



# STP16NK65Z STB16NK65Z-S

N-CHANNEL 650V - 0.38Ω - 13A TO-220 / I<sup>2</sup>SPAK  
Zener - Protected SuperMESH™ MOSFET

Table 1: General Features

TYPE	V <sub>DSS</sub>	R <sub>DS(on)</sub>	I <sub>D</sub>	P <sub>w</sub>
STP16NK65Z	650 V	< 0.50 Ω	13 A	190 W
STB16NK65Z-S	650 V	< 0.50 Ω	13 A	190 W

- TYPICAL R<sub>DS(on)</sub> = 0.38Ω
- EXTREMELY HIGH dv/dt CAPABILITY
- 100% AVALANCHE TESTED
- GATE CHARGE MINIMIZED
- VERY LOW INTRINSIC CAPACITANCES
- VERY GOOD MANUFACTURING REPEATABILITY

## DESCRIPTION

The SuperMESH™ series is obtained through an extreme optimization of ST's well established strippased 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.

## APPLICATIONS

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

Figure 1: Package

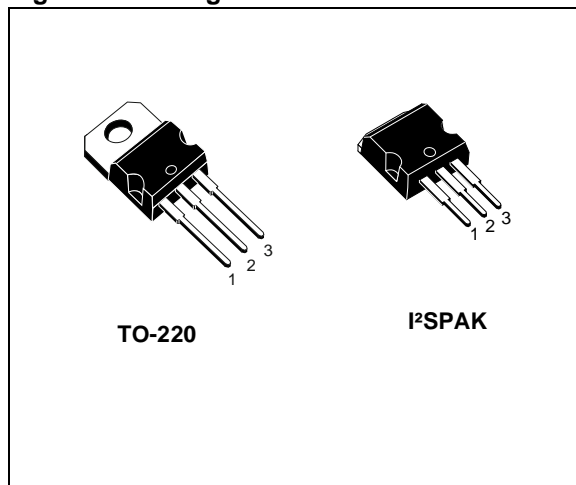


Figure 2: Internal Schematic Diagram

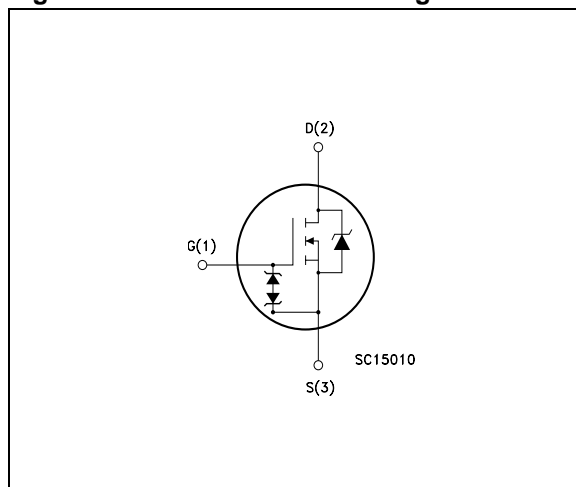


Table 2: Order Codes

SALES TYPE	MARKING	PACKAGE	PACKAGING
STP16NK65Z	P16NK65Z	TO-220	TUBE
STB16NK65Z-S	B16NK65Z	I <sup>2</sup> SPAK	TUBE

**Table 3: Absolute Maximum ratings**

Symbol	Parameter	Value	Unit
$V_{DS}$	Drain-source Voltage ( $V_{GS} = 0$ )	650	V
$V_{DGR}$	Drain-gate Voltage ( $R_{GS} = 20\text{ k}\Omega$ )	650	V
$V_{GS}$	Gate- source Voltage	$\pm 30$	V
$I_D$	Drain Current (continuous) at $T_C = 25^\circ\text{C}$	13	A
$I_D$	Drain Current (continuous) at $T_C = 100^\circ\text{C}$	8.19	A
$I_{DM} (*)$	Drain Current (pulsed)	52	A
$P_{TOT}$	Total Dissipation at $T_C = 25^\circ\text{C}$	190	W
	Derating Factor	1.51	W/°C
$V_{ESD(G-S)}$	Gate source EDS (HBM-C=100pF, R=1.5kΩ)	6000	V
dv/dt (1)	Peak Diode Recovery voltage slope	4.5	V/ns
$T_j$ $T_{stg}$	Operating Junction Temperature Storage Temperature	-55 to 150	°C

