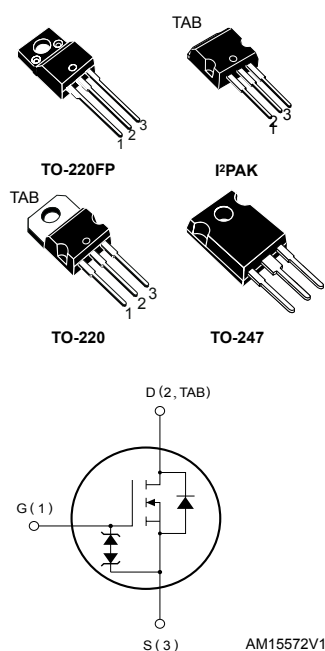


N-channel 600 V, 0.108 Ω typ., 26 A, MDmesh M2 Power MOSFETs in TO-220FP, I²PAK, TO-220 and TO-247 packages



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

($T_C = 25\text{ }^{\circ}\text{C}$ 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
		$V_{GS} = 0\text{ V}$, $V_{DS} = 600\text{ V}$, $T_C = 125\text{ }^{\circ}\text{C}$ ⁽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	$I_{SD} = 26\text{ A}$, $di/dt = 100\text{ A}/\mu\text{s}$ $V_{DD} = 60\text{ V}$ (see Figure 20. Test circuit for inductive load switching and diode recovery times)	-	375		ns
Q_{rr}	Reverse recovery charge		-	5.6		μC
I_{RRM}	Reverse recovery current	$I_{SD} = 26\text{ A}$, $di/dt = 100\text{ A}/\mu\text{s}$ $V_{DD} = 60\text{ V}$, $T_j = 150\text{ }^\circ\text{C}$ (see Figure 20. Test circuit for inductive load switching and diode recovery times)	-	30		A
t_{rr}	Reverse recovery time		-	478		ns
Q_{rr}	Reverse recovery charge		-	7.7		μC
I_{RRM}	Reverse recovery current		-	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)

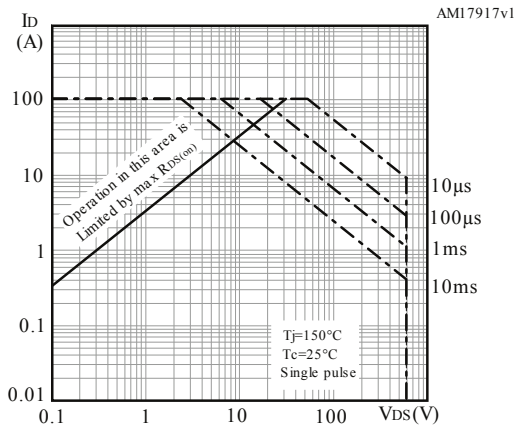
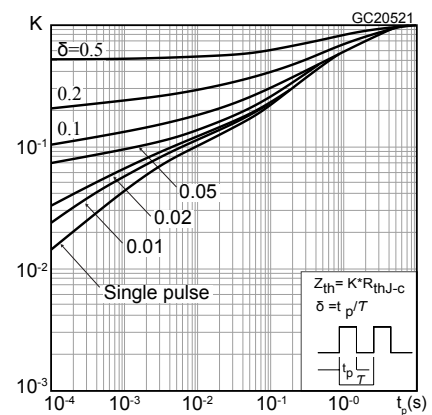
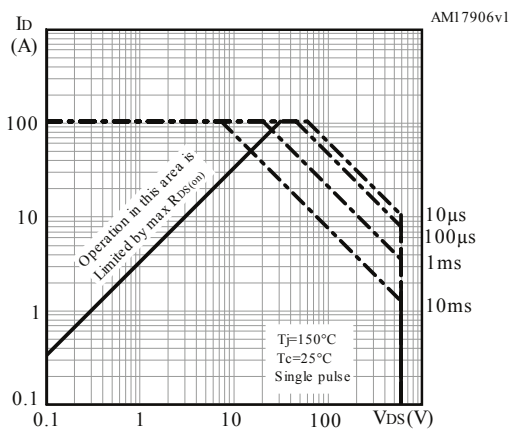
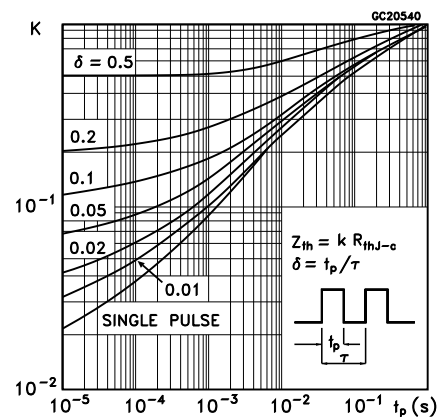
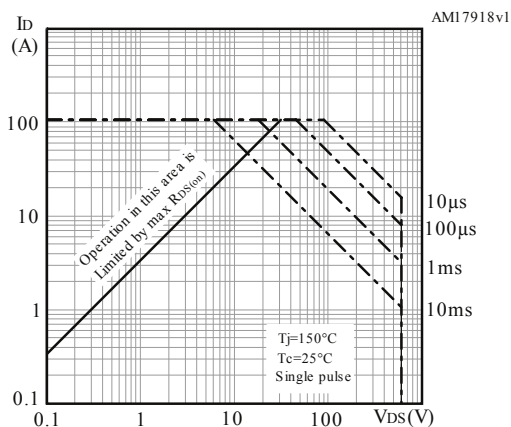
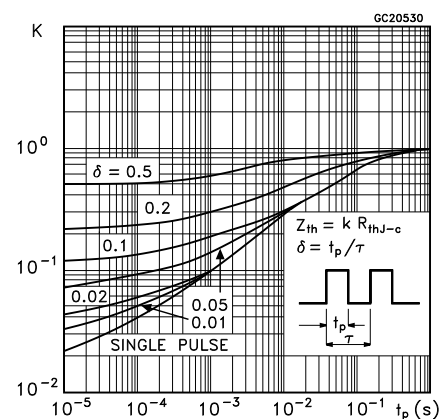
Figure 1. Safe operating area for TO-220FP

