



# STF13NM60N, STI13NM60N, STP13NM60N, STU13NM60N, STW13NM60N

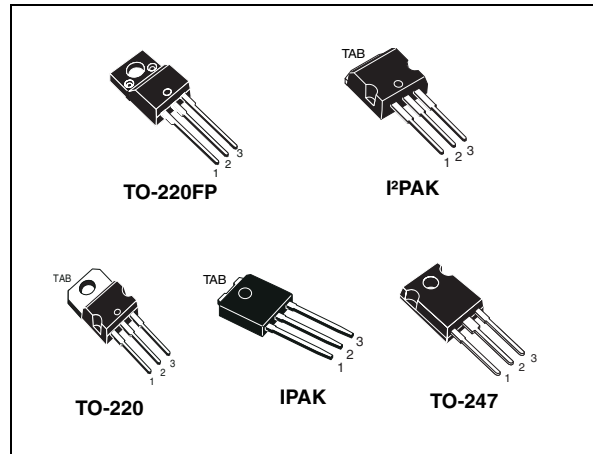
N-channel 600 V, 0.28  $\Omega$  typ., 11 A MDmesh™ II Power MOSFET  
in TO-220FP, I<sup>2</sup>PAK, TO-220, IPAK, TO-247 packages

Datasheet — production data

## Features

Order codes	V <sub>DSS</sub> (@T <sub>jmax</sub> )	R <sub>DS(on)</sub> max	I <sub>D</sub>
STF13NM60N STI13NM60N STP13NM60N STU13NM60N STW13NM60N	650 V	< 0.36 $\Omega$	11 A

- 100% avalanche tested
- Low input capacitance and gate charge
- Low gate input resistance



## Applications

- Switching applications

## Description

These devices are N-channel Power MOSFETs developed using the second generation of MDmesh™ technology. This revolutionary Power MOSFET associates a vertical structure to the company's strip layout to yield one of the world's lowest on-resistance and gate charge. It is therefore suitable for the most demanding high efficiency converters.

Figure 1. Internal schematic diagram

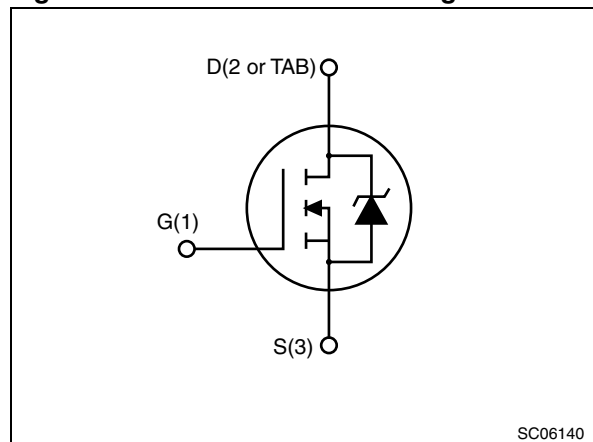


Table 1. Device summary

Order codes	Marking	Packages	Packaging
STF13NM60N STI13NM60N STP13NM60N STU13NM60N STW13NM60N	13NM60N	TO-220FP I <sup>2</sup> PAK TO-220 IPAK TO-247	Tube Tube Tube Tube Tube

## Contents

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value		Unit
		TO-220FP	I <sup>2</sup> PAK, TO-220, IPAK, TO-247	
V <sub>DS</sub>	Drain-source voltage	600		V
V <sub>GS</sub>	Gate-source voltage	± 25		V
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 25 °C	11 <sup>(1)</sup>	11	A
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 100 °C	6.93 <sup>(1)</sup>	6.93	A
I <sub>DM</sub> <sup>(2)</sup>	Drain current (pulsed)	44 <sup>(1)</sup>	44	A
P <sub>TOT</sub>	Total dissipation at T <sub>C</sub> = 25 °C	25	90	W
dv/dt <sup>(3)</sup>	Peak diode recovery voltage slope	15		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
- Pulse width limited by safe operating area
- I<sub>SD</sub> ≤ 11 A, di/dt ≤ 400 A/μs, V<sub>DS peak</sub> ≤ V<sub>(BR)DSS</sub>, V<sub>DD</sub> = 80% V<sub>(BR)DSS</sub>.

**Table 3. Thermal data**

Symbol	Parameter	Value				Unit
		TO-220FP	I <sup>2</sup> PAK TO-220	IPAK	TO-247	
R <sub>thj-case</sub>	Thermal resistance junction-case max	5	1.39			°C/W
R <sub>thj-amb</sub>	Thermal resistance junction-ambient max	62.5	62.5	100	50	°C/W

**Table 4. Avalanche characteristics**

Symbol	Parameter	Value	Unit
I <sub>AS</sub>	Avalanche current, repetitive or not-repetitive (pulse width limited by T <sub>j</sub> max)	3.5	A
E <sub>AS</sub>	Single pulse avalanche energy (starting T <sub>J</sub> =25 °C, I <sub>D</sub> =I <sub>AS</sub> , V <sub>DD</sub> =50 V)	200	mJ

## 2 Electrical characteristics

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

**Table 5. On/off states**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source breakdown voltage ( $V_{GS} = 0$ )	$I_D = 1\text{ mA}$	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 ( $V_{DS} = 0$ )	$V_{GS} = \pm 25\text{ V}$			$\pm 0.1$	$\mu\text{A}$
$V_{GS(th)}$	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	$V_{GS} = 10\text{ V}, I_D = 5.5\text{ A}$		0.28	0.36	$\Omega$

