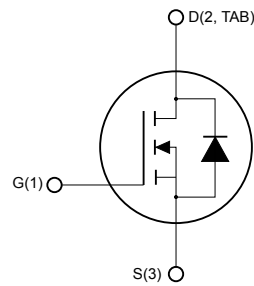
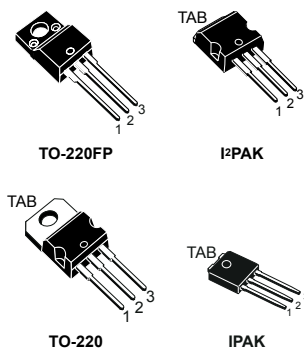


N-channel 600 V, 280 mΩ typ., 11 A MDmesh II Power MOSFETs  
in a TO-220FP, I<sup>2</sup>PAK, TO-220 and IPAK packages



NG1D2TS3



## Features

Order codes	V <sub>DS</sub>	R <sub>DS(on)</sub> max.	I <sub>D</sub>
STF13NM60N	600 V	360 mΩ	11 A
STI13NM60N			
STP13NM60N			
STU13NM60N			

- 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. 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.

### Product status link

[STF13NM60N](#)

[STI13NM60N](#)

[STP13NM60N](#)

[STU13NM60N](#)

# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

Symbol	Parameter	Value		Unit
		TO-220FP	I <sup>2</sup> PAK, TO-220, IPAK	
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
	Drain current (continuous) at T <sub>C</sub> = 100 °C	6.9 <sup>(1)</sup>	6.9	
I <sub>DM</sub> <sup>(2)</sup>	Drain current pulsed	44 <sup>(1)</sup>	44	A
P <sub>TOT</sub>	Total power 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)	2.5		kV
T <sub>J</sub>	Operating junction temperature range	-55 to 150		°C
T <sub>stg</sub>	Storage temperature range			°C

1. Limited by maximum junction temperature.
2. Pulse width limited by safe operating area.
3. I<sub>SD</sub> ≤ 11 A, di/dt ≤ 400 A/μs, V<sub>DD</sub> = 80% V<sub>(BR)DSS</sub>.

**Table 2. Thermal data**

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

**Table 3. 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

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

**Table 4. Static**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source breakdown voltage	$V_{GS} = 0\text{ V}$ , $I_D = 1\text{ mA}$	600			V
$I_{DSS}$	Zero gate voltage drain current	$V_{GS} = 0\text{ V}$ , $V_{DS} = 600\text{ V}$			1	$\mu\text{A}$
		$V_{GS} = 0\text{ V}$ , $V_{DS} = 600\text{ V}$ , $T_C = 125\text{ °C}$ <sup>(1)</sup>			100	
$I_{GSS}$	Gate-body leakage current	$V_{DS} = 0\text{ V}$ , $V_{GS} = \pm 25\text{ V}$			$\pm 100$	nA
$V_{GS(th)}$	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	$V_{GS} = 10\text{ V}$ , $I_D = 5.5\text{ A}$		280	360	m $\Omega$

1. Defined by design, not subject to production test.

**Table 5. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$C_{iss}$	Input capacitance	$V_{DS} = 50\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GS} = 0\text{ V}$	-	790	-	pF
$C_{oss}$	Output capacitance		-	60	-	pF
$C_{rss}$	Reverse transfer capacitance		-	3.6	-	pF
$C_{oss\text{ eq.}}^{(1)}$	Equivalent output capacitance	$V_{DS} = 0\text{ to }480\text{ V}$ , $V_{GS} = 0\text{ V}$	-	135	-	pF
$Q_g$	Total gate charge	$V_{DD} = 480\text{ V}$ , $I_D = 11\text{ A}$ , $V_{GS} = 0\text{ to }10\text{ V}$ (see Figure 17. Test circuit for gate charge behavior)	-	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	-

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 6. Switching times**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 300\text{ V}$ , $I_D = 5.5\text{ A}$ , $R_G = 4.7\text{ }\Omega$ , $V_{GS} = 10\text{ V}$	-	3	-	ns
$t_r$	Rise time		-	8	-	ns
$t_{d(off)}$	Turn-off delay time	(see Figure 16. Test circuit for resistive load switching times and Figure 21. Switching time waveform)	-	30	-	ns
$t_f$	Fall time		-	10	-	ns

**Table 7. 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	$V_{GS} = 0\text{ V}$ , $I_{SD} = 11\text{ A}$	-		1.5	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 11\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ ,	-	230		ns
$Q_{rr}$	Reverse recovery charge	$V_{DD} = 100\text{ V}$	-	2		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current	(see Figure 18. Test circuit for inductive load switching and diode recovery times)	-	18		A
$t_{rr}$	Reverse recovery time	$I_{SD} = 11\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ ,	-	290		ns
$Q_{rr}$	Reverse recovery charge	$V_{DD} = 100\text{ V}$ , $T_J = 150\text{ }^\circ\text{C}$	-	2.5		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current	(see Figure 18. Test circuit for inductive load switching and diode recovery times)	-	17		A

