STB21N90K5, STF21N90K5, STP21N90K5, STW21N90K5

N-channel 900 V, 0.25 Ω typ., 18.5 A Zener-protected SuperMESH™ 5 Power MOSFET in a D²PAK, TO-220FP, TO-220 and TO-247 packages

Datasheet — production data

Features

Order codes	V_{DSS}	$R_{DS(on)}$max	I_D	P_W
STB21N90K5	900 V	< 0.299 Ω	18.5 A	250 W
STF21N90K5				40 W
STP21N90K5				250 W
STW21N90K5				

- TO-220 worldwide best $R_{DS(on)}$
- Worldwide best FOM (figure of merit)
- Ultra low gate charge
- 100% avalanche tested
- Zener-protected

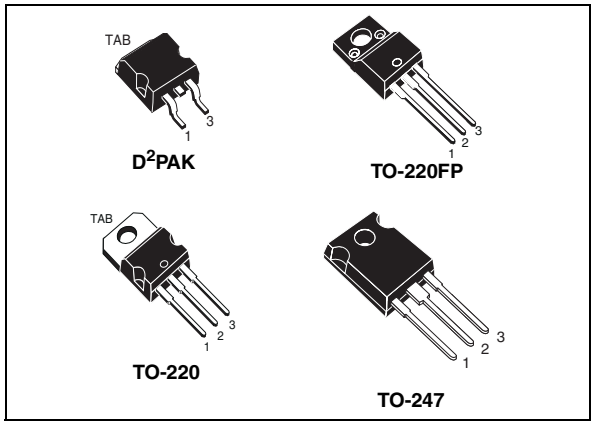
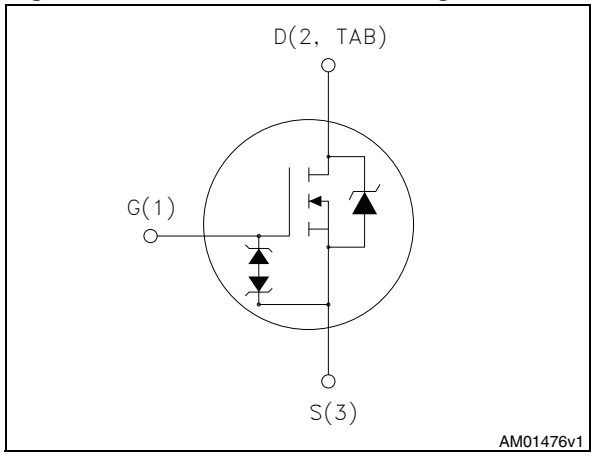


Figure 1. Internal schematic diagram



Applications

- Switching applications

Description

These devices are N-channel Power MOSFETs developed using SuperMESH™ 5 technology. This revolutionary, avalanche-rugged, high voltage Power MOSFET technology is based on an innovative proprietary vertical structure. The result is a drastic reduction in on-resistance and ultra low gate charge for applications which require superior power density and high efficiency.

Table 1. Device summary

Order codes	Marking	Package	Packaging
STB21N90K5	21N90K5	D²PAK	Tape and reel
STF21N90K5		TO-220FP	Tube
STP21N90K5		TO-220	
STW21N90K5		TO-247	

Contents

1 Electrical ratings

Table 2. Absolute maximum ratings

Symbol	Parameter	Value		Unit
		D^2PAK, TO-220, TO-247	TO-220FP	
V_{GS}	Gate- source voltage	± 30		V
I_D	Drain current (continuous) at T_C = 25 °C	18.5	18.5 (1)	A
I_D	Drain current (continuous) at T_C = 100 °C	11.6	11.6 (1)	A
I_{DM} (2)	Drain current (pulsed)	74	74 (1)	A
P_{TOT}	Total dissipation at T_C = 25 °C	250	40	W
I_{AR}	Max current during repetitive or single pulse avalanche (pulse width limited by T_{jmax})	6		A
E_{AS}	Single pulse avalanche energy (starting T_J = 25 °C, I_D=I_{AR}, V_{DD}= 50 V)	200		mJ
V_{iso}	Insulation withstand voltage (RMS) from all three leads to external heat sink (t=1 s;T_C=25 °C)		2500	V
dv/dt (3)	Peak diode recovery voltage slope	6		V/ns
T_j T_{stg}	Operating junction temperature Storage temperature	-55 to 150		°C

1. Limited by package.
2. Pulse width limited by safe operating area.
3. I_{SD} ≤ 18.5 A, di/dt ≤ 100 A/µs, $V_{DS(peak)}$ ≤$V_{(BR)DSS}$

Table 3. Thermal data

Symbol	Parameter	Value				Unit
		D^2PAK	TO-220FP	TO-220	TO-247	
Rthj-case	Thermal resistance junction-case max	0.5	3.13	0.5		°C/W
Rthj-amb	Thermal resistance junction-amb max		62.5		50	
Rthj-pcb	Thermal resistance junction-pcb max	30				

2 Electrical characteristics

(T_{CASE} = 25 °C unless otherwise specified).

Table 4. 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	900			V
I_{DSS}	Zero gate voltage drain current (V_{GS} = 0)	V_{DS} = 900 V V_{DS} = 900 V, Tc=125 °C			1 50	µA µA
I_{GSS}	Gate body leakage current (V_{DS} = 0)	V_{GS} = ± 20 V			±10	µA
$V_{GS(th)}$	Gate threshold voltage	V_{DS} = V_{GS}, I_D = 100 µA	3	4	5	V
$R_{DS(on)}$	Static drain-source on resistance	V_{GS} = 10 V, I_D= 9 A		0.25	0.299	Ω

Table 5. Dynamic

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
C_{iss}	Input capacitance	V_{DS} =100 V, f=1 MHz, V_{GS}=0	-	1645	-	pF
C_{oss}	Output capacitance			112		pF
C_{rss}	Reverse transfer capacitance			2		pF
$C_{o(tr)}$(1)	Equivalent capacitance time related	V_{GS} = 0, V_{DS} = 0 to 720 V	-	133	-	pF
$C_{o(er)}$(2)	Equivalent capacitance energy related		-	16	-	pF
R_G	Intrinsic gate resistance	f = 1MHz open drain	-	4	-	Ω
Q_g	Total gate charge	V_{DD} = 720 V, I_D = 18.5 A	-	43	-	nC
Q_{gs}	Gate-source charge	V_{GS} =10 V		12		nC
Q_{gd}	Gate-drain charge	*(see Figure 20)*		25		nC

1. Time related 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}
2. Energy related is defined as a constant equivalent capacitance giving the same stored energy 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
$t_{d(on)}$ t_r $t_{d(off)}$ t_f	Turn-on delay time Rise time Turn-off delay time Fall time	V_{DD} = 720 V, I_D = 10 A, R_G=4.7 Ω, V_{GS}=10 V *(see Figure 22)*	-	17 27 52 40	-	ns ns ns ns