**Table 6. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$C_{iss}$	Input capacitance	$V_{DS} = 50\text{ V}, f = 1\text{ MHz},$ $V_{GS} = 0$	-	790	-	pF
$C_{oss}$	Output capacitance			60		pF
$C_{rss}$	Reverse transfer capacitance			3.6		pF
$C_{oss\text{ eq.}}^{(1)}$	Equivalent output capacitance	$V_{GS} = 0, V_{DS} = 0\text{ to }480\text{ V}$	-	135	-	pF
$Q_g$	Total gate charge	$V_{DD} = 480\text{ V}, I_D = 11\text{ A},$ $V_{GS} = 10\text{ V},$ <i>(see Figure 20)</i>	-	27	-	nC
$Q_{gs}$	Gate-source charge			4		nC
$Q_{gd}$	Gate-drain charge			14		nC
$R_G$	Gate input resistance	$f = 1\text{ MHz}$ open drain	-	4.7	-	$\Omega$

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%  $V_{DS}$

**Table 7. Switching times**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit	
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 300\text{ V}$ , $I_D = 5.5\text{ A}$ $R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$ (see Figure 19)		3		ns	
$t_r$	Rise time			8		ns	
$t_{d(off)}$	Turn-off delay time				30		ns
$t_f$	Fall time				10		ns

**Table 8. Source drain diode**

Symbol	Parameter	Test conditions	Min	Typ.	Max.	Unit
$I_{SD}$	Source-drain current		-		11	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)				44	A
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 11\text{ A}$ , $V_{GS} = 0$	-		1.5	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 11\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ $V_{DD} = 100\text{ V}$ (see Figure 21)	-	230		ns
$Q_{rr}$	Reverse recovery charge			2		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current			18		A
$t_{rr}$	Reverse recovery time	$I_{SD} = 11\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ $V_{DD} = 100\text{ V}$ , $T_j = 150\text{ }^\circ\text{C}$ (see Figure 21)	-	290		ns
$Q_{rr}$	Reverse recovery charge			190		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current			17		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 I<sup>2</sup>PAK and TO-220

