

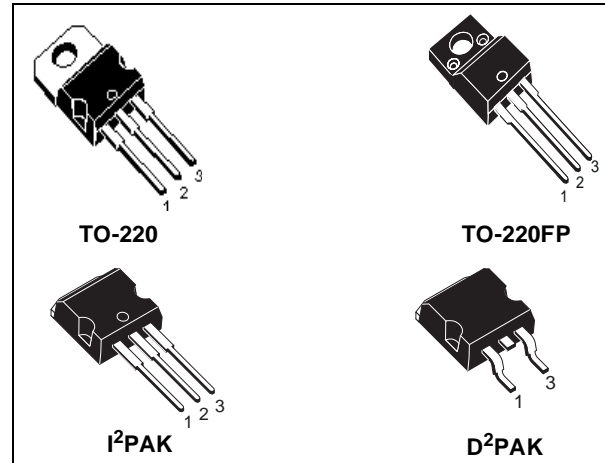


# STP9NK60Z - STP9NK60ZFP STB9NK60Z - STB9NK60Z-1

N-CHANNEL 600V - 0.85Ω - 7A TO-220/FP/D<sup>2</sup>PAK/I<sup>2</sup>PAK  
Zener-Protected SuperMESH™ Power MOSFET

TYPE	V <sub>DSS</sub>	R <sub>DS(on)</sub>	I <sub>D</sub>	P <sub>w</sub>
STP9NK60Z	600 V	< 0.95 Ω	7 A	125 W
STP9NK60ZFP	600 V	< 0.95 Ω	7 A	30 W
STB9NK60Z	600 V	< 0.95 Ω	7 A	125 W
STB9NK60Z-1	600 V	< 0.95 Ω	7 A	125 W

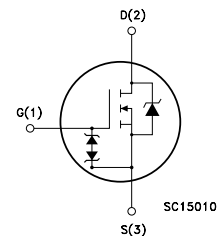
- TYPICAL R<sub>DS(on)</sub> = 0.85 Ω
- EXTREMELY HIGH dv/dt CAPABILITY
- IMPROVED ESD CAPABILITY
- 100% AVALANCHE RATED
- GATE CHARGE MINIMIZED
- VERY LOW INTRINSIC CAPACITANCES
- VERY GOOD MANUFACTURING REPEATIBILITY



## DESCRIPTION

The SuperMESH™ series is obtained through an extreme optimization of ST's well established strip-based PowerMESH™ layout. In addition to pushing on-resistance significantly down, special care is taken to ensure a very good dv/dt capability for the most demanding applications. Such series complements ST full range of high voltage MOSFETs including revolutionary MDmesh™ products.

## INTERNAL SCHEMATIC DIAGRAM



## APPLICATIONS

- HIGH CURRENT, HIGH SPEED SWITCHING
- IDEAL FOR OFF-LINE POWER SUPPLIES, ADAPTORS AND PFC

## ORDERING INFORMATION

SALES TYPE	MARKING	PACKAGE	PACKAGING
STP9NK60Z	P9NK60Z	TO-220	TUBE
STP9NK60ZFP	P9NK60ZFP	TO-220FP	TUBE
STB9NK60Z	B9NK60Z	D <sup>2</sup> PAK	TUBE
STB9NK60ZT4	B9NK60Z	D <sup>2</sup> PAK	TAPE & REEL
STB9NK60Z-1	B9NK60Z-1	I <sup>2</sup> PAK	TUBE

**STP9NK60Z / STP9NK60ZFP / STB9NK60Z / STB9NK60Z-1****ABSOLUTE MAXIMUM RATINGS**

Symbol	Parameter	Value		Unit
		TO-220 / D <sup>2</sup> PAK / I <sup>2</sup> PAK	TO-220FP	
V <sub>DS</sub>	Drain-source Voltage (V <sub>GS</sub> = 0)	600		V
V <sub>DGR</sub>	Drain-gate Voltage (R <sub>GS</sub> = 20 kΩ)	600		V
V <sub>GS</sub>	Gate- source Voltage	± 30		V
I <sub>D</sub>	Drain Current (continuous) at T <sub>C</sub> = 25°C	7	7 (*)	A
I <sub>D</sub>	Drain Current (continuous) at T <sub>C</sub> = 100°C	4.4	4.4 (*)	A
I <sub>DM</sub> (•)	Drain Current (pulsed)	28	28 (*)	A
P <sub>TOT</sub>	Total Dissipation at T <sub>C</sub> = 25°C	125	30	W
	Derating Factor	1	0.24	W/°C
V <sub>ESD(G-S)</sub>	Gate source ESD(HBM-C=100pF, R=1.5KΩ)	4000		V
dv/dt (1)	Peak Diode Recovery voltage slope	4.5		V/ns
V <sub>ISO</sub>	Insulation Withstand Voltage (DC)	-	2500	V
T <sub>j</sub> T <sub>stg</sub>	Operating Junction Temperature Storage Temperature	-55 to 150 -55 to 150		°C °C

(•) Pulse width limited by safe operating area

(1) I<sub>SD</sub> ≤ 7A, di/dt ≤ 200 μA, V<sub>DD</sub> ≤ V<sub>(BR)DSS</sub>, T<sub>j</sub> ≤ T<sub>JMAX</sub>.

(\*) Limited only by maximum temperature allowed

**THERMAL DATA**

		TO-220 I <sup>2</sup> PAK	D <sup>2</sup> PAK	TO- 220FP	
R <sub>thj-case</sub>	Thermal Resistance Junction-case Max	1		4.16	°C/W
R <sub>thj-pcb</sub>	Thermal Resistance Junction-pcb Max (When mounted on minimum Footprint)		30		°C/W
R <sub>thj-amb</sub>	Thermal Resistance Junction-ambient Max	62.5			°C/W
T <sub>l</sub>	Maximum Lead Temperature For Soldering Purpose	300			°C

**AVALANCHE CHARACTERISTICS**

Symbol	Parameter	Max Value	Unit
I <sub>AR</sub>	Avalanche Current, Repetitive or Not-Repetitive (pulse width limited by T <sub>j</sub> max)	7	A
E <sub>AS</sub>	Single Pulse Avalanche Energy (starting T <sub>j</sub> = 25 °C, I <sub>D</sub> = I <sub>AR</sub> , V <sub>DD</sub> = 50 V)	235	mJ

**GATE-SOURCE ZENER DIODE**

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
BV <sub>GSO</sub>	Gate-Source Breakdown Voltage	I <sub>gs</sub> = ± 1mA (Open Drain)	30			V

**PROTECTION FEATURES OF GATE-TO-SOURCE ZENER DIODES**

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.