Table 7. Source drain diode

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{SD} I_{SDM}	Source-drain current Source-drain current (pulsed)		-		19 76	A A
V_{SD} (1)	Forward on voltage	I_{SD}= 18.5 A, V_{GS}=0	-		1.5	V
t_{rr} Q_{rr} I_{RRM}	Reverse recovery time Reverse recovery charge Reverse recovery current	I_{SD}= 18.5 A, V_{DD}= 60 V di/dt = 100 A/µs, *(see Figure 21)*	-	548 12 46		ns µC A
t_{rr} Q_{rr} I_{RRM}	Reverse recovery time Reverse recovery charge Reverse recovery current	I_{SD}= 18.5 A,V_{DD}= 60 V di/dt=100 A/µs, Tj=150 °C *(see Figure 21)*	-	660 15 45		ns µC A

1. Pulsed: pulse duration = 300µs, duty cycle 1.5%

Table 8. Gate-source Zener diode

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)GSO}$	Gate-source breakdown voltage	I_{GS} = ±1 mA, I_D = 0	30	-	-	V

The built-in-back Zener diodes have specifically been designed to enhance not only the device's ESD capability, but also to make them safely absorb possible voltage transients that may occasionally be applied from gate to source. In this respect the Zener voltage is appropriate to achieve an efficient and cost-effective intervention to protect the device's integrity. These integrated Zener diodes thus avoid the usage of external components.

