STF13NM60N, STI13NM60N, STP13NM60N, STU13NM60N, STW13NM60N

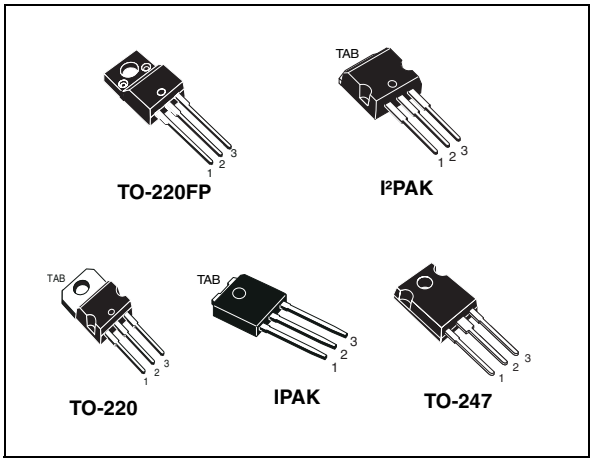
N-channel 600 V, 0.28 Ω typ., 11 A MDmesh™ II Power MOSFET in TO-220FP, I²PAK, TO-220, IPAK, TO-247 packages

Datasheet — production data

Features

Order codes	V_{DSS} (@Tjmax)	$R_{DS(on)}$ max	I_D
STF13NM60N STI13NM60N STP13NM60N STU13NM60N STW13NM60N	650 V	< 0.36 Ω	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

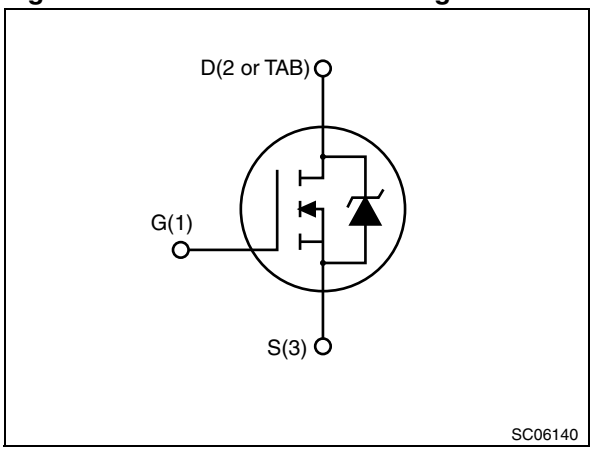


Table 1. Device summary

Order codes	Marking	Packages	Packaging
STF13NM60N	13NM60N	TO-220FP	Tube
STI13NM60N		I²PAK	Tube
STP13NM60N		TO-220	Tube
STU13NM60N		IPAK	Tube
STW13NM60N		TO-247	Tube

Contents

1 Electrical ratings

Table 2. Absolute maximum ratings

Symbol	Parameter	Value		Unit
		TO-220FP	I²PAK, TO-220, IPAK, TO-247	
V_{DS}	Drain-source voltage	600		V
V_{GS}	Gate-source voltage	± 25		V
I_D	Drain current (continuous) at T_C = 25 °C	11(1)	11	A
I_D	Drain current (continuous) at T_C = 100 °C	6.93(1)	6.93	A
I_{DM} (2)	Drain current (pulsed)	44(1)	44	A
P_{TOT}	Total dissipation at T_C = 25 °C	25	90	W
dv/dt (3)	Peak diode recovery voltage slope	15		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	- 55 to 150		°C
T_j	Max. operating junction temperature	150		°C

1. Limited by maximum junction temperature
2. Pulse width limited by safe operating area
3. I_{SD} ≤11 A, di/dt ≤ 400 A/µs, $V_{DS\ peak}$ ≤ $V_{(BR)DSS}$, V_{DD} = 80% $V_{(BR)DSS}$.

Table 3. Thermal data

Symbol	Parameter	Value				Unit
		TO-220FP	I²PAK TO-220	IPAK	TO-247	
$R_{thj\text{-}case}$	Thermal resistance junction-case max	5	1.39			°C/W
$R_{thj\text{-}amb}$	Thermal resistance junction-ambient max	62.5	62.5	100	50	°C/W

Table 4. Avalanche characteristics

Symbol	Parameter	Value	Unit
I_{AS}	Avalanche current, repetitive or not-repetitive (pulse width limited by Tj max)	3.5	A
E_{AS}	Single pulse avalanche energy (starting T_J=25 °C, I_D=I_{AS}, V_{DD}=50 V)	200	mJ

2 Electrical characteristics

(T_{CASE} = 25 °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 mA	600			V
I_{DSS}	Zero gate voltage drain current (V_{GS} = 0)	V_{DS} = 600 V V_{DS} = 600 V, T_C=125 °C			1 100	µA µA
I_{GSS}	Gate-body leakage current (V_{DS} = 0)	V_{GS} = ± 25 V			±0.1	µA
$V_{GS(th)}$	Gate threshold voltage	V_{DS} = V_{GS}, I_D = 250 µA	2	3	4	V
$R_{DS(on)}$	Static drain-source on-resistance	V_{GS} = 10 V, I_D = 5.5 A		0.28	0.36	Ω

Table 6. Dynamic

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

1. $C_{oss\ eq.}$ 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 V, I_D = 5.5 A	-	3	-	ns
t_r	Rise time	R_G = 4.7 Ω V_{GS} = 10 V		8		ns
$t_{d(off)}$	Turn-off delay time	*(see Figure 19)*		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 A, V_{GS} = 0	-		1.5	V
t_{rr}	Reverse recovery time	I_{SD} = 11 A, di/dt = 100 A/µs	-	230		ns
Q_{rr}	Reverse recovery charge	V_{DD} = 100 V		2		µC
I_{RRM}	Reverse recovery current	*(see Figure 21)*		18		A
t_{rr}	Reverse recovery time	I_{SD} = 11 A, di/dt = 100 A/µs	-	290		ns
Q_{rr}	Reverse recovery charge	V_{DD} = 100 V, T_j = 150 °C		190		µC
I_{RRM}	Reverse recovery current	*(see Figure 21)*		17		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 2. Safe operating area for I²PAK and TO-220