(\*) Pulse width limited by safe operating area

(1)  $I_{SD} \leq 13\text{ A}$ ,  $di/dt \leq 200\text{ A}/\mu\text{s}$ ,  $V_{DD} \leq V_{(BR)DSS}$ ,  $T_j \leq T_{JMAX}$

**Table 4: Thermal Data**

Rthj-case	Thermal Resistance Junction-case Max	0.66	°C/W
Rthj-amb	Thermal Resistance Junction-ambient Max	62.5	°C/W
$T_l$	Maximum Lead Temperature For Soldering Purpose	300	°C

**Table 5: Avalanche Characteristics**

Symbol	Parameter	Max. Value	Unit
$I_{AR}$	Avalanche Current, Repetitive or Not-Repetitive (pulse width limited by $T_j$ max)	13	A
$E_{AS}$	Single Pulse Avalanche Energy (starting $T_j = 25^\circ\text{C}$ , $I_D = I_{AR}$ , $V_{DD} = 50\text{ V}$ )	350	mJ

**Table 6: Gate-Source Zener Diode**

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
$BV_{GSO}$	Gate-Source Breakdown Voltage	$I_{gs} = \pm 1\text{ mA}$ (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.

**ELECTRICAL CHARACTERISTICS** ( $T_{CASE} = 25^{\circ}C$  UNLESS OTHERWISE SPECIFIED)**Table 7: On/Off**

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source Breakdown Voltage	$I_D = 1 \text{ mA}, V_{GS} = 0$	650			V
$I_{DSS}$	Zero Gate Voltage Drain Current ( $V_{GS} = 0$ )	$V_{DS} = \text{Max Rating}$ $V_{DS} = \text{Max Rating}, T_C = 125^{\circ}C$			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	$V_{GS} = 10\text{V}, I_D = 6.5 \text{ A}$		0.38	0.50	$\Omega$

**Table 8: Dynamic**

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$g_{fs} (1)$	Forward Transconductance	$V_{DS} = 15 \text{ V}, I_D = 6.5 \text{ A}$		12		S
$C_{iss}$ $C_{oss}$ $C_{rss}$	Input Capacitance Output Capacitance Reverse Transfer Capacitance	$V_{DS} = 25 \text{ V}, f = 1 \text{ MHz}, V_{GS} = 0$		2750 275 60		pF pF pF
$C_{oss \text{ eq.}} (*)$	Equivalent Output Capacitance	$V_{GS} = 0\text{V}, V_{DS} = 6.5 \text{ V to } 520 \text{ V}$		188		pF
$t_{d(on)}$ $t_r$ $t_{d(off)}$ $t_f$	Turn-on Delay Time Rise Time Turn-off Delay Time Fall Time	$V_{DD} = 325 \text{ V}, I_D = 6.5 \text{ A}$ $R_G = 4.7\Omega, V_{GS} = 10 \text{ V}$ (see Figure 17)		25 25 68 17		ns ns ns ns
$Q_g$ $Q_{gs}$ $Q_{gd}$	Total Gate Charge Gate-Source Charge Gate-Drain Charge	$V_{DD} = 520 \text{ V}, I_D = 13 \text{ A},$ $V_{GS} = 10 \text{ V}$ (see Figure 20)		89 18 45		nC nC nC

**Table 9: Source Drain Diode**

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$I_{SD}$ $I_{SDM} (2)$	Source-drain Current Source-drain Current (pulsed)				13 52	A A
$V_{SD} (1)$	Forward On Voltage	$I_{SD} = 13 \text{ A}, V_{GS} = 0$			1.6	V
$t_{rr}$ $Q_{rr}$ $I_{RRM}$	Reverse Recovery Time Reverse Recovery Charge Reverse Recovery Current	$I_{SD} = 13 \text{ A}, di/dt = 100 \text{ A}/\mu\text{s},$ $V_{DD} = 100 \text{ V}, T_j = 25^{\circ}C$ (see Figure 18)		500 5.2 21		ns $\mu\text{C}$ A
$t_{rr}$ $Q_{rr}$ $I_{RRM}$	Reverse Recovery Time Reverse Recovery Charge Reverse Recovery Current	$I_{SD} = 13 \text{ A}, di/dt = 100 \text{ A}/\mu\text{s},$ $V_{DD} = 100 \text{ V}, T_j = 150^{\circ}C$ (see Figure 18)		615 7 22.5		ns $\mu\text{C}$ A

