

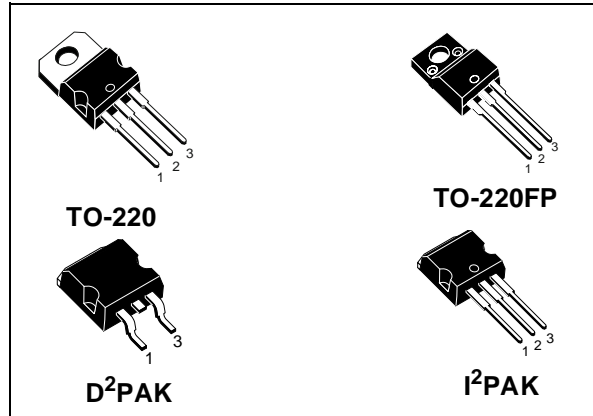


# STP11NM60FD- STB11NM60FD STP11NM60FDFP - STB11NM60FD-1

N-CHANNEL 600V-0.40Ω-11A TO-220/TO-220FP/I<sup>2</sup>PAK/D<sup>2</sup>PAK  
FDmesh™ Power MOSFET (with FAST DIODE)

TYPE	V <sub>DSS</sub>	R <sub>DS(on)</sub>	I <sub>D</sub>
STP11NM60FD	600 V	< 0.45Ω	11 A
STP11NM60FDFP	600 V	< 0.45Ω	11 A
STB11NM60FD	600 V	< 0.45Ω	11 A
STB11NM60FD-1	600 V	< 0.45Ω	11 A

- TYPICAL R<sub>DS(on)</sub> = 0.40Ω
- HIGH dv/dt AND AVALANCHE CAPABILITIES
- 100% AVALANCHE TESTED
- LOW INPUT CAPACITANCE AND GATE CHARGE
- LOW GATE INPUT RESISTANCE
- TIGHT PROCESS CONTROL AND HIGH MANUFACTURING YIELDS



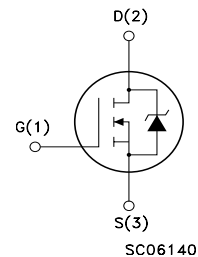
## DESCRIPTION

The FDmesh™ associates all advantages of reduced on-resistance and fast switching with an intrinsic fast-recovery body diode. It is therefore strongly recommended for bridge topologies, in particular ZVS phase-shift converters.

## APPLICATIONS

- ZVS PHASE-SHIFT FULL BRIDGE CONVERTERS FOR SMPS AND WELDING EQUIPMENT

## INTERNAL SCHEMATIC DIAGRAM



## ORDER CODES

PART NUMBER	MARKING	PACKAGE	PACKAGING
STP11NM60FD	P11NM60FD	TO-220	TUBE
STP11NM60FDFP	P11NM60FDFP	TO-220FP	TUBE
STB11NM60FDT4	B11NM60FD	D <sup>2</sup> PAK	TAPE & REEL
STB11NM60FD-1	B11NM60FD	I <sup>2</sup> PAK	TUBE

# STP11NM60FD - STP11NM60FDFP - STB11NM60FD - STB11NM60FD-1

## ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value		Unit
		STP11NM60FD STB11NM60FD STB11NM60FD-1	STP11NM60FDFP	
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	11	11 (*)	A
I <sub>D</sub>	Drain Current (continuous) at T <sub>C</sub> = 100°C	7	7 (*)	A
I <sub>DM</sub> (•)	Drain Current (pulsed)	44	44 (*)	A
P <sub>TOT</sub>	Total Dissipation at T <sub>C</sub> = 25°C	160	35	W
	Derating Factor	0.88	0.28	W/°C
dv/dt (1)	Peak Diode Recovery voltage slope	20		V/ns
V <sub>ISO</sub>	Insulation Withstand Voltage (DC)	--	2500	V
T <sub>stg</sub>	Storage Temperature	-65 to 150		°C
T <sub>j</sub>	Max. Operating Junction Temperature			

(•)Pulse width limited by safe operating area

(1)I<sub>SD</sub><11A, di/dt<400A/μs, 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/l <sup>2</sup> PAK D <sup>2</sup> PAK	TO-220FP	
R <sub>thj-case</sub>	Thermal Resistance Junction-case	Max	0.78	3.57	°C/W
R <sub>thj-amb</sub>	Thermal Resistance Junction-ambient	Max	62.5		°C/W
T <sub>I</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)	5.5	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> = 35 V)	350	mJ

## ELECTRICAL CHARACTERISTICS (T<sub>CASE</sub> = 25 °C UNLESS OTHERWISE SPECIFIED) ON/OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V <sub>(BR)DSS</sub>	Drain-source Breakdown Voltage	I <sub>D</sub> = 250 μA, V <sub>GS</sub> = 0	600			V
I <sub>DSS</sub>	Zero Gate Voltage Drain Current (V <sub>GS</sub> = 0)	V <sub>DS</sub> = Max Rating			1	μA
		V <sub>DS</sub> = Max Rating, T <sub>C</sub> = 125 °C			100	μA
I <sub>GSS</sub>	Gate-body Leakage Current (V <sub>DS</sub> = 0)	V <sub>GS</sub> = ±30V			±100	nA
V <sub>GS(th)</sub>	Gate Threshold Voltage	V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250 μA	3	4	5	V
R <sub>DS(on)</sub>	Static Drain-source On Resistance	V <sub>GS</sub> = 10V, I <sub>D</sub> = 5.5 A		0.40	0.45	Ω