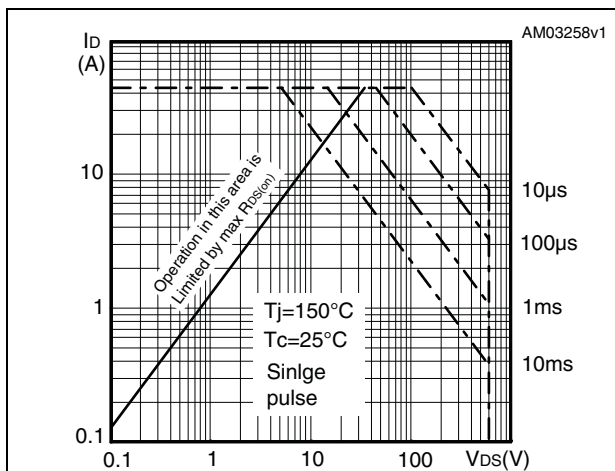


Figure 3. Thermal impedance for I<sup>2</sup>PAK and TO-220

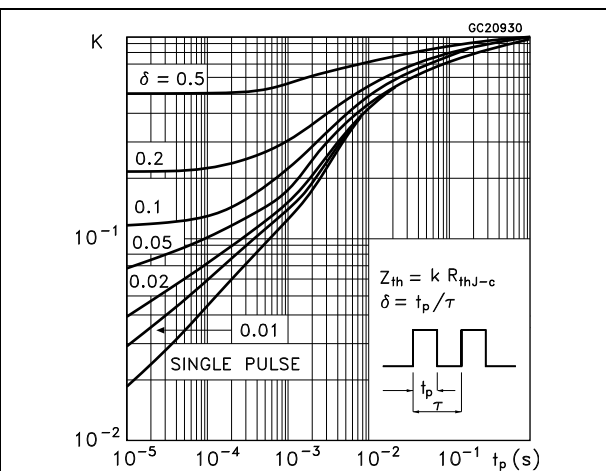


Figure 4. Safe operating area for TO-220FP

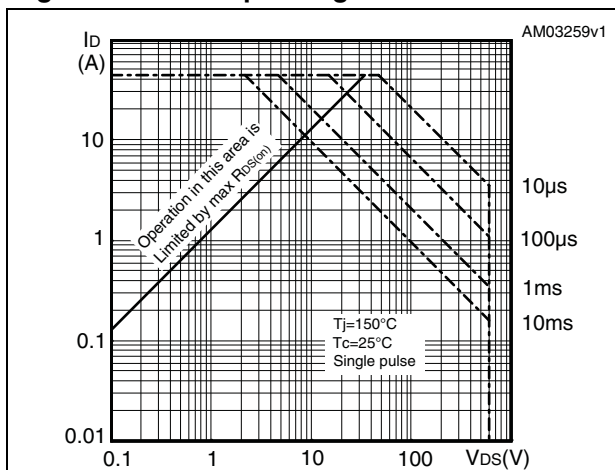


Figure 5. Thermal impedance for TO-220FP

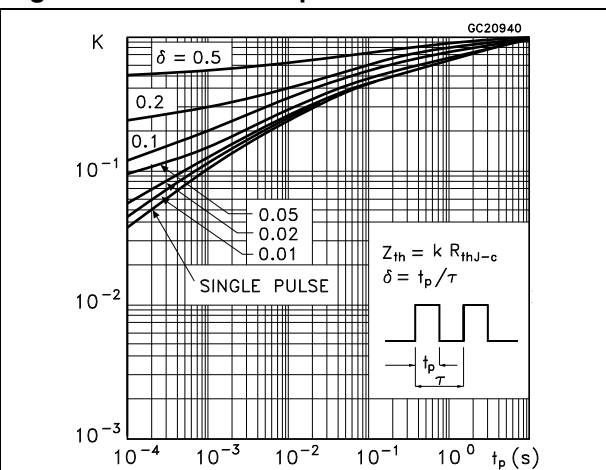


Figure 6. Safe operating area for TO-247

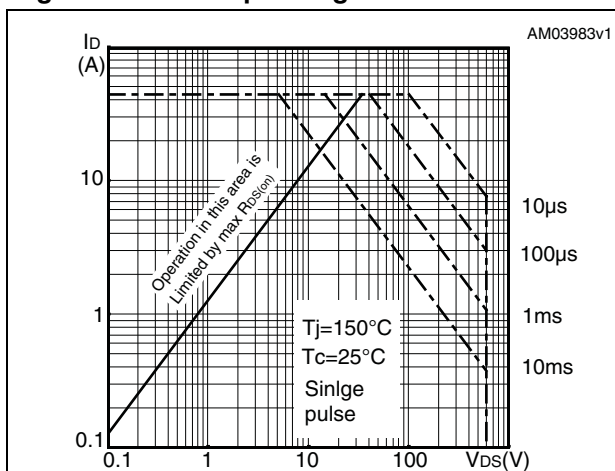


Figure 7. Thermal impedance for TO-247

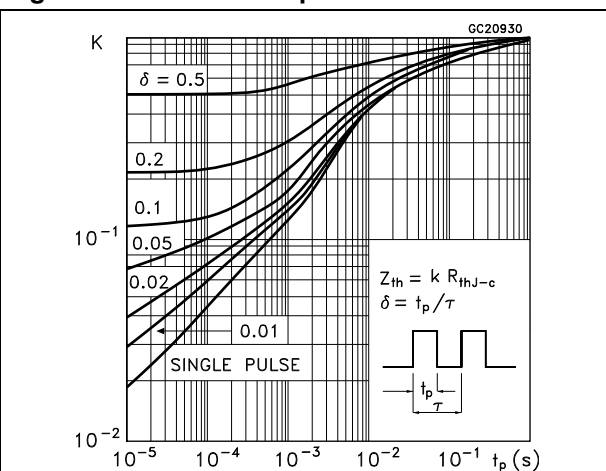


Figure 8. Safe operating area for IPAK

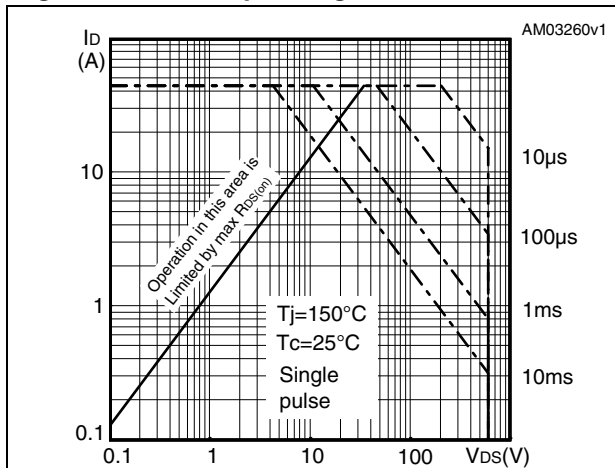


Figure 9. Thermal impedance for IPAK