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

(2) Pulse width limited by safe operating area

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

Figure 3: Safe Operating Area

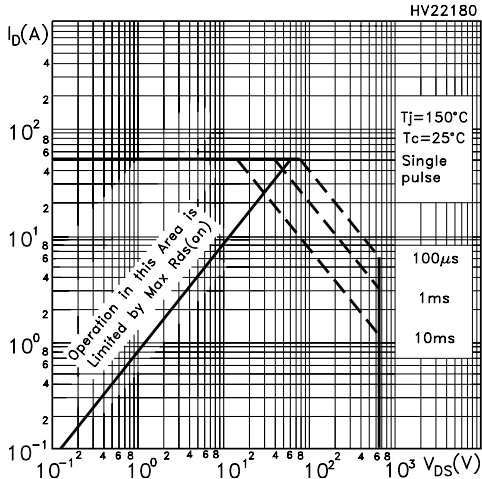


Figure 4: Output Characteristics

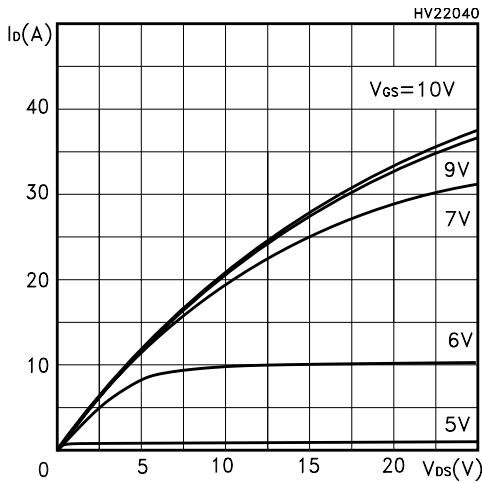


Figure 5: Transconductance

