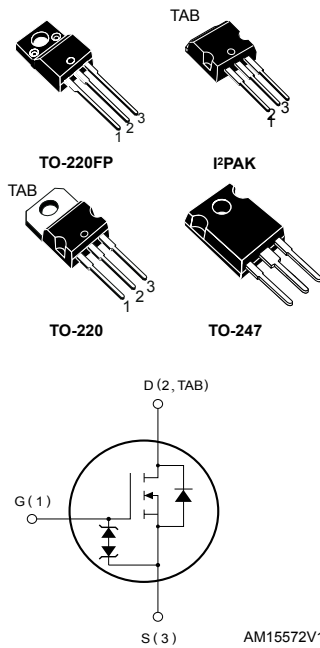


N-channel 600 V, 0.108 Ω typ., 26 A, MDmesh M2 Power MOSFETs in TO-220FP, I²PAK, TO-220 and TO-247 packages



Features

Order codes	$V_{DS} @ T_{Jmax}$	$R_{DS(on)}$ max.	I_D	Package
STF33N60M2	650 V	0.125 Ω	26 A	TO-220FP
STI33N60M2				I ² PAK
STP33N60M2				TO-220
STW33N60M2				TO-247

- Extremely low gate charge
- Excellent output capacitance (C_{OSS}) profile
- 100% avalanche tested
- Zener-protected

Applications

- Switching applications
- LLC converters, resonant converters

Description

These devices are N-channel Power MOSFETs developed using the MDmesh M2 technology. Thanks to their strip layout and improved vertical structure, these devices exhibit low on-resistance and optimized switching characteristics, rendering them suitable for the most demanding high-efficiency converters.



Product status links

[STF33N60M2](#)

[STI33N60M2](#)

[STP33N60M2](#)

[STW33N60M2](#)

1 Electrical ratings

Table 1. Absolute maximum ratings

Symbol	Parameter	Value		Unit
		TO-220FP	I ² PAK, TO-220, TO-247	
V _{GS}	Gate-source voltage	±25		V
I _D	Drain current (continuous) at T _C = 25 °C	26 ⁽¹⁾	26	A
	Drain current (continuous) at T _C = 100 °C	16 ⁽¹⁾	16	A
I _{DM} ⁽²⁾	Drain current (pulsed)	104 ⁽¹⁾	104	A
P _{TOT}	Total power dissipation at T _C = 25 °C	35	190	W
dv/dt ⁽³⁾	Peak diode recovery voltage slope	15		V/ns
dv/dt ⁽⁴⁾	MOSFET dv/dt ruggedness	50		V/ns
V _{ISO}	Insulation withstand voltage (RMS) from all three leads to external heat sink (t = 1 s, T _C = 25 °C)	2500		V
T _{stg}	Storage temperature range	-50 to 150		°C
T _j	Operating junction temperature range			

- Limited by maximum junction temperature.
- Pulse width is limited by safe operating area.
- I_{SD} ≤ 26 A, di/dt ≤ 400 A/μs, V_{DS peak} < V_{(BR)DSS}, V_{DD} = 400 V
- V_{DS} ≤ 480 V

Table 2. Thermal data

Symbol	Parameter	Value			Unit
		TO-220FP	I ² PAK TO-220	TO-247	
R _{thj-case}	Thermal resistance junction-case	3.6	0.66		°C/W
R _{thj-amb}	Thermal resistance junction-ambient	62.5		50	°C/W

Table 3. Avalanche characteristics

Symbol	Parameter	Value	Unit
I _{AR}	Avalanche current, repetitive or not repetitive (pulse width limited by T _{jmax})	5	A
E _{AS}	Single pulse avalanche energy (starting T _j = 25 °C, I _D = I _{AR} , V _{DD} = 50 V)	450	mJ

2 Electrical characteristics

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

Table 4. On/off states

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source breakdown voltage	$I_D = 1\text{ mA}$, $V_{GS} = 0\text{ V}$	600			V
I_{DSS}	Zero gate voltage drain current	$V_{GS} = 0\text{ V}$, $V_{DS} = 600\text{ V}$			1	μA
		$V_{GS} = 0\text{ V}$, $V_{DS} = 600\text{ V}$, $T_C = 125\text{ °C}^{(1)}$			100	μA
I_{GSS}	Gate-body leakage current	$V_{DS} = 0\text{ V}$, $V_{GS} = \pm 25\text{ V}$			± 10	μA
$V_{GS(th)}$	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	Ω

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

Table 5. Dynamic

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
C_{iss}	Input capacitance	$V_{DS} = 100\text{ V}$, $f = 1\text{ MHz}$, $V_{GS} = 0\text{ V}$	-	1781	-	pF
C_{oss}	Output capacitance		-	85	-	pF
C_{rss}	Reverse transfer capacitance		-	2.5	-	pF
$C_{oss\text{ eq.}}^{(1)}$	Equivalent output capacitance	$V_{DS} = 0\text{ to }480\text{ V}$, $V_{GS} = 0\text{ V}$	-	135	-	pF
R_G	Intrinsic gate resistance	$f = 1\text{ MHz}$, $I_D = 0\text{ V}$	-	5.2	-	Ω
Q_g	Total gate charge	$V_{DD} = 480\text{ V}$, $I_D = 26\text{ A}$, $V_{GS} = 0\text{ to }10\text{ V}$ (see Figure 19. Test circuit for gate charge behavior)	-	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 6. Switching times

