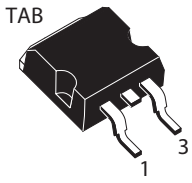
STB9NK60ZD

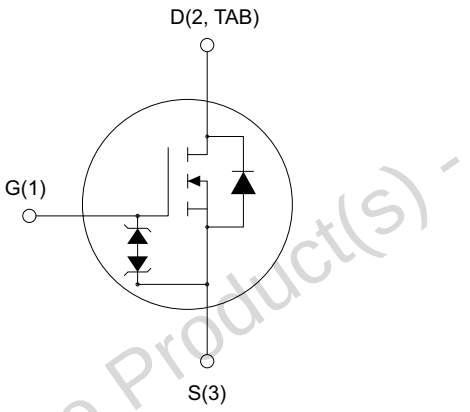
N-channel 600 V, 0.85 Ω typ., 7 A Zener-protected SuperFREDMESH™ Power MOSFET (with fast diode) in D²PAK

Datasheet - production data



D²PAK

Figure 1. Internal schematic diagram



Features

Order code	V_{DS}	$R_{DS(on)}$ max.	I_D	P_{TOT}
STB9NK60ZDT4	600 V	0.95 Ω	7 A	125 W

- Extremely high dv/dt capability
- Zener-protected
- 100% avalanche tested
- Gate charge minimized
- Low intrinsic capacitances
- Fast internal recovery diode

Applications

- Switching applications
- Fast internal recovery diode

Description

The device is developed using the revolutionary SuperFREDMesh™ technology. It associates all advantages of reduced on-resistance, Zener gate protection and very high dv/dt capability with a fast body-drain recovery diode. Such series complements the “FDmesh™” advanced technology.

Table 1. Device summary

Order code	Marking	Package	Packaging
STB9NK60ZDT4	B9NK60ZD	D²PAK	Tape and reel

Contents

1 Electrical ratings

Table 2. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{DS}	Drain-source voltage	600	V
V_{GS}	Gate-source voltage	±30	V
I_D	Drain current (continuous) at T_C = 25 °C	7	A
I_D	Drain current (continuous) at T_C = 100 °C	4.3	A
I_{DM} (1)	Drain current (pulsed)	28	A
P_{TOT}	Total dissipation at T_C = 25 °C	125	W
	Derating factor	1	W/°C
$V_{ESD(G-S)}$	Gate-source ESD (HBM-C=100 pF, R=1.5 kΩ)	4000	V
dv/dt (2)	Peak diode recovery voltage slope	15	V/ns
T_j	Max. operating junction temperature	- 55 to 150	°C
T_{stg}	Storage temperature		

1. Pulse width limited by safe operating area.
2. $I_{SD} \leq 7$ A, di/dt ≤ 500 A/µs; V_{DD} = 80% $V_{(BR)DSS}$.

Table 3. Thermal data

Symbol	Parameter	Value	Unit
$R_{thj\text{-}case}$	Thermal resistance junction-case max.	1	°C/W
$R_{thj\text{-}pcb}$	Thermal resistance junction-pcb max.(1)	30	°C/W

1. When mounted on 1 inch² FR-4, 2 Oz copper board.

Table 4. Avalanche characteristics

Symbol	Parameter	Value	Unit
I_{AR}	Avalanche current, repetitive or not repetitive (pulse width limited by T_{jmax})	7	A
E_{AS}	Single pulse avalanche energy (starting T_j=25 °C, I_D= I_{AR}; V_{DD}= 50)	235	mJ

2 Electrical characteristics

(T_C = 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	I_D = 1 mA, V_{GS} = 0	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 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	2.5	3.5	4.5	V
$R_{DS(on)}$	Static drain-source on-resistance	V_{GS} = 10 V, I_D = 3.5 A		0.85	0.95	Ω

Table 6. Dynamic

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
g_{fs} (1)	Forward transconductance	V_{DS} = 15 V, I_D= 3.5 A	-	5.3		S
C_{iss}	Input capacitance	V_{DS} = 25 V, f = 1 MHz, V_{GS} = 0	-	1110		pF
C_{oss}	Output capacitance		-	135		pF
C_{rss}	Reverse transfer capacitance		-	30		pF
$C_{oss\ eq.}$ (2)	Equivalent output capacitance	V_{DS} = 0 to 480 V, V_{GS} = 0	-	72		pF
Q_g	Total gate charge	V_{DD} = 480 V, I_D = 11 A, V_{GS} = 10 V (see *Figure 15*)	-	41	53	nC
Q_{gs}	Gate-source charge		-	8.7		nC
Q_{gd}	Gate-drain charge		-	21		nC

1. Pulsed: pulse duration= 300 µs, duty cycle 1.5%.
2. $C_{oss\ eq.}$ is defined as a constant equivalent capacitance giving the same charging time as C_{oss} when V_{DS} increases from 0 to 80% V_{DSS}.