1. Pulse width is limited by safe operating area.

2. Pulse test: pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%.

## 2.1 Electrical characteristics (curves)

Figure 1. Safe operating area for I<sup>2</sup>PAK and TO-220

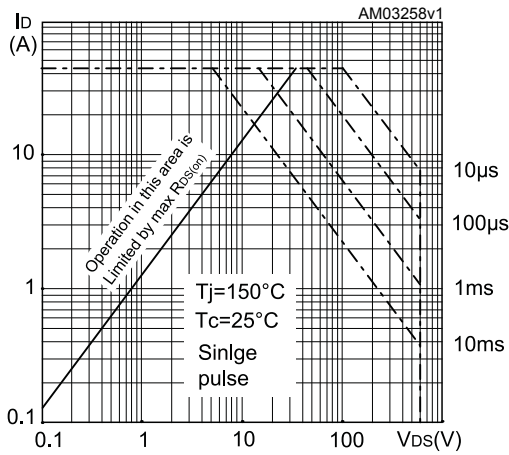


Figure 2. Thermal impedance for I<sup>2</sup>PAK and TO-220

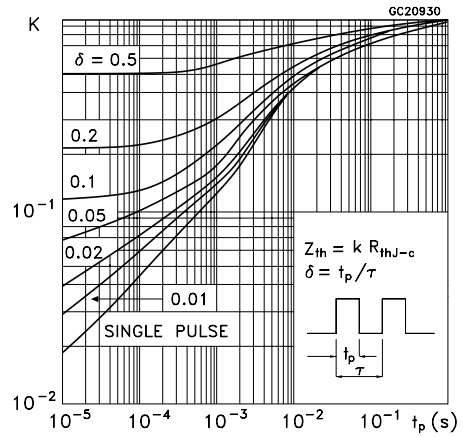


Figure 3. Safe operating area for TO-220FP

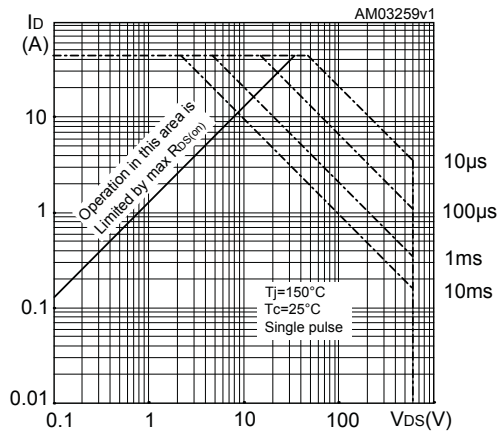