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 300\text{ V}$, $I_D = 13\text{ A}$, $R_G = 4.7\text{ }\Omega$, $V_{GS} = 10\text{ V}$	-	16	-	ns
t_r	Rise time		-	9.6	-	ns
$t_{d(off)}$	Turn-off delay time	(see Figure 18. Test circuit for resistive load switching times and Figure 23. Switching time waveform)	-	109	-	ns
t_f	Fall time		-	9	-	ns

Table 7. 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	$I_{SD} = 26\text{ A}$, $V_{GS} = 0\text{ V}$	-		1.6	V
t_{rr}	Reverse recovery time	$I_{SD} = 26\text{ A}$, $di/dt = 100\text{ A}/\mu\text{s}$	-	375		ns
Q_{rr}	Reverse recovery charge	$V_{DD} = 60\text{ V}$	-	5.6		μC
I_{RRM}	Reverse recovery current	(see Figure 20. Test circuit for inductive load switching and diode recovery times)	-	30		A
t_{rr}	Reverse recovery time	$I_{SD} = 26\text{ A}$, $di/dt = 100\text{ A}/\mu\text{s}$	-	478		ns
Q_{rr}	Reverse recovery charge	$V_{DD} = 60\text{ V}$, $T_j = 150\text{ }^\circ\text{C}$	-	7.7		μC
I_{RRM}	Reverse recovery current	(see Figure 20. Test circuit for inductive load switching and diode recovery times)	-	35.5		A

1. Pulse width limited by safe operating area.
2. Pulsed: pulse duration = 300 μs , duty cycle 1.5%.

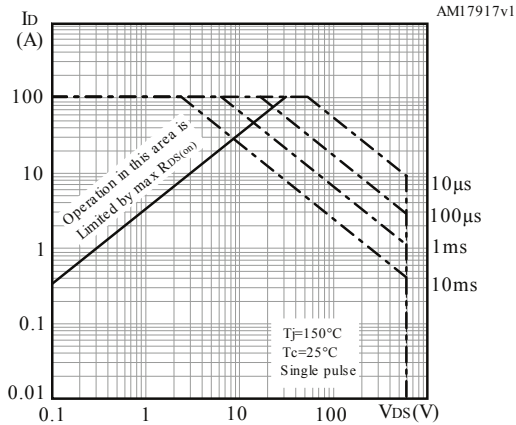
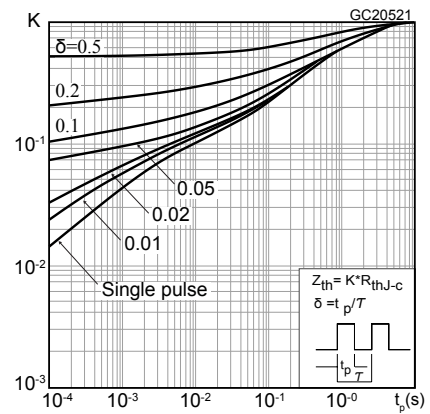
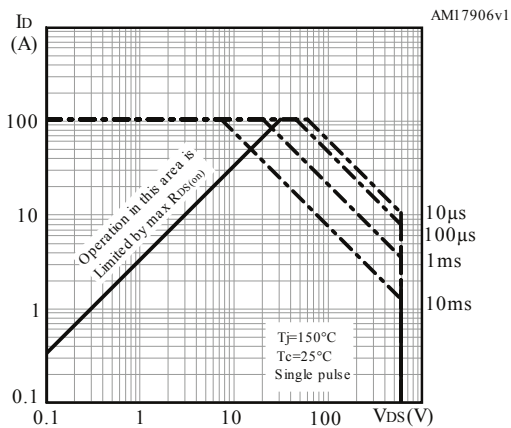
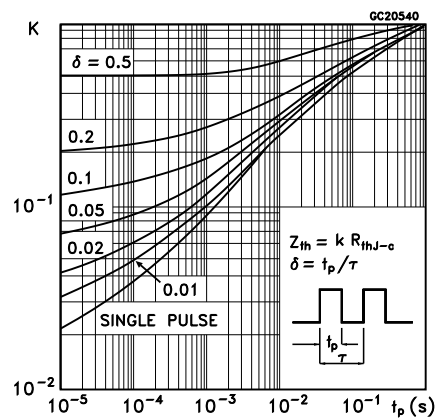
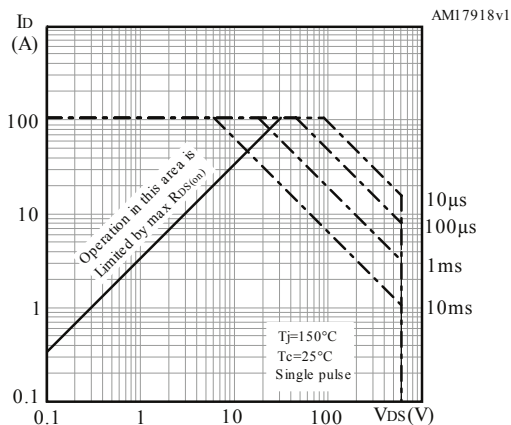
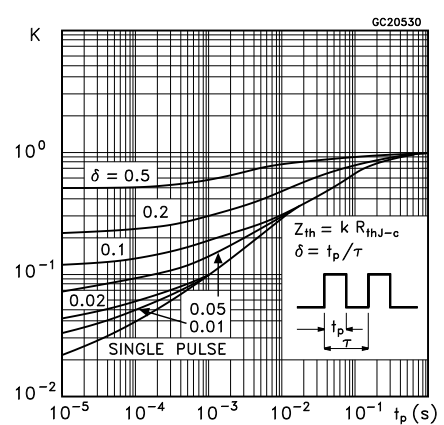
2.1 Electrical characteristics (curves)
Figure 1. Safe operating area for TO-220FP