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 = 3.5 A, R_G = 4.7 Ω, V_{GS} = 10 V (see *Figure 14* and *Figure 19*)	-	11.4	-	ns
t_r	Rise time		-	13.6	-	ns
$t_{d(off)}$	Turn-off delay time		-	23.1	-	ns
t_f	Fall time		-	15	-	ns
$t_{r(Voff)}$	Off-voltage rise time	V_{DD} = 480 V, I_D = 7 A, R_G = 4.7 Ω, V_{GS} = 10 V (see *Figure 14* and *Figure 19*)	-	11	-	ns
t_f	Fall time		-	8	-	ns
t_c	Cross-overtime		-	20	-	ns

Table 8. Source - drain diode

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{SD}	Source-drain current		-		7	A
I_{SDM} (1)	Source-drain current (pulsed)		-		28	A
V_{SD} (2)	Forward on voltage	I_{SD} = 7 A, V_{GS} = 0	-		1.6	V
t_{rr}	Reverse recovery time	I_{SD} = 7 A, di/dt = 100 A/µs V_{DD} = 30 V (see *Figure 16*)	-	130		ns
Q_{rr}	Reverse recovery charge		-	550		nC
I_{RRM}	Reverse recovery current		-	8.4		A
t_{rr}	Reverse recovery time	I_{SD} = 7 A, di/dt = 100 A/µs V_{DD} = 30 V, T_j = 150 °C (see *Figure 16*)	-	176		ns
Q_{rr}	Reverse recovery charge		-	880		nC
I_{RRM}	Reverse recovery current		-	10		A

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

Table 9. Gate - source Zener diode

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
BV_{GSO} (1)	Gate-source breakdown voltage	Igs= ± 1 mA (open drain)	30			V