## STP11NM60FD - STP11NM60FDFP - STB11NM60FD - STB11NM60FD-1

### DYNAMIC

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$g_{fs}$ (1)	Forward Transconductance	$V_{DS} > I_{D(on)} \times R_{DS(on)max}$ , $I_D = 5.5A$		5.2		S
$C_{iss}$	Input Capacitance	$V_{DS} = 25V$ , $f = 1$ MHz, $V_{GS} = 0$		1000		pF
$C_{oss}$	Output Capacitance			208		pF
$C_{rss}$	Reverse Transfer Capacitance			28		pF
$C_{oss\ eq.}$ (2)	Equivalent Output Capacitance	$V_{GS} = 0V$ , $V_{DS} = 0V$ to 400V		100		pF
$R_G$	Gate Input Resistance	$f=1$ MHz Gate DC Bias = 0 Test Signal Level = 20mV Open Drain		3		$\Omega$

Note: 1. Pulsed: Pulse duration = 300  $\mu$ s, 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%  $V_{DSS}$ .

### SWITCHING ON

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on Delay Time	$V_{DD} = 250V$ , $I_D = 5.5A$ $R_G = 4.7\Omega$ , $V_{GS} = 10V$ (see test circuit, Figure 3)		20		ns
$t_r$	Rise Time				16	
$Q_g$	Total Gate Charge	$V_{DD} = 400V$ , $I_D = 11A$ , $V_{GS} = 10V$		28	40	nC
$Q_{gs}$	Gate-Source Charge			7.8		nC
$Q_{gd}$	Gate-Drain Charge			13		nC

### SWITCHING OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit	
$t_{r(Voff)}$	Off-voltage Rise Time	$V_{DD} = 400V$ , $I_D = 11A$ , $R_G = 4.7\Omega$ , $V_{GS} = 10V$ (see test circuit, Figure 5)		10		ns	
$t_f$	Fall Time				15		ns
$t_c$	Cross-over Time				24		ns

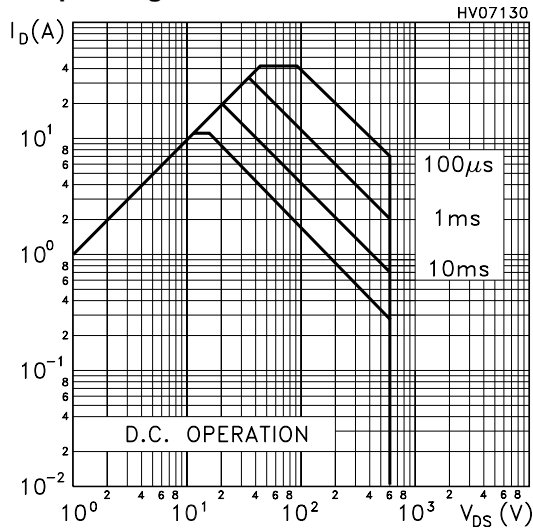
### SOURCE DRAIN DIODE

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit	
$I_{SD}$	Source-drain Current				11	A	
$I_{SDM}$ (2)	Source-drain Current (pulsed)				44	A	
$V_{SD}$ (1)	Forward On Voltage	$I_{SD} = 11A$ , $V_{GS} = 0$			1.5	V	
$t_{rr}$	Reverse Recovery Time	$I_{SD} = 11A$ , $di/dt = 100A/\mu$ s, $V_{DD} = 50V$ (see test circuit, Figure 5)		190		ns	
$Q_{rr}$	Reverse Recovery Charge				1.1		$\mu$ C
$I_{RRM}$	Reverse Recovery Current				14.5		A

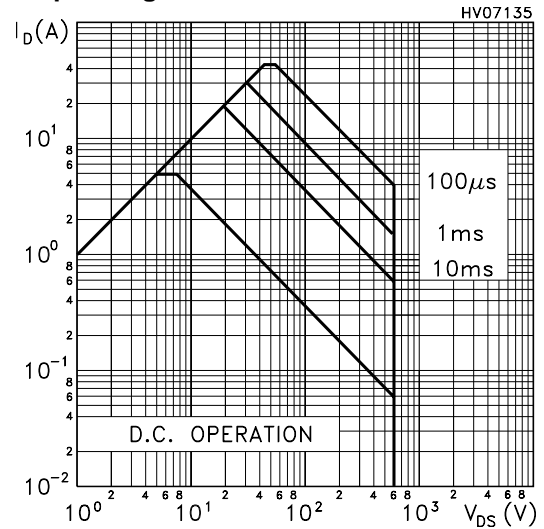
Note: 1. Pulsed: Pulse duration = 300  $\mu$ s, duty cycle 1.5 %.