Figure 2. Thermal impedance for TO-220FP

Figure 3. Safe operating area for I²PAK and TO-220

Figure 4. Thermal impedance for I²PAK and TO-220

Figure 5. Safe operating area for TO-247

Figure 6. Thermal impedance for TO-247


Figure 7. Output characteristics

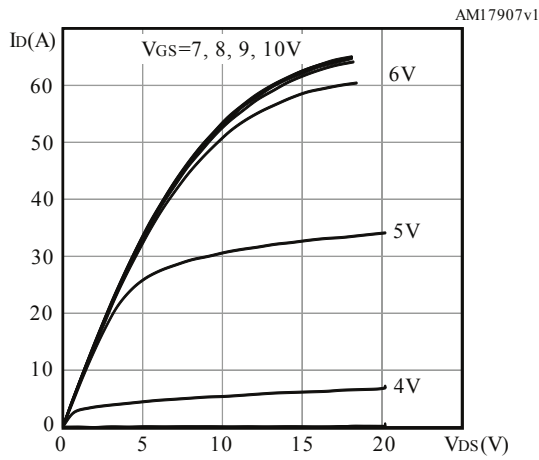


Figure 8. Transfer characteristics

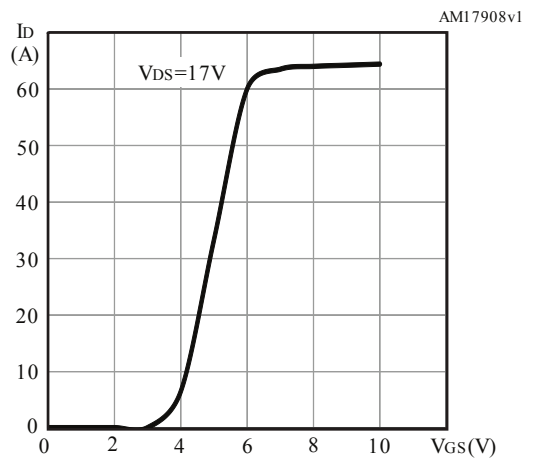


Figure 9. Gate charge vs gate-source voltage

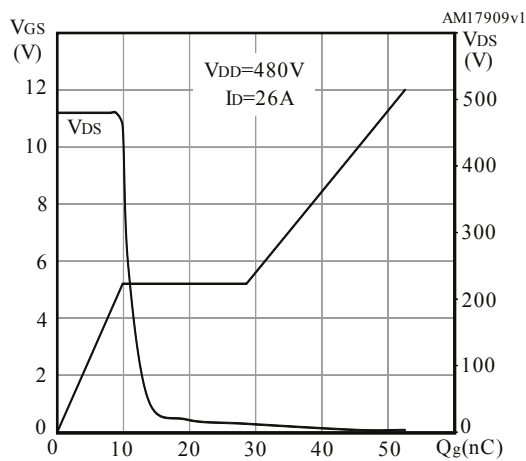


Figure 10. Static drain-source on-resistance

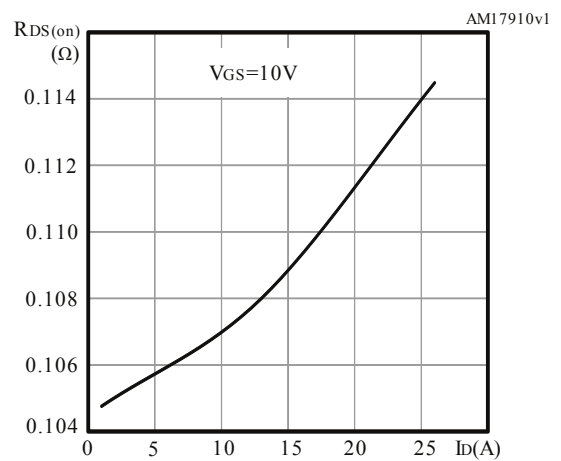


Figure 11. Capacitance variations