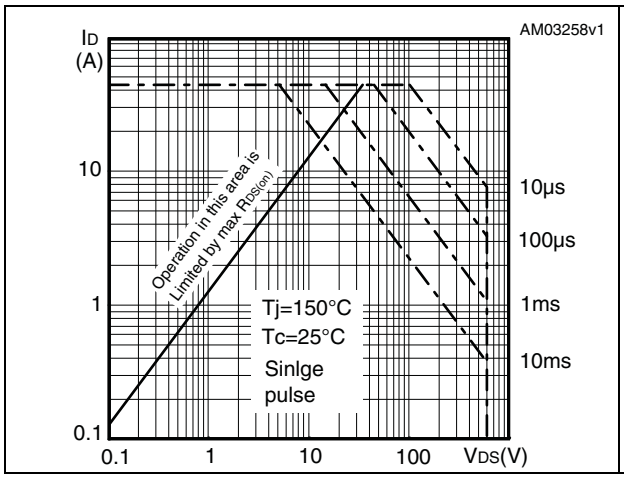


Figure 3. Thermal impedance for I²PAK and TO-220

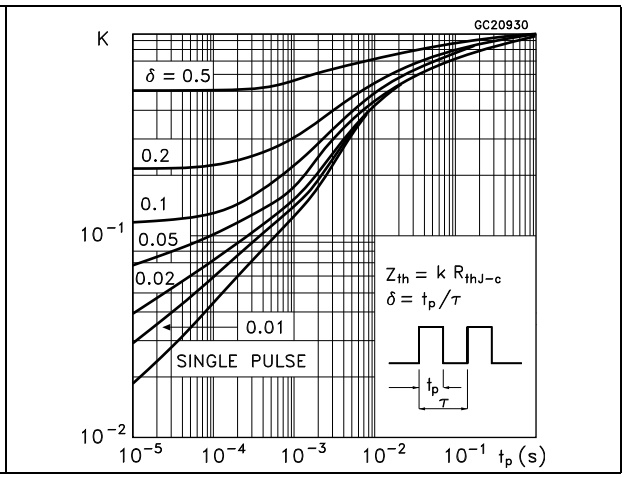


Figure 4. Safe operating area for TO-220FP

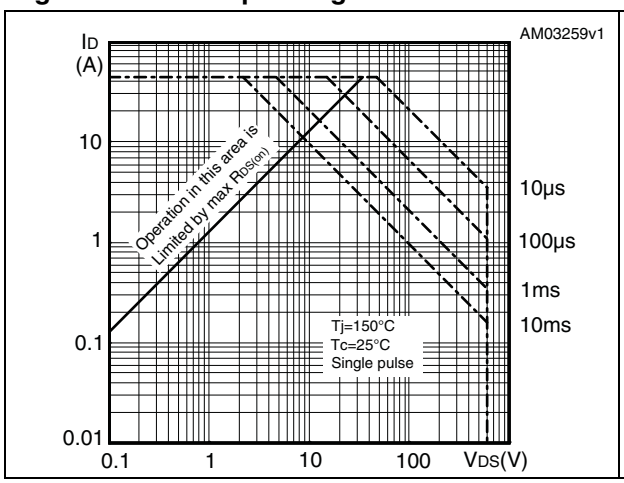


Figure 5. Thermal impedance for TO-220FP

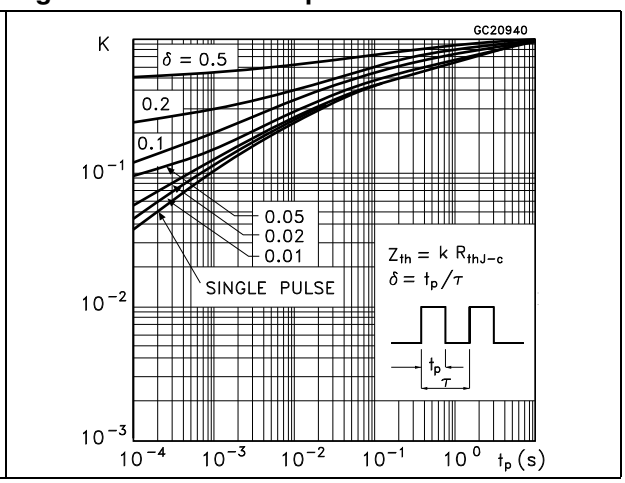


Figure 6. Safe operating area for TO-247

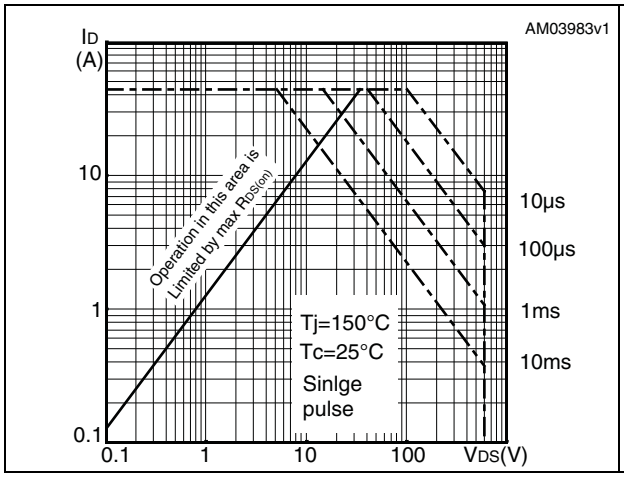


Figure 7. Thermal impedance for TO-247

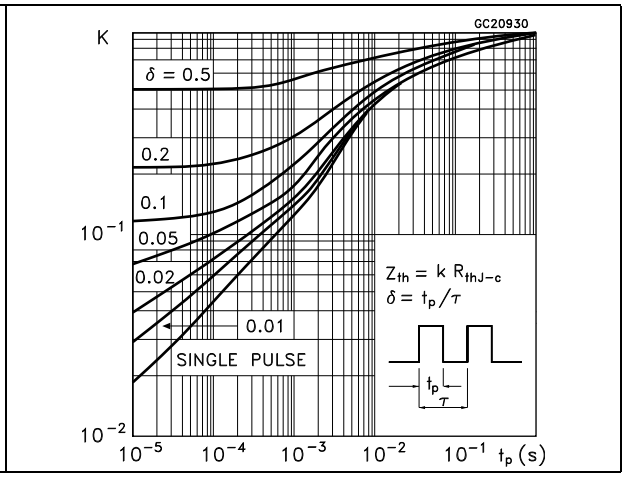