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


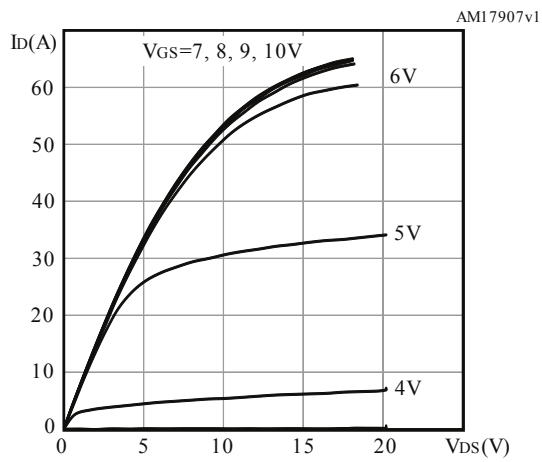
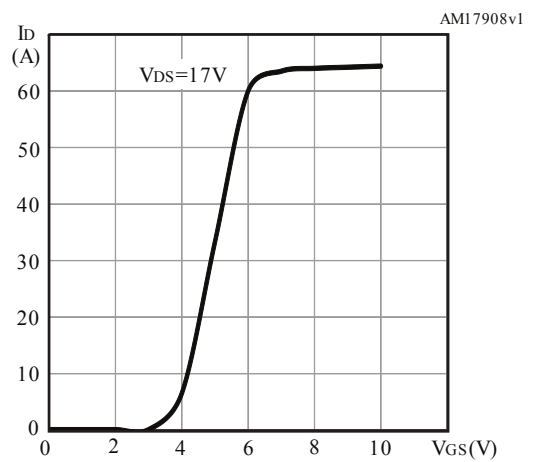
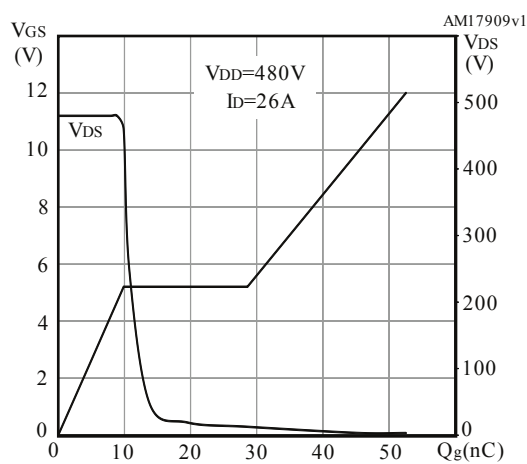
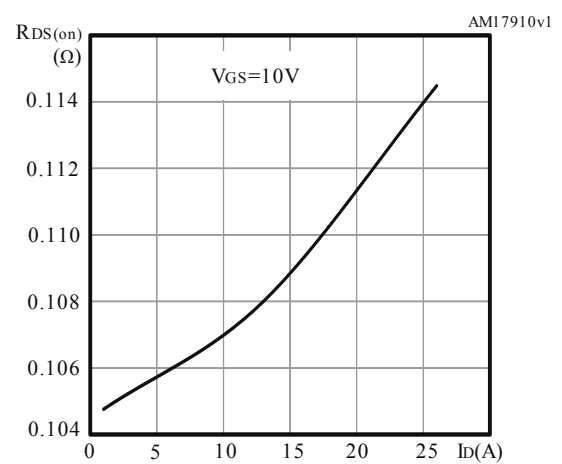
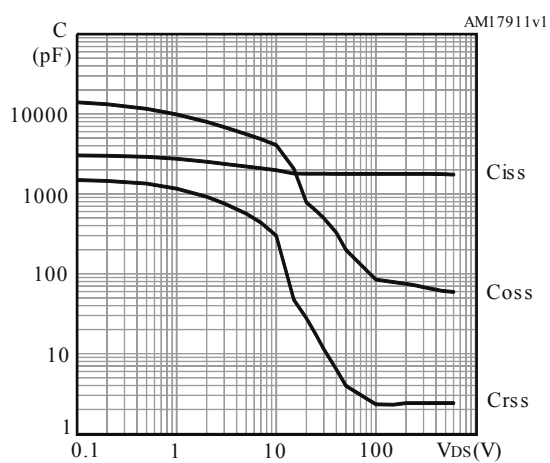
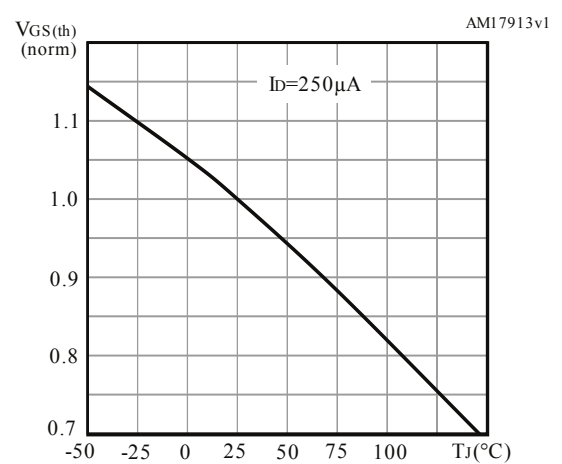
