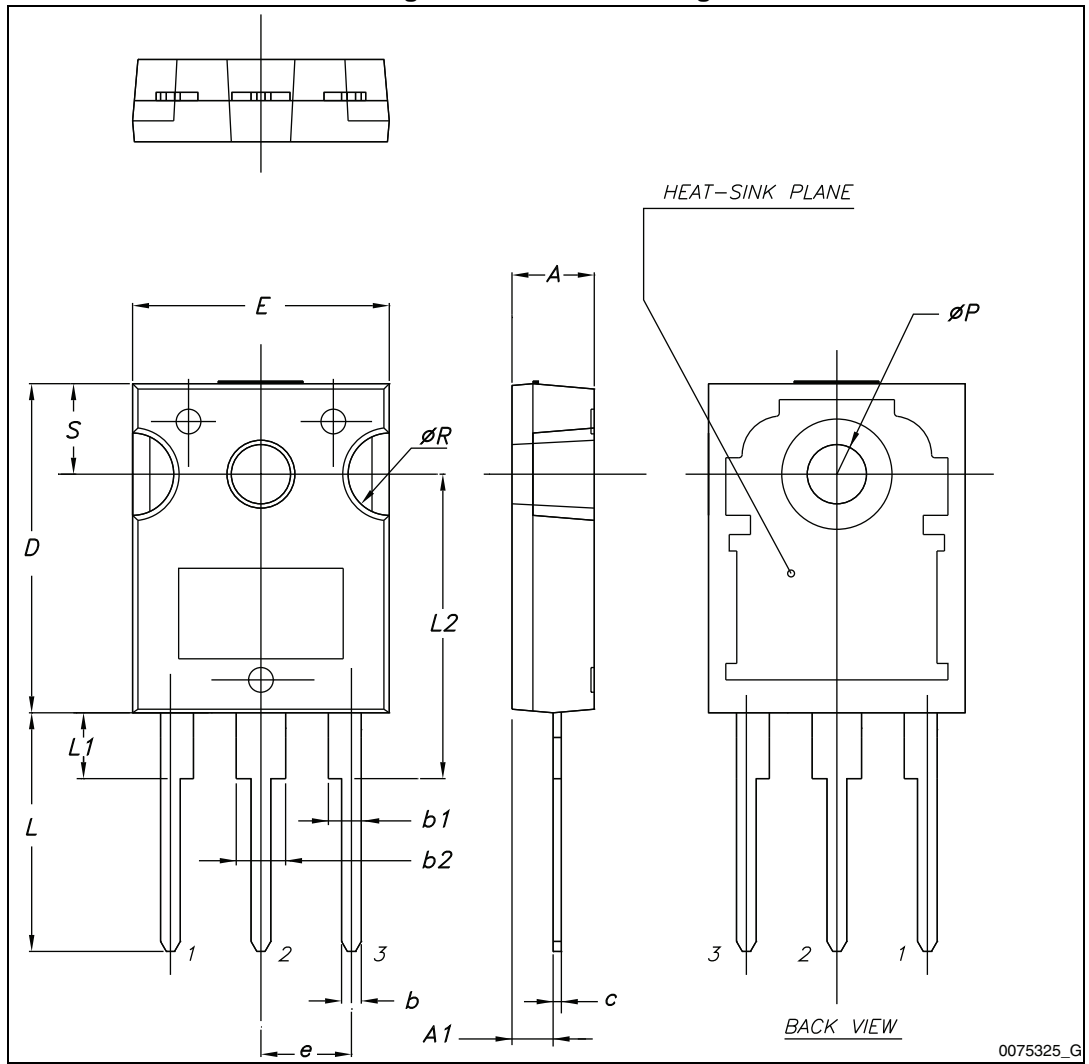


Table 12. TO-247 mechanical data

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 27. TO-247 drawing



0075325\_G

## 5 Revision history

Table 13. Document revision history

Date	Revision	Changes
13-Sep-2013	1	First release.
19-Nov-2013	2	<ul style="list-style-type: none"><li>– Modified: <math>R_{DS(on)}</math> and <math>I_D</math> values in cover page</li><li>– Modified: values in <a href="#">Table 4</a></li><li>– Modified: <math>R_{DS(on)}</math> typical and maximum values in <a href="#">Table 5</a>, the entire typical values in <a href="#">Table 6, 7</a> and <a href="#">8</a></li><li>– Added: <a href="#">Section 2.1: Electrical characteristics (curves)</a></li><li>– Minor text changes</li></ul>

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