Figure 4. Thermal impedance for TO-220FP

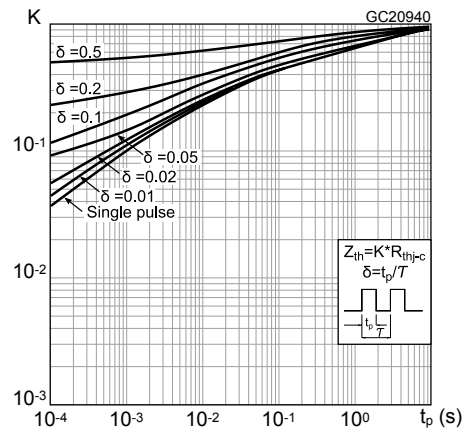


Figure 5. Safe operating area for IPAK

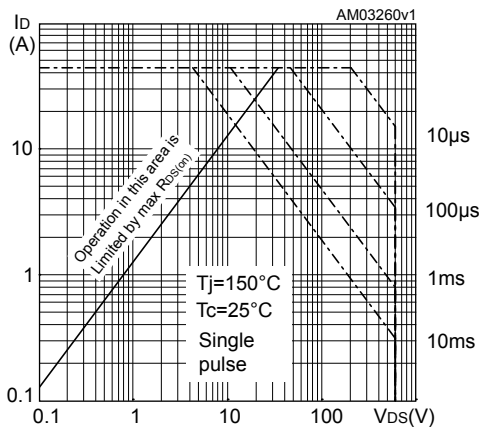
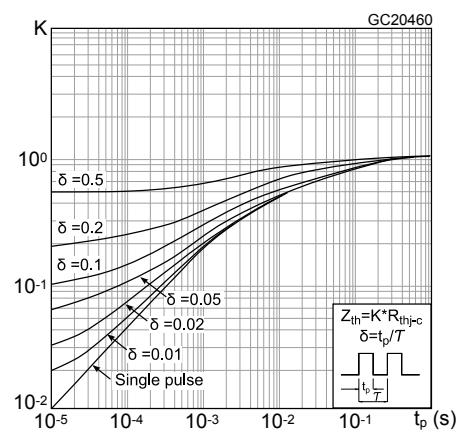
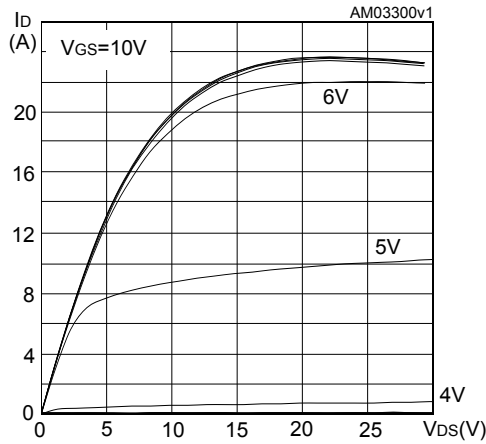
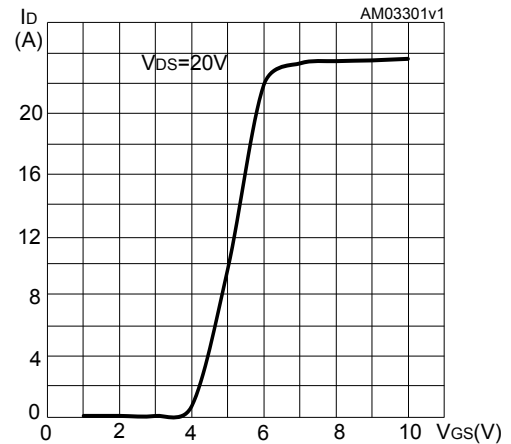
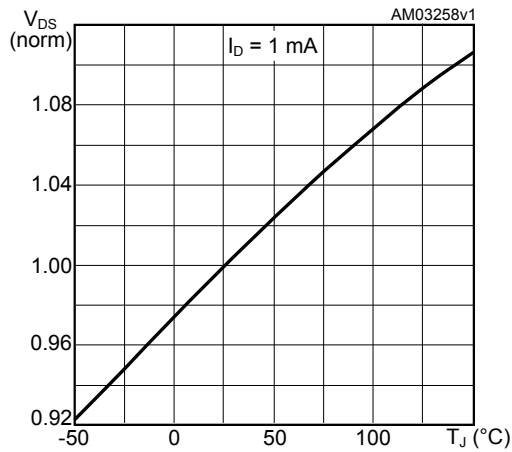
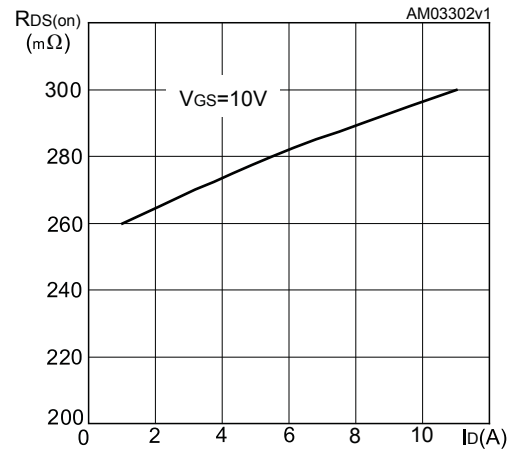
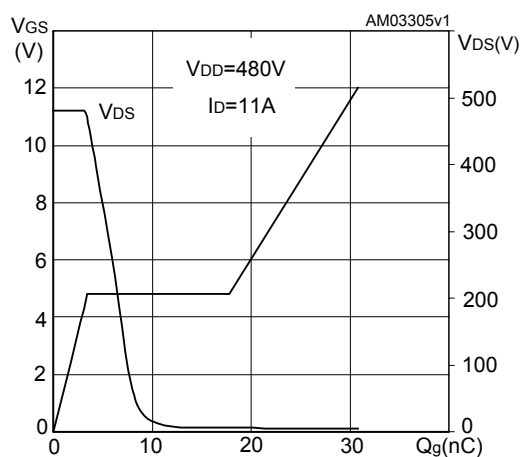
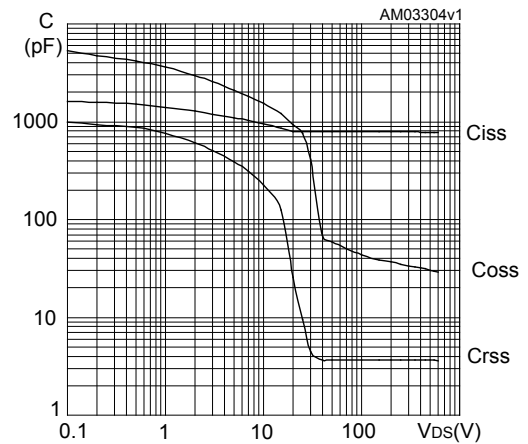
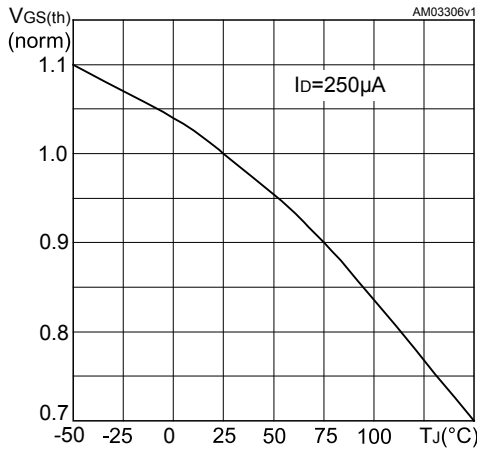