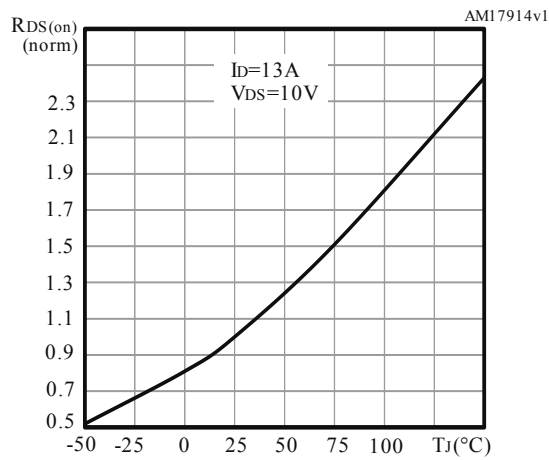
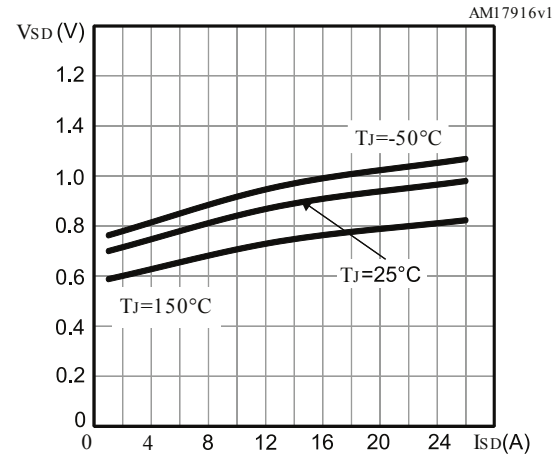
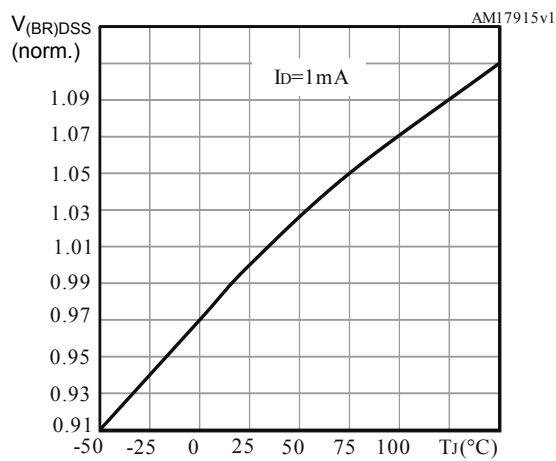
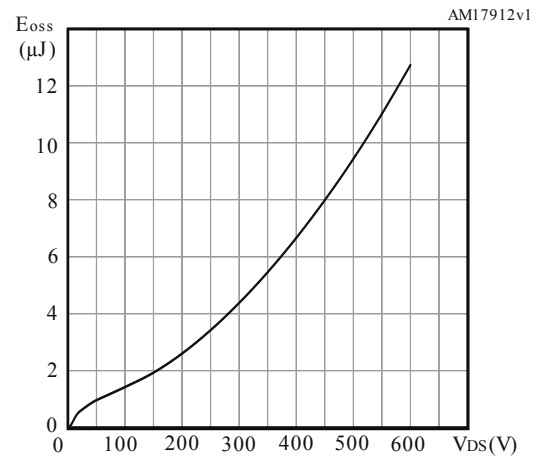
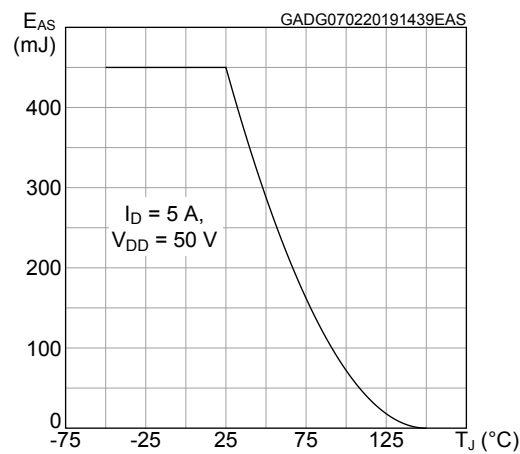
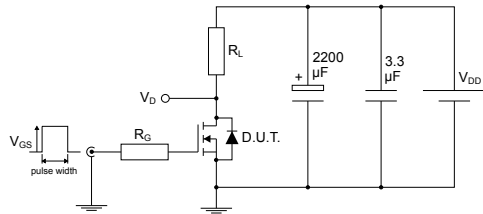
Figure 7. Output characteristics