2. Pulse width limited by safe operating area.

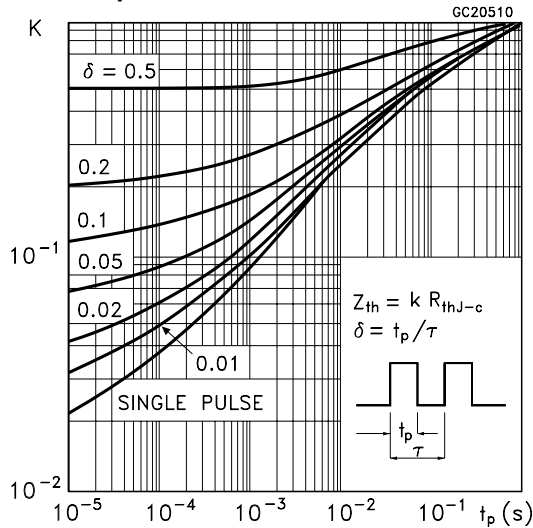
Safe Operating for TO-220/I<sup>2</sup>PAK/D<sup>2</sup>PAK



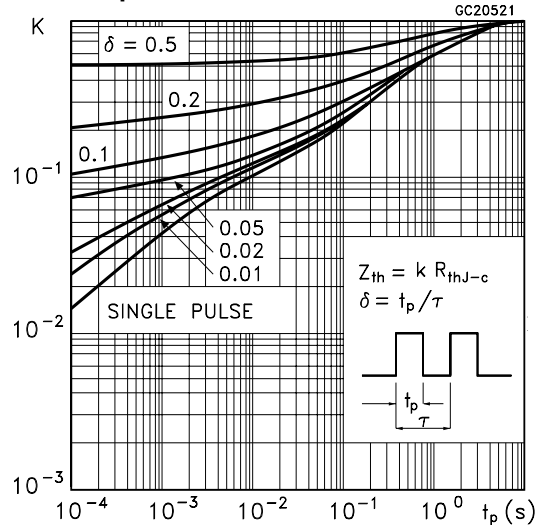
Safe Operating Area for TO-220FP



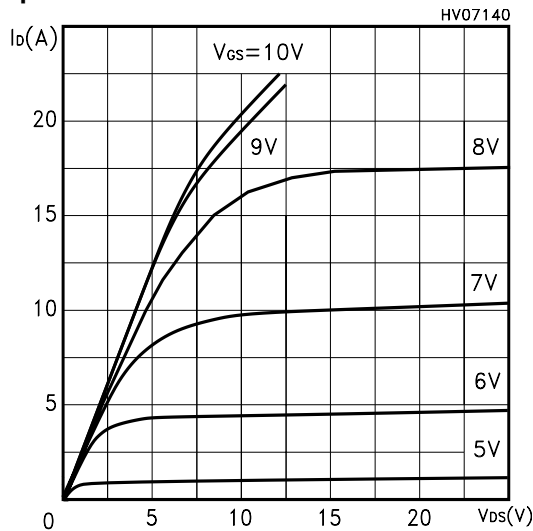
Thermal Impedance for TO-220/I<sup>2</sup>PAK



