



September, 2013

## SJ-FET

# TSP10N60S/TSF10N60S /TSB10N60S 600V N-Channel MOSFET

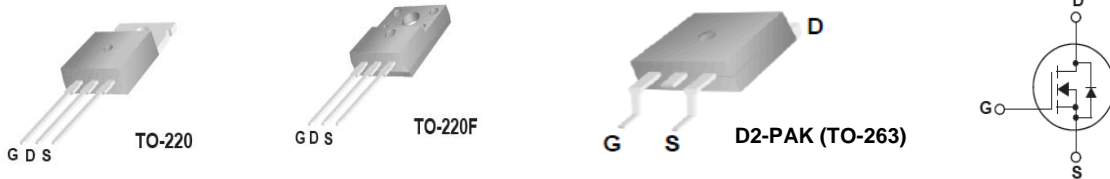
### Description

SJ-FET is new generation of high voltage MOSFET family that is utilizing an advanced charge balance mechanism for outstanding low on-resistance and lower gate charge performance.

This advanced technology has been tailored to minimize conduction loss, provide superior switching performance, and withstand extreme dv/dt rate and higher avalanche energy. SJ-FET is suitable for various AC/DC power conversion in switching mode operation for higher efficiency.

### Features

- 650V @T<sub>J</sub> = 150 °C
- Typ. RDS(on) = 0.42 Ω
- Ultra Low Gate Charge (typ. Q<sub>g</sub> = 35nC)
- 100% avalanche tested
- Rohs Compliant



### Absolute Maximum Ratings

Symbol	Parameter	TSB10N60S	TSP10N60S	TSF10N60S	Unit
V <sub>DSS</sub>	Drain-Source Voltage	600			V
I <sub>D</sub>	Drain Current -Continuous (TC = 25°C) -Continuous (TC = 100°C)	9.5* 8*	9.5 8	9.5* 8*	A
I <sub>DM</sub>	Drain Current - Pulsed (Note 1)	40*	40	40*	A
V <sub>GSS</sub>	Gate-Source voltage	±30			V
E <sub>AS</sub>	Single Pulsed Avalanche Energy (Note 2)	120			mJ
I <sub>AR</sub>	Avalanche Current (Note 1)	2			A
E <sub>AR</sub>	Repetitive Avalanche Energy (Note 1)	60			mJ
dv/dt	Peak Diode Recovery dv/dt (Note 3)	4.5			V/ns
P <sub>D</sub>	Power Dissipation (TC = 25°C) -Derate above 25°C	83 1.5	83 1.67	35 0.3	W W/°C
T <sub>J</sub> , T <sub>STG</sub>	Operating and Storage Temperature Range	-55 to +150			°C
T <sub>L</sub>	Maximum Lead Temperature for Soldering Purpose, 1/8" from Case for 5 Seconds	300			°C

\* Drain current limited by maximum junction temperature.

### Thermal Characteristics

Symbol	Parameter	TSB10N60S	TSP10N60S	TSF10N60S	Unit
R <sub>θJC</sub>	Thermal Resistance, Junction-to-Case	1.5	0.6	3.6	°C/W
R <sub>θCS</sub>	Thermal Resistance, Case-to-Sink Typ.	0.5	--	--	°C/W
R <sub>θJA</sub>	Thermal Resistance, Junction-to-Ambient	75	62	62	°C/W

TSP10N60S / TSF10N60S/TSB10N60S 600V N-Channel MOSFET

## Electrical Characteristics TC = 25°C unless otherwise noted

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>Off Characteristics</b>						
BV <sub>DSS</sub>	Drain-Source Breakdown Voltage	V <sub>GS</sub> = 0V, I <sub>D</sub> = 250μA, T <sub>J</sub> = 25°C	600	--	--	V
		V <sub>GS</sub> = 0V, I <sub>D</sub> = 250μA, T <sub>J</sub> = 150°C	--	650	--	V
ΔBV <sub>DSS</sub> / ΔT <sub>J</sub>	Breakdown Voltage Temperature Coefficient	I <sub>D</sub> = 250μA, Referenced to 25°C	--	0.6	--	V/°C
IDSS	Zero Gate Voltage Drain Current	V <sub>DS</sub> = 600V, V <sub>GS</sub> = 0V V <sub>DS</sub> = 480V, TC = 125°C	--	--	1 10	μA μA
IGT <sub>SF</sub>	Gate-Body Leakage Current, Forward	V <sub>GS</sub> = 30V, V <sub>DS</sub> = 0V	--	--	100	nA
IG <sub>SSR</sub>	Gate-Body Leakage Current, Reverse	V <sub>GS</sub> = -30V, V <sub>DS</sub> = 0V	--	--	-100	nA
<b>On Characteristics</b>						
V <sub>GS(th)</sub>	Gate Threshold Voltage	V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250μA	2.5	--	4.5	V
R <sub>DS(on)</sub>	Static Drain-Source On-Resistance	V <sub>GS</sub> = 10V, I <sub>D</sub> = 5A	--	0.42	0.47	Ω
g <sub>FS</sub>	Forward Transconductance	V <sub>DS</sub> = 40V, I <sub>D</sub> = 5A (Note 4)	--	16	--	S
R <sub>g</sub>	Gate Resistance	F=1MHz, open drain	--	4.5	--	Ω
<b>Dynamic Characteristics</b>						
C <sub>iss</sub>	Input Capacitance	V <sub>DS</sub> = 25V, V <sub>GS</sub> = 0V, f = 1.0MHz	--	600	--	pF
C <sub>oss</sub>	Output Capacitance		--	120	--	pF
C <sub>rss</sub>	Reverse Transfer Capacitance		--	55	--	pF
<b>Switching Characteristics</b>						
t <sub>d(on)</sub>	Turn-On Delay Time	V <sub>DD</sub> = 400V, I <sub>D</sub> = 5A R <sub>G</sub> = 20Ω (Note 4, 5)	--	25	--	ns
t <sub>r</sub>	Turn-On Rise Time		--	55	--	ns
t <sub>d(off)</sub>	Turn-Off Delay Time		--	70	--	ns
t <sub>f</sub>	Turn-Off Fall Time		--	40	--	ns
Q <sub>g</sub>	Total Gate Charge	V <sub>DS</sub> = 480V, I <sub>D</sub> = 10A V <sub>GS</sub> = 10V (Note 4, 5)	--	35	--	nC
Q <sub>gs</sub>	Gate-Source Charge		--	3.8	--	nC
Q <sub>gd</sub>	Gate-Drain Charge		--	4	--	nC
<b>Drain-Source Diode Characteristics and Maximum Ratings</b>						
I <sub>S</sub>	Maximum Continuous Drain-Source Diode Forward Current		--	--	9.5	A
I <sub>SM</sub>	Maximum Pulsed Drain-Source Diode Forward Current		--	--	38	A
V <sub>SD</sub>	Drain-Source Diode Forward Voltage	V <sub>GS</sub> = 0V, I <sub>S</sub> = 9.5A	--	--	1.5	V
t <sub>rr</sub>	Reverse Recovery Time	V <sub>GS</sub> = 0V, I <sub>S</sub> = 9.5A dI <sub>F</sub> /dt = 100A/μs (Note 4)	--	240	--	ns
Q <sub>rr</sub>	Reverse Recovery Charge		--	3.1	--	μC