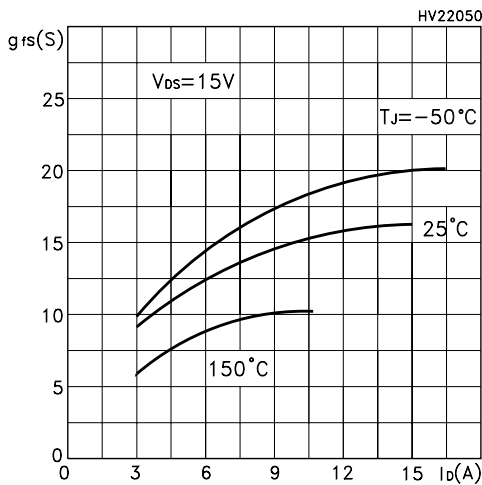


Figure 6: Thermal Impedance

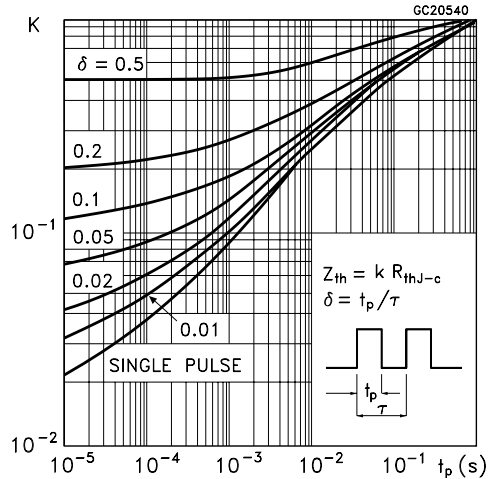


Figure 7: Transfer Characteristics

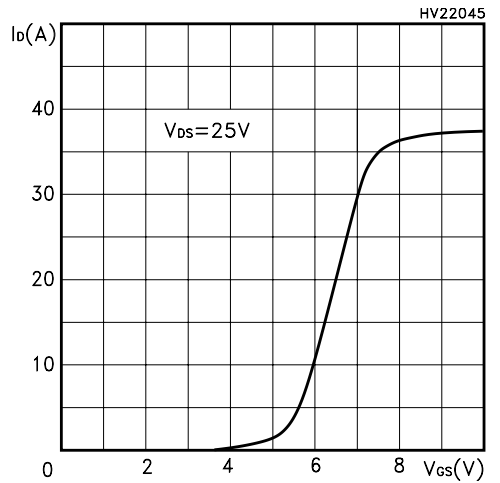


Figure 8: Static Drain-source On Resistance

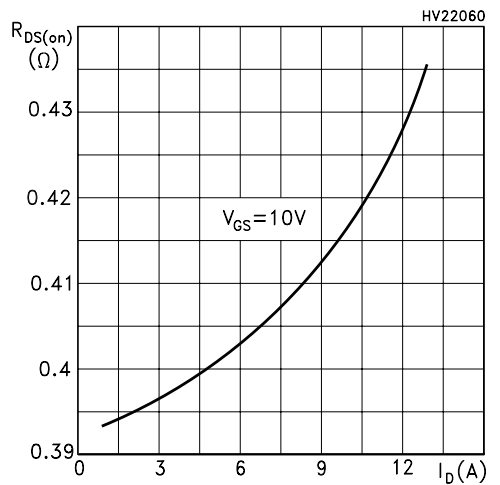


Figure 9: Gate Charge vs Gate-source Voltage

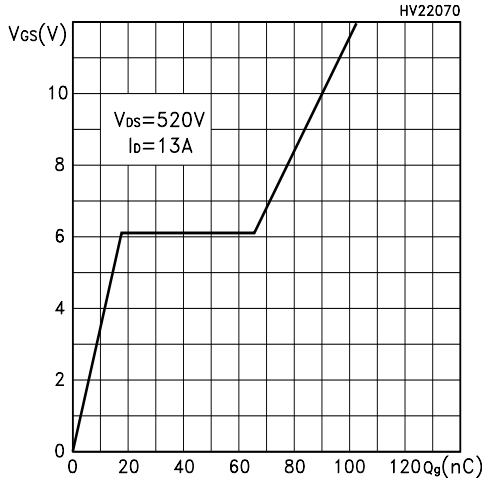