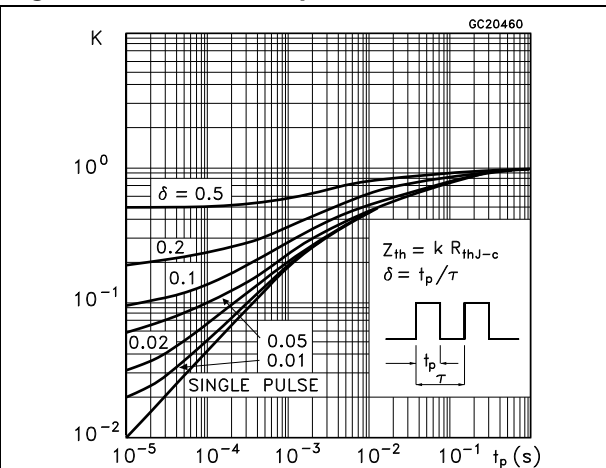


Figure 10. Output characteristics

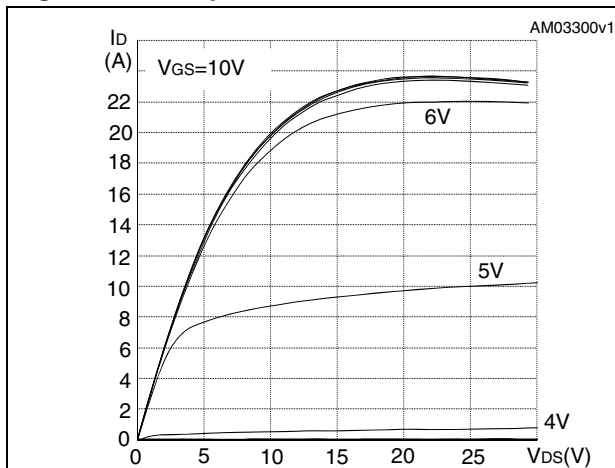


Figure 11. Transfer characteristics

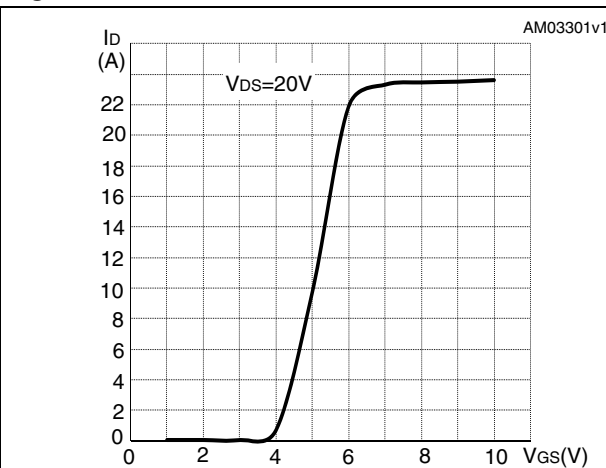


Figure 12. Normalized VDS vs temperature

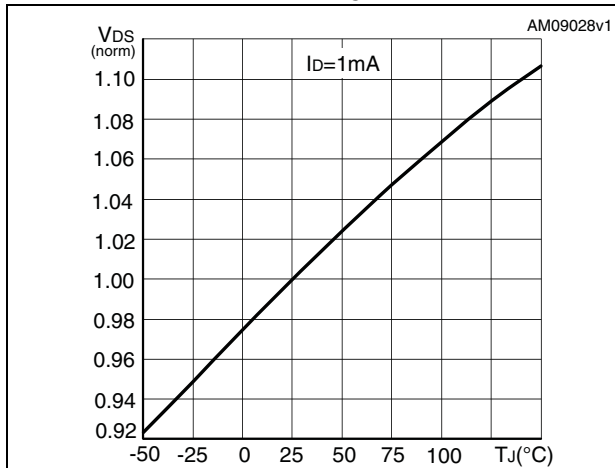


Figure 13. Static drain-source on-resistance

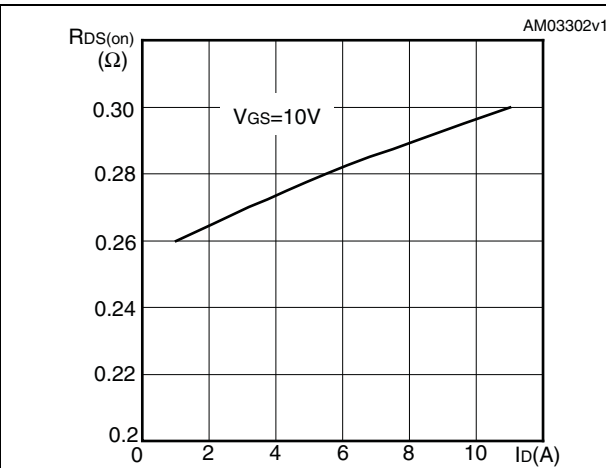


Figure 14. Gate charge vs gate-source voltage Figure 15. Capacitance variations

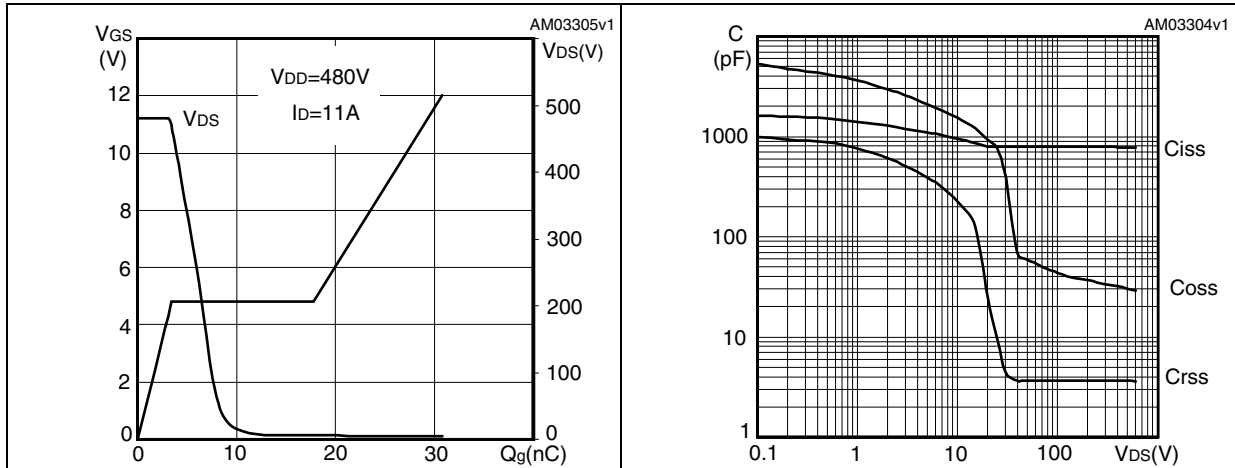


Figure 16. Normalized gate threshold voltage vs temperature Figure 17. Normalized on-resistance vs temperature