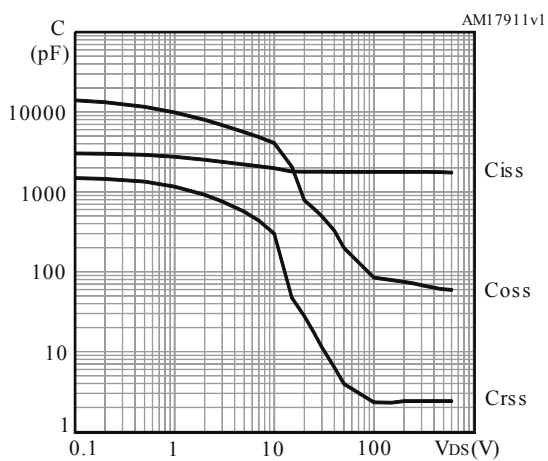


Figure 12. Normalized gate threshold voltage vs temperature

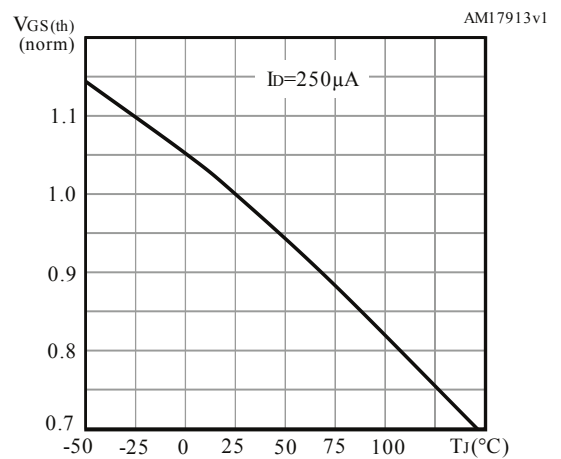


Figure 13. Normalized on-resistance vs temperature

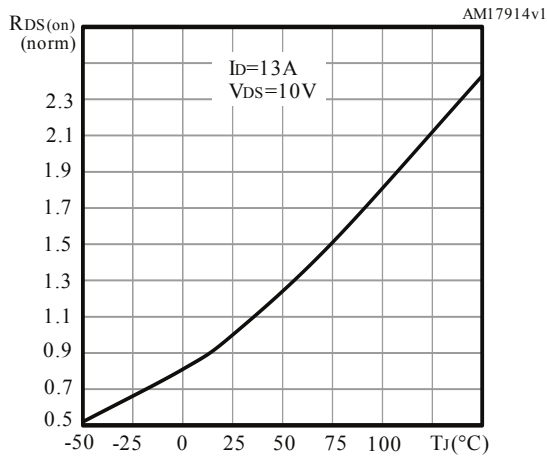


Figure 14. Source-drain diode forward characteristics

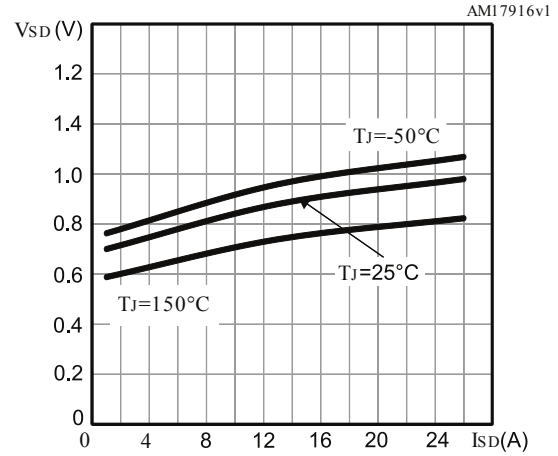


Figure 15. Normalized $V_{(BR)DSS}$ vs temperature

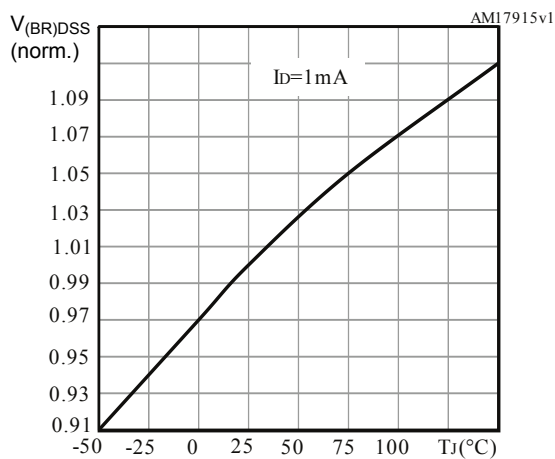


Figure 16. Output capacitance stored energy

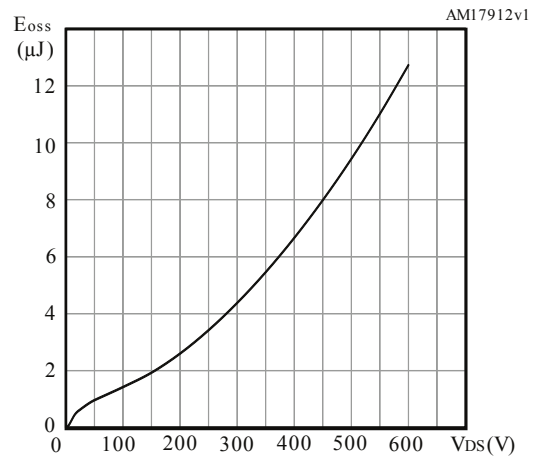
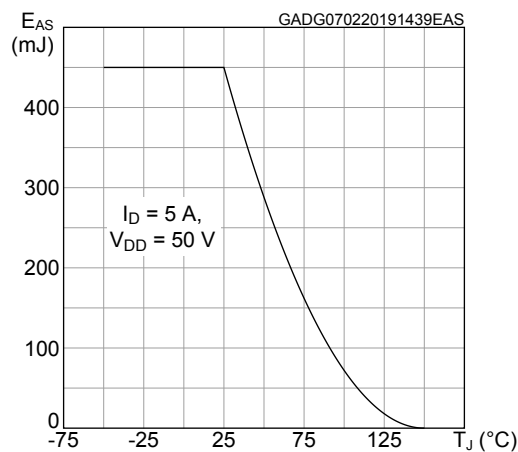


Figure 17. Maximum avalanche energy vs temperature