Figure 8. Safe operating area for IPAK

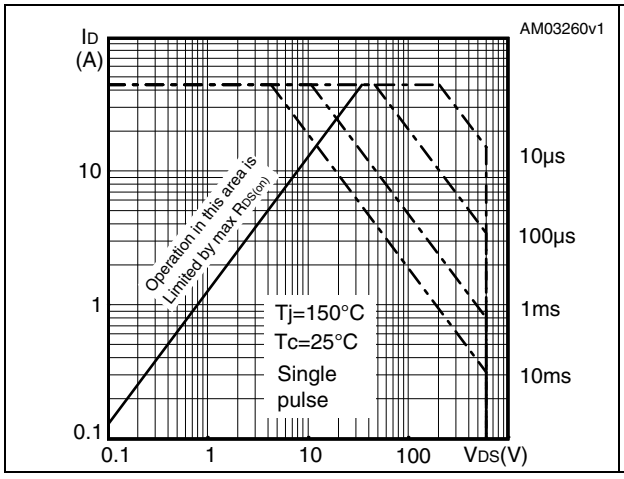


Figure 9. Thermal impedance for IPAK

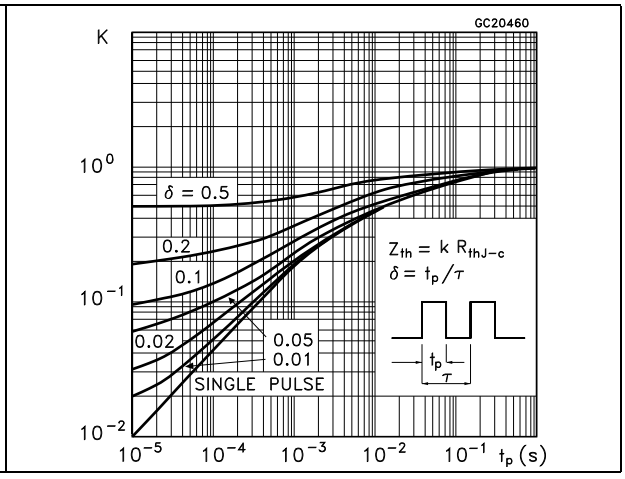


Figure 10. Output characteristics

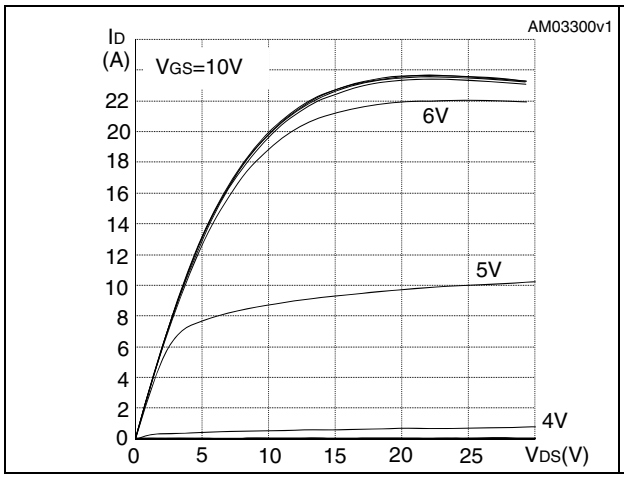


Figure 11. Transfer characteristics

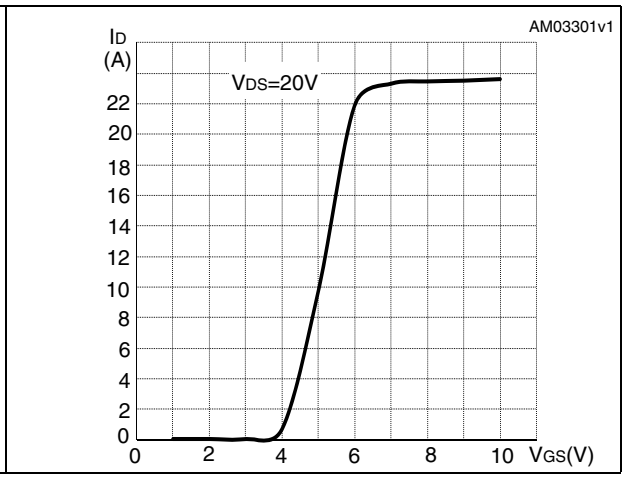


Figure 12. Normalized V_{DS} vs temperature

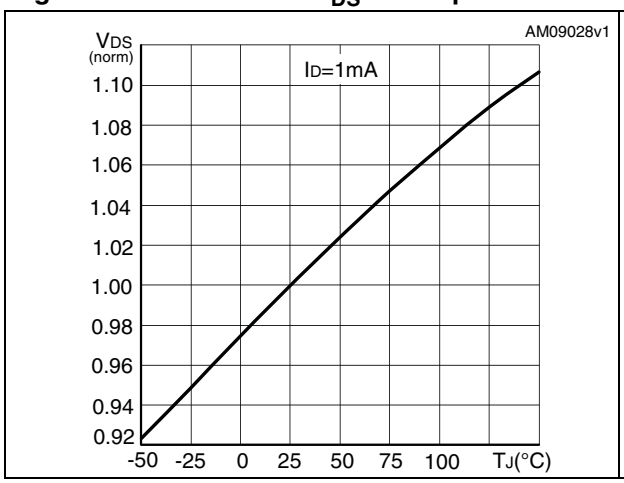


Figure 13. Static drain-source on-resistance