1. The built-in back-to-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

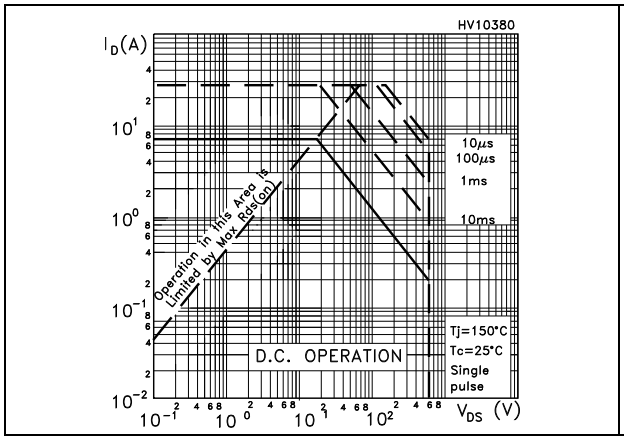


Figure 3. Thermal impedance

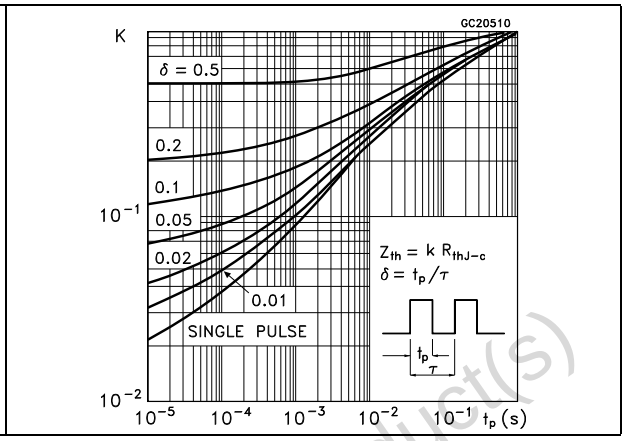


Figure 4. Output characteristics

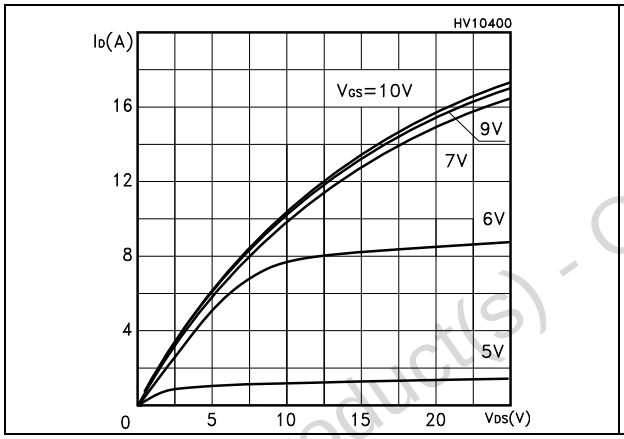


Figure 5. Transfer characteristics

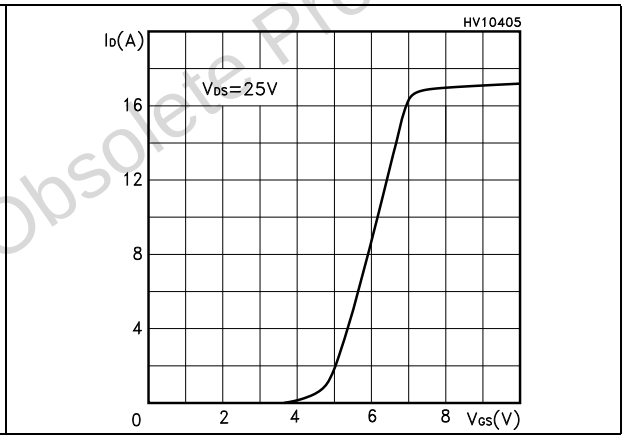