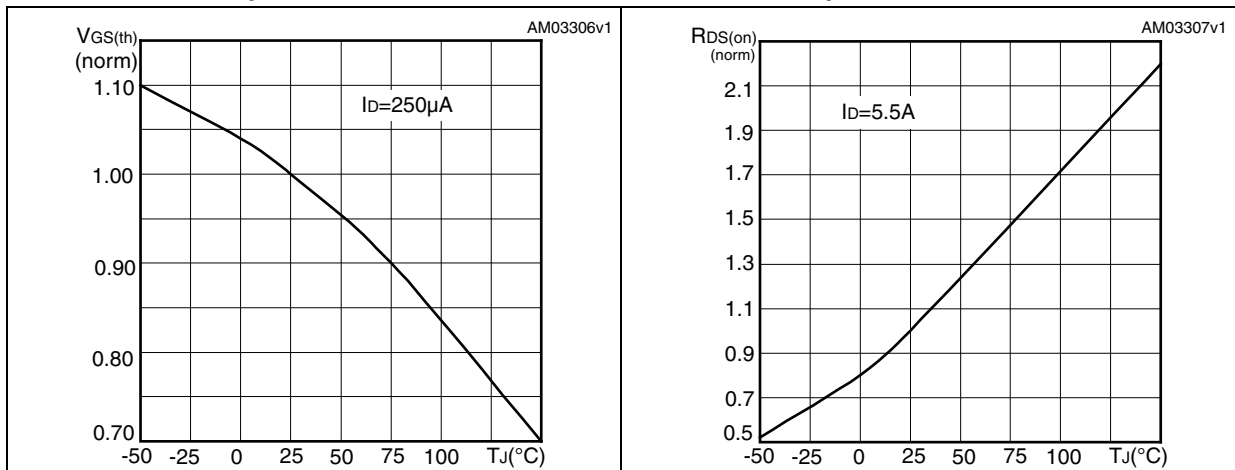
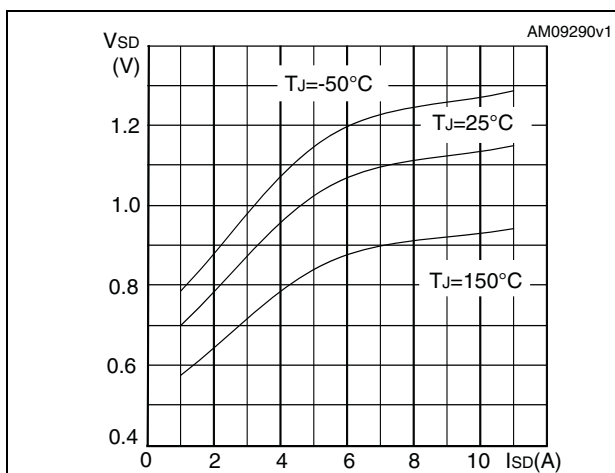