Figure 6. Thermal impedance for IPAK

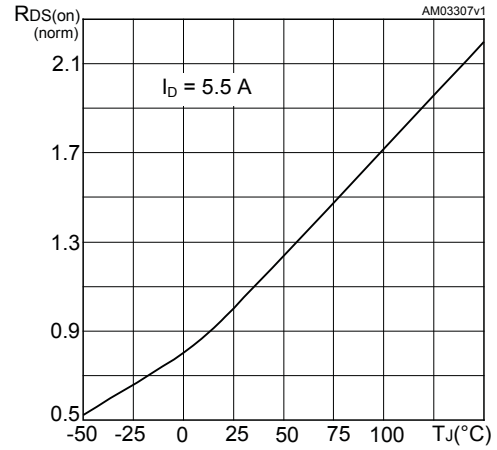


**Figure 7. Output characteristics**

**Figure 8. Transfer characteristics**

**Figure 9. Normalized  $V_{DS}$  vs temperature**

**Figure 10. Static drain-source on-resistance**

**Figure 11. Gate charge vs gate-source voltage**

**Figure 12. Capacitance variations**


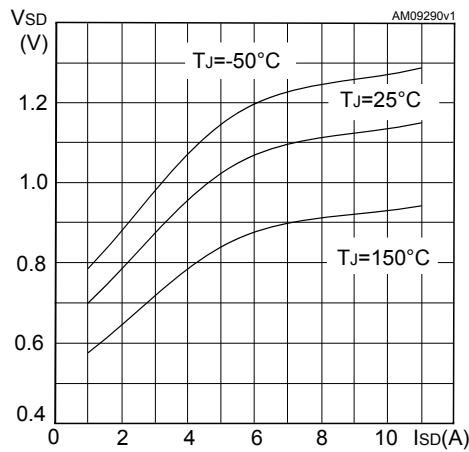
**Figure 13. Normalized gate threshold voltage vs temperature**



**Figure 14. Normalized on resistance vs temperature**

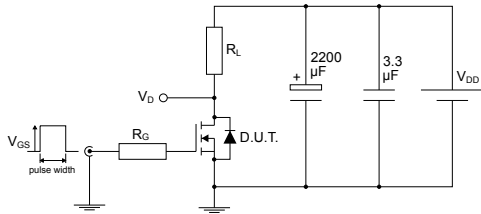


**Figure 15. Source-drain diode forward characteristics**



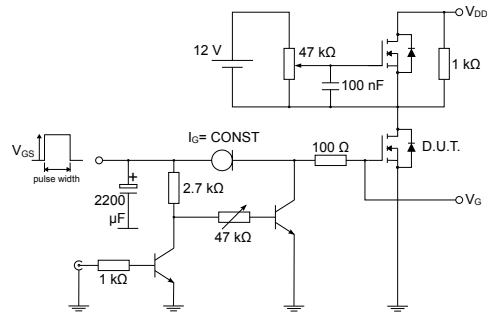
### 3 Test circuits

Figure 16. Test circuit for resistive load switching times



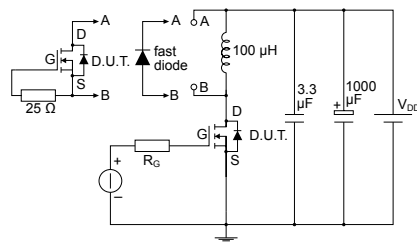
AM01468v1

Figure 17. Test circuit for gate charge behavior



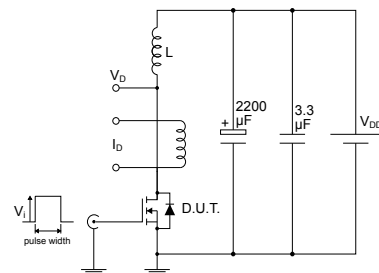
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Figure 18. Test circuit for inductive load switching and diode recovery times



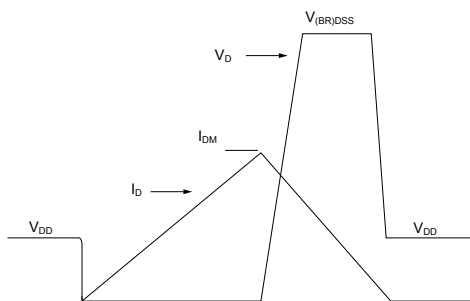
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Figure 19. Unclamped inductive load test circuit