**STP9NK60Z / STP9NK60ZFP / STB9NK60Z / STB9NK60Z-1****ELECTRICAL CHARACTERISTICS (TCASE = 25°C UNLESS OTHERWISE SPECIFIED)  
ON/OFF**

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source Breakdown Voltage	$I_D = 1 \text{ mA}, V_{GS} = 0$	600			V
$I_{DSS}$	Zero Gate Voltage Drain Current ( $V_{GS} = 0$ )	$V_{DS} = \text{Max Rating}$ $V_{DS} = \text{Max Rating}, T_C = 125^\circ\text{C}$			1 50	$\mu\text{A}$ $\mu\text{A}$
$I_{GSS}$	Gate-body Leakage Current ( $V_{DS} = 0$ )	$V_{GS} = \pm 20\text{V}$			$\pm 10$	$\mu\text{A}$
$V_{GS(th)}$	Gate Threshold Voltage	$V_{DS} = V_{GS}, I_D = 100\mu\text{A}$	3	3.75	4.5	V
$R_{DS(on)}$	Static Drain-source On Resistance	$V_{GS} = 10\text{V}, I_D = 3.5 \text{ A}$		0.85	0.95	$\Omega$

**DYNAMIC**

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$g_{fs} (1)$	Forward Transconductance	$V_{DS} = 15 \text{ V}, I_D = 3.5 \text{ A}$		5.3		S
$C_{iss}$ $C_{oss}$ $C_{rss}$	Input Capacitance Output Capacitance Reverse Transfer Capacitance	$V_{DS} = 25\text{V}, f = 1 \text{ MHz}, V_{GS} = 0$		1110 135 30		pF pF pF
$C_{oss \text{ eq.}} (3)$	Equivalent Output Capacitance	$V_{GS} = 0\text{V}, V_{DS} = 0\text{V to } 480 \text{ V}$		72		pF

**SWITCHING ON**

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ $t_r$	Turn-on Delay Time Rise Time	$V_{DD} = 300 \text{ V}, I_D = 3.5 \text{ A}$ $R_G = 4.7\Omega, V_{GS} = 10 \text{ V}$ (Resistive Load see, Figure 3)		19 17		ns ns
$Q_g$ $Q_{gs}$ $Q_{gd}$	Total Gate Charge Gate-Source Charge Gate-Drain Charge	$V_{DD} = 480 \text{ V}, I_D = 7 \text{ A},$ $V_{GS} = 10\text{V}$		38 7 21	53	nC nC nC

**SWITCHING OFF**

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(off)}$ $t_f$	Turn-off Delay Time Fall Time	$V_{DD} = 300 \text{ V}, I_D = 3.5 \text{ A}$ $R_G = 4.7\Omega, V_{GS} = 10 \text{ V}$ (Resistive Load see, Figure 3)		43 15		ns ns
$t_{r(Voff)}$ $t_f$ $t_c$	Off-voltage Rise Time Fall Time Cross-over Time	$V_{DD} = 300 \text{ V}, I_D = 7 \text{ A},$ $R_G = 4.7\Omega, V_{GS} = 10\text{V}$ (Inductive Load see, Figure 5)		11 8 20		ns ns ns

**SOURCE DRAIN DIODE**

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$I_{SD}$ $I_{SDM} (2)$	Source-drain Current Source-drain Current (pulsed)				7 28	A A
$V_{SD} (1)$	Forward On Voltage	$I_{SD} = 7 \text{ A}, V_{GS} = 0$			1.6	V
$t_{rr}$ $Q_{rr}$ $I_{RRM}$	Reverse Recovery Time Reverse Recovery Charge Reverse Recovery Current	$I_{SD} = 7 \text{ A}, di/dt = 100\text{A}/\mu\text{s}$ $V_{DD} = 30\text{V}, T_j = 150^\circ\text{C}$ (see test circuit, Figure 5)		480 3.5 14.5		ns $\mu\text{C}$ A

Note: 1. Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5 %.

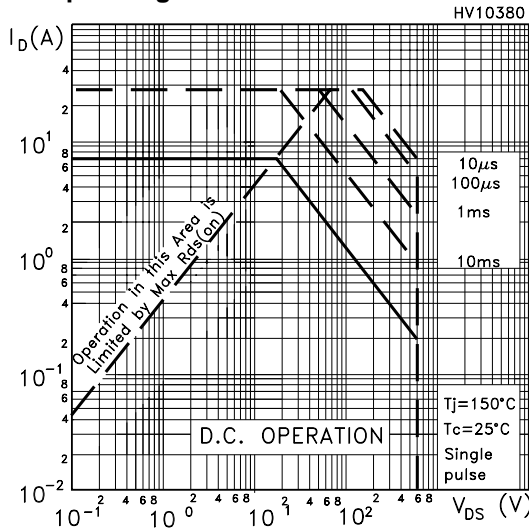
2. Pulse width limited by safe operating area.

3.  $C_{oss \text{ eq.}}$  is defined as a constant equivalent capacitance giving the same charging time as  $C_{oss}$  when  $V_{DS}$  increases from 0 to 80%  $V_{DSS}$ .