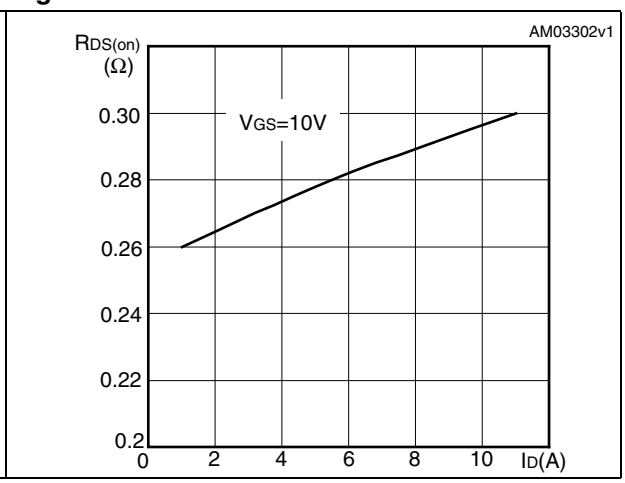


Figure 14. Gate charge vs gate-source voltage

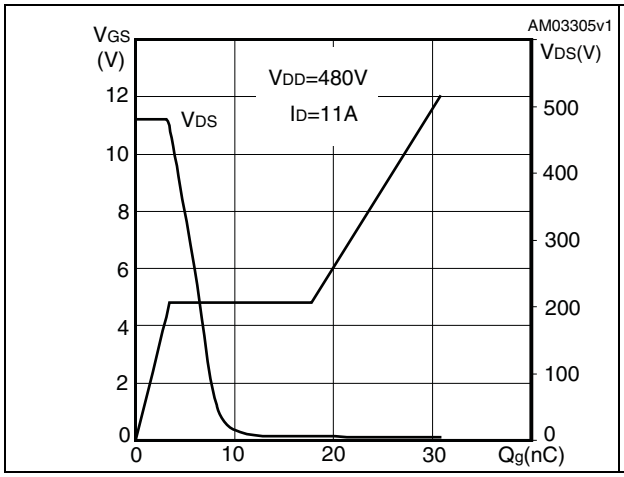


Figure 15. Capacitance variations

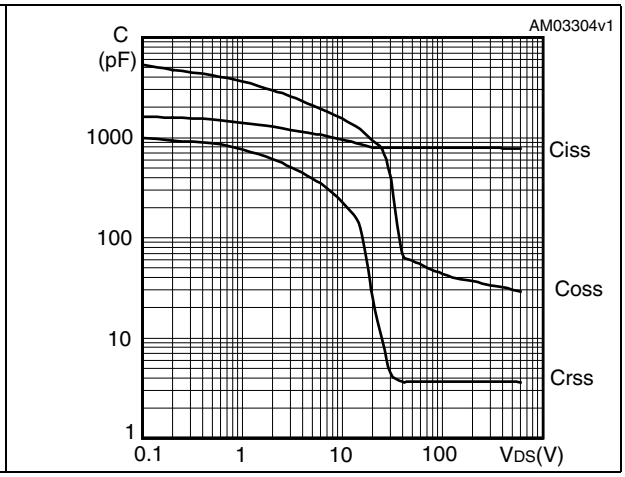


Figure 16. Normalized gate threshold voltage vs temperature

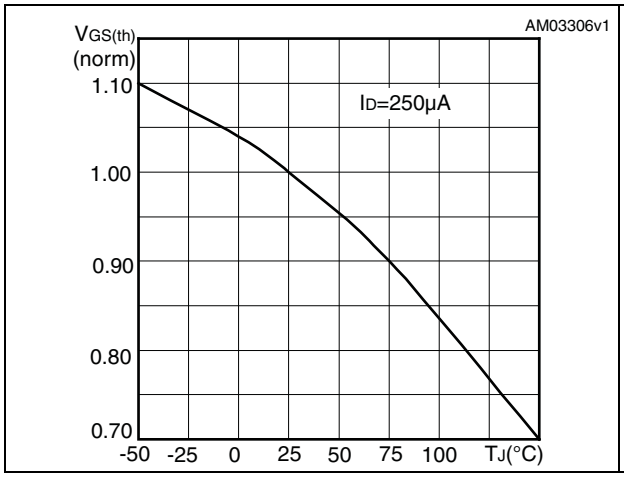


Figure 17. Normalized on-resistance vs temperature

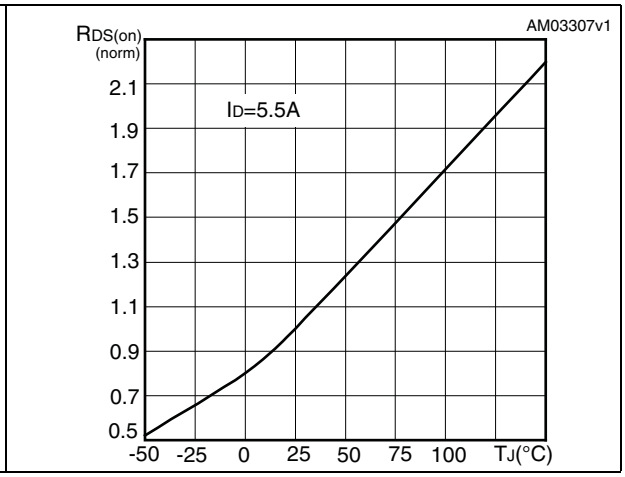
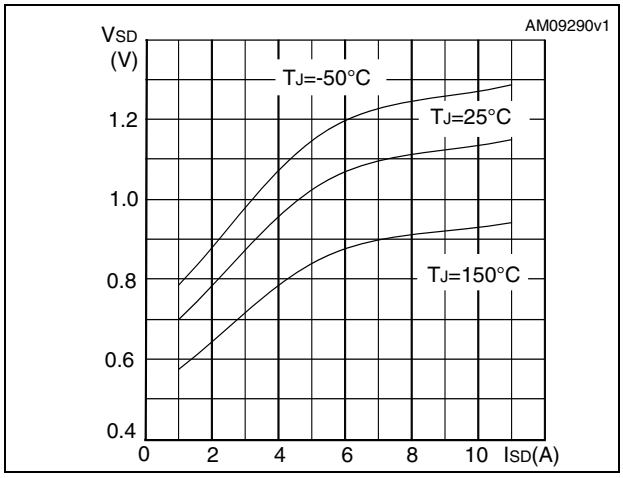