Figure 18. Source-drain diode forward characteristics





### 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

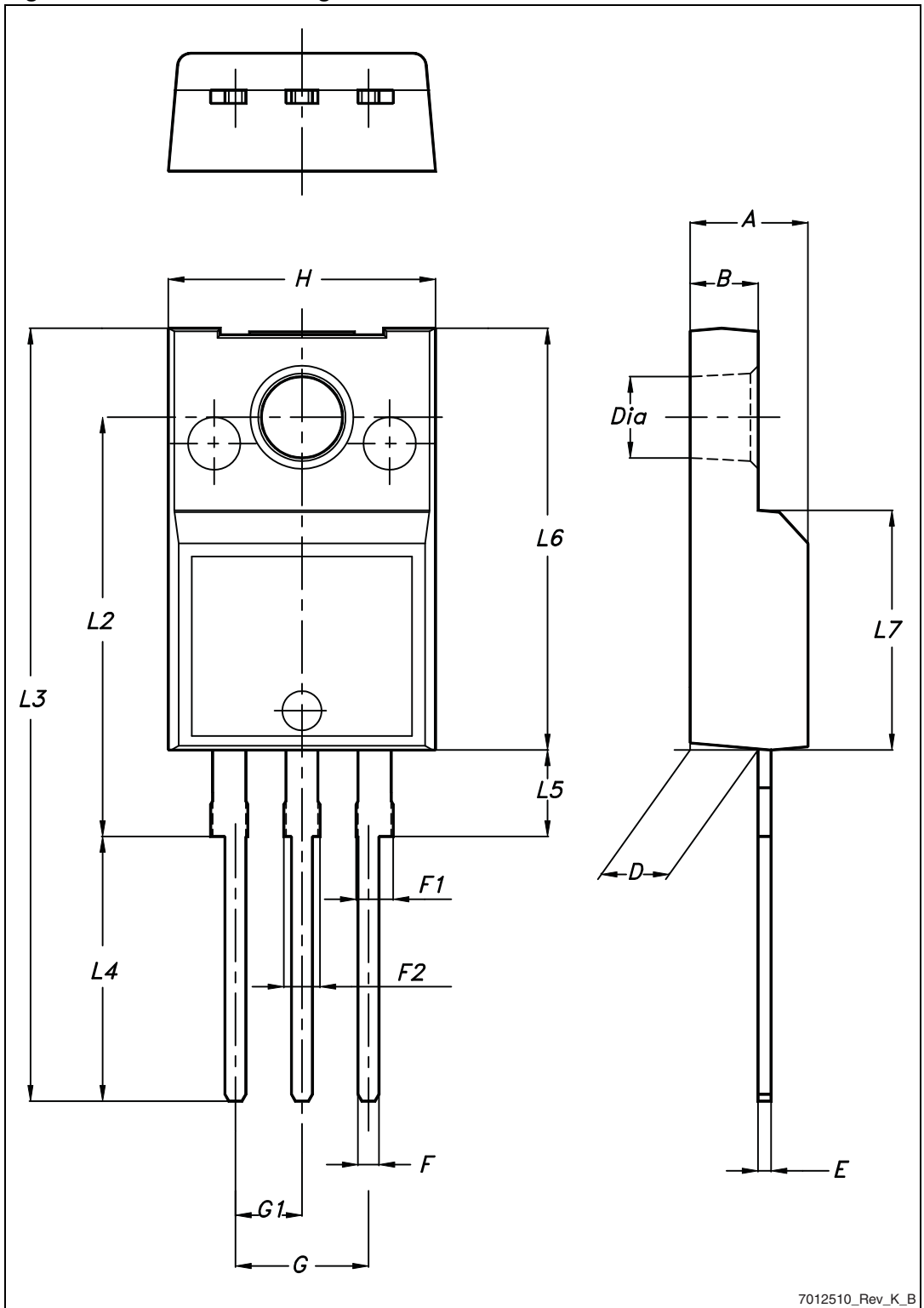
## 4 Package mechanical data

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 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

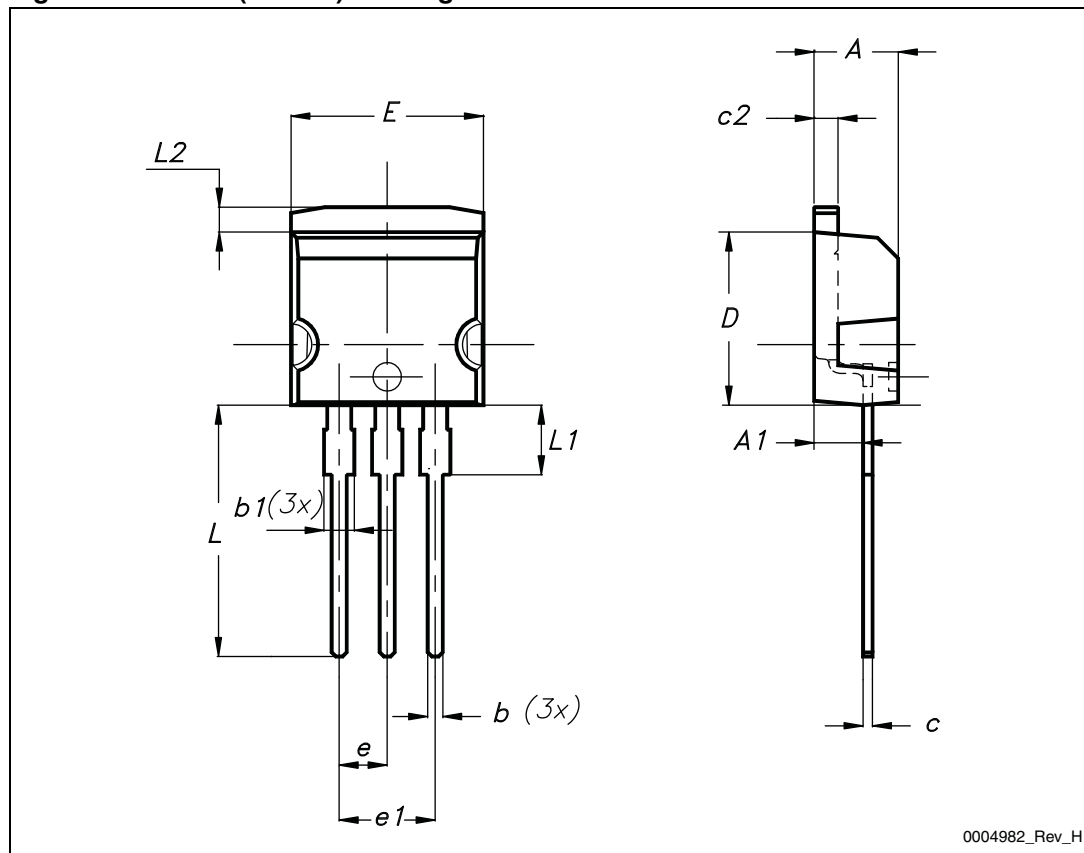


7012510\_Rev\_K\_B

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 26. 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 27. TO-220 type A drawing