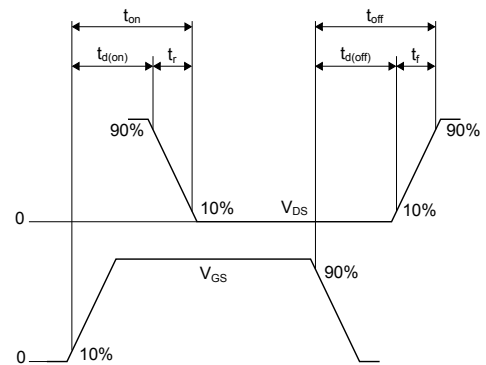
AM01471v1

Figure 20. Unclamped inductive waveform



AM01472v1

Figure 21. Switching time waveform



AM01473v1

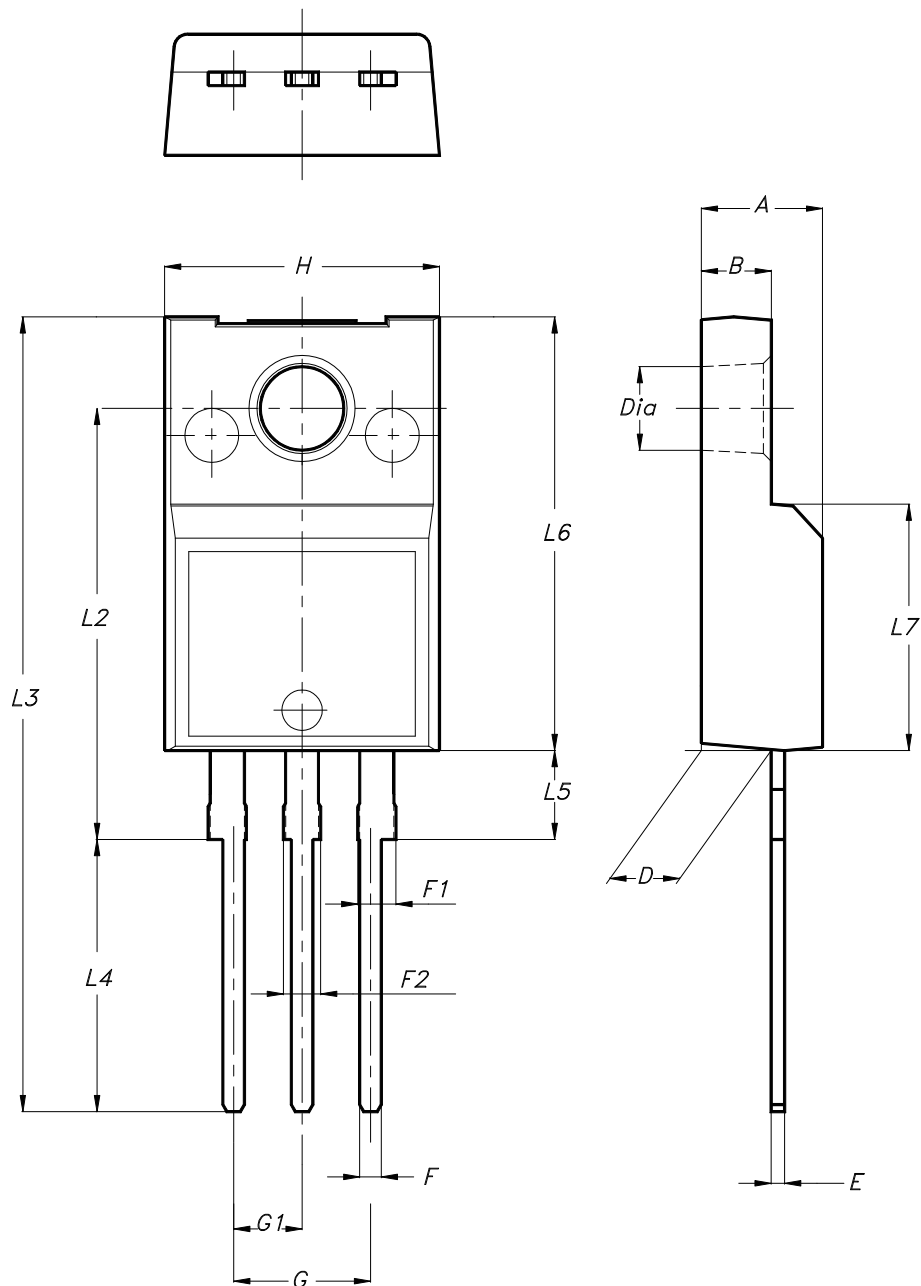


## 4 Package information

In order to meet environmental requirements, ST offers these devices in different grades of **ECOPACK** packages, depending on their level of environmental compliance. ECOPACK specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK is an ST trademark.