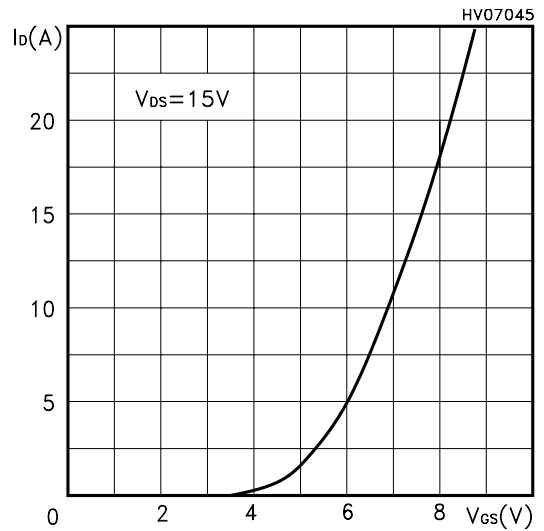
Thermal Impedance for TO-220FP



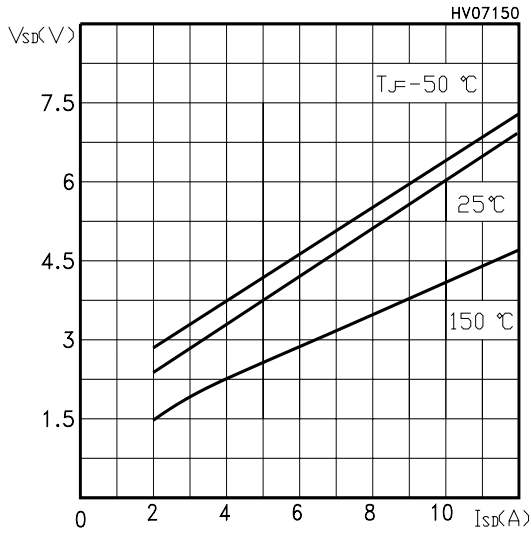
Output Characteristics



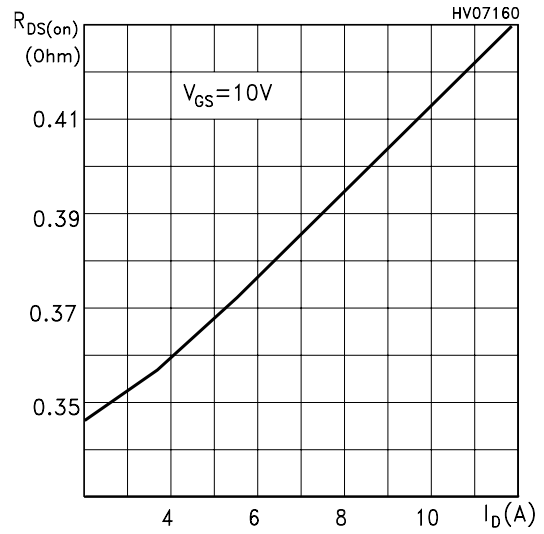
Transfer Characteristics



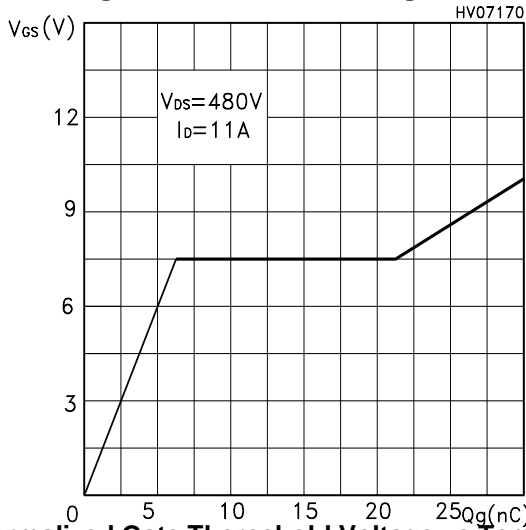
**Transconductance**



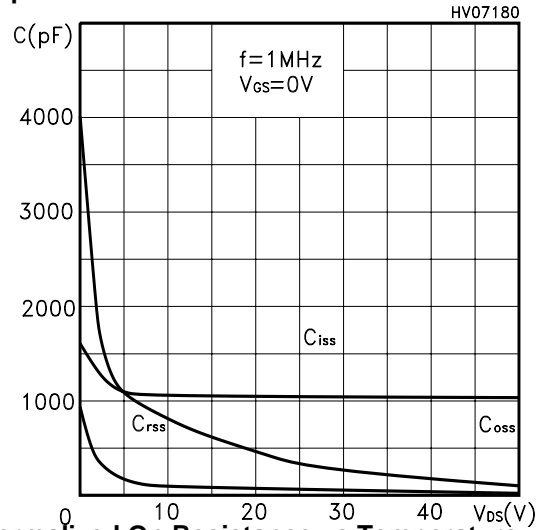
**Static Drain-source On Resistance**



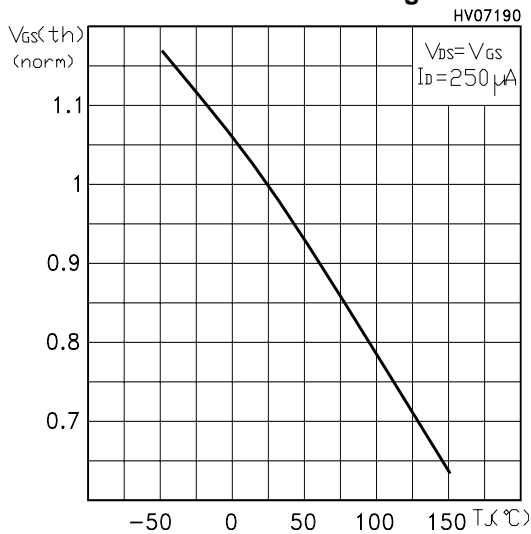
**Gate Charge vs Gate-source Voltage**



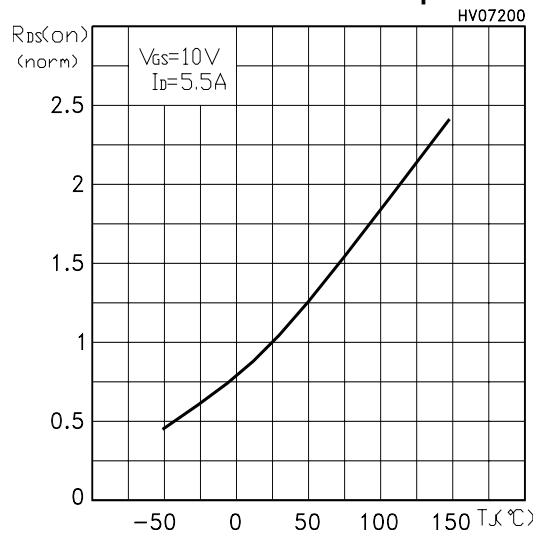