2.1 Electrical characteristics (curves)

Figure 2. Safe operating area for TO-220 / D²PAK

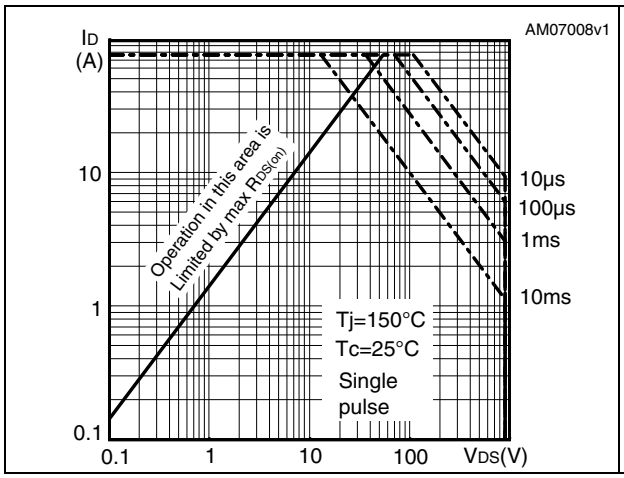


Figure 3. Thermal impedance for TO-220 / D²PAK

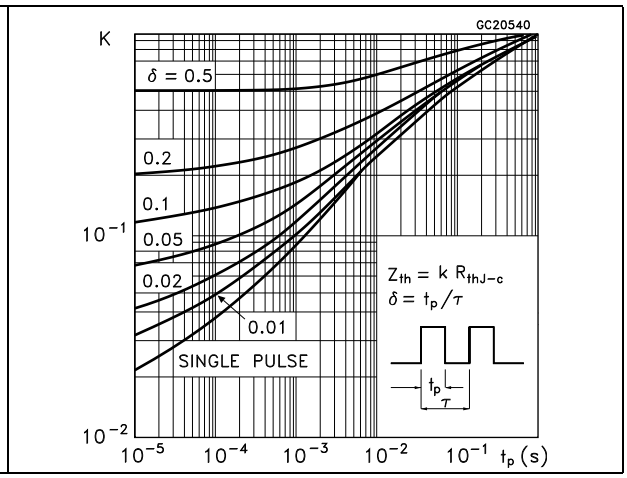


Figure 4. Safe operating area for TO-220FP

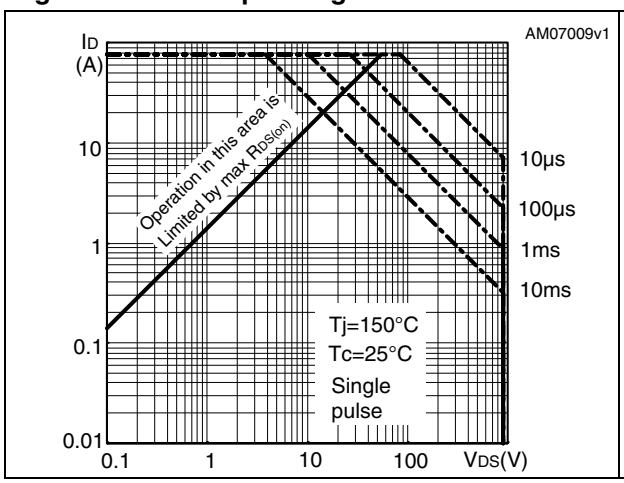


Figure 5. Thermal impedance for TO-220FP

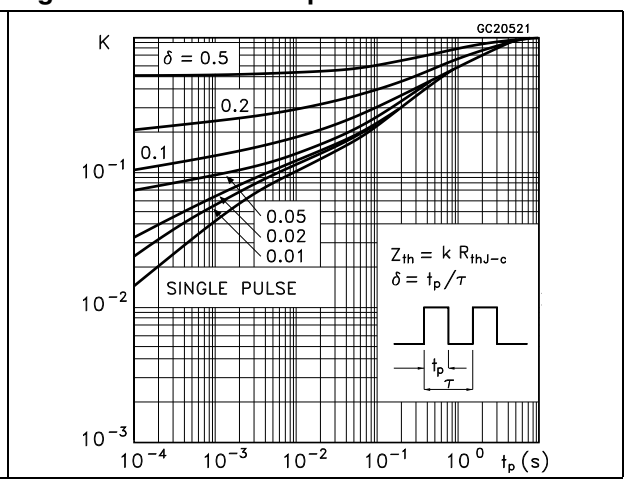


Figure 6. Safe operating area for TO-247

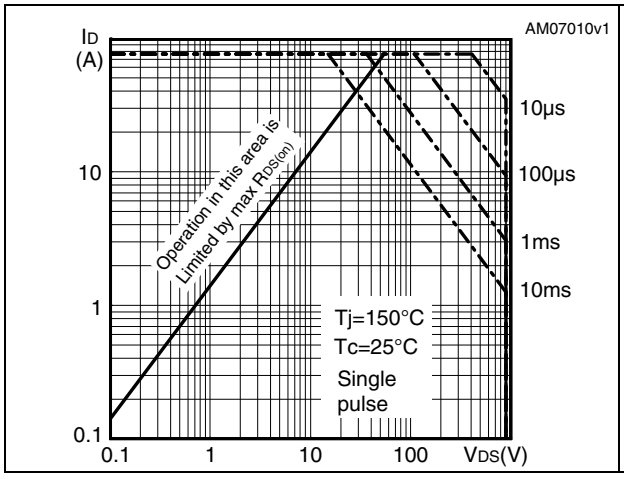


Figure 7. Thermal impedance for TO-247

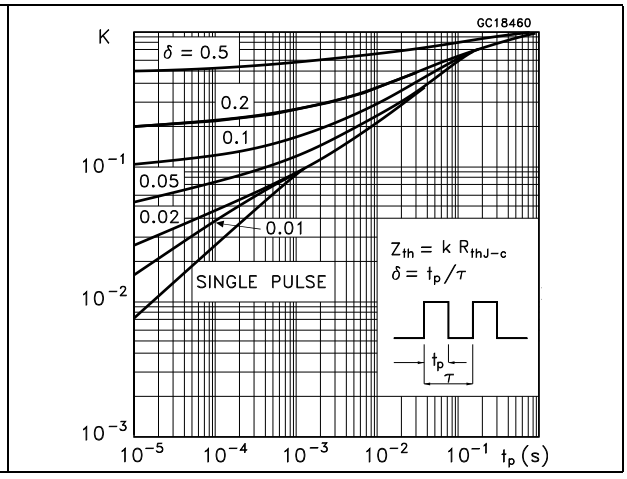


Figure 8. Output characteristics

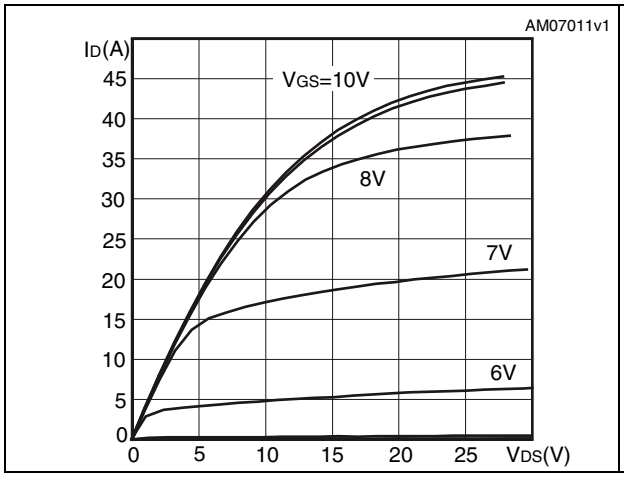


Figure 9. Transfer characteristics

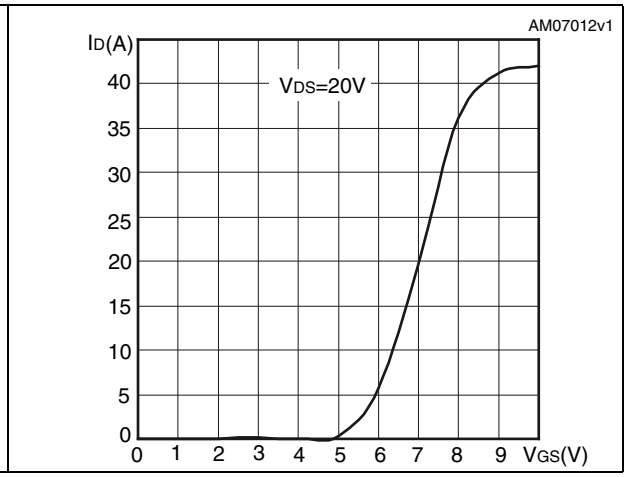


Figure 10. Gate charge vs gate-source voltage