Figure 6. Normalized BVDSS vs temperature

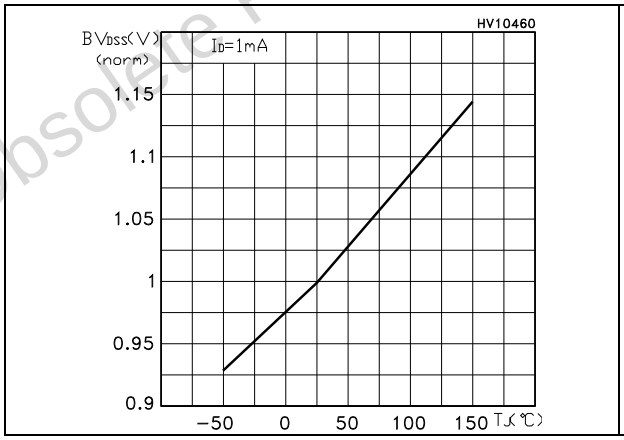


Figure 7. Static drain-source on-resistance

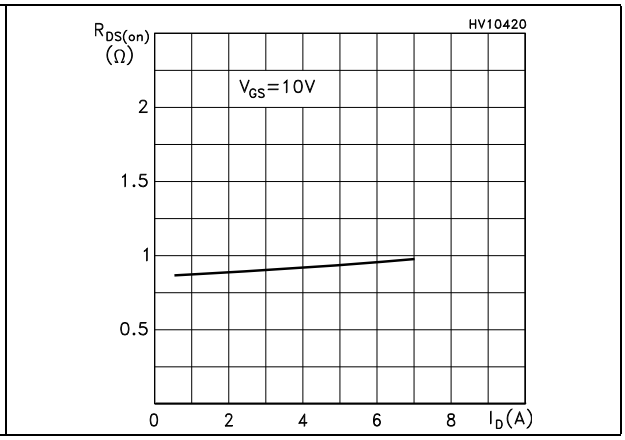


Figure 8. Gate charge vs gate-source voltage

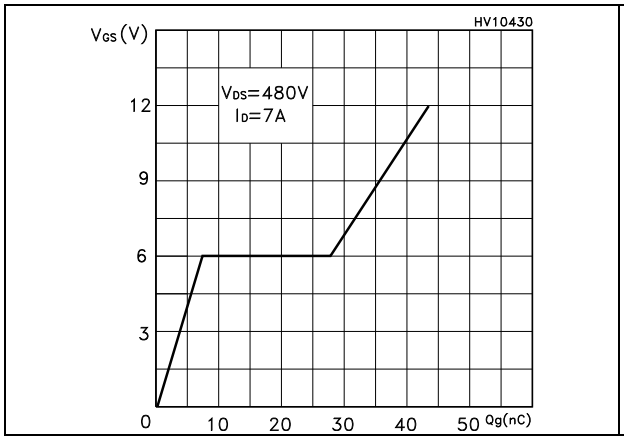


Figure 9. Capacitance variations

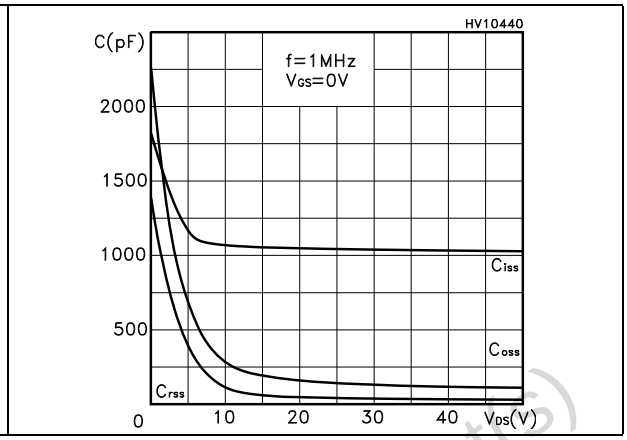