**Capacitance Variations**



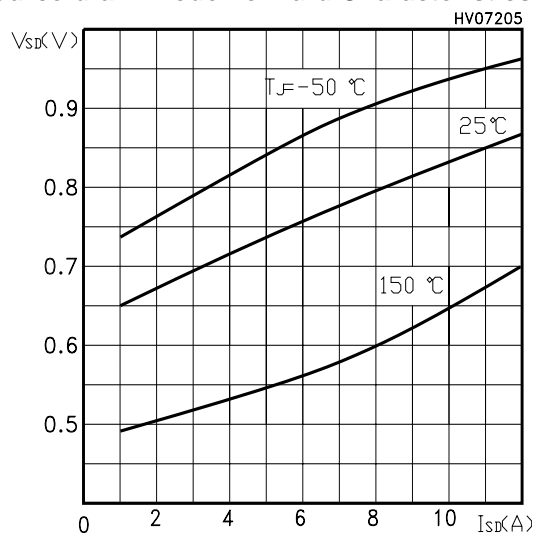
**Normalized Gate Threshold Voltage vs Temp.**



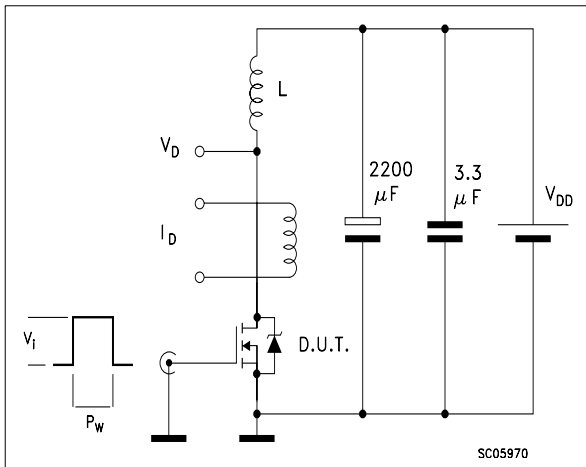
**Normalized On Resistance vs Temperature**



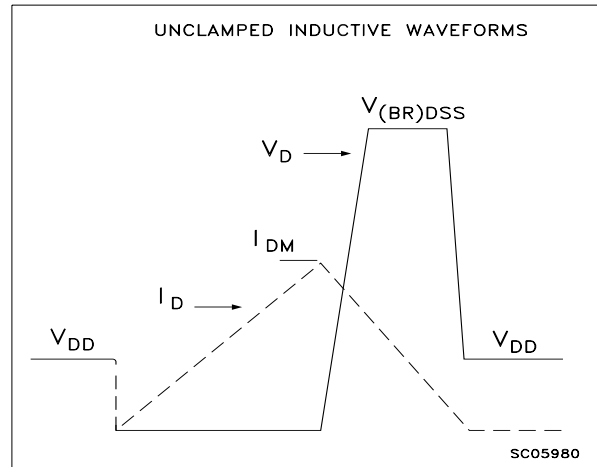
Source-drain Diode Forward Characteristics



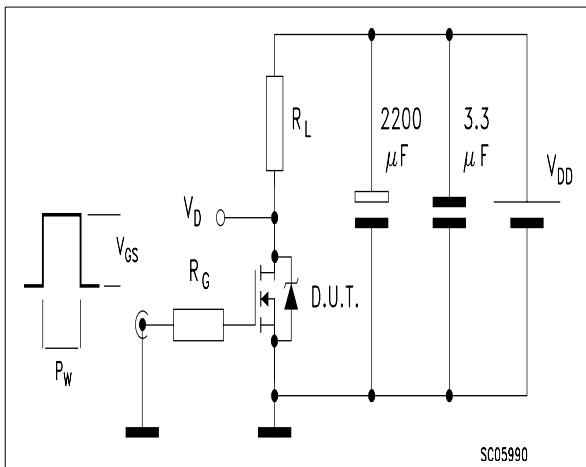
**Fig. 1: Unclamped Inductive Load Test Circuit**



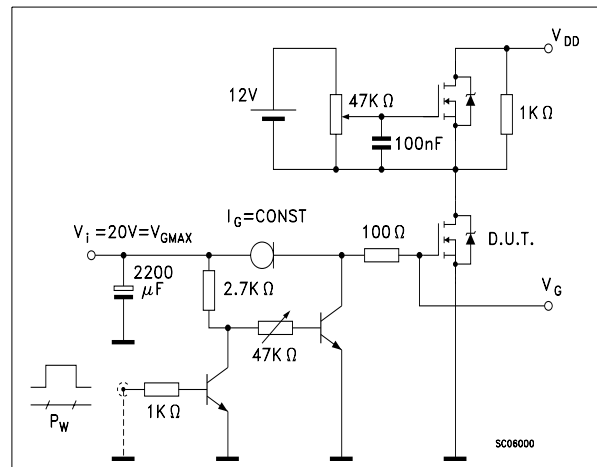
**Fig. 2: Unclamped Inductive Waveform**