Figure 18. Source-drain diode forward characteristics



3 Test circuits

Figure 19. Switching times test circuit for resistive load

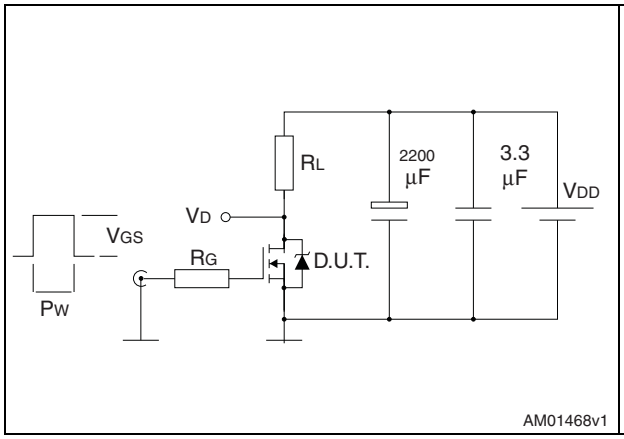


Figure 20. Gate charge test circuit

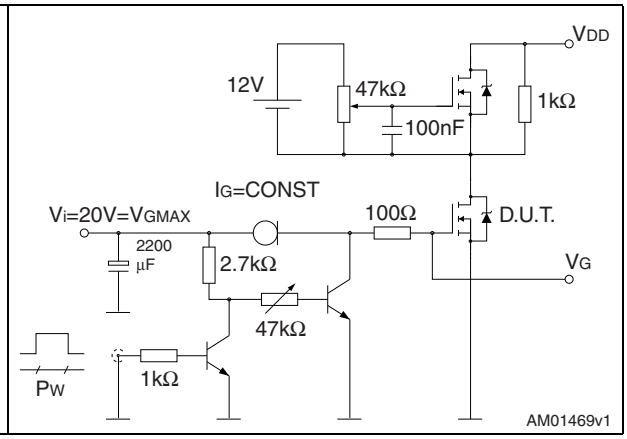


Figure 21. Test circuit for inductive load switching and diode recovery times

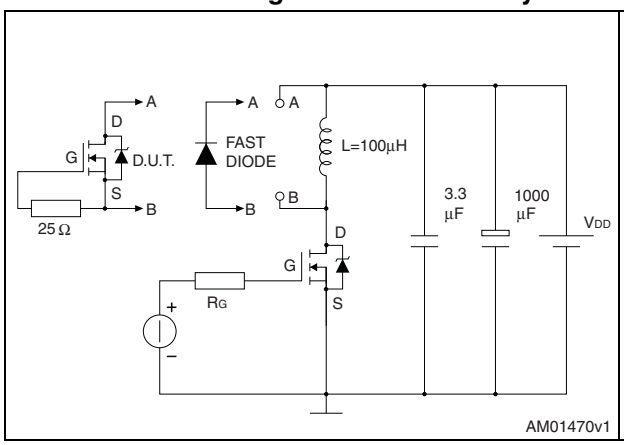


Figure 22. Unclamped inductive load test circuit

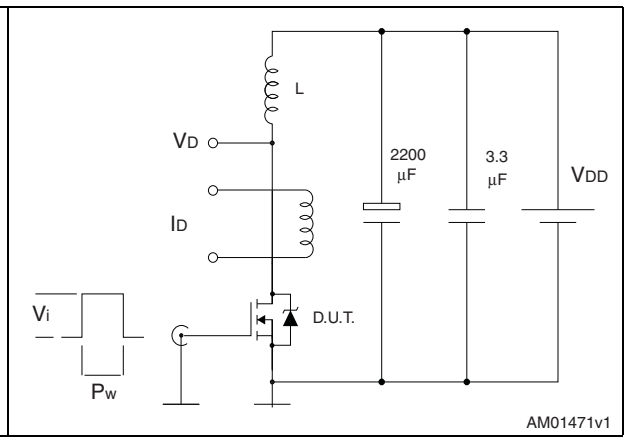


Figure 23. Unclamped inductive waveform

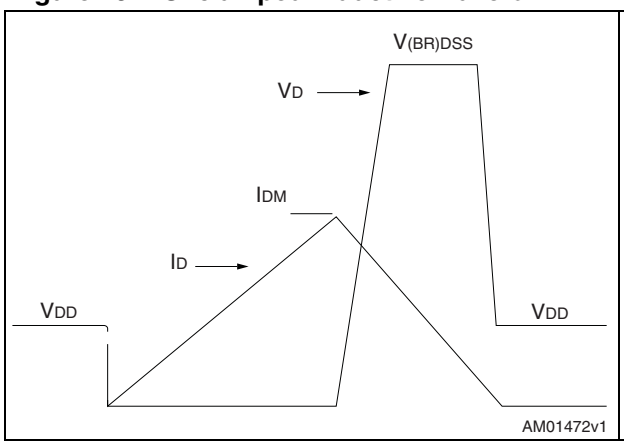
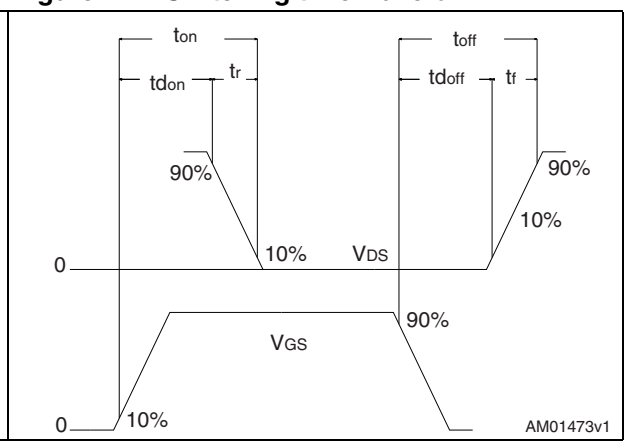


Figure 24. Switching time waveform



4 Package mechanical data

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.