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


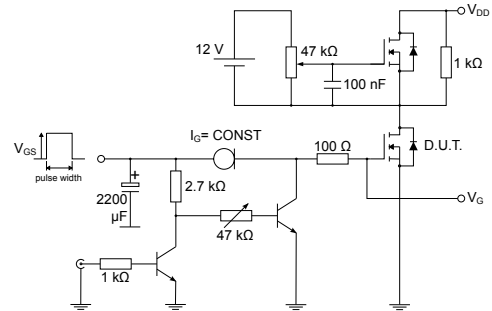
3 Test circuits

Figure 18. Test circuit for resistive load switching times



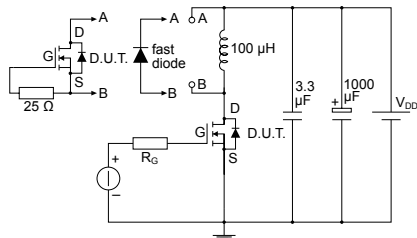
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Figure 19. Test circuit for gate charge behavior



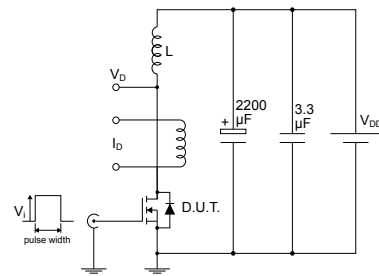
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Figure 20. Test circuit for inductive load switching and diode recovery times