Figure 10. Normalized gate threshold voltage vs temperature

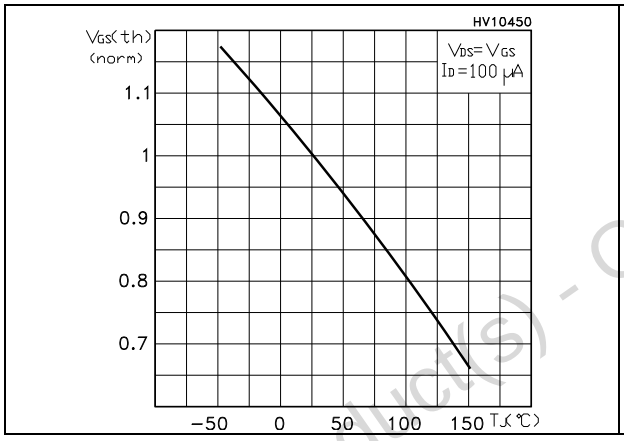


Figure 11. Normalized on-resistance vs temperature

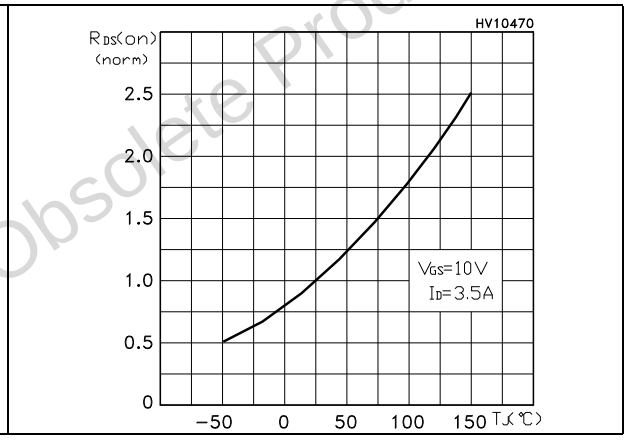


Figure 12. Source-drain diode forward characteristics

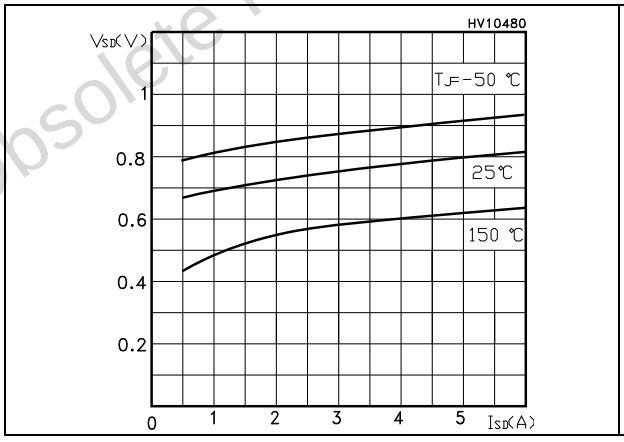
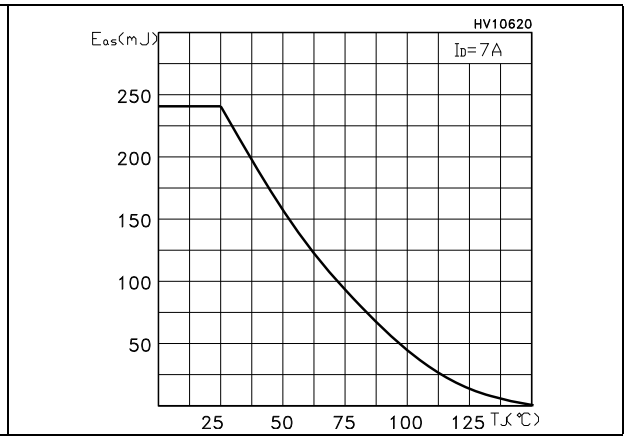