Figure 10: Normalized Gate Threshold Voltage vs Temperature

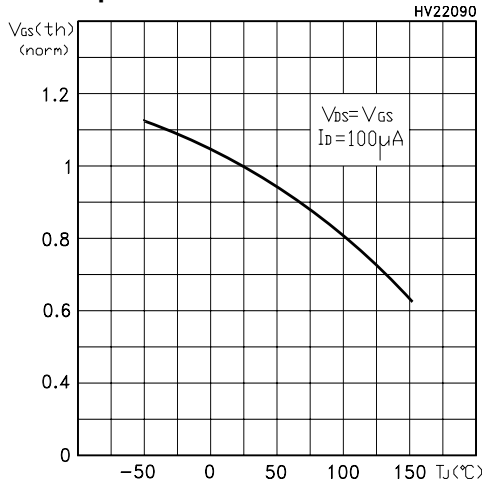


Figure 11: Dource-Drain Diode Forward Characteristics

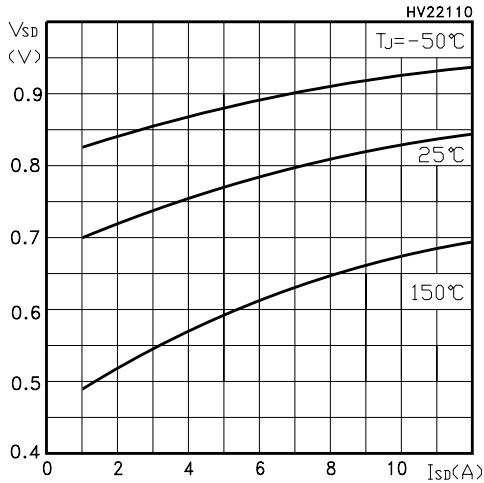


Figure 12: Capacitance Variations

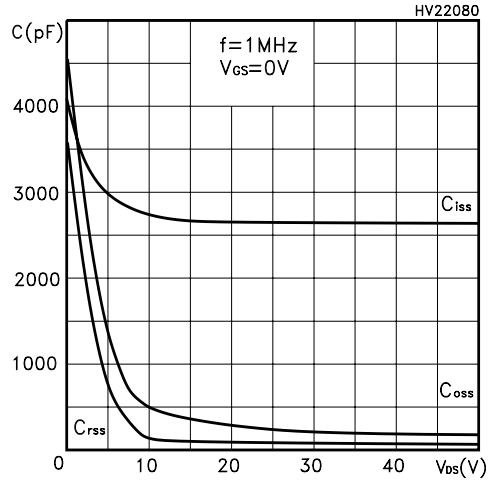


Figure 13: Normalized On Resistance vs Temperature