### 4.1 TO-220FP package information

Figure 22. TO-220FP package outline



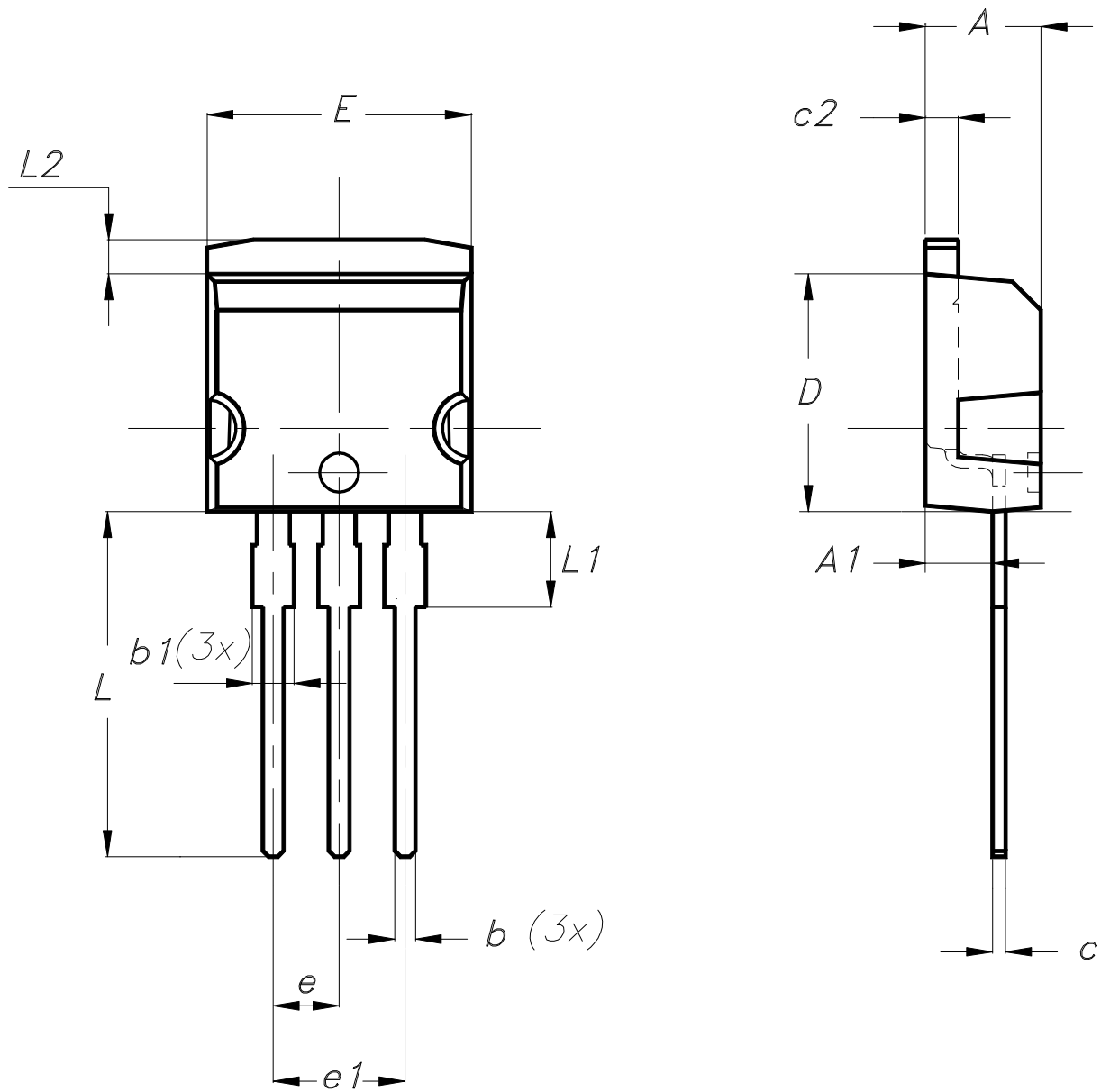
7012510\_Rev\_13\_B

**Table 8. TO-220FP package mechanical data**

Dim.	mm		
	Min.	Typ.	Max.
A	4.40		4.60
B	2.50		2.70
D	2.50		2.75
E	0.45		0.70
F	0.75		1.00
F1	1.15		1.70
F2	1.15		1.70
G	4.95		5.20
G1	2.40		2.70
H	10.00		10.40
L2		16.00	
L3	28.60		30.60
L4	9.80		10.60
L5	2.90		3.60
L6	15.90		16.40
L7	9.00		9.30
Dia	3.00		3.20