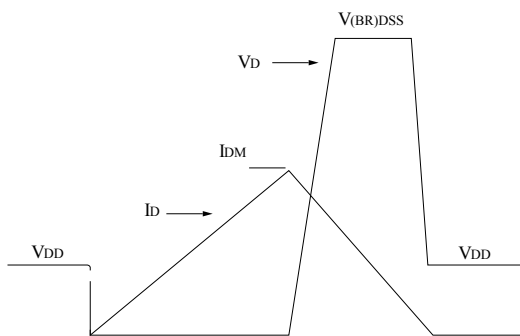
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Figure 21. Unclamped inductive load test circuit



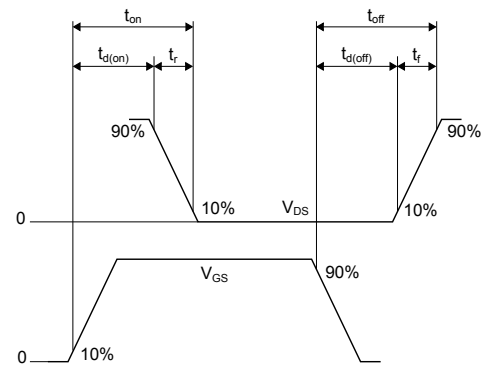
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Figure 22. Unclamped inductive waveform



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Figure 23. Switching time waveform



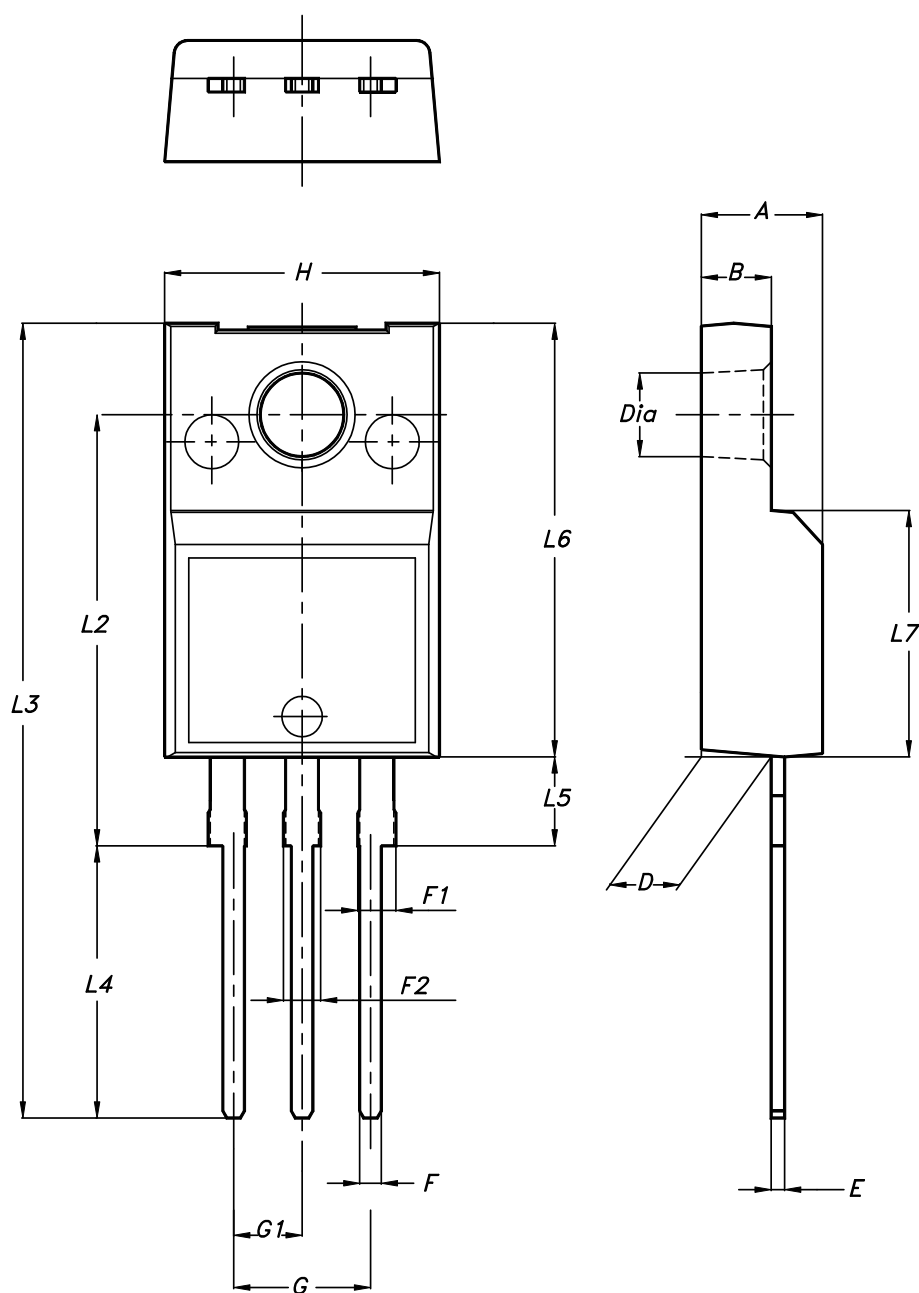
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4 Package information