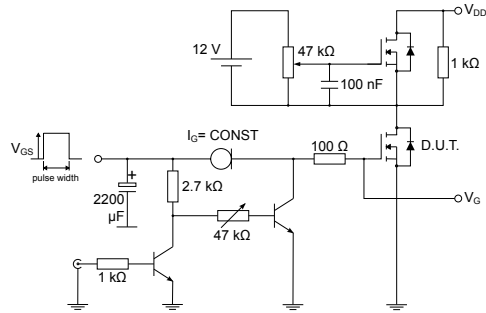
3 Test circuits

Figure 18. Test circuit for resistive load switching times



AM01468v1

Figure 19. Test circuit for gate charge behavior



AM01469v1

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



AM01470v1

Figure 21. Unclamped inductive load test circuit



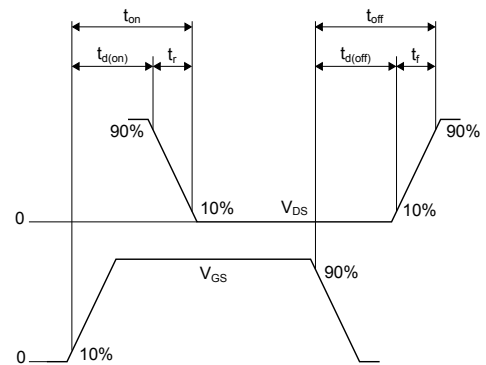
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Figure 22. Unclamped inductive waveform



AM01472v1

Figure 23. Switching time waveform



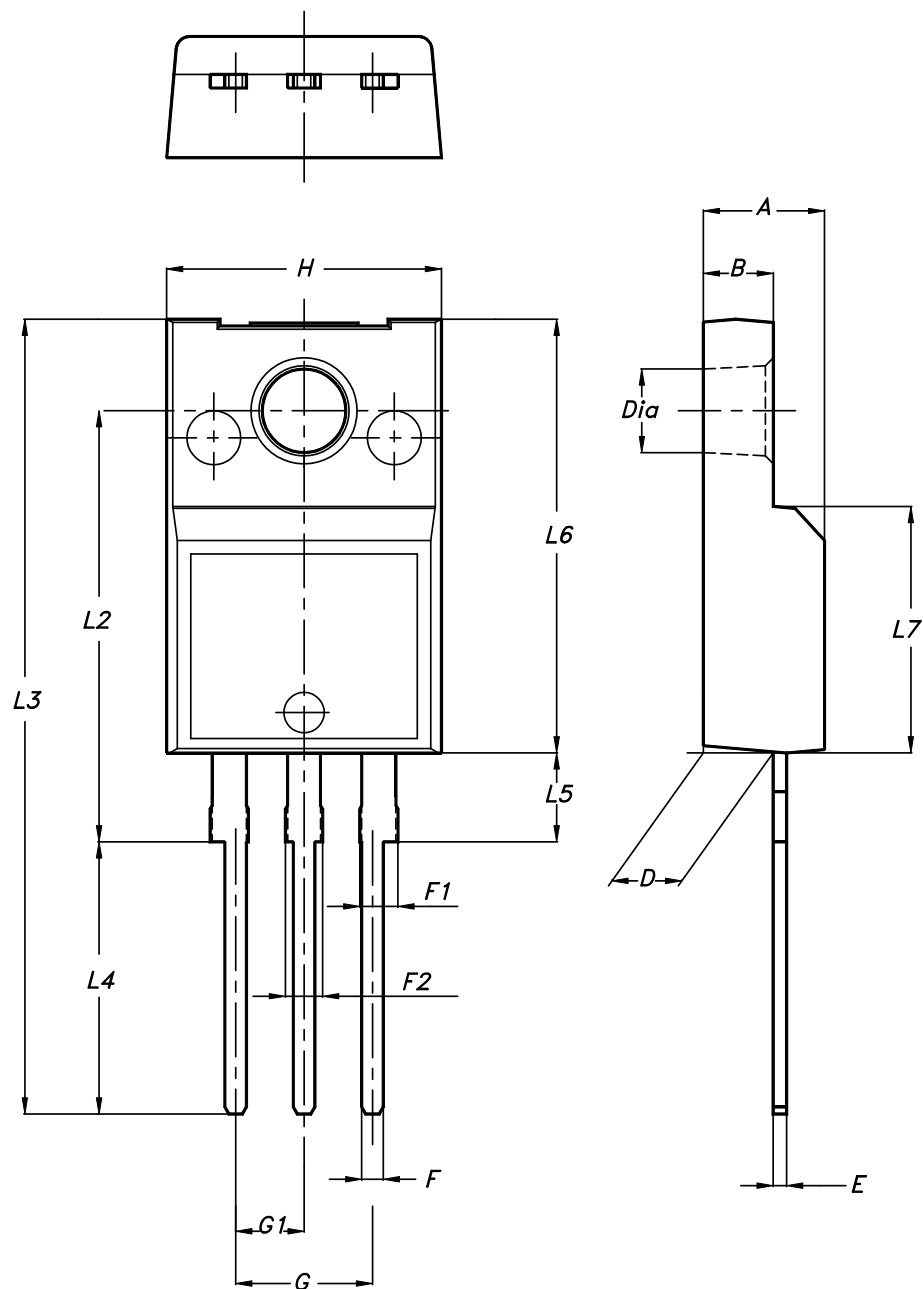
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4 Package information