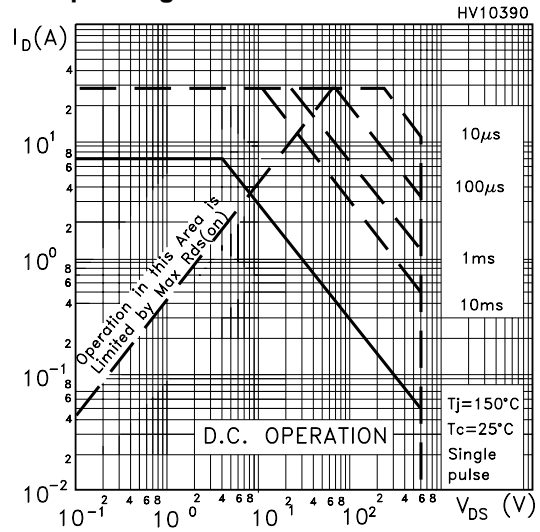


**STP9NK60Z / STP9NK60ZFP / STB9NK60Z / STB9NK60Z-1**

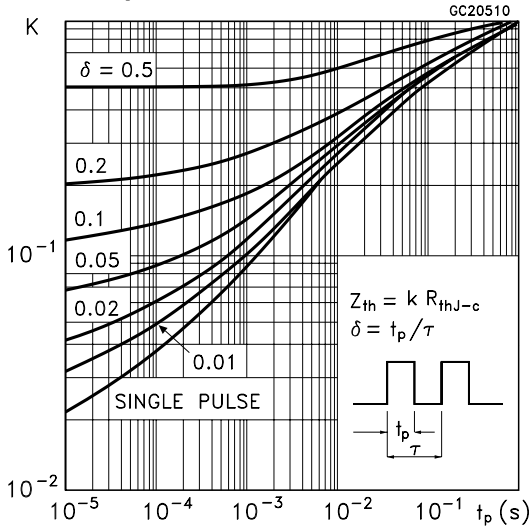
**Safe Operating Area For TO-220/D2PAK/I2PAK**



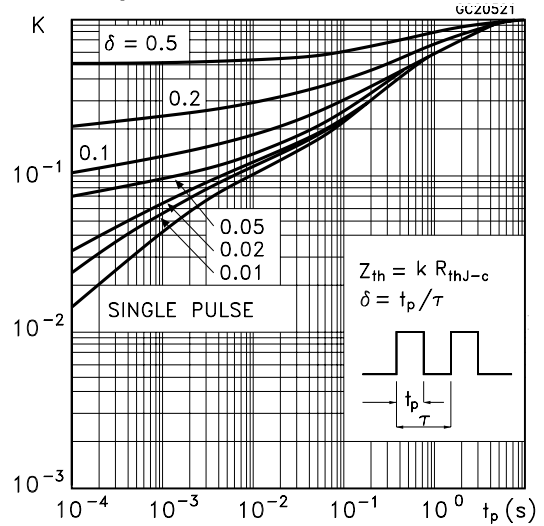
**Safe Operating Area For TO-220FP**



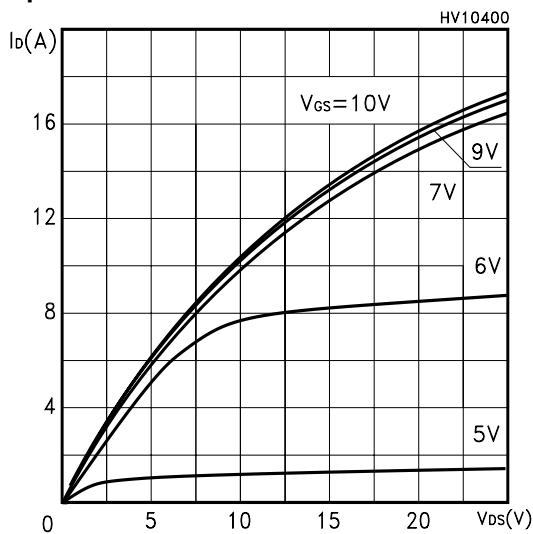
**Thermal Impedance For TO-220/D2PAK/I2PAK**