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



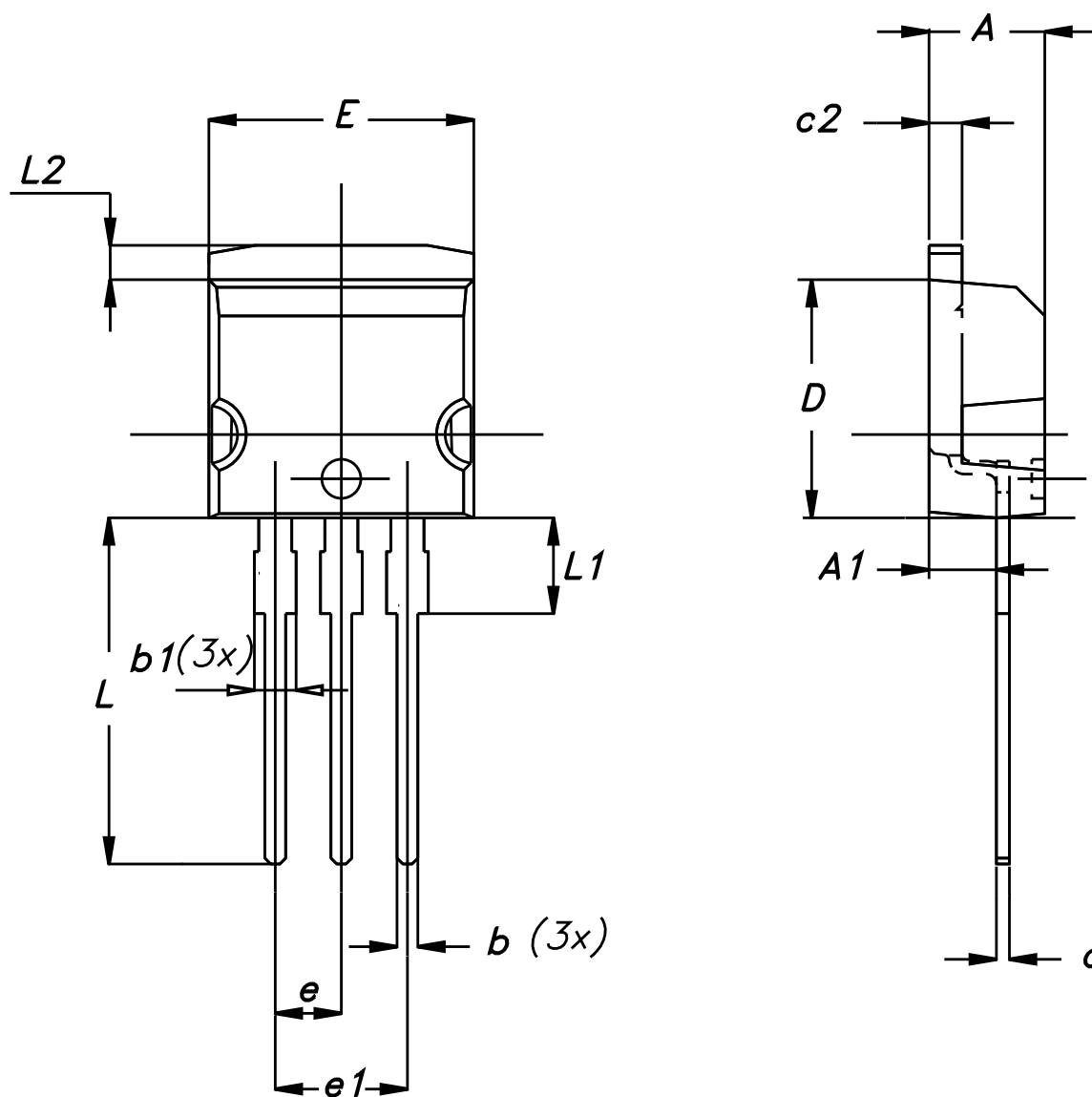
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Table 8. TO-220FP package mechanical data