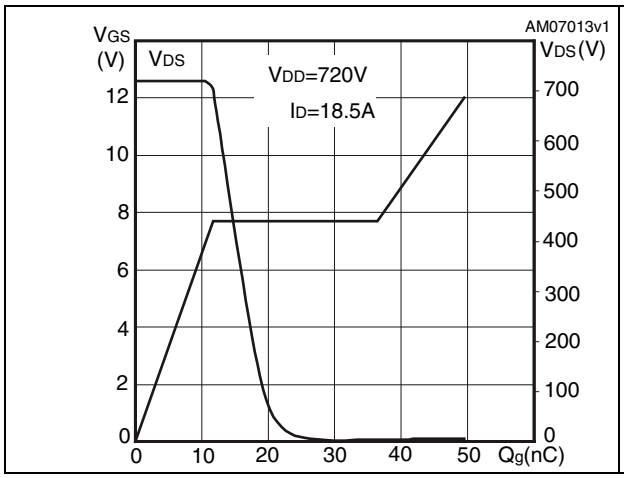


Figure 11. Static drain-source on resistance

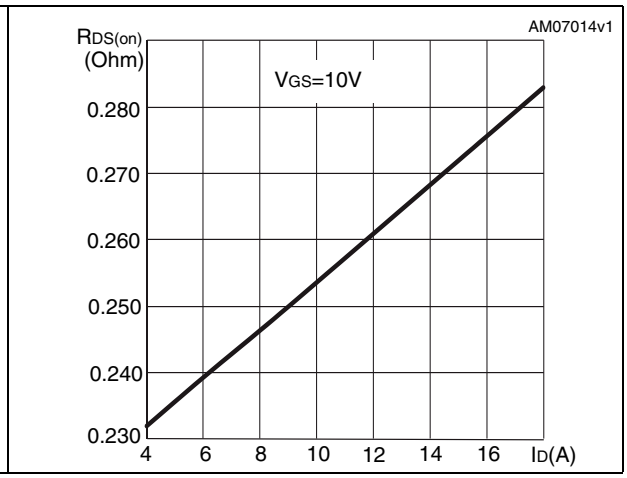


Figure 12. Capacitance variations

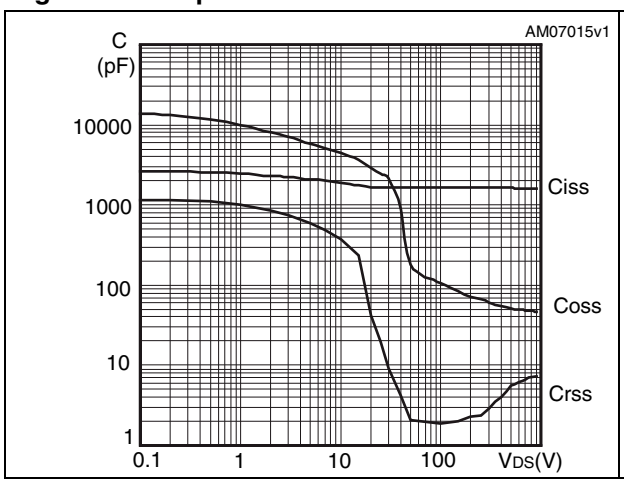


Figure 13. Output capacitance stored energy

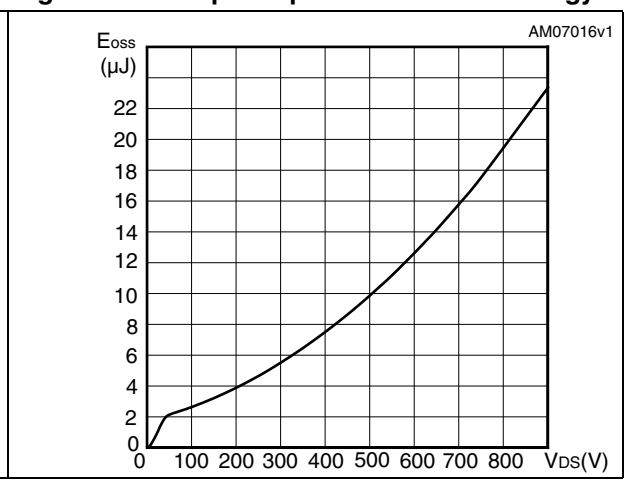


Figure 14. Normalized gate threshold voltage vs temperature

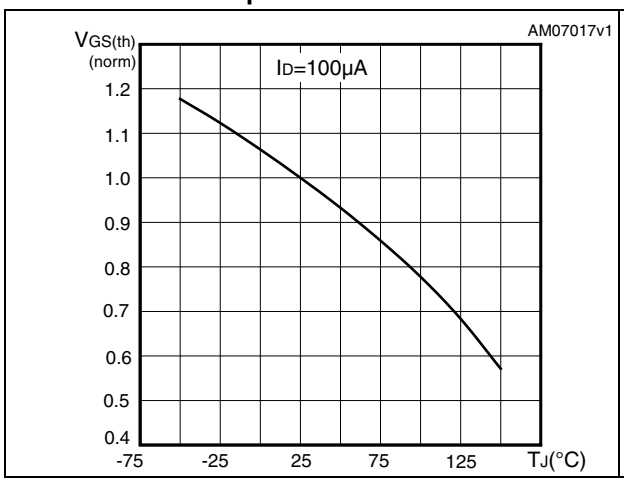


Figure 15. Normalized on-resistance vs temperature

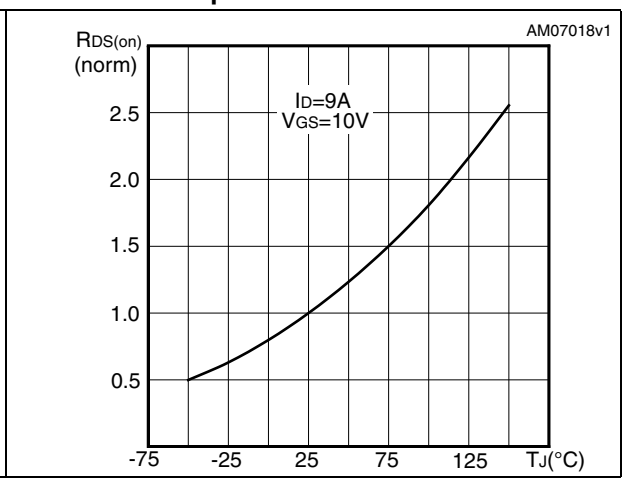


Figure 16. Source-drain diode forward characteristics

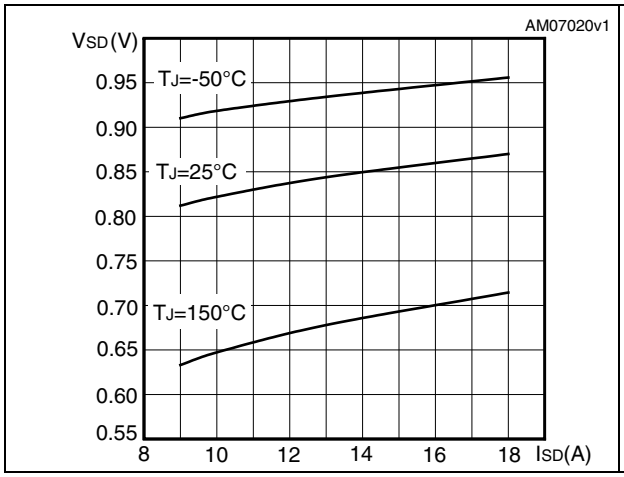


Figure 17. Normalized B_{VDSS} vs temperature

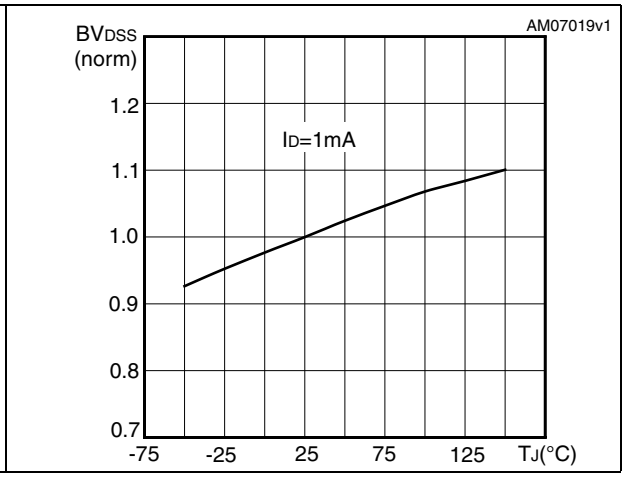
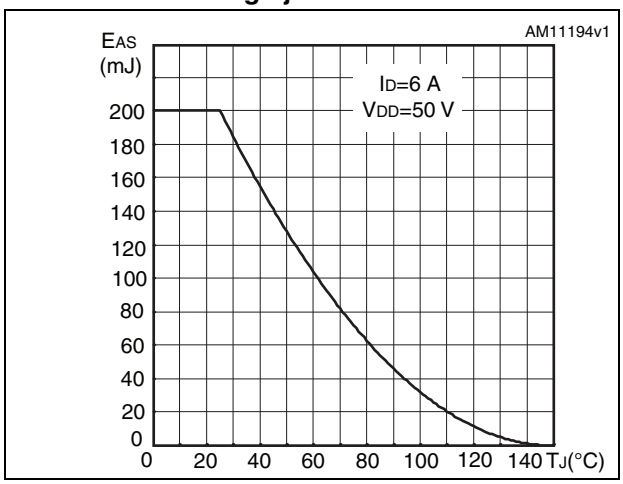