4.2 I<sup>2</sup>PAK package information

Figure 23. I<sup>2</sup>PAK package outline



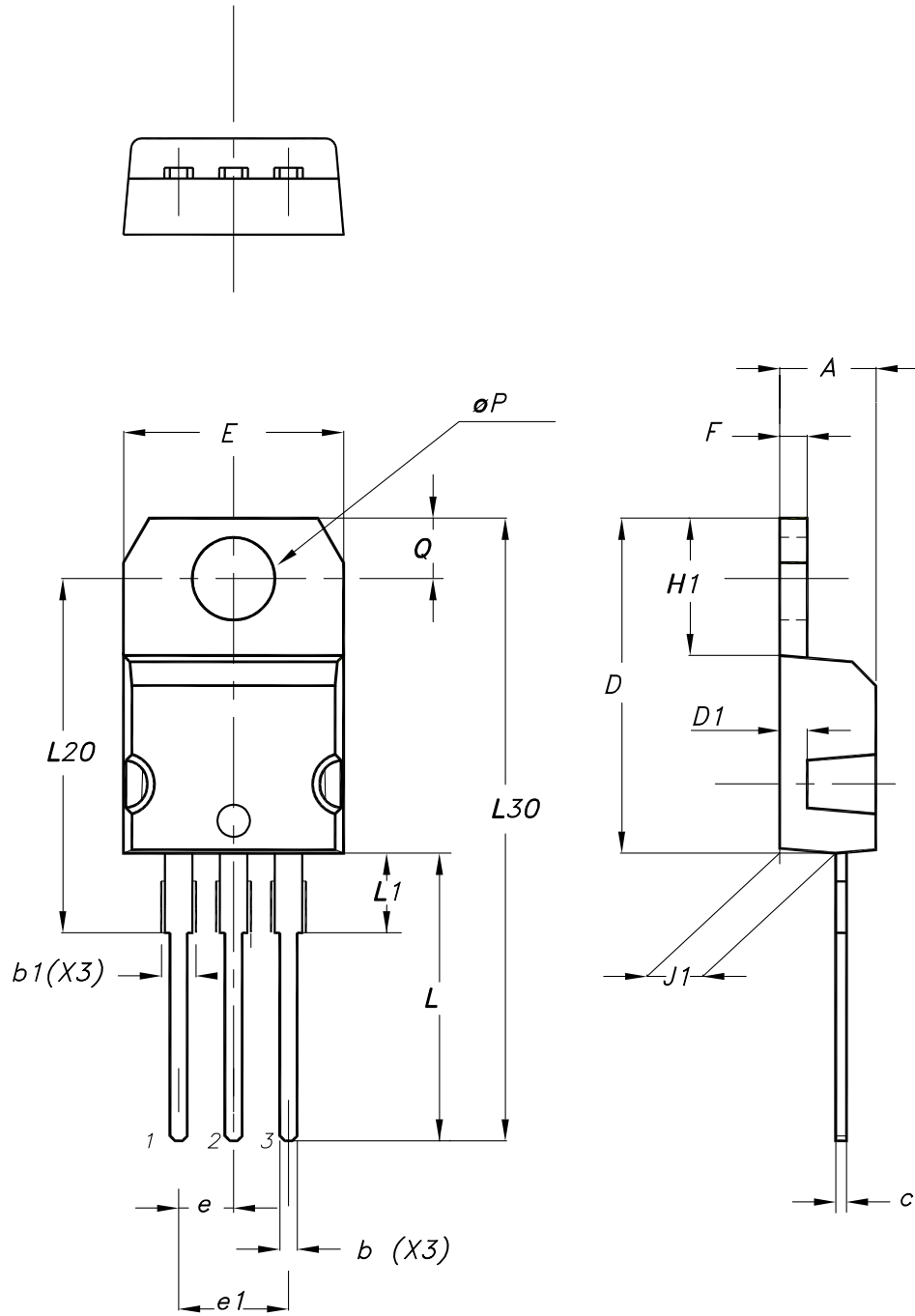
0004982\_Rev\_9

**Table 9. I<sup>2</sup>PAK package 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	10.00	-	10.40
L	13.00	-	14.00
L1	3.50	-	3.93
L2	1.27	-	1.40