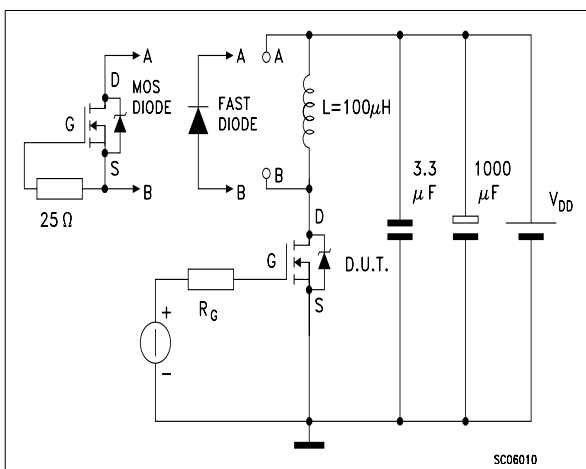
**Fig. 3: Switching Times Test Circuit For Resistive Load**



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

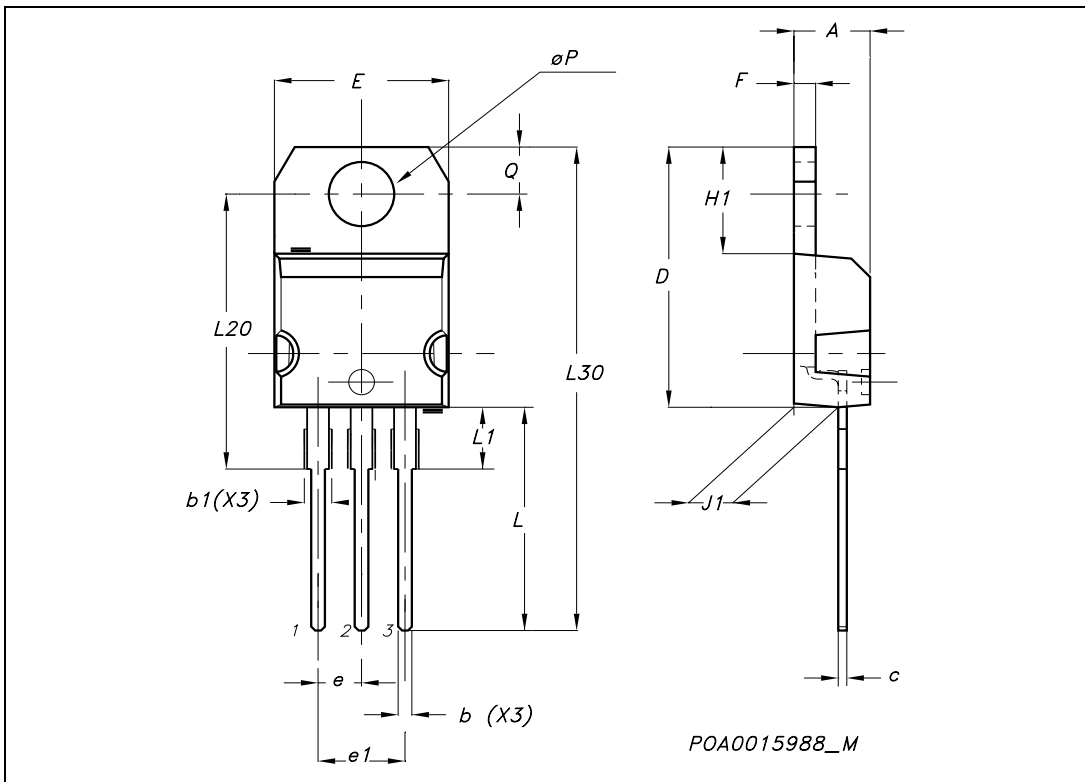


**Fig. 5: Test Circuit For Inductive Load Switching And Diode Recovery Times**



**TO-220 MECHANICAL DATA**

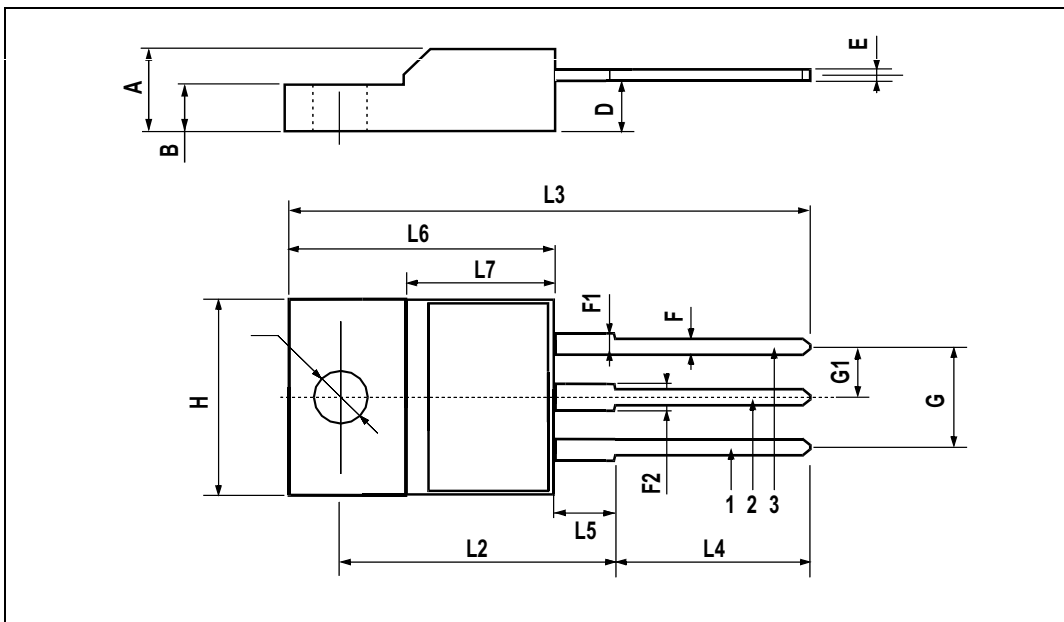
DIM.	mm.			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	4.40		4.60	0.173		0.181
b	0.61		0.88	0.024		0.034