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. ECOPACK is an ST trademark.

4.1 TO-220FP package information

Figure 24. TO-220FP package outline



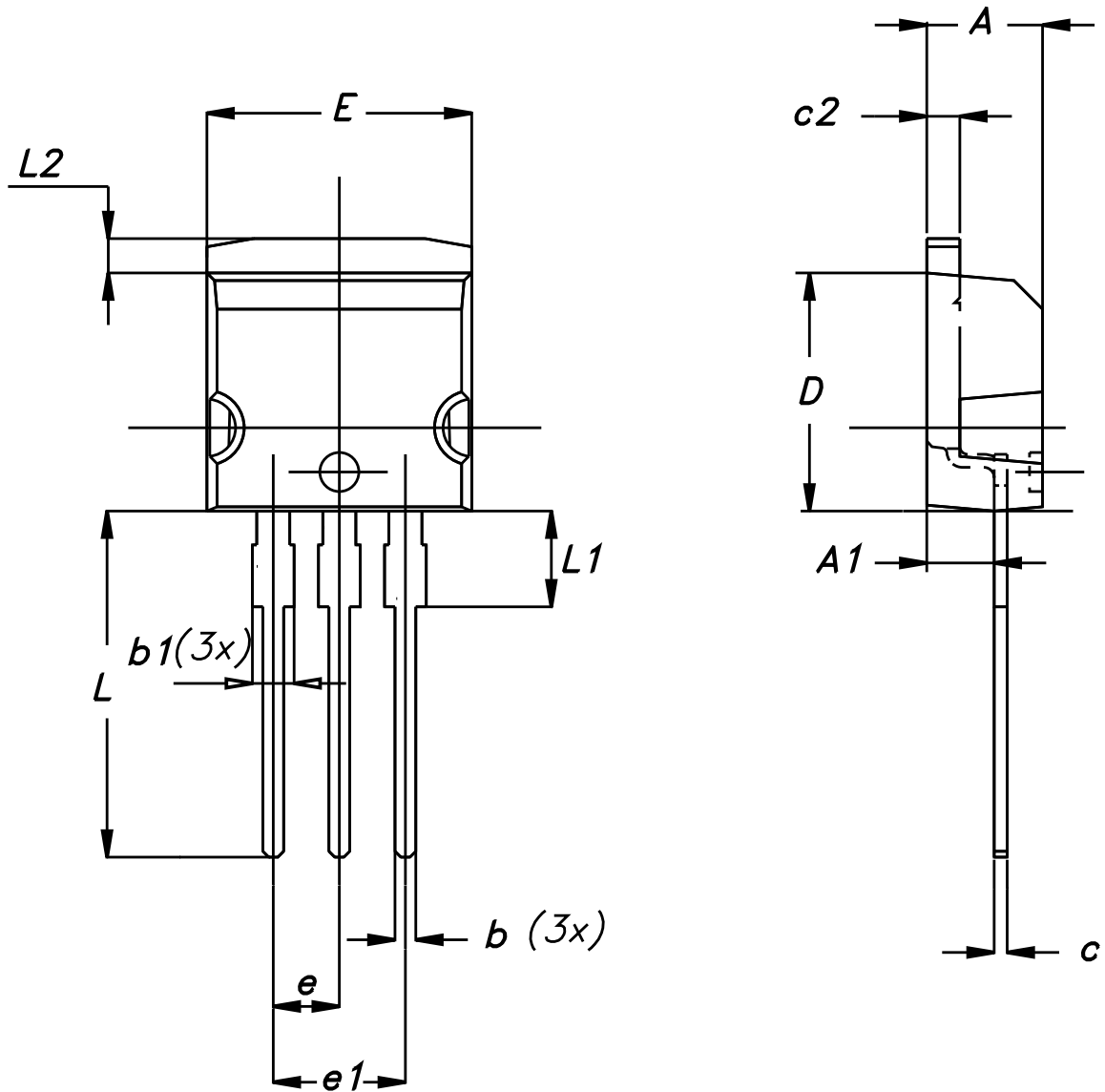
7012510_Rev_13_B

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 I²PAK package information