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



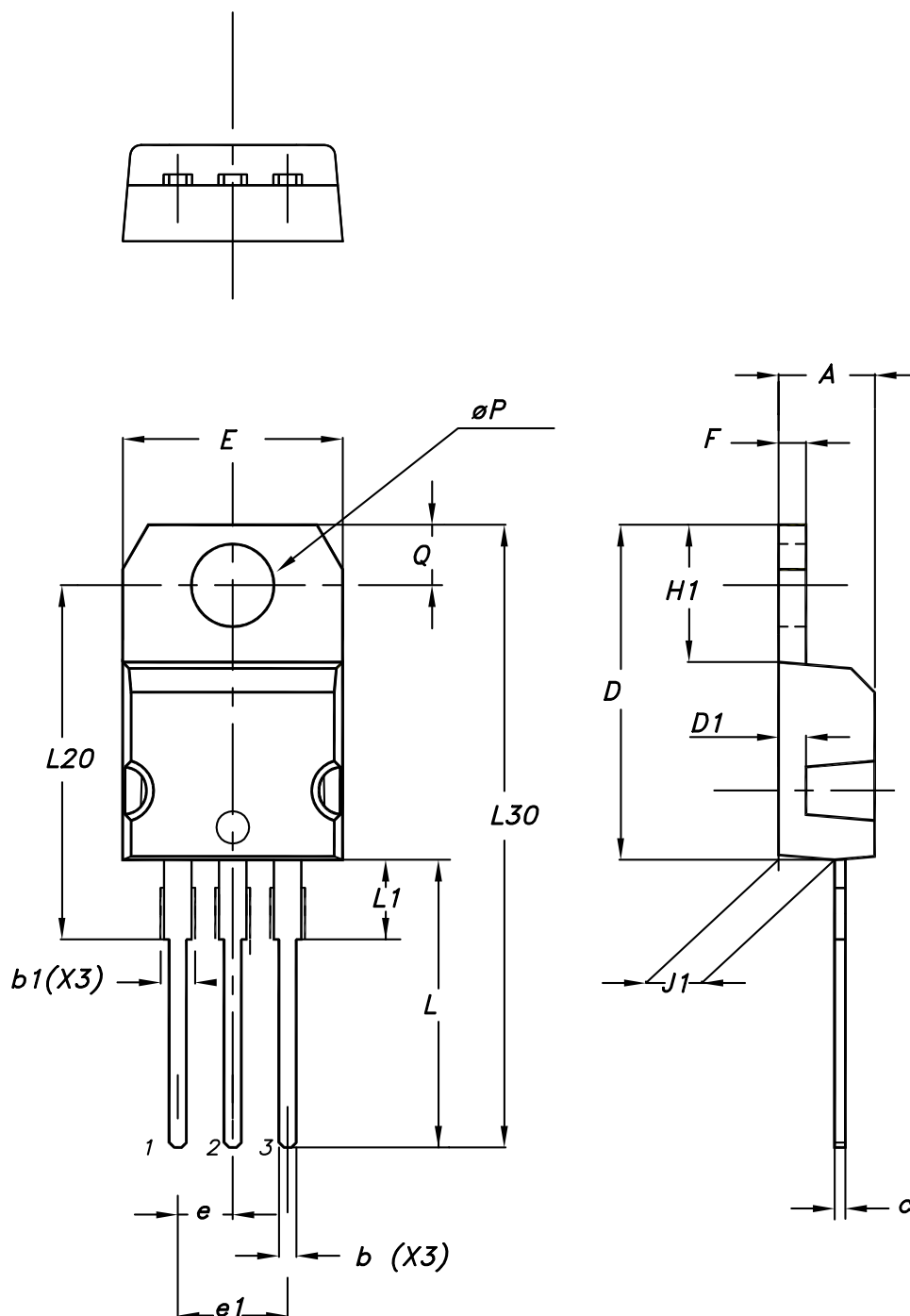
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Table 9. I²PAK package mechanical data