Figure 18. Maximum avalanche energy vs starting Tj



3 Test circuits

Figure 19. Switching times test circuit for resistive load

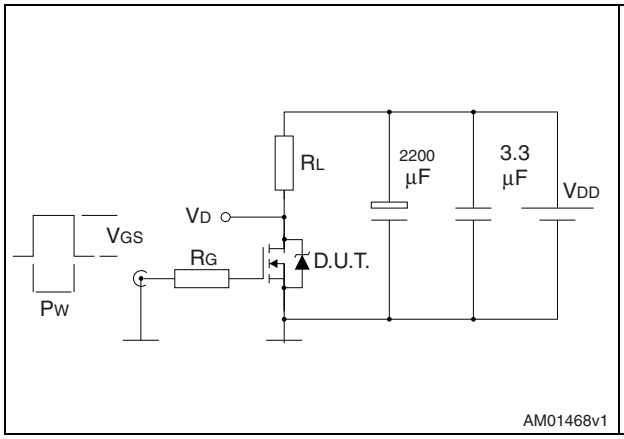


Figure 20. Gate charge test circuit

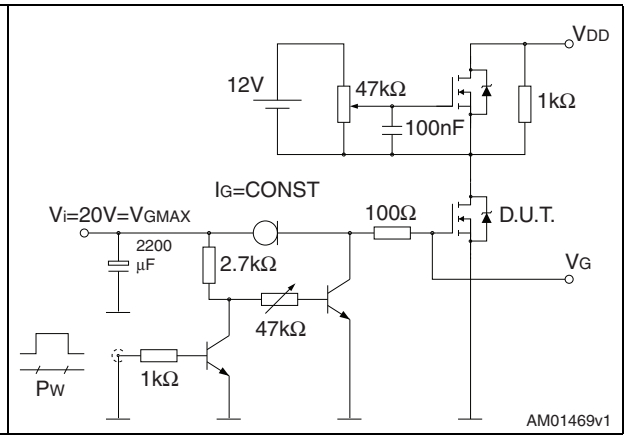


Figure 21. Test circuit for inductive load switching and diode recovery times

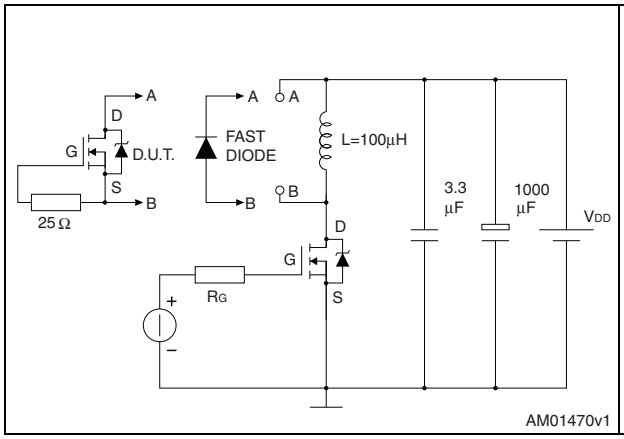


Figure 22. Unclamped inductive load test circuit

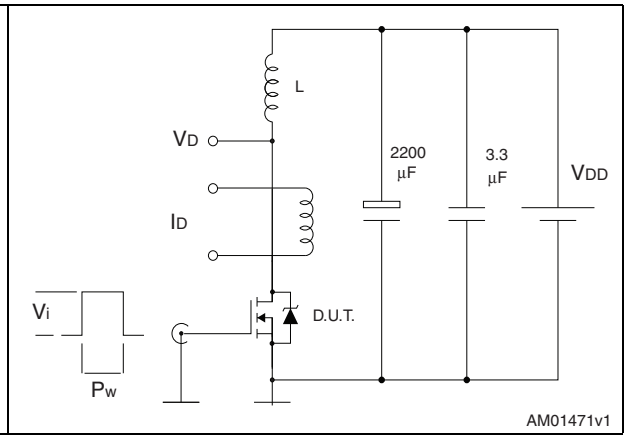


Figure 23. Unclamped inductive waveform

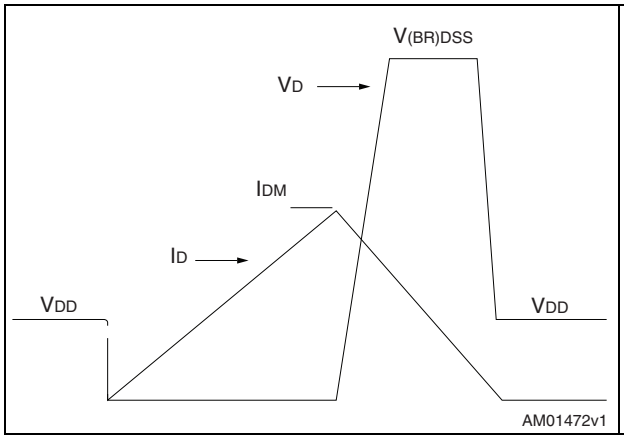