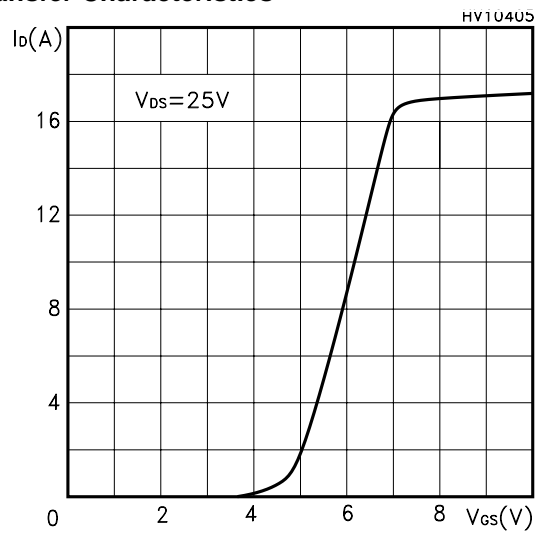
**Thermal Impedance For TO-220FP**



**Output Characteristics**

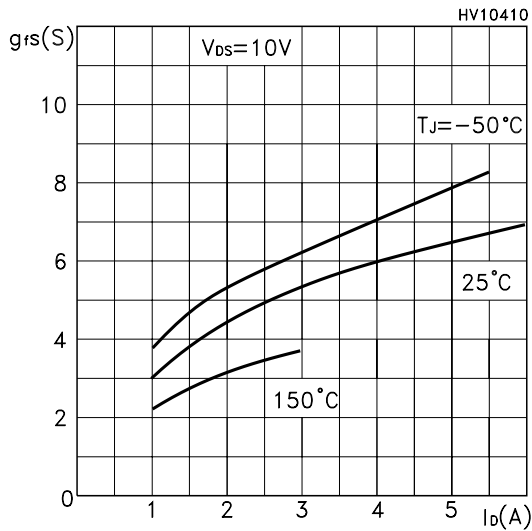


**Transfer Characteristics**

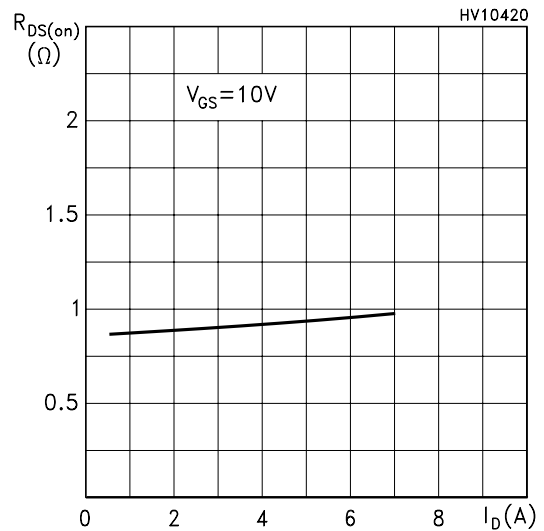


**STP9NK60Z / STP9NK60ZFP / STB9NK60Z / STB9NK60Z-1**

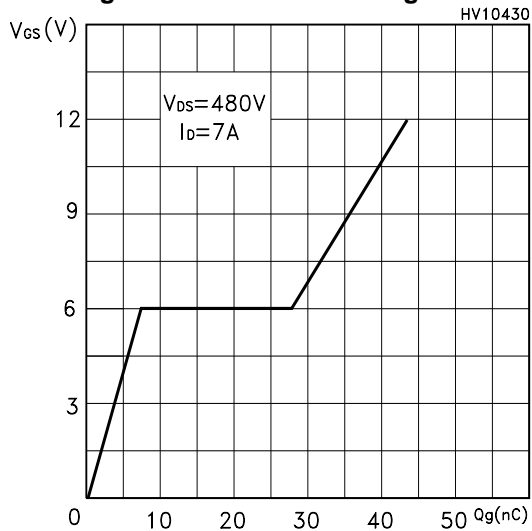
**Transconductance**



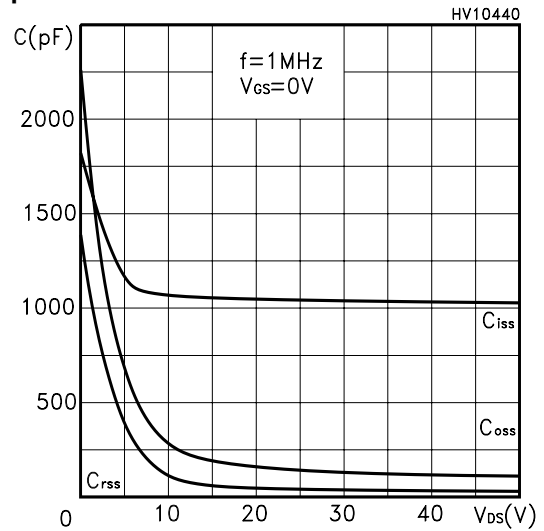
**Static Drain-source On Resistance**



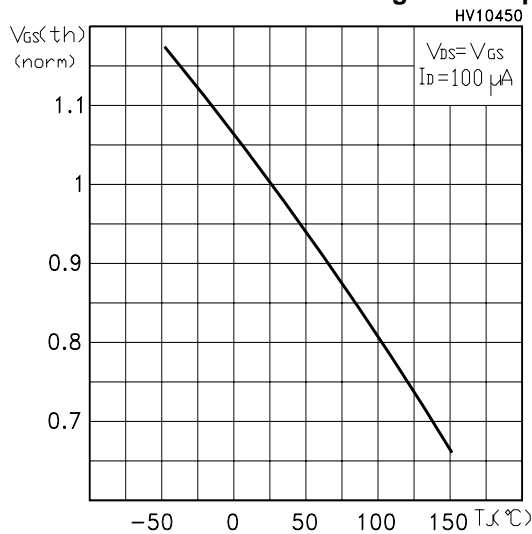
**Gate Charge vs Gate-source Voltage**



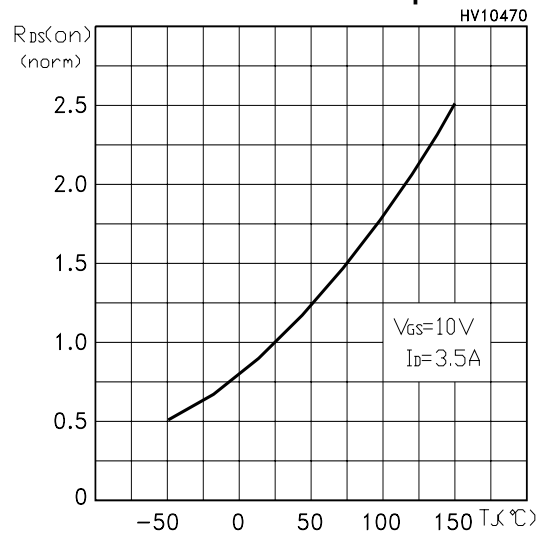
**Capacitance Variations**



**Normalized Gate Threshold Voltage vs Temp.**

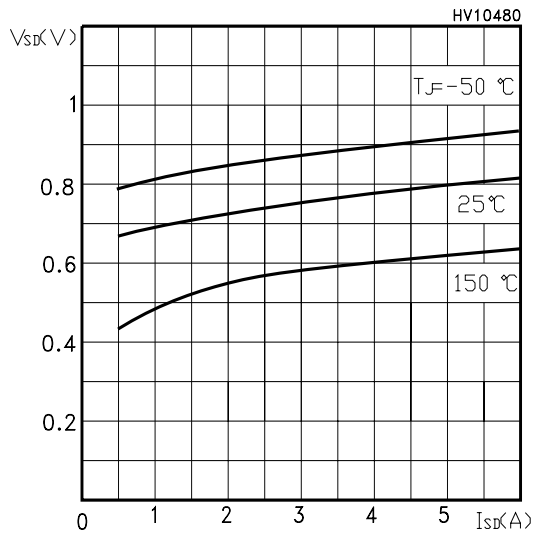