Figure 25. I²PAK package outline



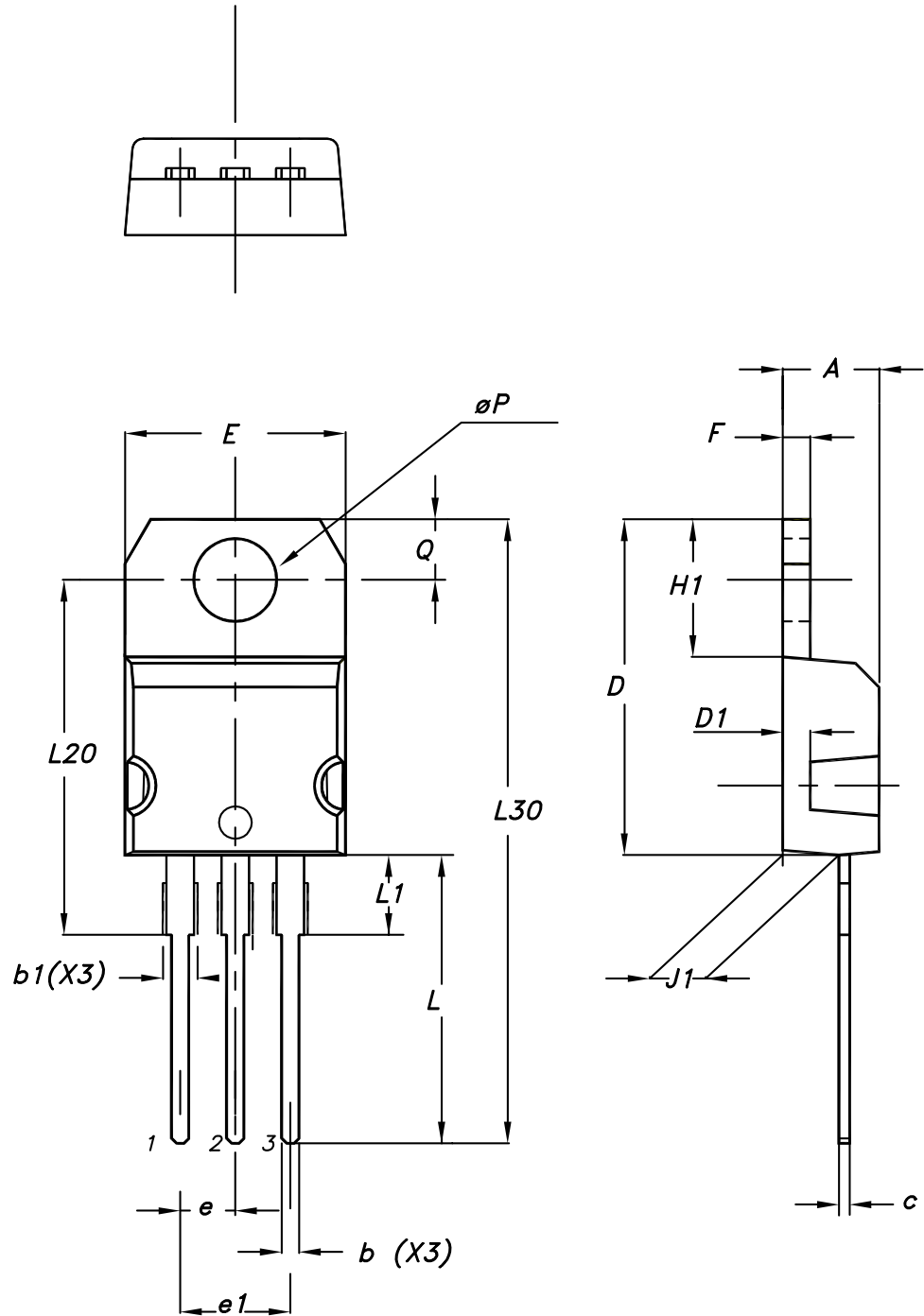
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Table 9. I²PAK package mechanical data

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	-	10.40
L	13	-	14
L1	3.50	-	3.93
L2	1.27	-	1.40