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



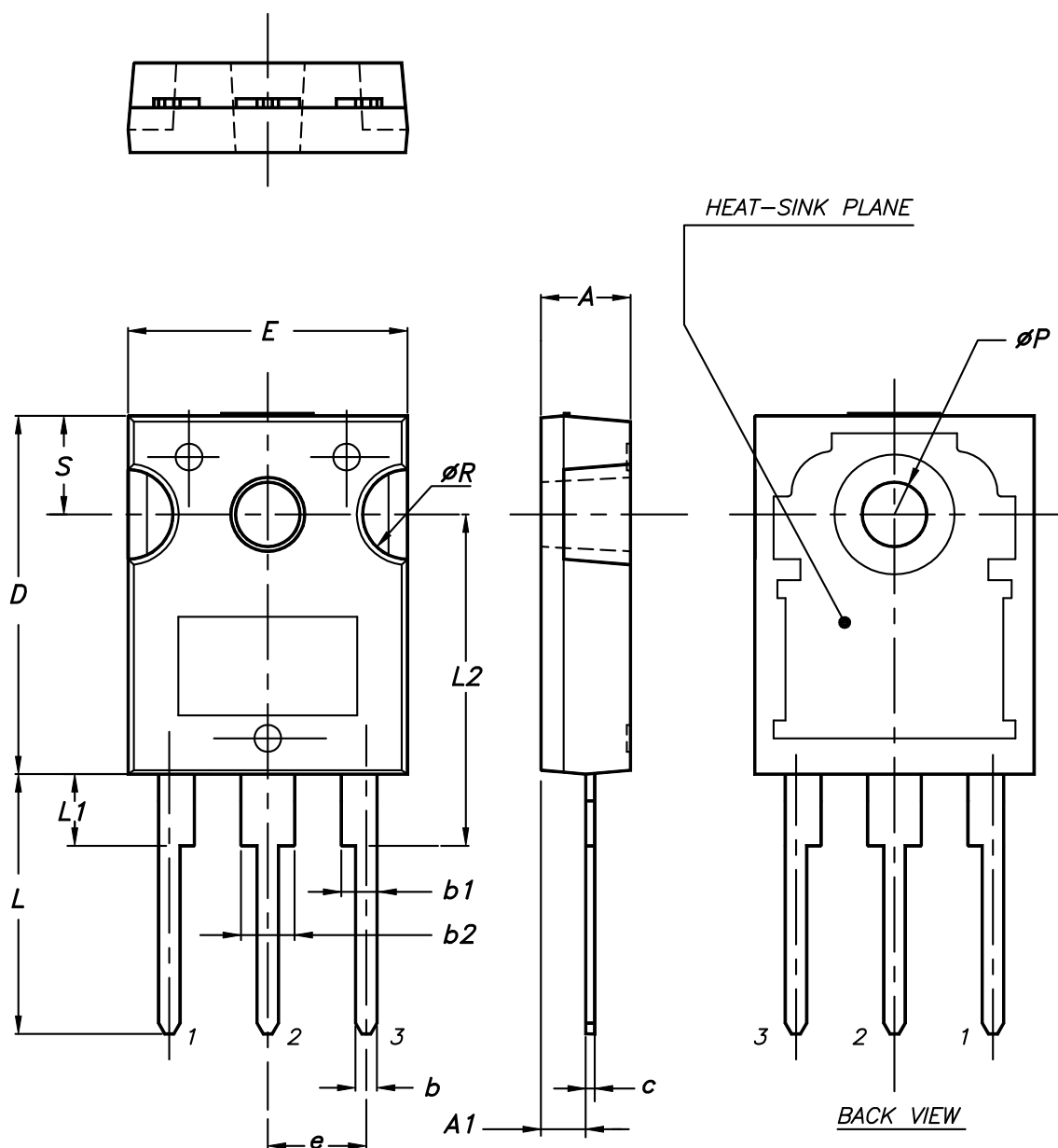
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Table 10. TO-220 type A package mechanical data

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

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