**Normalized On Resistance vs Temperature**

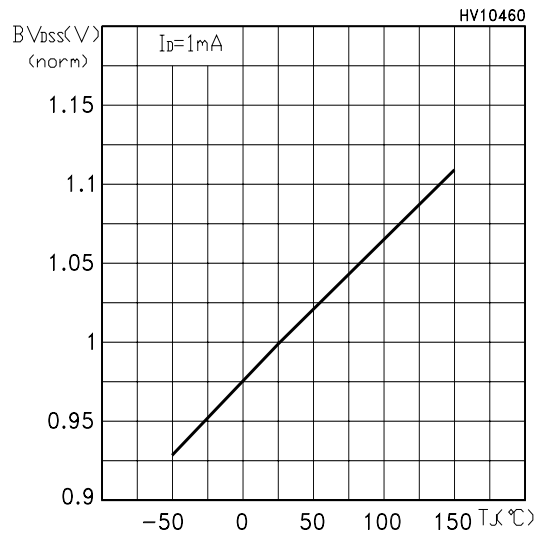


**STP9NK60Z / STP9NK60ZFP / STB9NK60Z / STB9NK60Z-1**

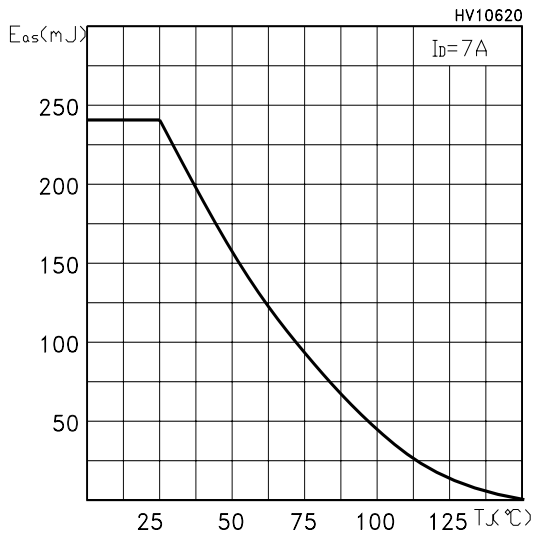
**Source-drain Diode Forward Characteristics**



**Normalized BVDSS vs Temperature**

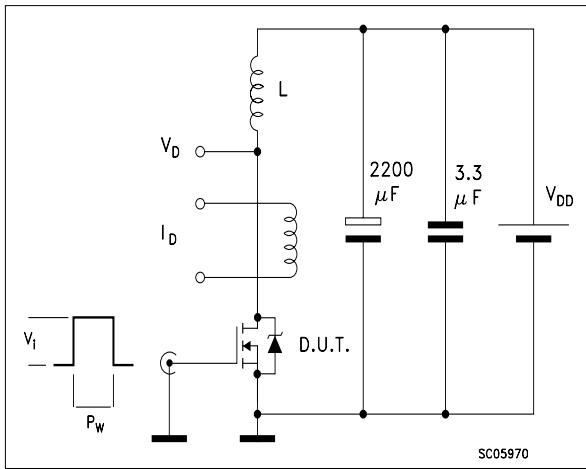


**Maximum Avalanche Energy vs Temperature**

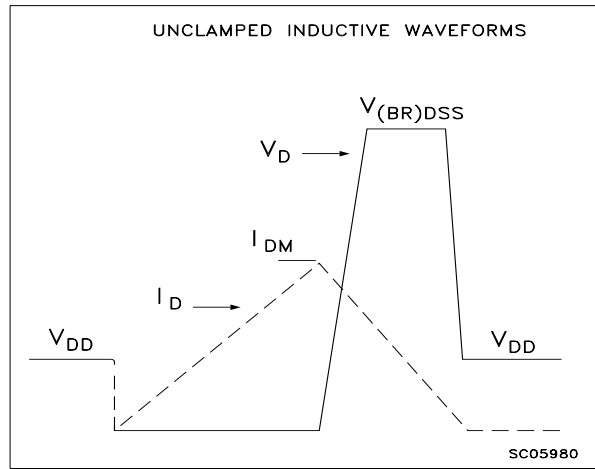


**STP9NK60Z / STP9NK60ZFP / STB9NK60Z / STB9NK60Z-1**

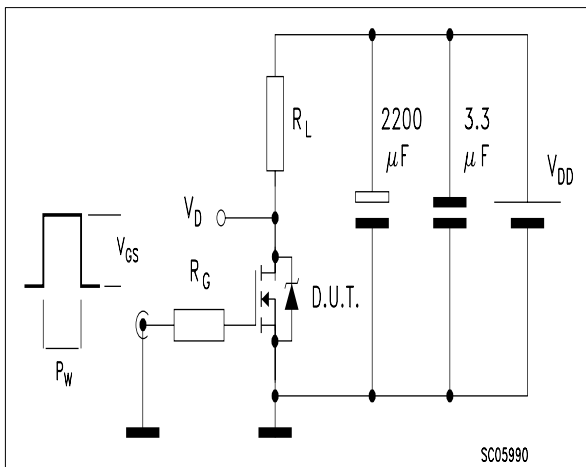
**Fig. 1: Unclamped Inductive Load Test Circuit**



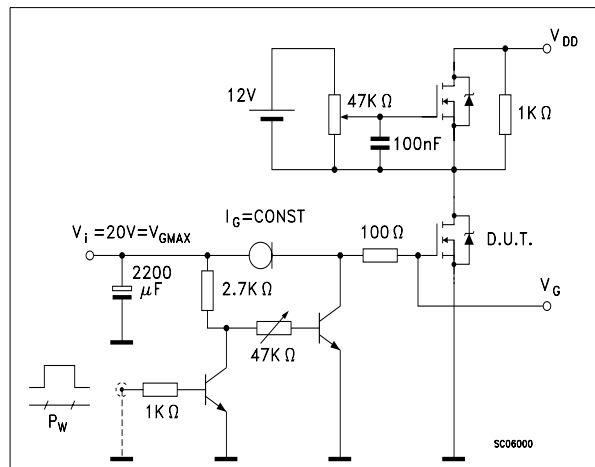
**Fig. 2: Unclamped Inductive Waveform**