Figure 13. Maximum avalanche energy vs temperature



3 Test circuits

Figure 14. Switching time test circuit for resistive load

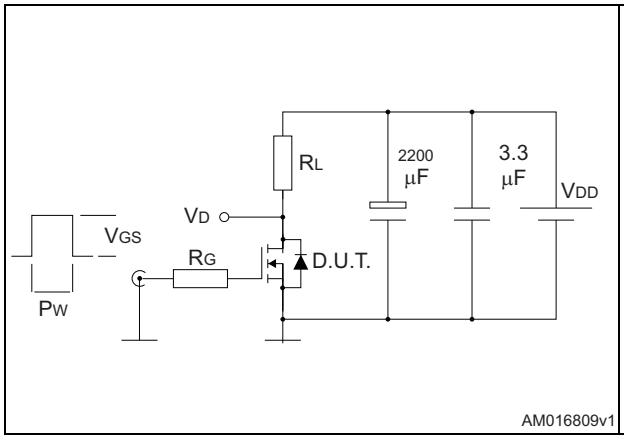


Figure 15. Gate charge test circuit

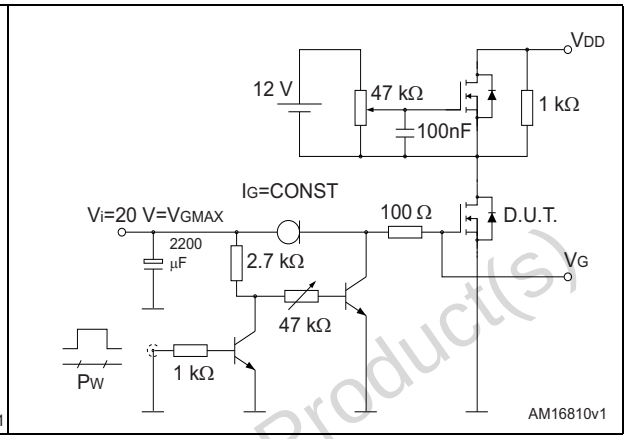


Figure 16. Test circuit for inductive load switching and diode recovery times

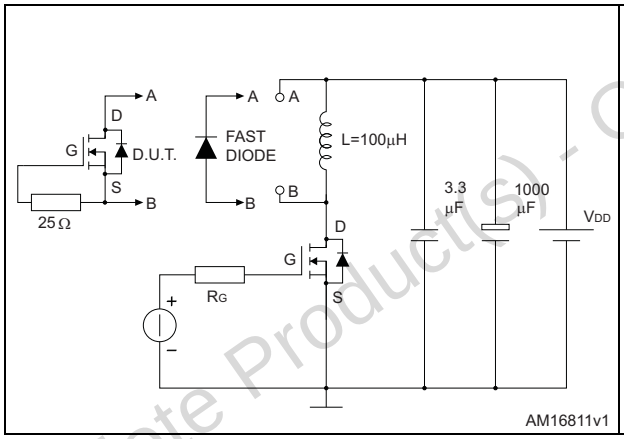


Figure 17. Unclamped inductive load test circuit