### 4.3 TO-220 type A package information

Figure 24. TO-220 type A package outline



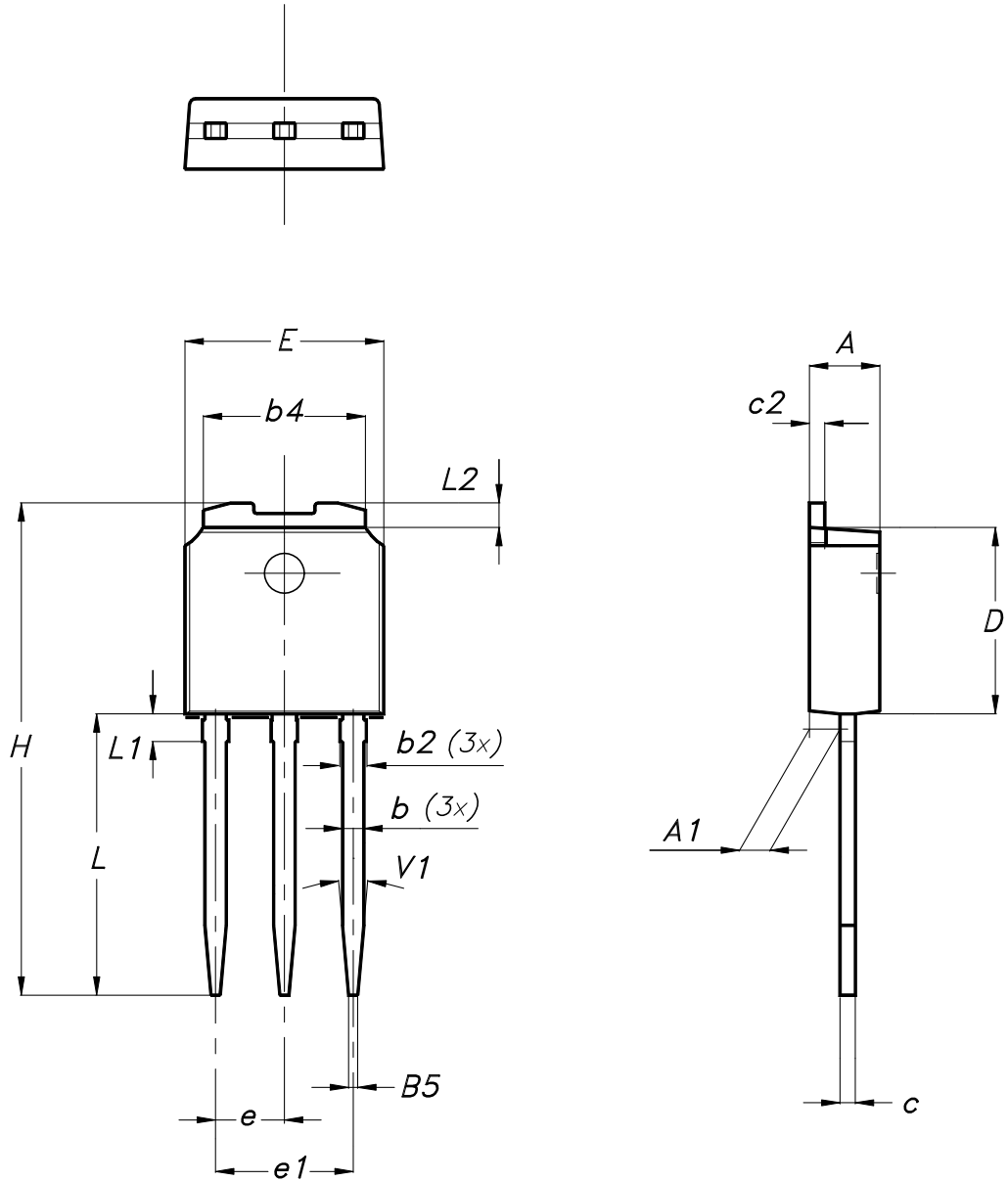
0015988\_typeA\_Rev\_23

**Table 10. TO-220 type A package mechanical data**

Dim.	mm		
	Min.	Typ.	Max.
A	4.40		4.60
b	0.61		0.88
b1	1.14		1.55
c	0.48		0.70
D	15.25		15.75
D1		1.27	
E	10.00		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	13.00		14.00
L1	3.50		3.93
L20		16.40	
L30		28.90	
øP	3.75		3.85
Q	2.65		2.95
Slug flatness		0.03	0.10

#### 4.4 IPAK (TO-251) type A package information

Figure 25. IPAK (TO-251) type A package outline



0068771\_IK\_typeA\_rev15

**Table 11. IPAK (TO-251) type A package 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		0.30	
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°	



## 5 Ordering information

Table 12. Order codes

Order codes	Marking	Package	Packing
STF13NM60N	13NM60N	TO-220FP	Tube
STI13NM60N		I <sup>2</sup> PAK	
STP13NM60N		TO-220	
STU13NM60N		IPAK	

## Revision history

**Table 13. Document revision history**

Date	Revision	Changes
29-Feb-2009	1	First release
13-Jan-2010	2	<ul style="list-style-type: none"> <li>– Added new package, mechanical data: TO-247</li> <li>– Added new package, mechanical data: D<sup>2</sup>PAK</li> </ul>
08-Nov-2010	3	<ul style="list-style-type: none"> <li>– Modified <i>Figure 4</i></li> <li>– Added new package, mechanical data: I<sup>2</sup>PAK</li> </ul>
18-Jan-2012	4	<ul style="list-style-type: none"> <li>– Added new package, mechanical data: IPAK</li> <li>– Minor text changes</li> </ul>
14-Nov-2012	5	<p>The part numbers STB13NM60N and STD13NM60N have been moved to a separate datasheet.</p> <p><i>Section 4: Package mechanical data</i> has been updated.</p>
26-Oct-2020	6	<p>The part number STW13NM60N have been moved to a separate datasheet and the document has been updated accordingly.</p> <p>Updated cover page.</p> <p>Updated <a href="#">Section 1 Electrical ratings</a>.</p> <p>Updated <a href="#">Table 4. Static</a> and <a href="#">Table 7. Source-drain diode</a>.</p> <p>Updated <a href="#">Section 4 Package information</a>.</p> <p>Added <a href="#">Section 5 Ordering information</a>.</p> <p>Minor text changes.</p>

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