b1	1.15		1.70	0.045		0.066
c	0.49		0.70	0.019		0.027
D	15.25		15.75	0.60		0.620
E	10		10.40	0.393		0.409
e	2.40		2.70	0.094		0.106
e1	4.95		5.15	0.194		0.202
F	1.23		1.32	0.048		0.052
H1	6.20		6.60	0.244		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





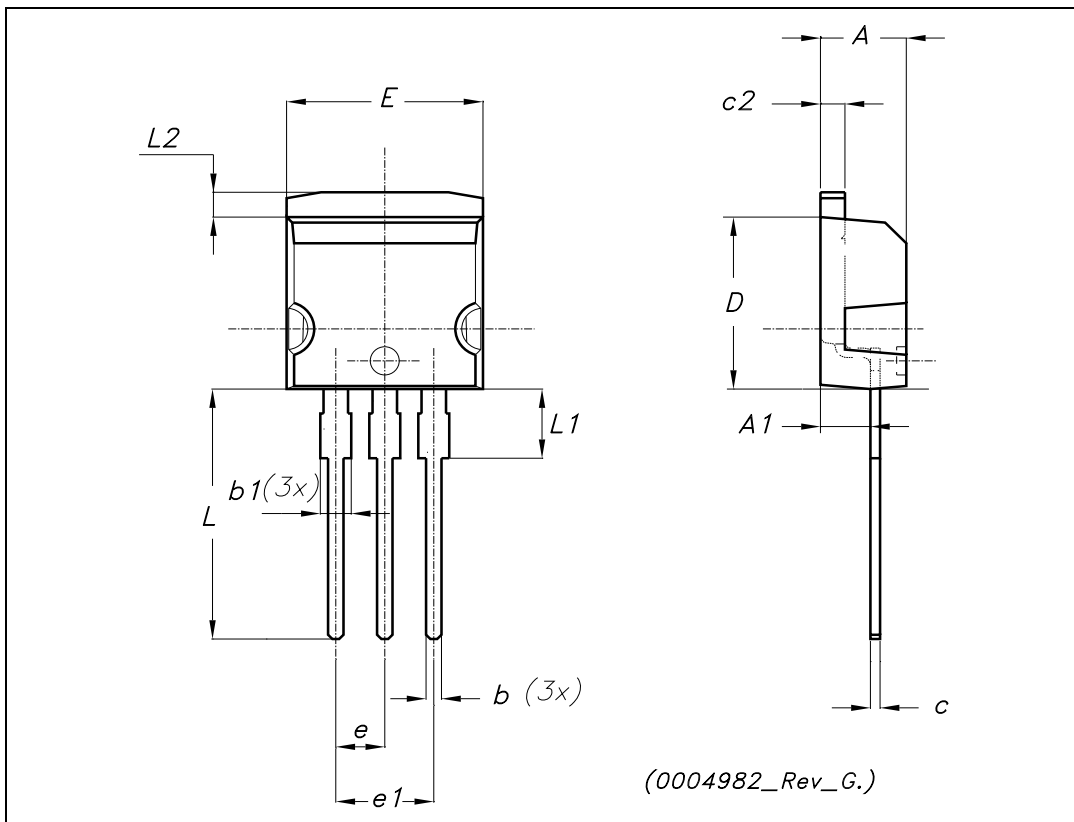
**TO-220FP MECHANICAL DATA**

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		1.7	0.045		0.067
F2	1.15		1.7	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