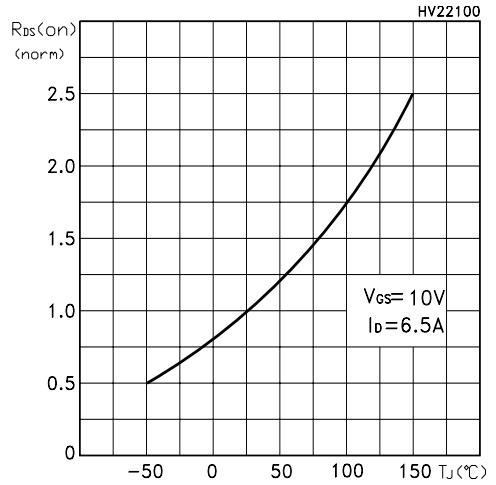


Figure 14: Normalized BVds vs Temperature

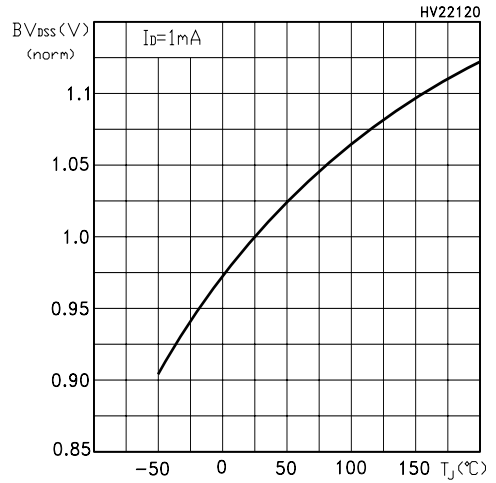


Figure 15: Avalanche Energy vs Starting T<sub>j</sub>

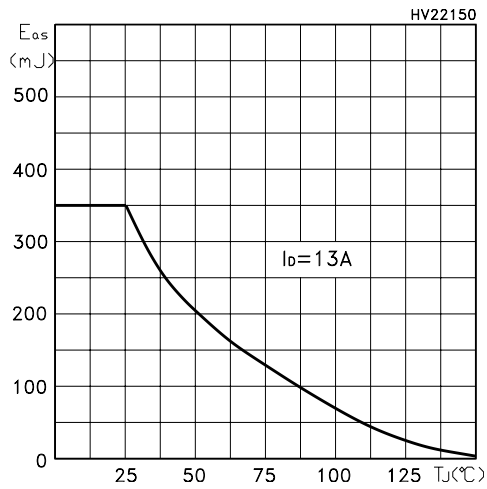


Figure 16: Unclamped Inductive Load Test Circuit

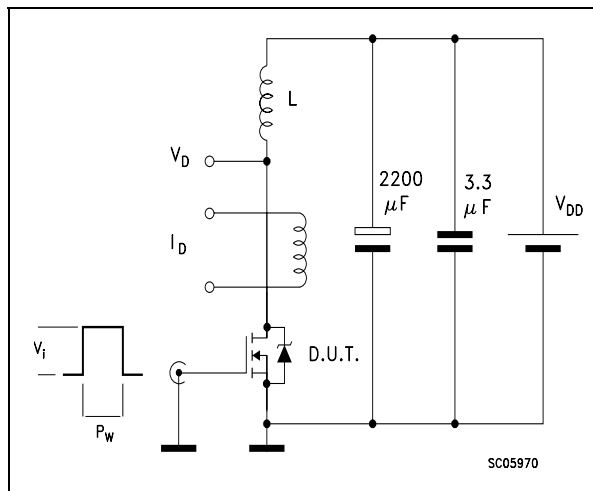


Figure 17: Switching Times Test Circuit For Resistive Load