4.3 TO-220 type A package information

Figure 26. TO-220 type A package outline



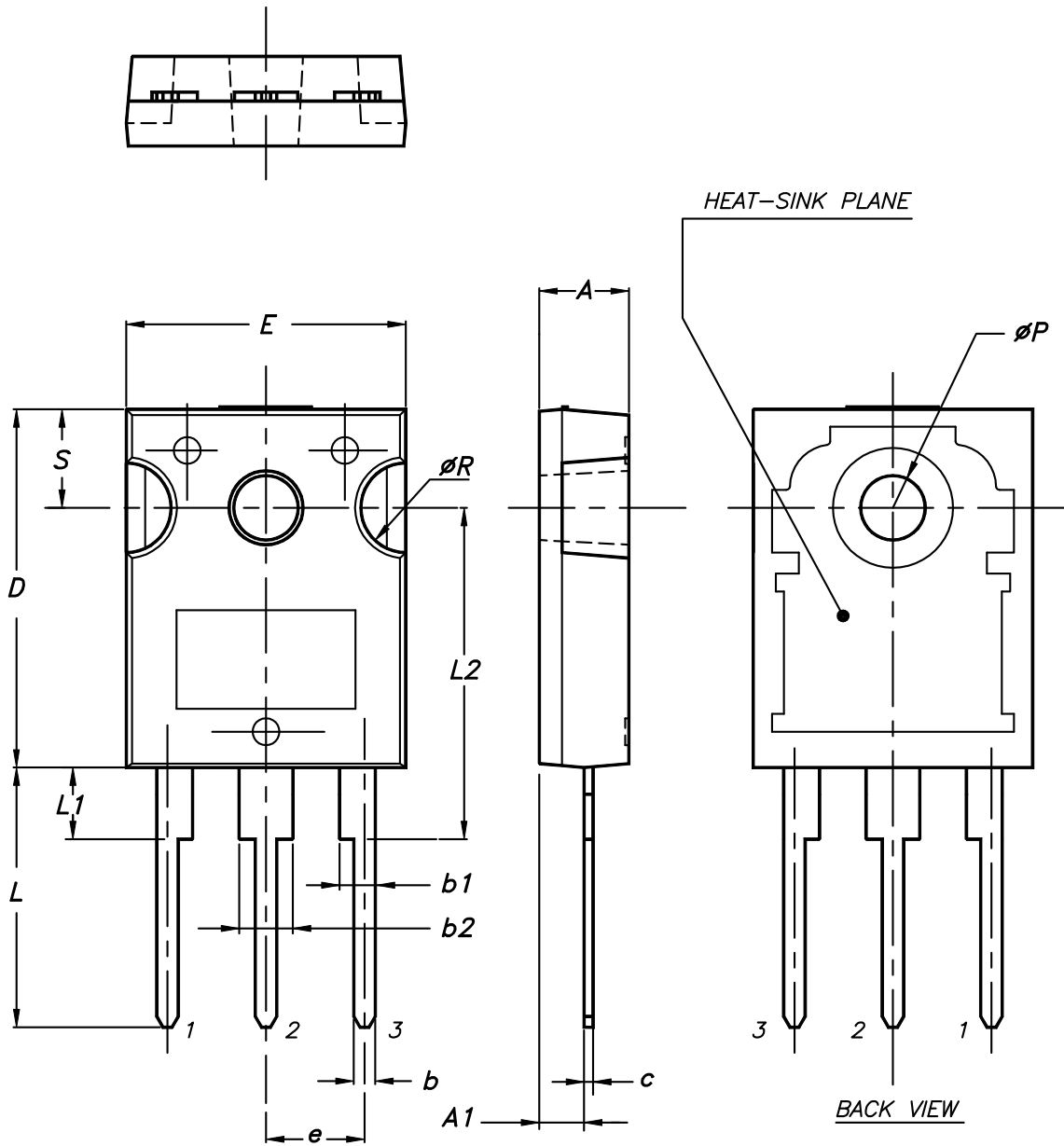
0015988_typeA_Rev_22

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

4.4 TO-247 package information

Figure 27. TO-247 package outline



0075325_9

Table 11. TO-247 package 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

5 Ordering information

Table 12. Order codes

Order code	Marking	Package	Packing
STF33N60M2	33N60M2	TO-220FP	Tube
STI33N60M2		I ² PAK	
STP33N60M2		TO-220	
STW33N60M2		TO-247	

Revision history

Table 13. Document revision history

Date	Version	Changes
13-Sep-2013	1	First release.
19-Nov-2013	2	<p>Modified: $R_{DS(on)}$ and I_D values in cover page</p> <p>Modified: values in <i>Table 4</i></p> <p>Modified: $R_{DS(on)}$ typical and maximum values in <i>Table 5</i>, the entire typical values in <i>Table 6, 7 and 8</i></p> <p>Added: <i>Section 2.1: Electrical characteristics (curves)</i></p> <p>Minor text changes</p>
14-Jun-2019	3	<p>Removed maturity status indication from cover page.</p> <p>Updated title, features and description.</p> <p>Updated Table 3. Avalanche characteristics.</p> <p>Added Figure 17. Maximum avalanche energy vs temperature.</p> <p>Minor text changes</p>

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