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

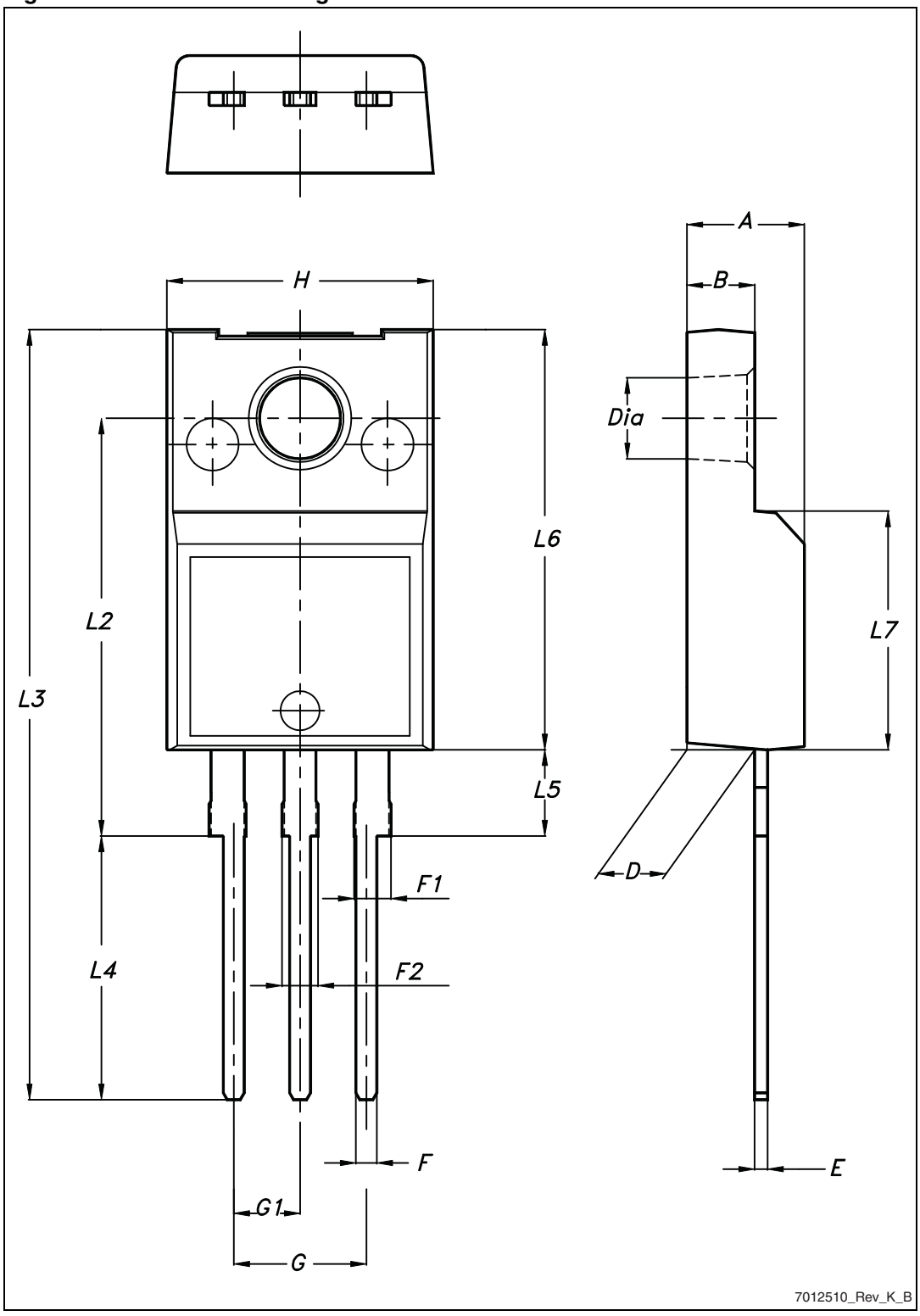


Table 10. I²PAK (TO-262) mechanical data

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. I²PAK (TO-262) drawing

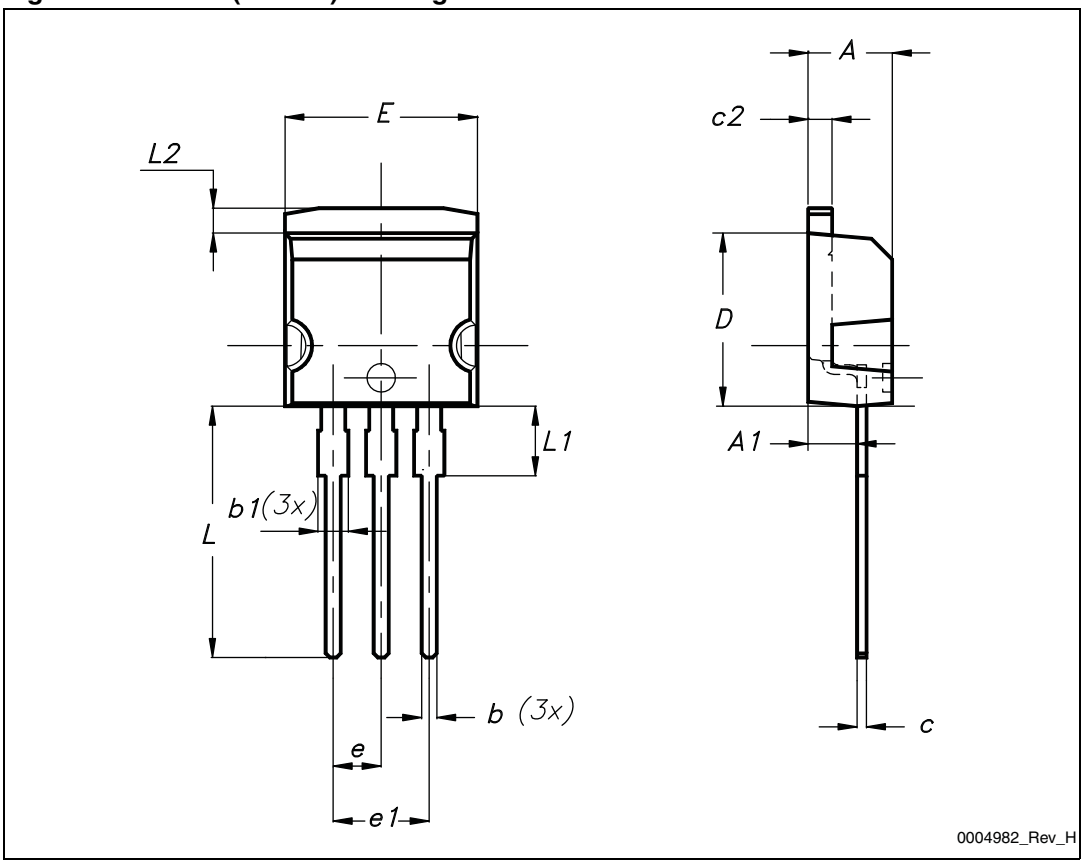


Table 11. TO-220 type A mechanical data

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	
∅P	3.75		3.85
Q	2.65		2.95