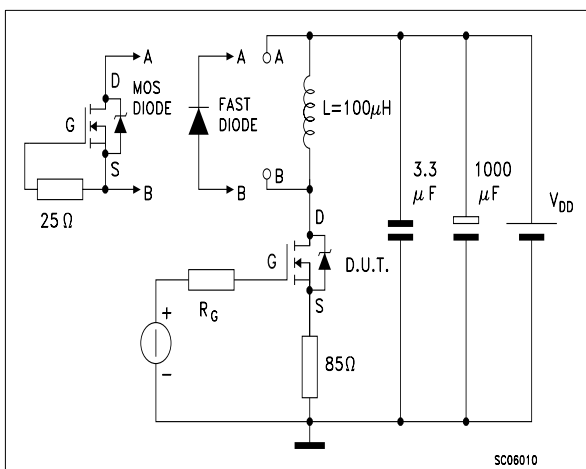
**Fig. 3: Switching Times Test Circuit For Resistive Load**



**Fig. 4: Gate Charge test Circuit**

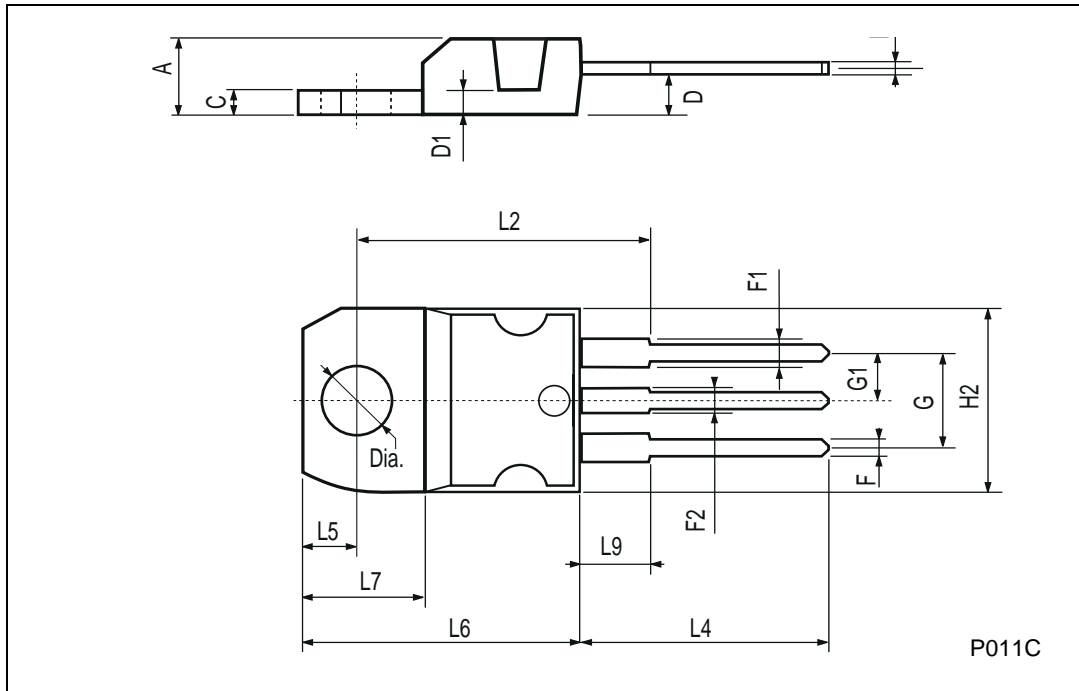


**Fig. 5: Test Circuit For Inductive Load Switching And Diode Recovery Times**



**STP9NK60Z / STP9NK60ZFP / STB9NK60Z / STB9NK60Z-1****TO-220 MECHANICAL DATA**

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	4.40		4.60	0.173		0.181
C	1.23		1.32	0.048		0.051
D	2.40		2.72	0.094		0.107
D1		1.27			0.050	
E	0.49		0.70	0.019		0.027
F	0.61		0.88	0.024		0.034
F1	1.14		1.70	0.044		0.067
F2	1.14		1.70	0.044		0.067
G	4.95		5.15	0.194		0.203
G1	2.4		2.7	0.094		0.106
H2	10.0		10.40	0.393		0.409
L2		16.4			0.645	
L4	13.0		14.0	0.511		0.551
L5	2.65		2.95	0.104		0.116
L6	15.25		15.75	0.600		0.620
L7	6.2		6.6	0.244		0.260
L9	3.5		3.93	0.137		0.154
DIA.	3.75		3.85	0.147		0.151