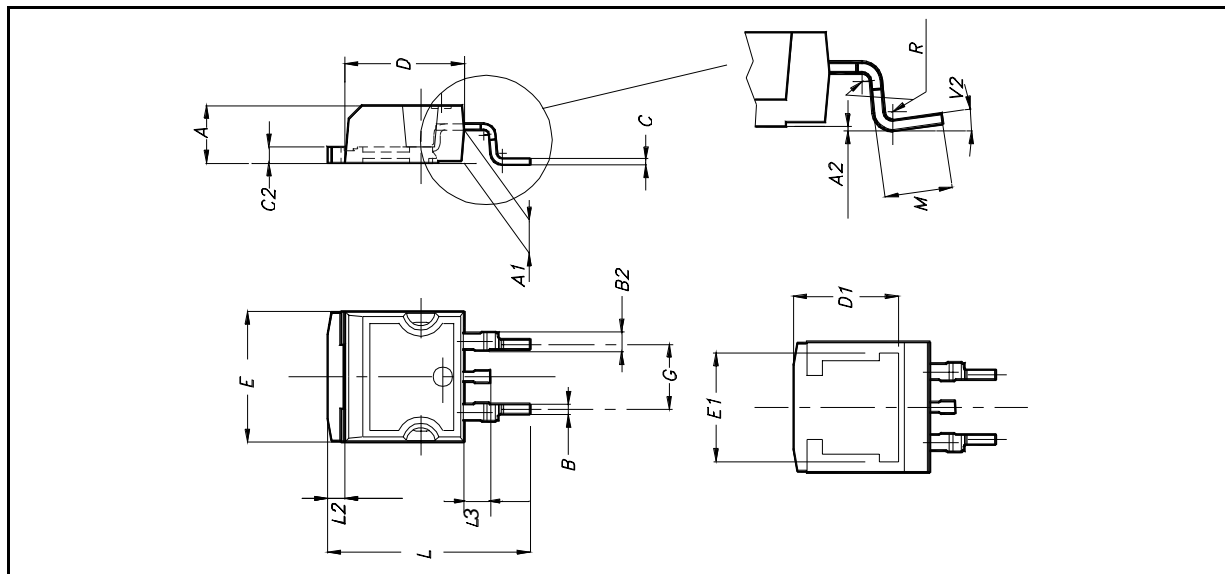
**TO-262 (I<sup>2</sup>PAK) MECHANICAL DATA**

DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A	4.40		4.60	0.173		0.181
A1	2.40		2.72	0.094		0.107
b	0.61		0.88	0.024		0.034
b1	1.14		1.70	0.044		0.066
c	0.49		0.70	0.019		0.027
c2	1.23		1.32	0.048		0.052
D	8.95		9.35	0.352		0.368
e	2.40		2.70	0.094		0.106
e1	4.95		5.15	0.194		0.202
E	10		10.40	0.393		0.410
L	13		14	0.511		0.551
L1	3.50		3.93	0.137		0.154
L2	1.27		1.40	0.050		0.055

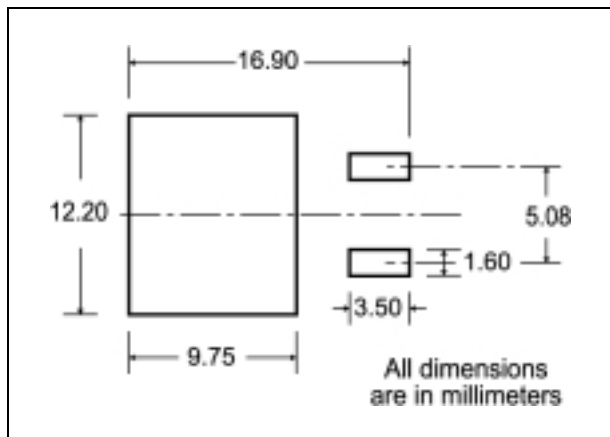


**D<sup>2</sup>PAK MECHANICAL DATA**

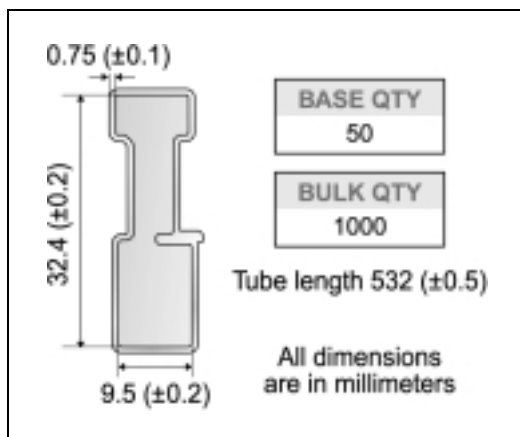
DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A	4.4		4.6	0.173		0.181
A1	2.49		2.69	0.098		0.106
A2	0.03		0.23	0.001		0.009
B	0.7		0.93	0.027		0.036
B2	1.14		1.7	0.044		0.067
C	0.45		0.6	0.017		0.023
C2	1.23		1.36	0.048		0.053
D	8.95		9.35	0.352		0.368
D1		8			0.315	
E	10		10.4	0.393		
E1		8.5			0.334	
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°		4°			



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



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



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

40 mm min. Access hole at slot location  
Full radius  
Tape slot in core for tape start 2.5mm min. width  
G measured at hub

**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

**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

10 pitches cumulative tolerance on tape +/- 0.2 mm  
TOP COVER TAPE  
User Direction of Feed  
FEED DIRECTION  
Bending radius R min.

\* on sales type



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