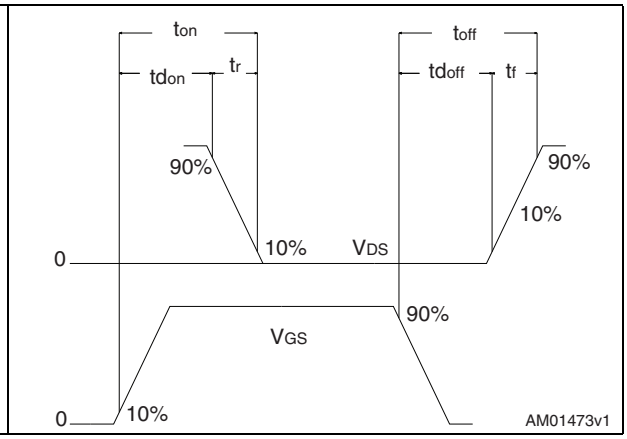


Figure 24. Switching time waveform



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. D²PAK (TO-263) mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	4.40		4.60
A1	0.03		0.23
b	0.70		0.93
b2	1.14		1.70
c	0.45		0.60
c2	1.23		1.36
D	8.95		9.35
D1	7.50		
E	10		10.40
E1	8.50		
e		2.54	
e1	4.88		5.28
H	15		15.85
J1	2.49		2.69
L	2.29		2.79
L1	1.27		1.40
L2	1.30		1.75
R		0.4	
V2	0°		8°

Figure 25. D²PAK (TO-263) drawing

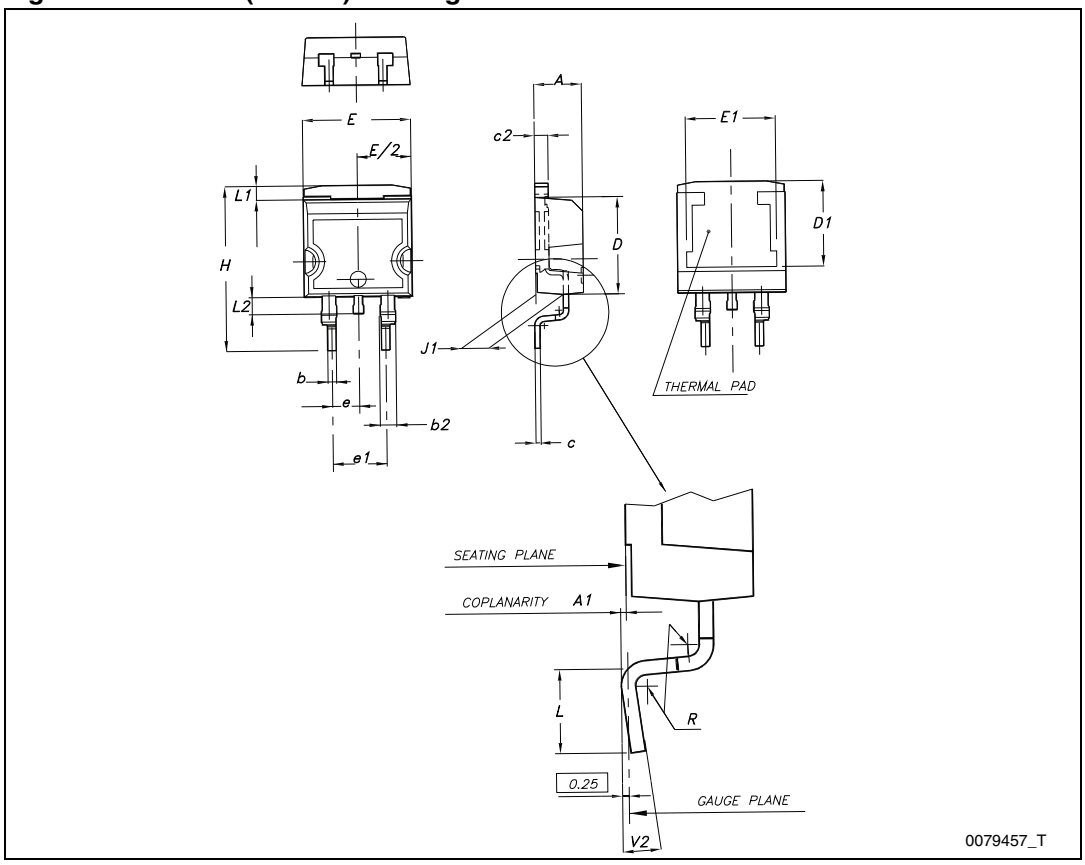
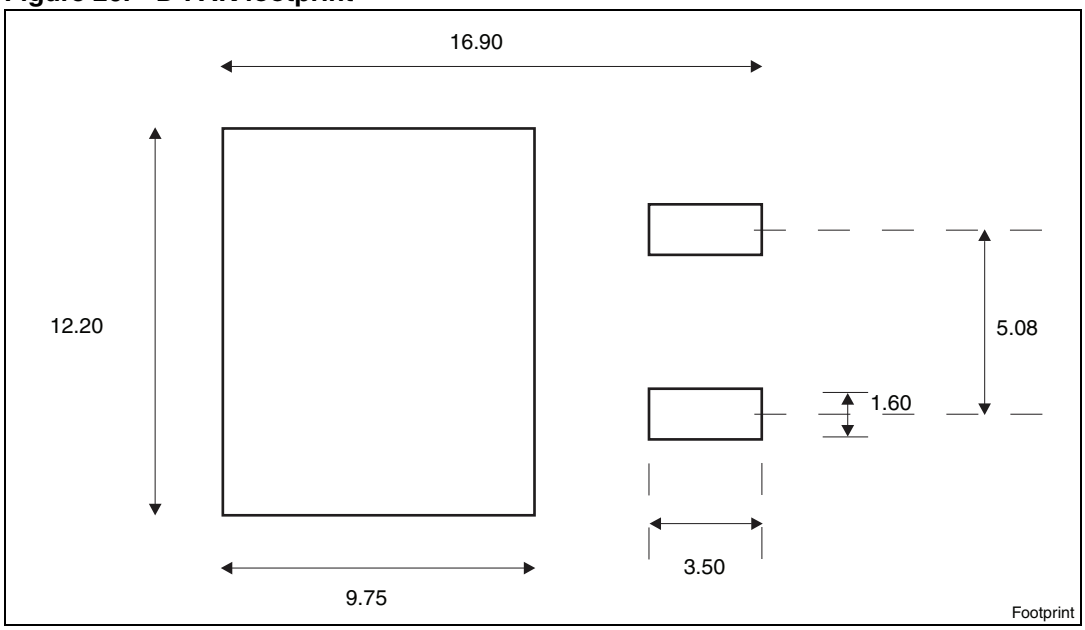