Figure 27. TO-220 type A drawing

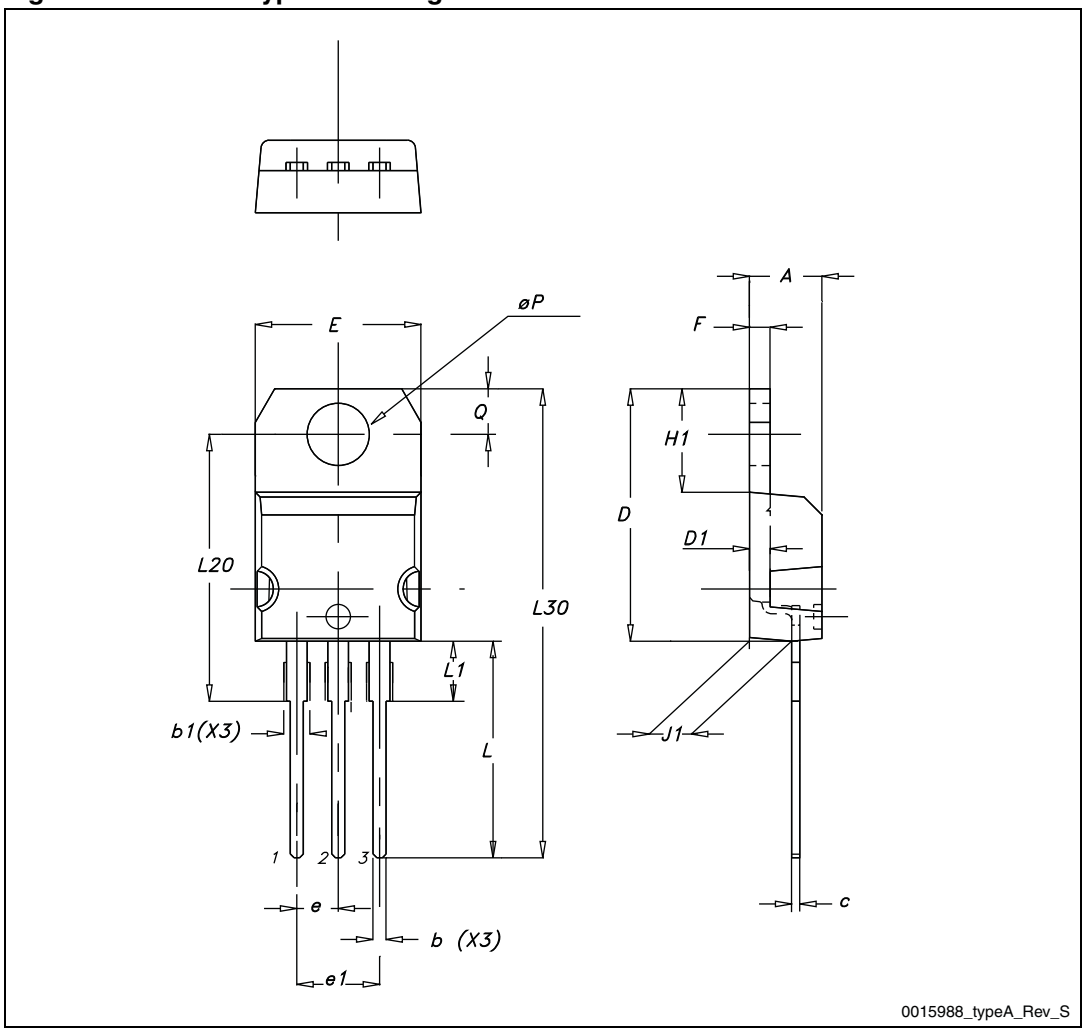


Table 12. IPAK (TO-251) mechanical data

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 ^{o}	

Figure 28. IPAK (TO-251) drawing

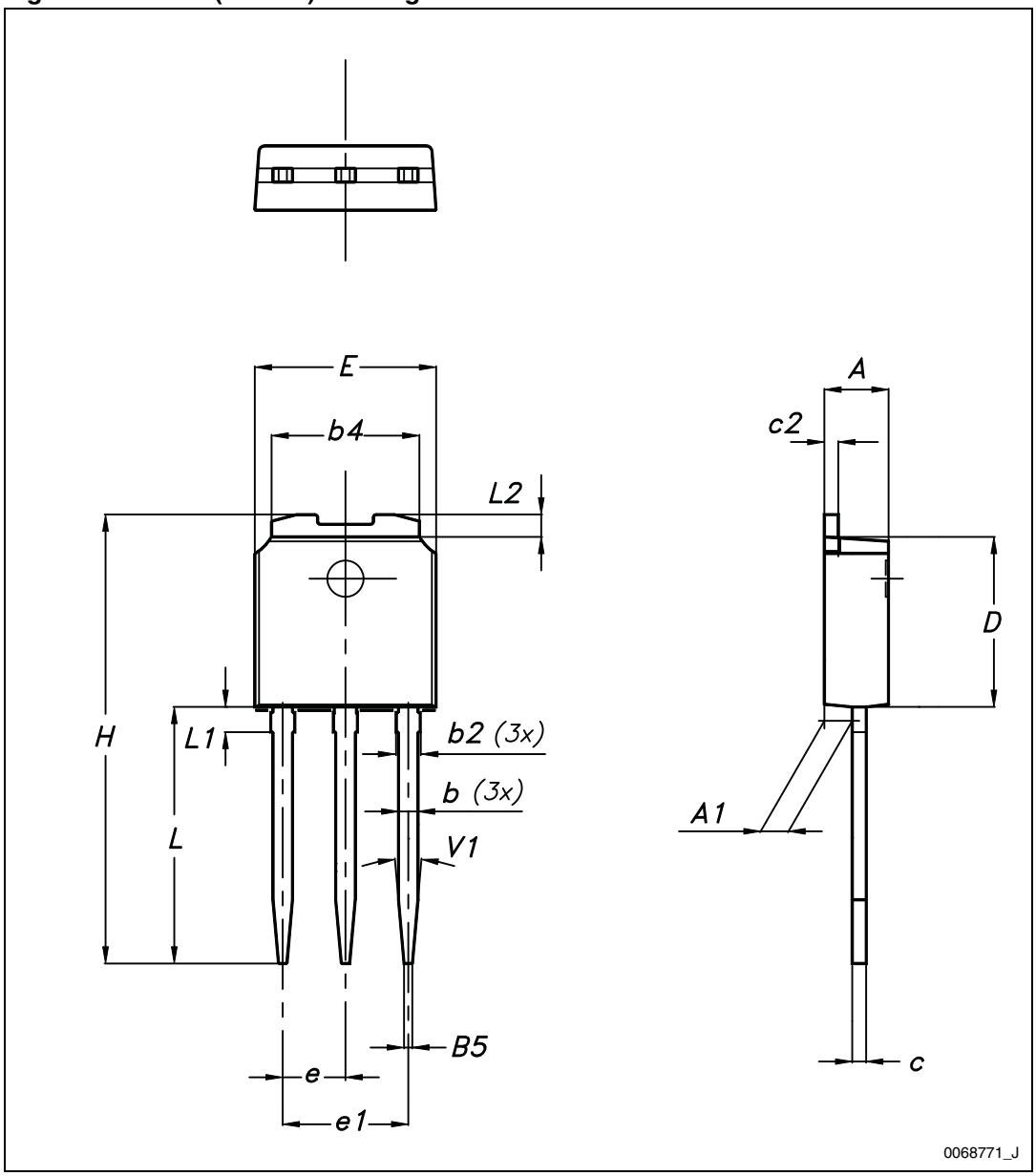
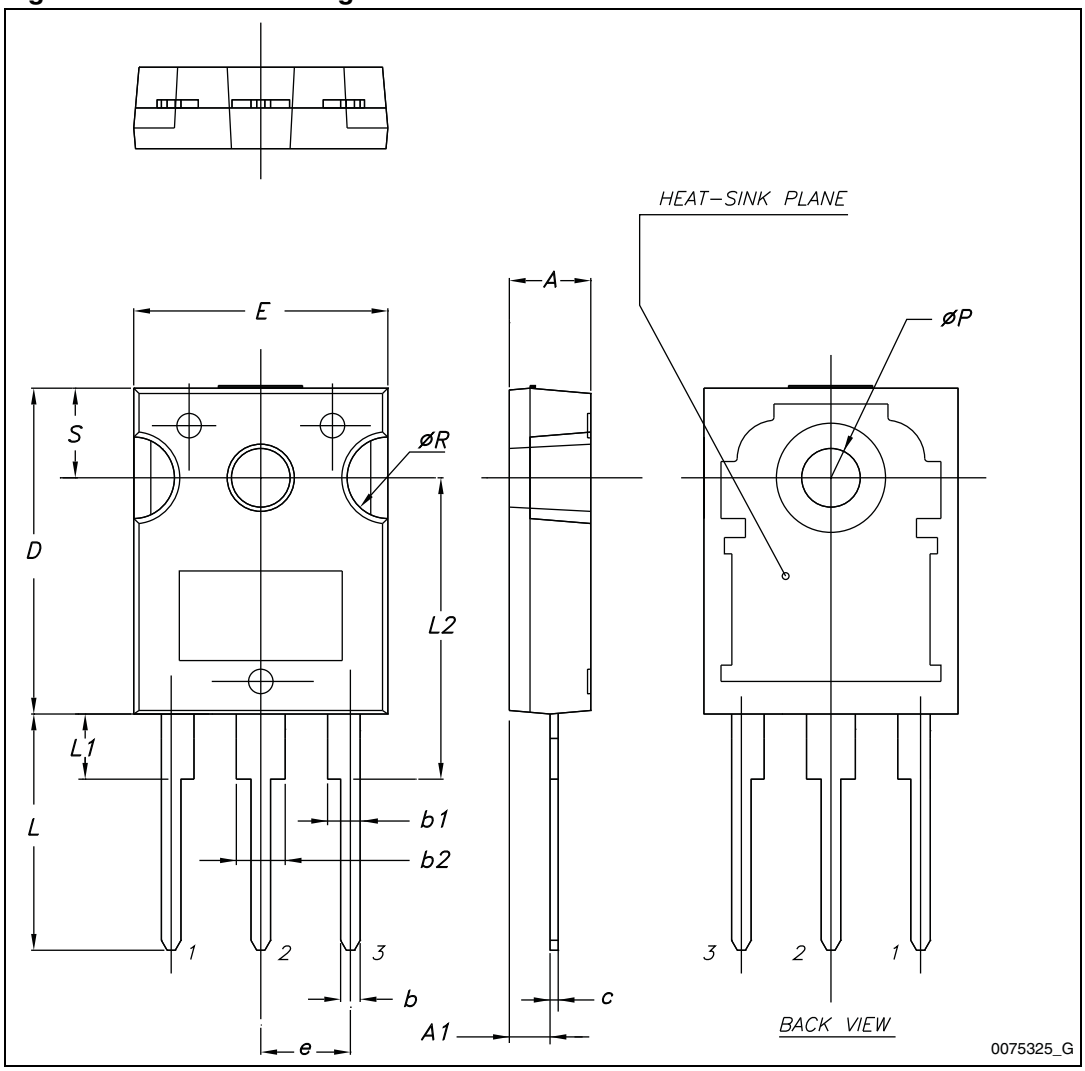


Table 13. TO-247 mechanical data

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	
∅P	3.55		3.65
∅R	4.50		5.50
S	5.30	5.50	5.70

Figure 29. TO-247 drawing



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: D²PAK
08-Nov-2010	3	– Modified *Figure 4* – Added new package, mechanical data: I²PAK
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. *Section 4: Package mechanical data* has been updated.

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