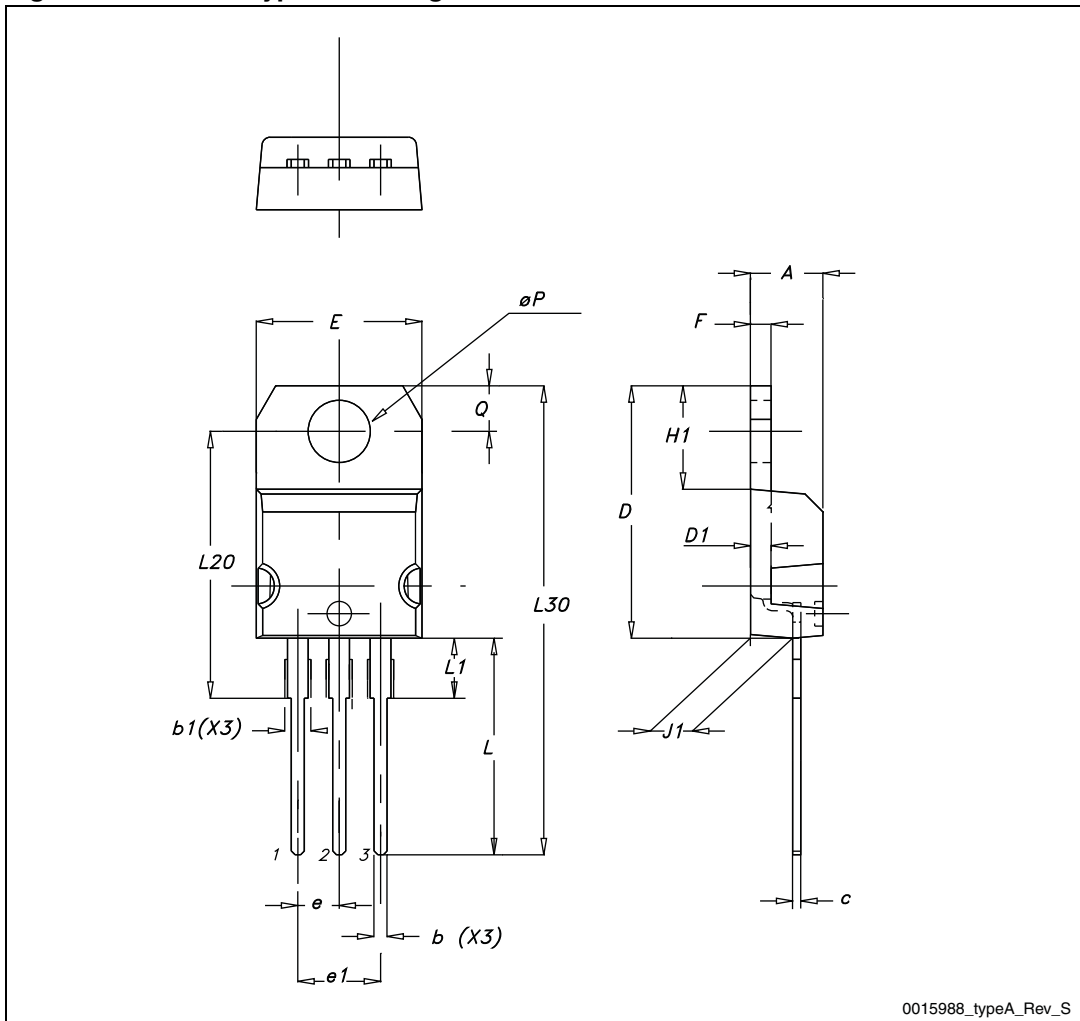
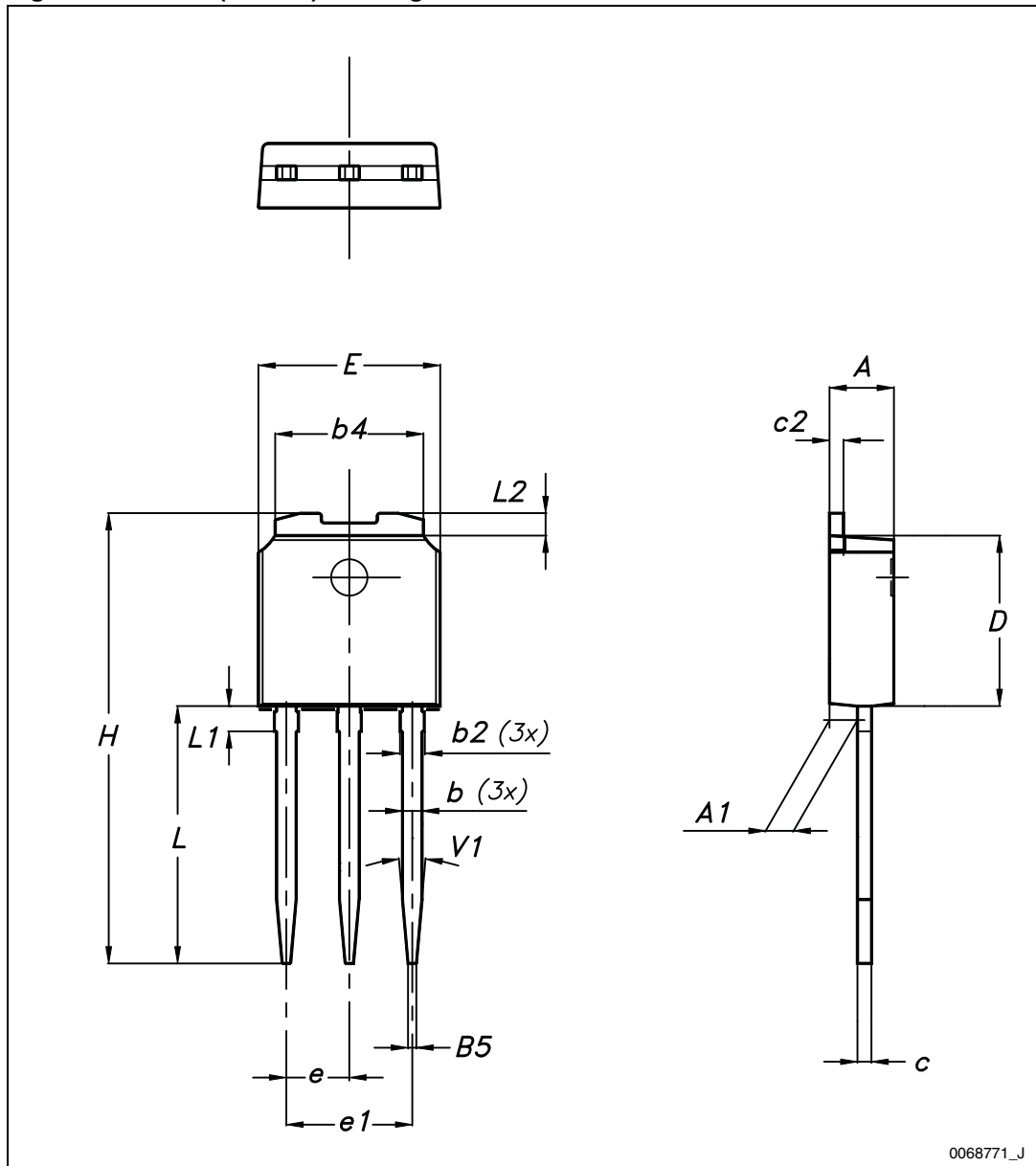