Figure 26. D²PAK footprint[a]



a. All dimensions are in millimeters

Table 10. 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 27. TO-220FP drawing

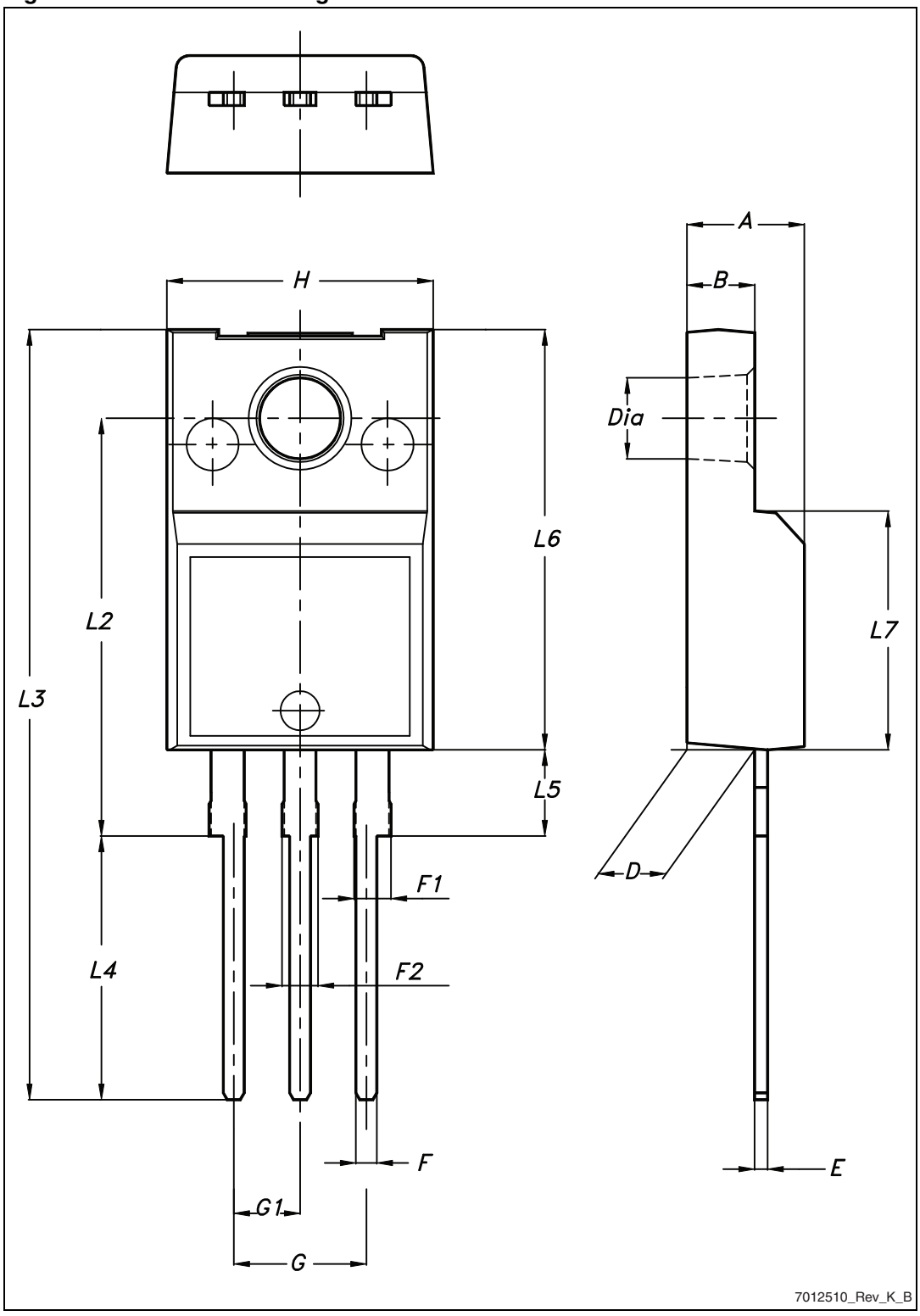


Table 11. TO-220 type A mechanical data

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 28. TO-220 type A drawing

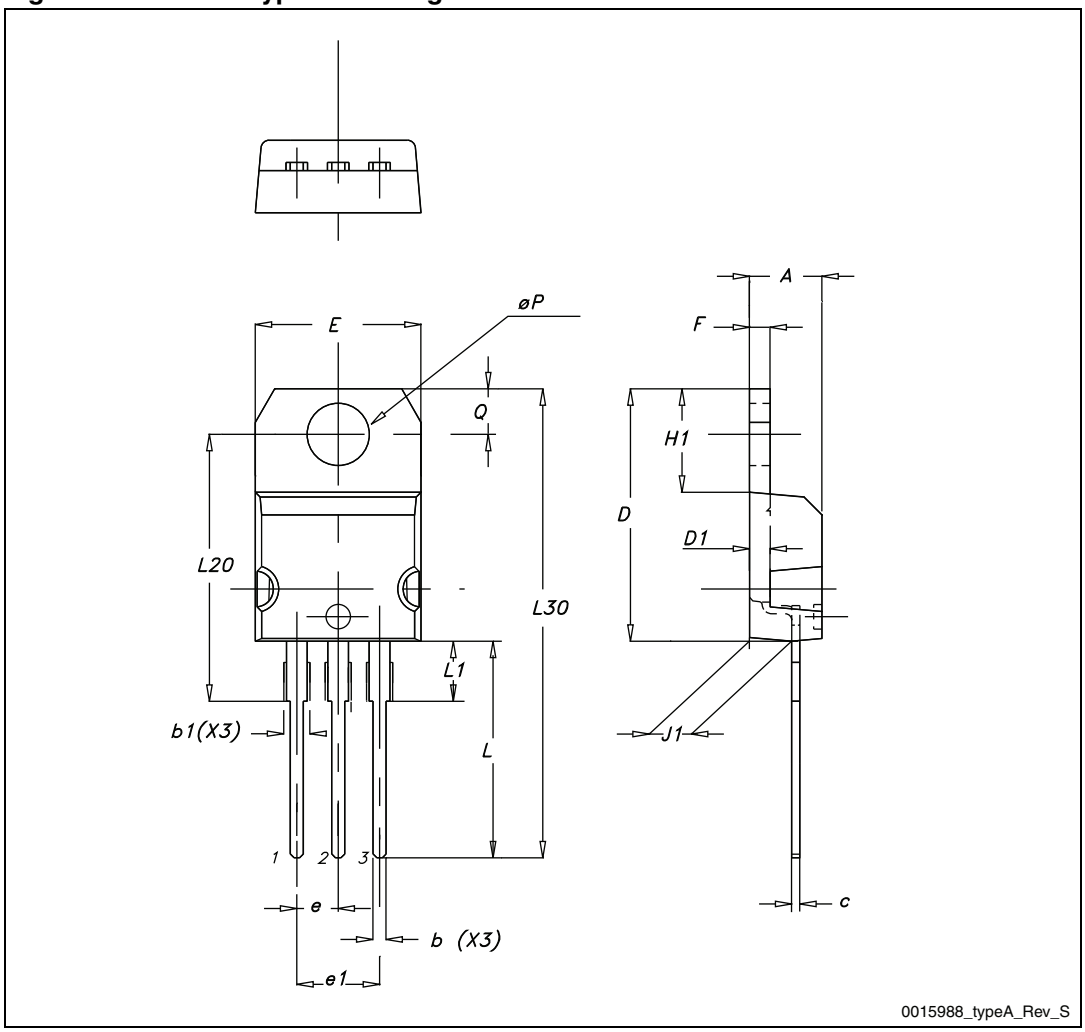
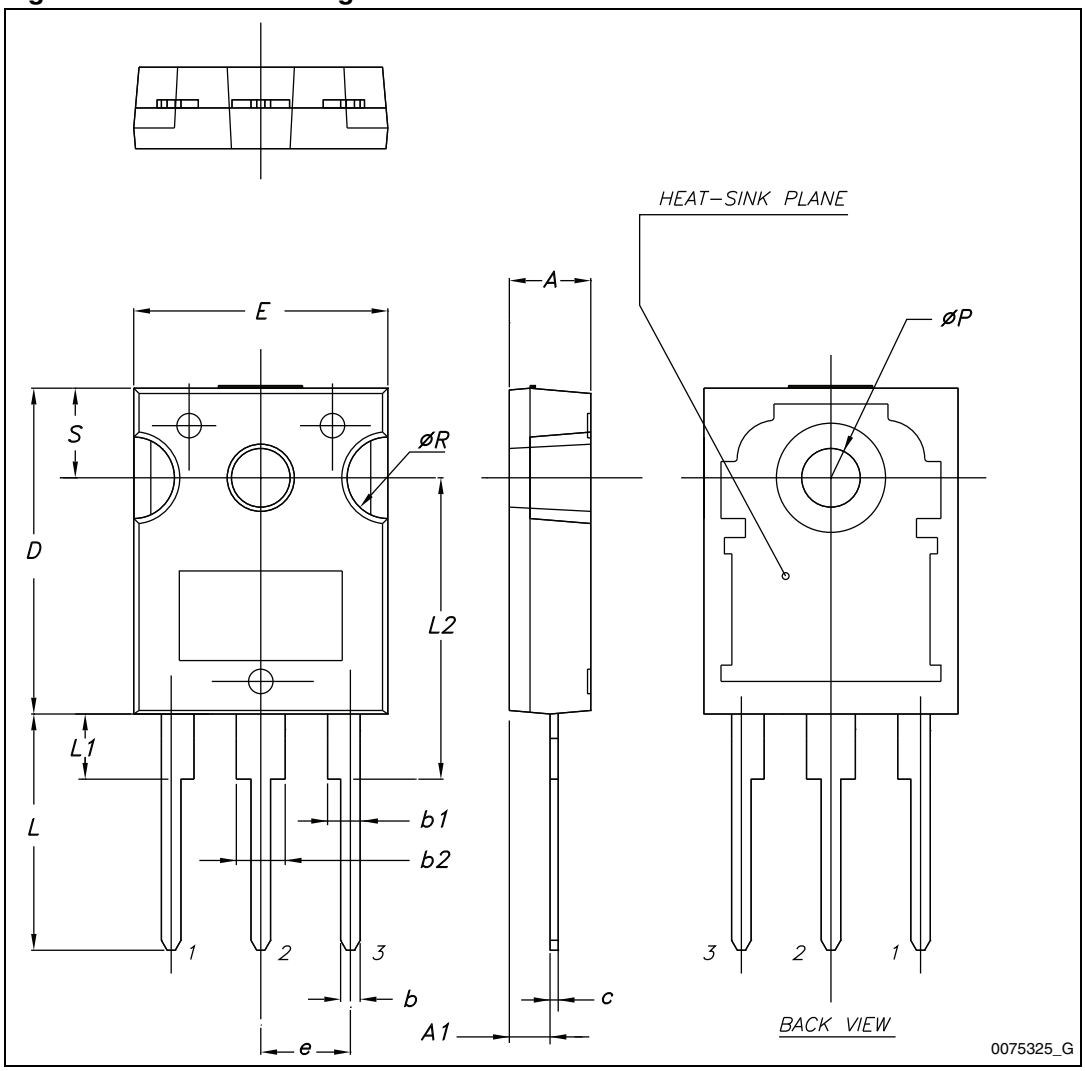