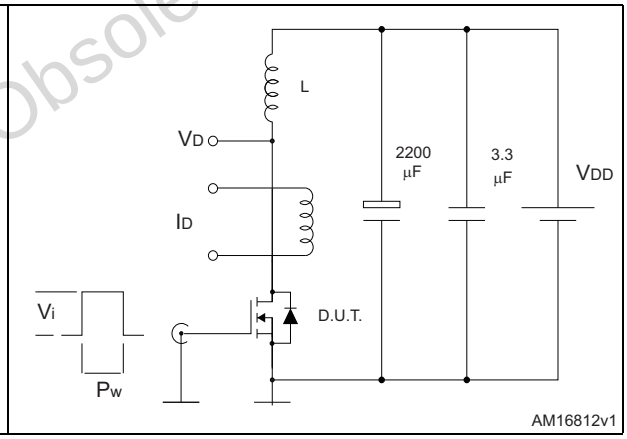


Figure 18. Unclamped inductive waveform

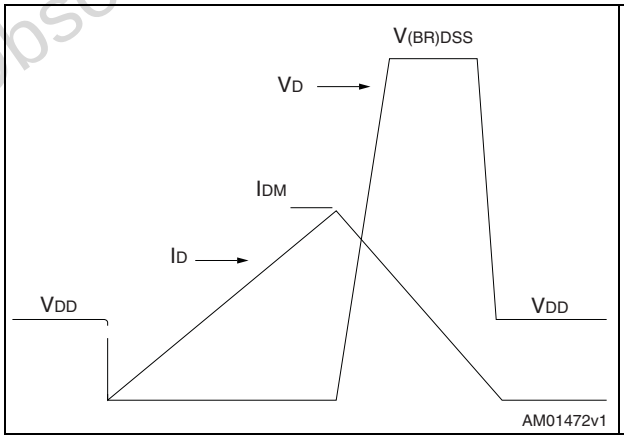
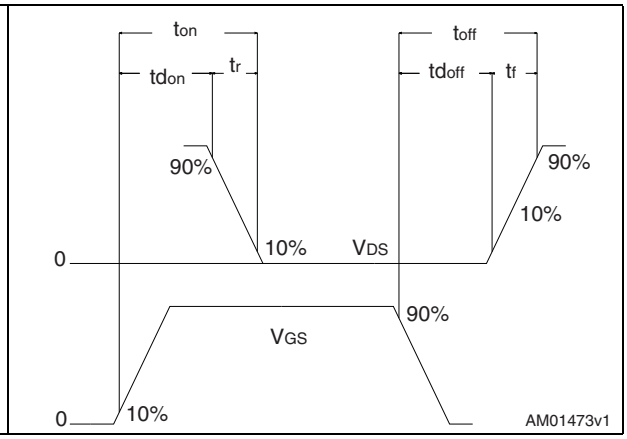


Figure 19. Switching time waveform



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 10. 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 20. D²PAK (TO-263) drawing

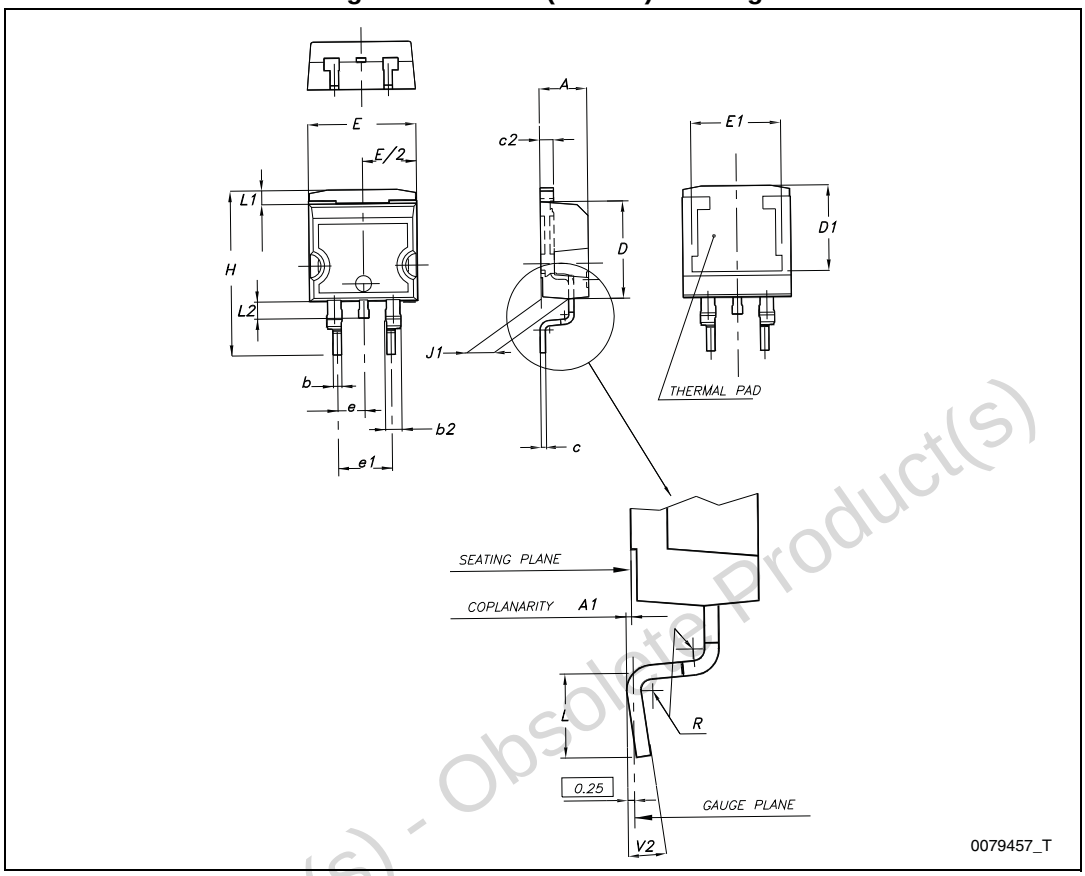
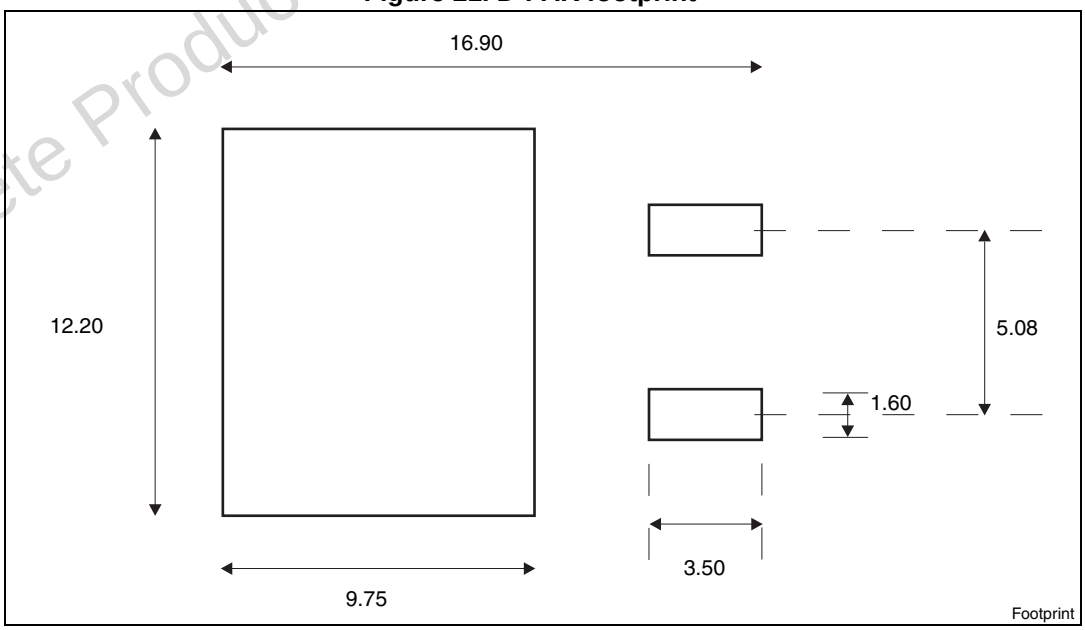