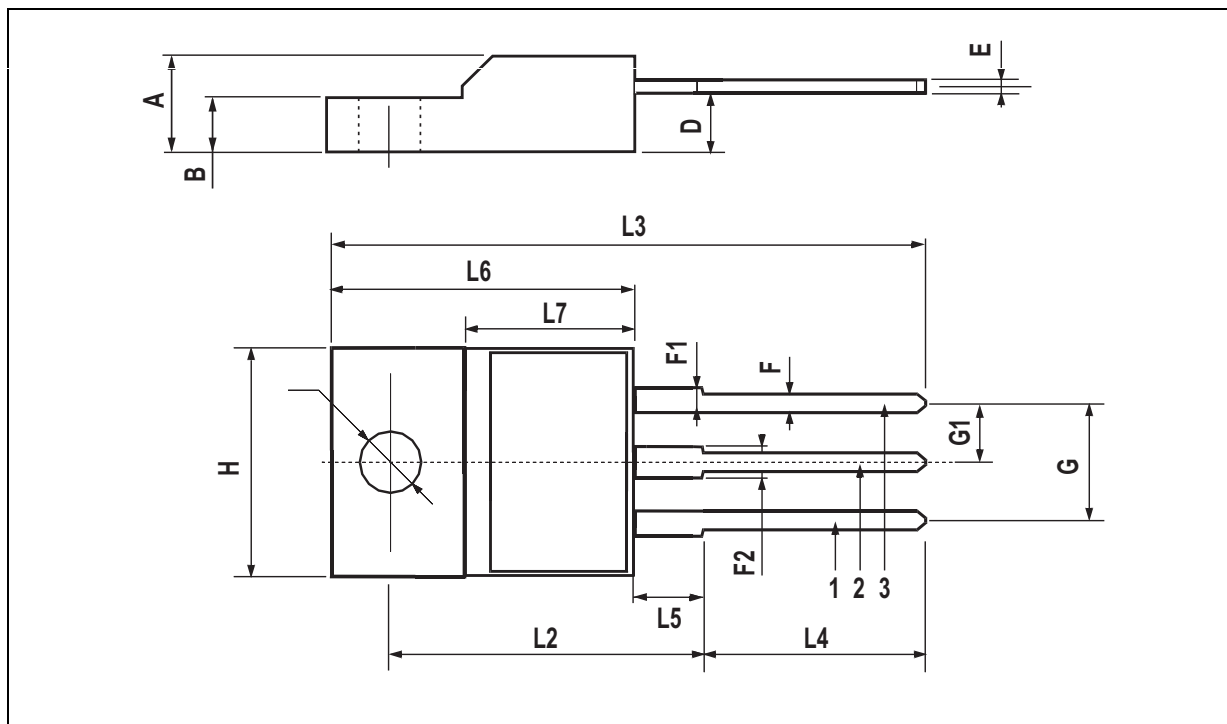




## STP9NK60Z / STP9NK60ZFP / STB9NK60Z / STB9NK60Z-1

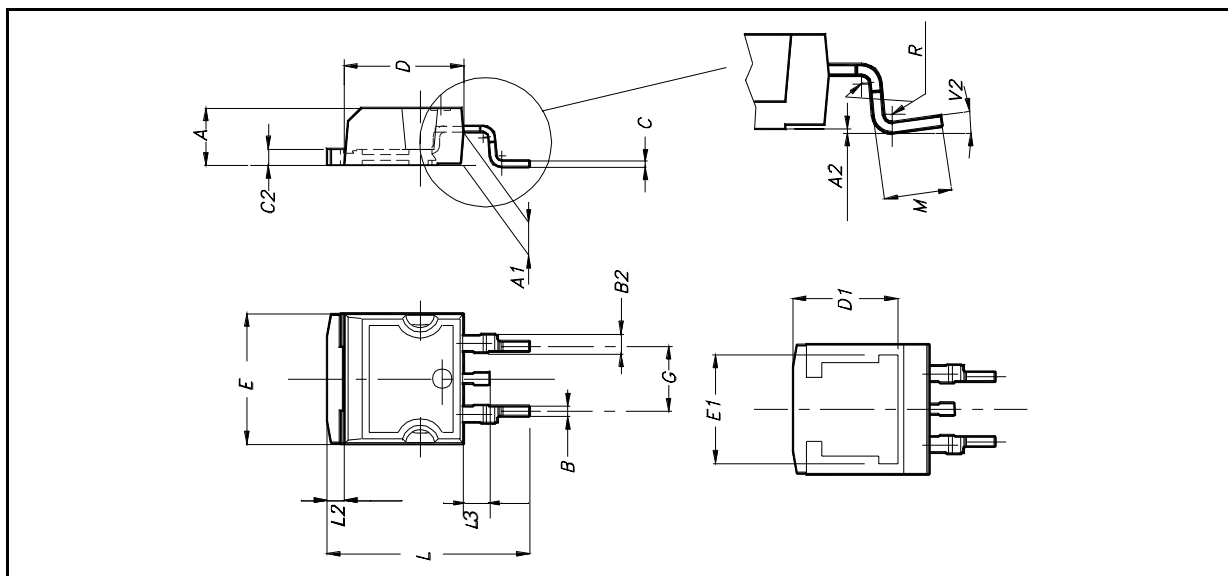
## TO-220FP MECHANICAL DATA

DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A	4.4		4.6	0.173		0.181
B	2.5		2.7	0.098		0.106
D	2.5		2.75	0.098		0.108
E	0.45		0.7	0.017		0.027
F	0.75		1	0.030		0.039
F1	1.15		1.5	0.045		0.067
F2	1.15		1.5	0.045		0.067
G	4.95		5.2	0.195		0.204
G1	2.4		2.7	0.094		0.106
H	10		10.4	0.393		0.409
L2		16			0.630	
L3	28.6		30.6	1.126		1.204
L4	9.8		10.6	.0385		0.417
L5	2.9		3.6	0.114		0.141
L6	15.9		16.4	0.626		0.645
L7	9		9.3	0.354		0.366
∅	3		3.2	0.118		0.126



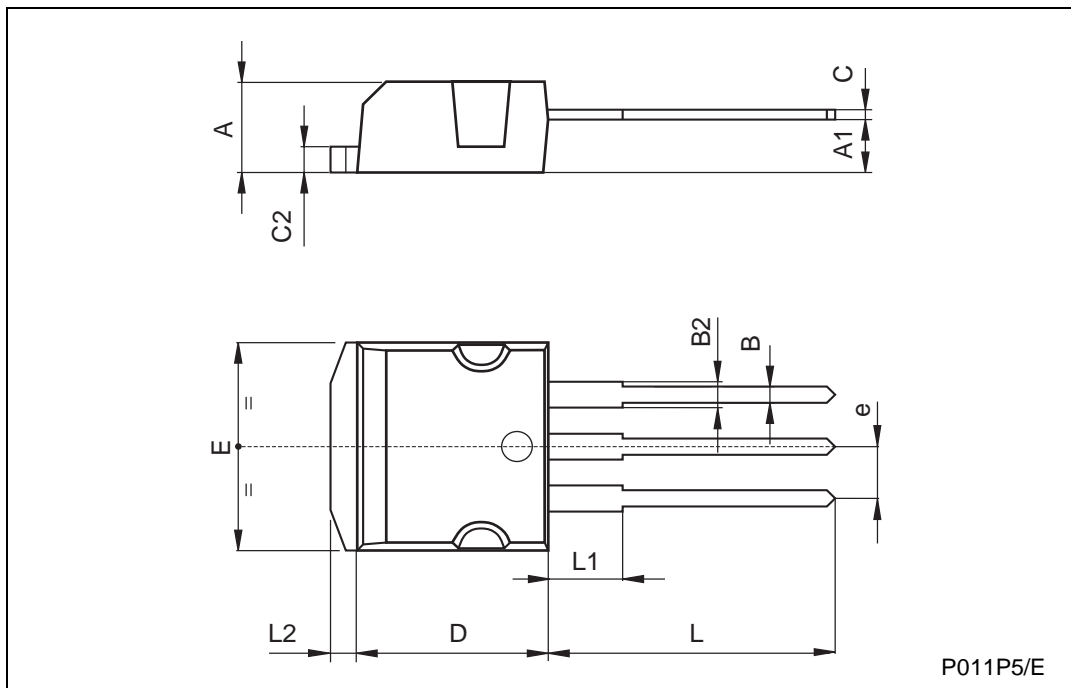
**STP9NK60Z / STP9NK60ZFP / STB9NK60Z / STB9NK60Z-1****D<sup>2</sup>PAK MECHANICAL DATA**

DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A	4.4		4.6	0.173		0.181
A1	2.49		2.69	0.098		0.106
A2	0.03		0.23	0.001		0.009
B	0.7		0.93	0.027		0.036
B2	1.14		1.7	0.044		0.067
C	0.45		0.6	0.017		0.023
C2	1.23		1.36	0.048		0.053
D	8.95		9.35	0.352		0.368
D1		8			0.315	
E	10		10.4	0.393		
E1		8.5			0.334	
G	4.88		5.28	0.192		0.208
L	15		15.85	0.590		0.625
L2	1.27		1.4	0.050		0.055
L3	1.4		1.75	0.055		0.068
M	2.4		3.2	0.094		0.126
R		0.4			0.015	
V2	0°		8°			



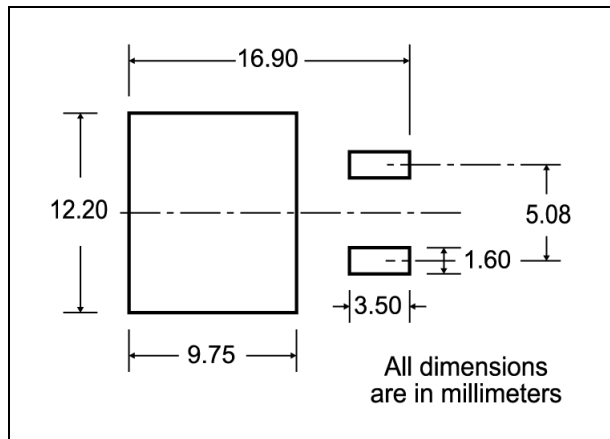
**STP9NK60Z / STP9NK60ZFP / STB9NK60Z / STB9NK60Z-1**
**TO-262 (I<sup>2</sup>PAK) MECHANICAL DATA**

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	4.4		4.6	0.173		0.181
A1	2.49		2.69	0.098		0.106
B	0.7		0.93	0.027		0.036
B2	1.14		1.7	0.044		0.067
C	0.45		0.6	0.017		0.023
C2	1.23		1.36	0.048		0.053
D	8.95		9.35	0.352		0.368
e	2.4		2.7	0.094		0.106
E	10		10.4	0.393		0.409
L	13.1		13.6	0.515		0.531
L1	3.48		3.78	0.137		0.149
L2	1.27		1.4	0.050		0.055

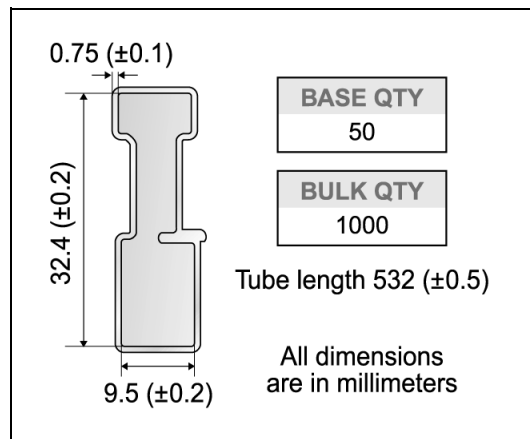


**STP9NK60Z / STP9NK60ZFP / STB9NK60Z / STB9NK60Z-1**

**D<sup>2</sup>PAK FOOTPRINT**



**TUBE SHIPMENT (no suffix)\***



**TAPE AND REEL SHIPMENT (suffix "T4")\***

Diagram showing the tape mechanical data. It includes a circular reel view with dimensions A (reel diameter), B (slot width), C (slot depth), D (slot diameter), and D1 (slot diameter). A note indicates a 40 mm min. access hole at the slot location. Another note indicates a tape slot in the core for tape start with a 2.5 mm min. width. A side view shows dimensions T (tape thickness), C (carrier thickness), N (carrier width), and G (measured at hub).

**REEL MECHANICAL DATA**

DIM.	mm		inch	
	MIN.	MAX.	MIN.	MAX.
A		330		12.992
B	1.5		0.059	
C	12.8	13.2	0.504	0.520
D	20.2		0.795	
G	24.4	26.4	0.960	1.039
N	100		3.937	
T		30.4		1.197

BASE QTY	BULK QTY
1000	1000

**TAPE MECHANICAL DATA**

DIM.	mm		inch	
	MIN.	MAX.	MIN.	MAX.
A0	10.5	10.7	0.413	0.421
B0	15.7	15.9	0.618	0.626
D	1.5	1.6	0.059	0.063
D1	1.59	1.61	0.062	0.063
E	1.65	1.85	0.065	0.073
F	11.4	11.6	0.449	0.456
K0	4.8	5.0	0.189	0.197
P0	3.9	4.1	0.153	0.161
P1	11.9	12.1	0.468	0.476
P2	1.9	2.1	0.075	0.082
R	50		1.574	
T	0.25	0.35	0.0098	0.0137
W	23.7	24.3	0.933	0.956

Diagram showing the tape carrier with dimensions K<sub>0</sub>, D, P<sub>2</sub>, P<sub>0</sub>, E, F, W, B<sub>0</sub>, D<sub>1</sub>, A<sub>0</sub>, P<sub>1</sub>. A note indicates 10 pitches cumulative tolerance on tape +/- 0.2 mm. The center line of the cavity is also shown.

**TRL**

Diagram showing the TRL (Tape Reel Lead) with dimensions A<sub>0</sub>, P<sub>1</sub>, and a note for FEED DIRECTION.

Diagram showing the bending radius R min. and the bending radius.

\* on sales type



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**STP9NK60Z / STP9NK60ZFP / STB9NK60Z / STB9NK60Z-1**

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