Table 12. TO-247 mechanical data

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 Packaging mechanical data

Table 13. D²PAK (TO-263) tape and reel mechanical data

Tape			Reel		
Dim.	mm		Dim.	mm	
	Min.	Max.		Min.	Max.
A0	10.5	10.7	A		330
B0	15.7	15.9	B	1.5	
D	1.5	1.6	C	12.8	13.2
D1	1.59	1.61	D	20.2	
E	1.65	1.85	G	24.4	26.4
F	11.4	11.6	N	100	
K0	4.8	5.0	T		30.4
P0	3.9	4.1			
P1	11.9	12.1	Base qty		1000
P2	1.9	2.1	Bulk qty		1000
R	50				
T	0.25	0.35			
W	23.7	24.3			

Figure 30. Tape for D²PAK (TO-263) and DPAK (TO-252)

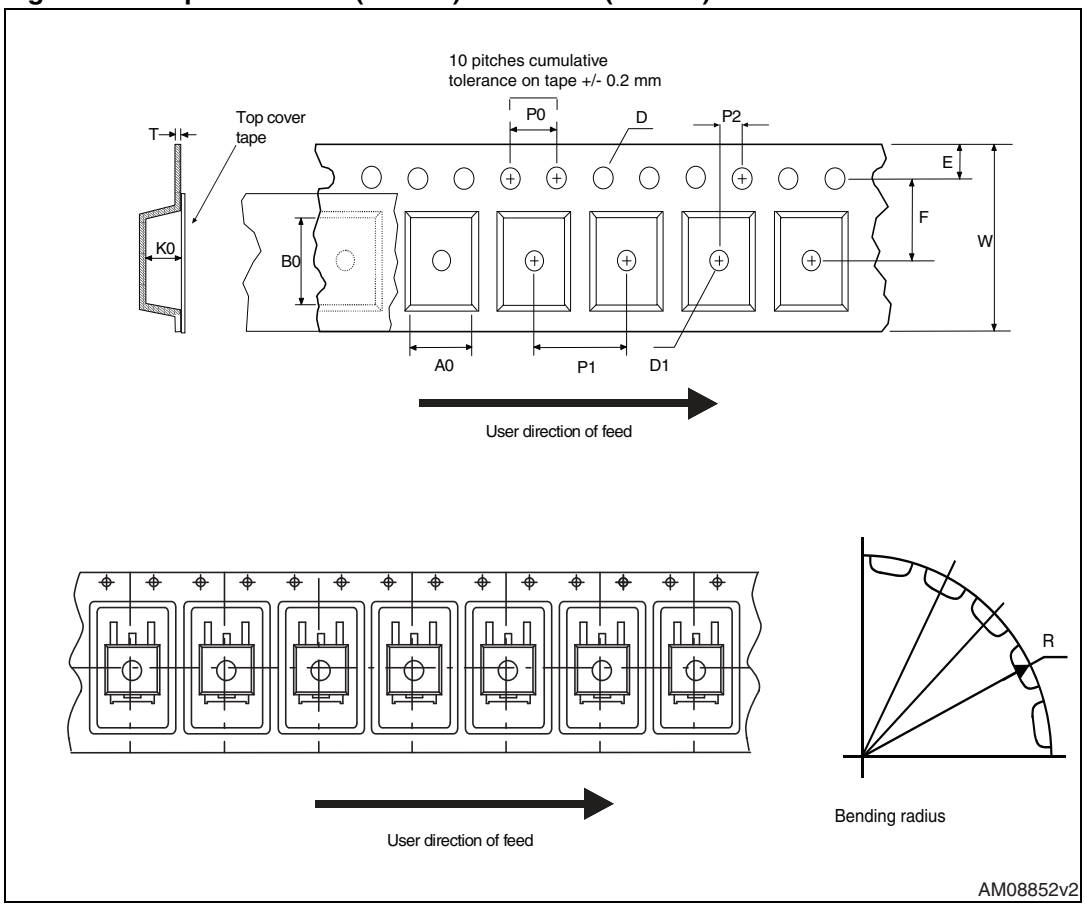
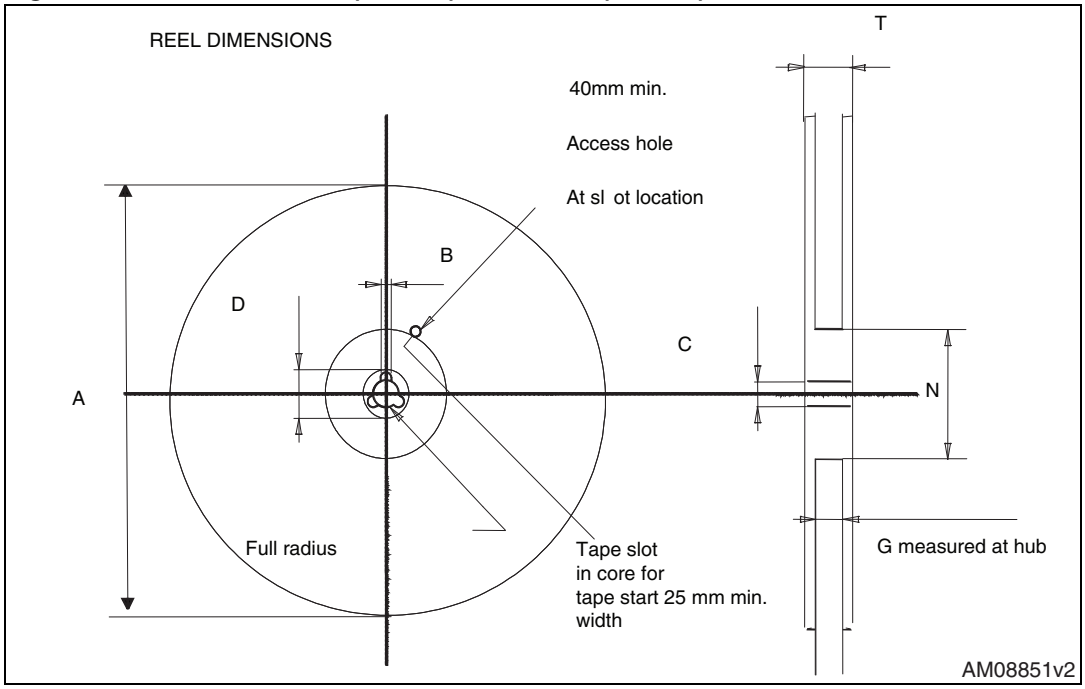


Figure 31. Reel for D²PAK (TO-263) and DPAK (TO-252)



6 Revision history

Table 14. Document revision history

Date	Revision	Changes
05-Nov-2009	1	First release.
18-Nov-2009	2	Updated description on cover page
12-Jan-2010	3	Corrected V_{GS} value in *Table 2: Absolute maximum ratings*
14-Jul-2010	4	Document status promoted from preliminary data to datasheet.
21-Dec-2011	5	– Inserted device in D^2PAK. – Updated *Figure 2: Safe operating area for TO-220 / D2PAK*, *Figure 4: Safe operating area for TO-220FP* and *Figure 6: Safe operating area for TO-247*. – Inserted *Section 5: Packaging mechanical data on page 19*. – Minor text changes.
12-Oct-2012	6	– Updated: Q_g value (test conditions) in *Table 5* – Updated: $T_{d(on)}$ value (test conditions) in *Table 6* – Updated: values (test conditions) in *Table 8* – Updated: *Figure 10* – Updated: *Section 4: Package mechanical data*