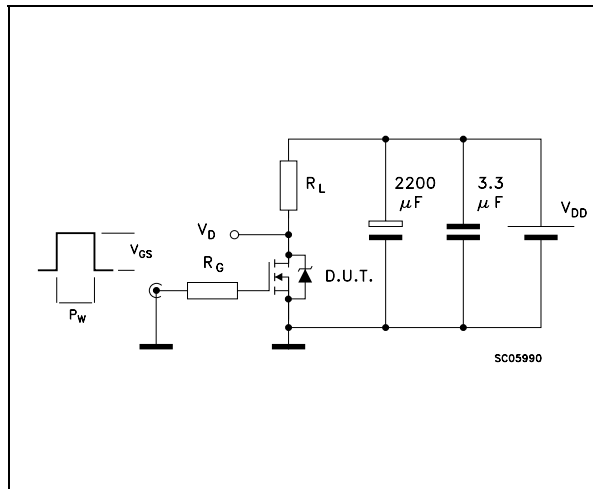


Figure 18: Test Circuit For Inductive Load Switching and Diode Recovery Times

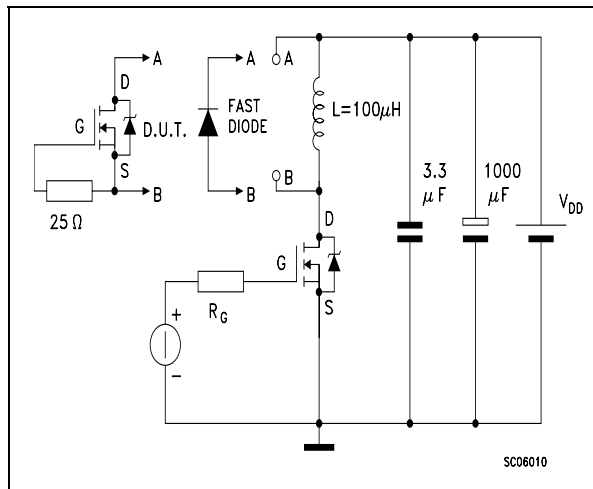


Figure 19: Unclamped Inductive Waferform

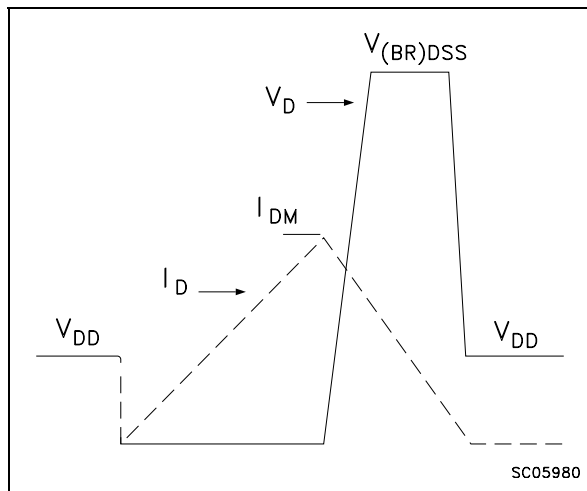
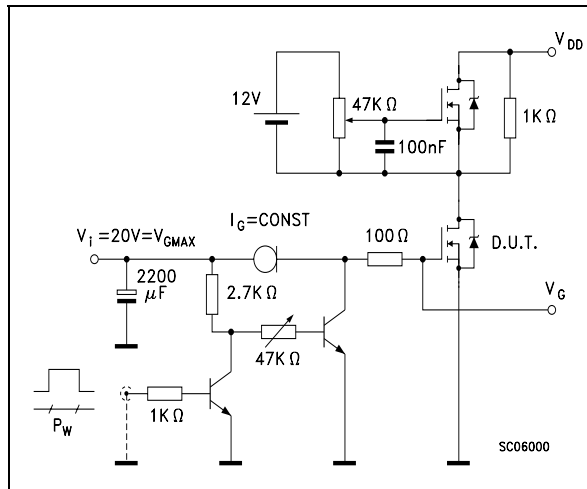
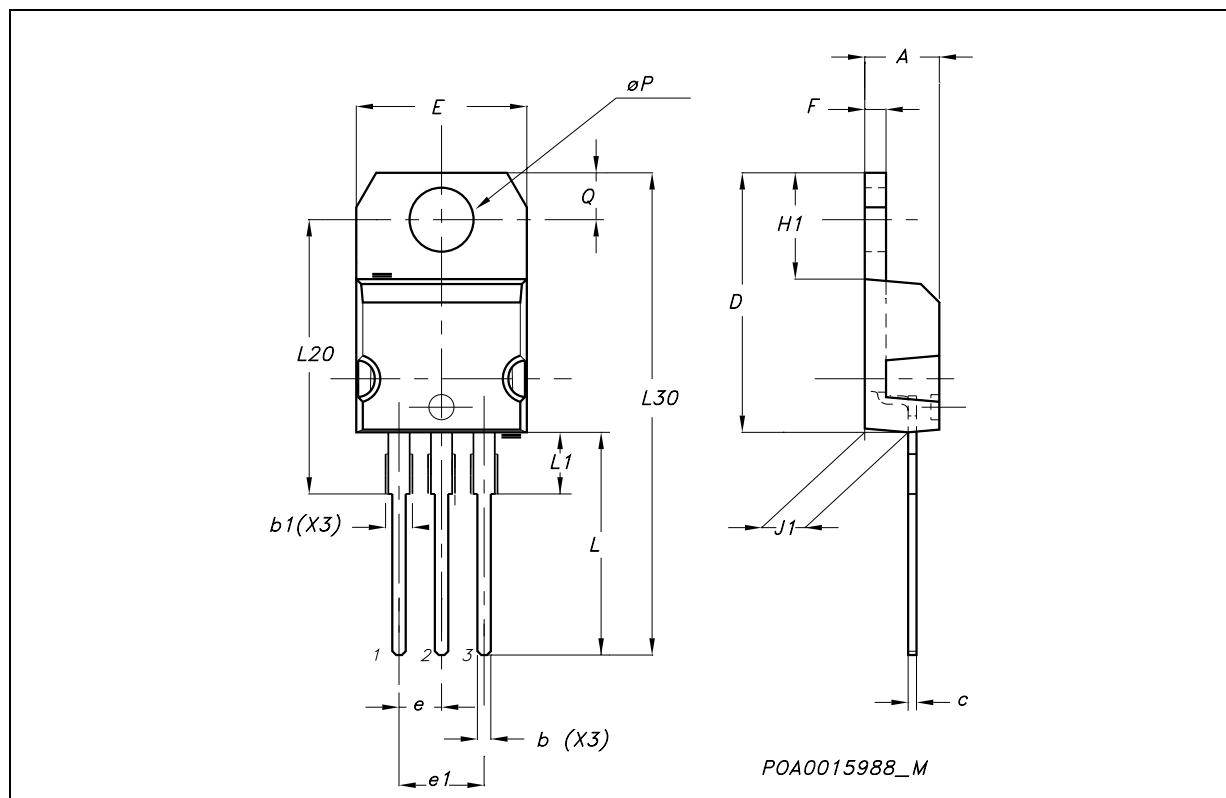