Table 12. IPAK (TO-251) mechanical data

DIM.	mm.		
	min.	typ	max.
A	2.20		2.40
A1	0.90		1.10
b	0.64		0.90
b2			0.95
b4	5.20		5.40
B5		0.3	
c	0.45		0.60
c2	0.48		0.60
D	6.00		6.20
E	6.40		6.60
e		2.28	
e1	4.40		4.60
H		16.10	
L	9.00		9.40
L1	0.80		1.20
L2		0.80	1.00
V1		10 °	



Figure 28. IPAK (TO-251) drawing

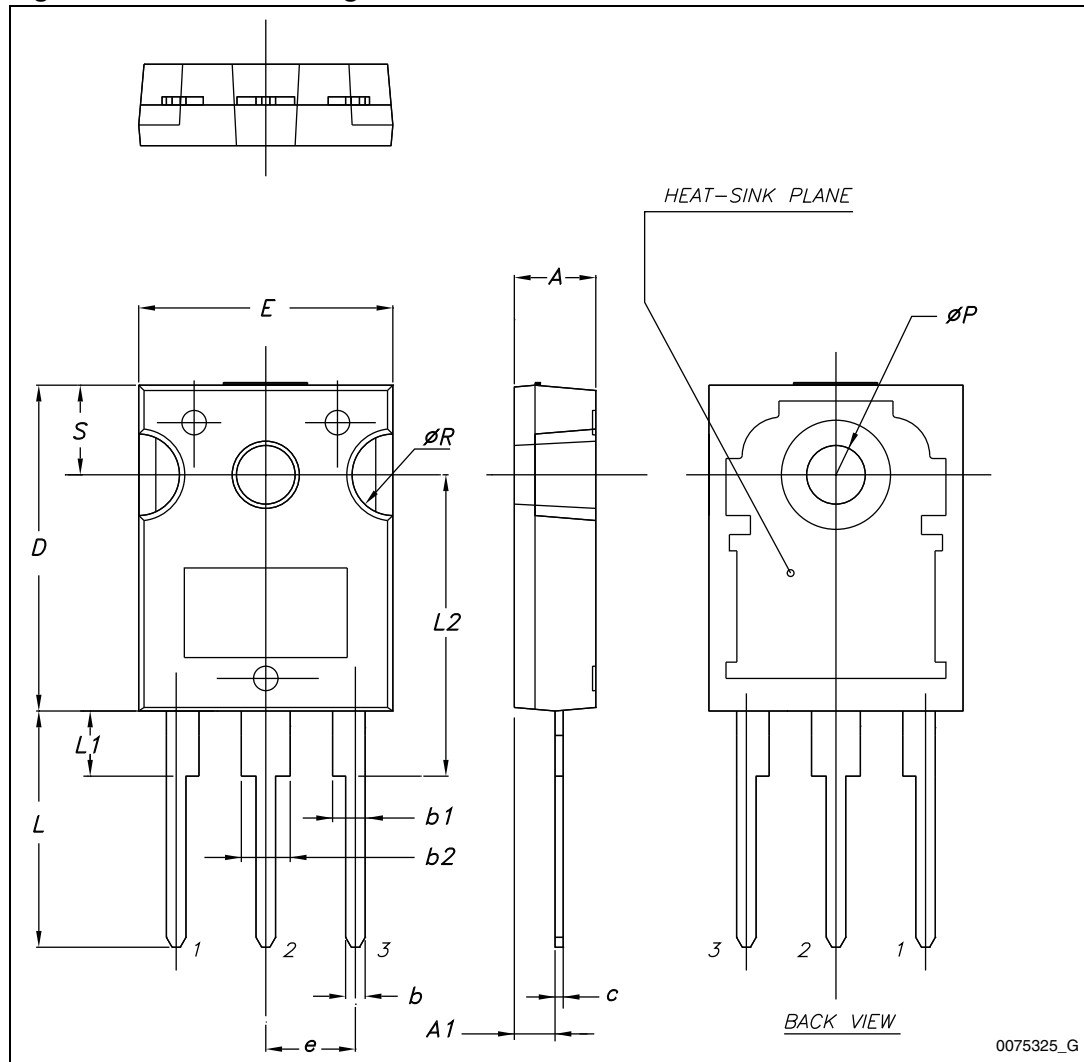


0068771\_J

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 29. TO-247 drawing



0075325\_G

## 5 Revision history

**Table 14. Document revision history**

Date	Revision	Changes
29-Feb-2009	1	First release
13-Jan-2010	2	– Added new package, mechanical data: TO-247 – Added new package, mechanical data: D <sup>2</sup> PAK
08-Nov-2010	3	– Modified <a href="#">Figure 4</a> – Added new package, mechanical data: I <sup>2</sup> PAK
18-Jan-2012	4	– Added new package, mechanical data: IPAK – Minor text changes
14-Nov-2012	5	The part numbers STB13NM60N and STD13NM60N have been moved to a separate datasheet. <a href="#">Section 4: Package mechanical data</a> has been updated.

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