Figure 21. D²PAK footprint[(a)]



a. All dimensions are in millimeters.

5 Packaging mechanical data

Table 11. 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 22. D²PAK (TO-263) tape

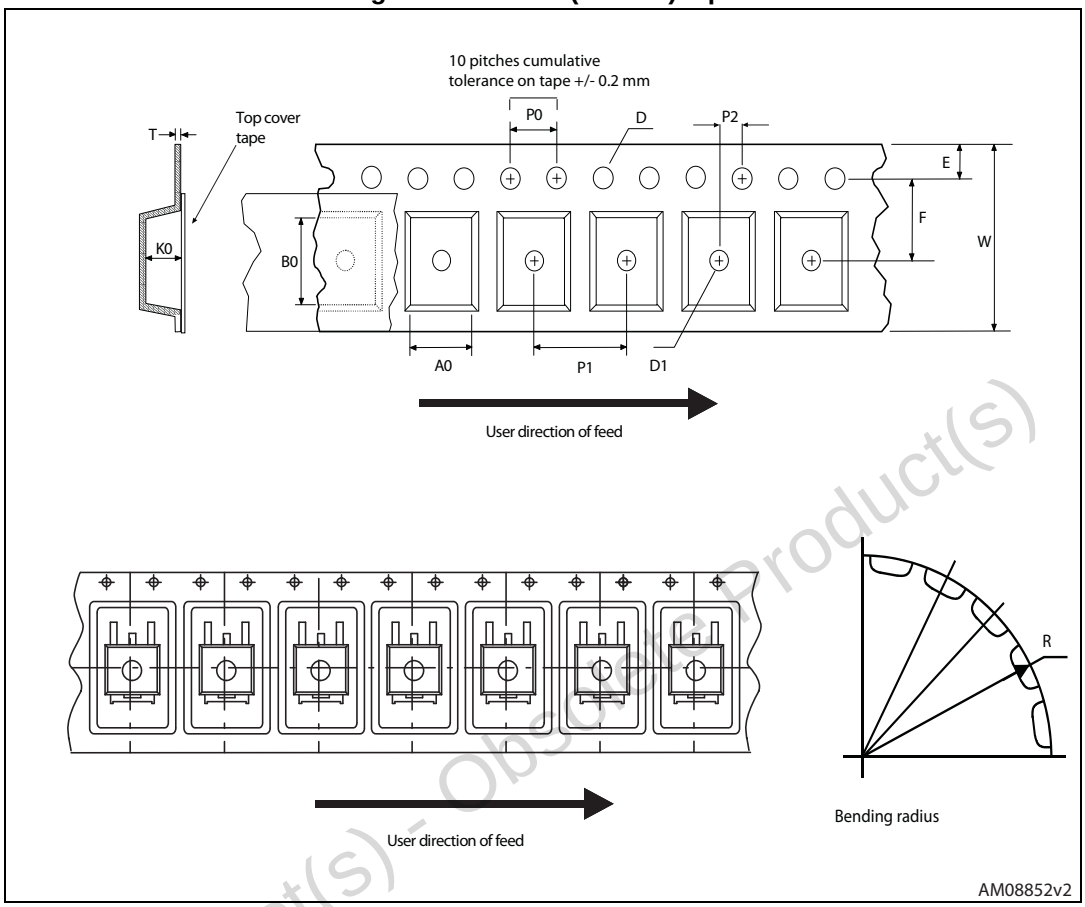
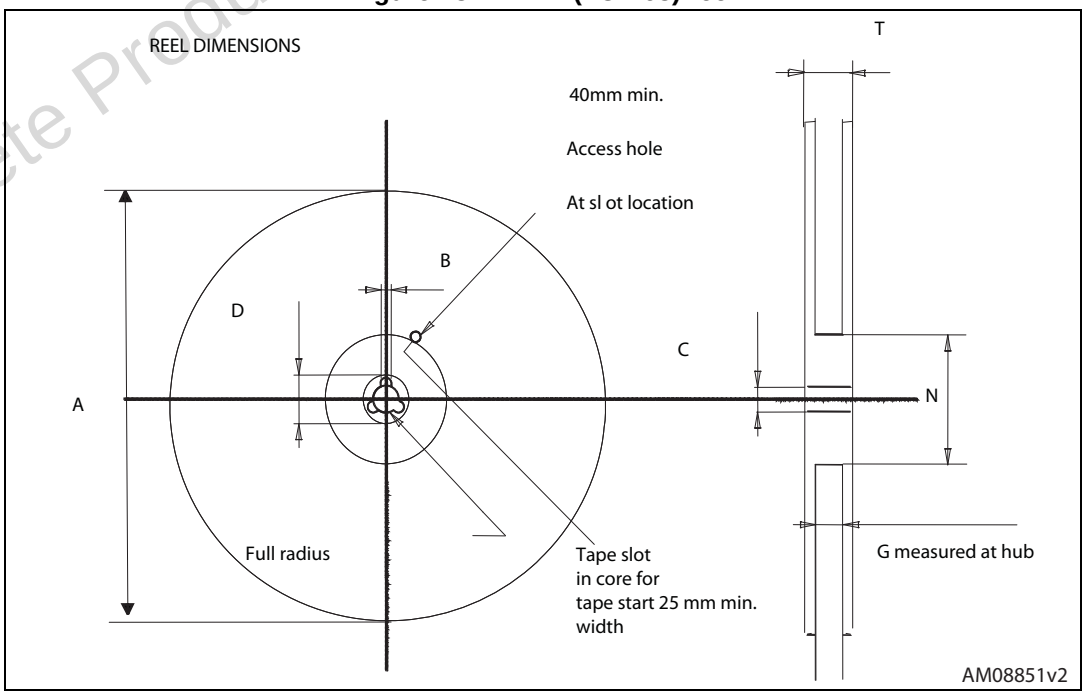


Figure 23. D²PAK (TO-263) reel



6 Revision history

Table 12. Document revision history

Date	Revision	Changes
29-Sep-2003	6	Data updated.
13-Jun-2006	7	The doc. has been reformatted.
14-Apr-2008	8	Table 8 has been corrected. Package mechanical data updated.
11-Jul-2013	9	-The part numbers: STF9NK60ZD and STP9NK60ZD have been moved to a separate datasheet. -Changed the title and *Figure 1*. -Added Zener-protected to the features. -Minor text changes.

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