Figure 20: Gate Charge Test Circuit



TO-220 MECHANICAL DATA

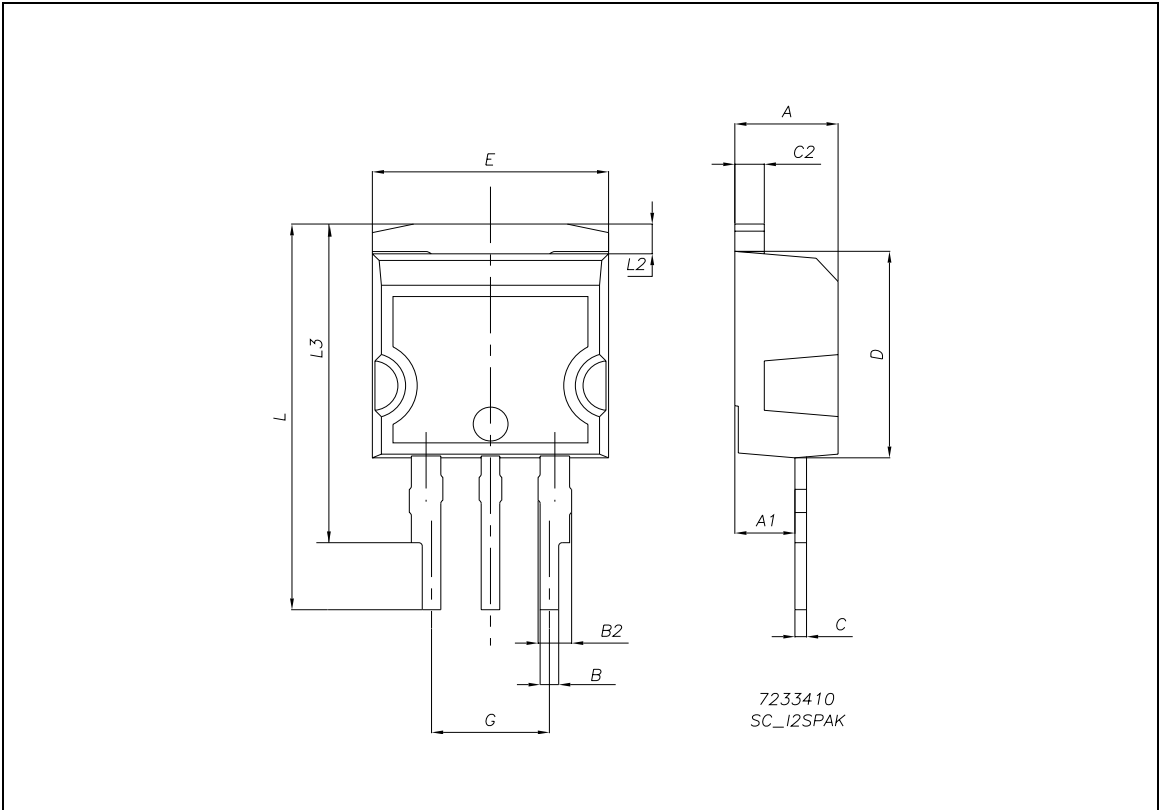
DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A	4.40		4.60	0.173		0.181
b	0.61		0.88	0.024		0.034
b1	1.15		1.70	0.045		0.066
c	0.49		0.70	0.019		0.027
D	15.25		15.75	0.60		0.620
E	10		10.40	0.393		0.409
e	2.40		2.70	0.094		0.106
e1	4.95		5.15	0.194		0.202
F	1.23		1.32	0.048		0.052
H1	6.20		6.60	0.244		0.256
J1	2.40		2.72	0.094		0.107
L	13		14	0.511		0.551
L1	3.50		3.93	0.137		0.154
L20		16.40			0.645	
L30		28.90			1.137	
øP	3.75		3.85	0.147		0.151
Q	2.65		2.95	0.104		0.116





**I<sup>2</sup>SPAK MECHANICAL DATA**

DIM.	mm.			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	4.40		4.60	0.173		0.181
A1	2.49		2.69	0.098		0.106
B	0.70		0.93	0.027		0.037
B2	1.14		1.70	0.045		0.067
C	0.45		0.60	0.018		0.024
C2	1.23		1.36	0.048		0.053
D	8.95		9.35	0.352		0.368
E	10.00		10.40	0.394		0.409
G	4.88		5.28	0.192		0.208
L	16.7		17.5	0.657		0.689
L2	1.27		1.4	0.05		0.055
L3	13.82		14.42	0.544		0.568



**Table 10: Revision History**

<b>Date</b>	<b>Revision</b>	<b>Description of Changes</b>
06-Aug-2004	1	First Release.
02-Sep-2004	2	Complete Version

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