**NOTES:**

1. Repetitive Rating: Pulse width limited by maximum junction temperature
2. L=60mH, I<sub>AS</sub>=1.5A, V<sub>DD</sub>=150V, Starting T<sub>J</sub>=25°C
3. I<sub>SD</sub> ≤ 10A, di/dt ≤ 200A/μs, V<sub>DD</sub> ≤ BV<sub>DSS</sub>, Starting T<sub>J</sub> = 25°C
4. Pulse Test: Pulse width ≤ 300μs, Duty Cycle ≤ 2%
5. Essentially Independent of Operating Temperature Typical Characteristics

## Typical Performance Characteristics

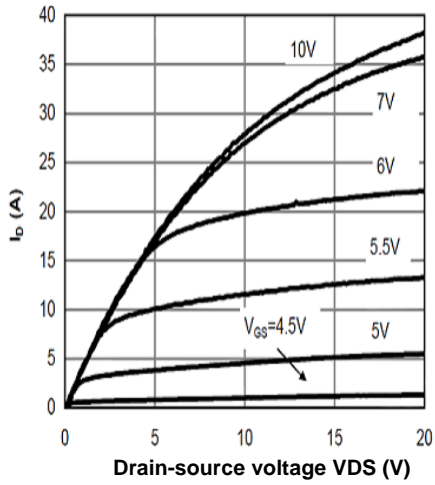


Figure 1: On-Region Characteristics @ 25° C

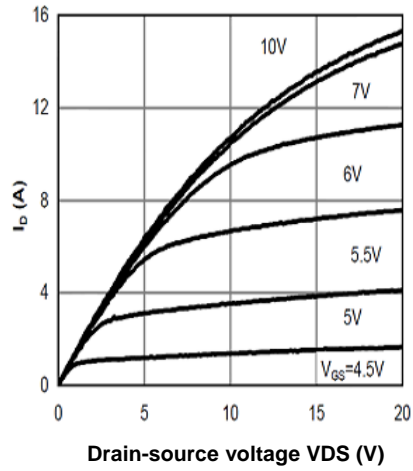


Figure 2: On-Region Characteristics @ 125° C

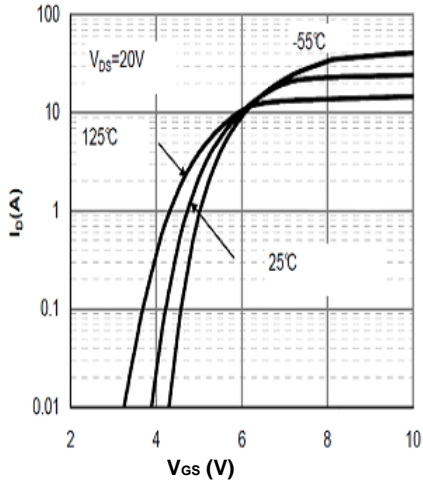


Figure 3: Transfer Characteristics

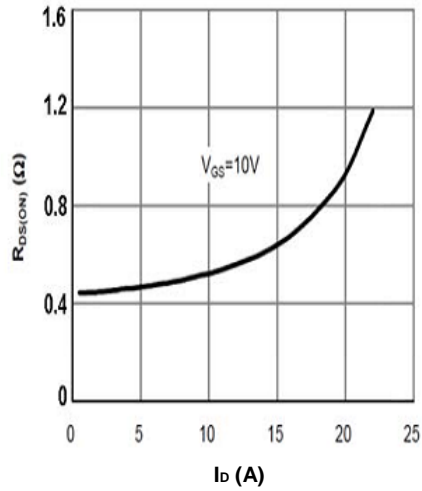


Figure 4: On-Resistance vs. Drain Current and Gate Voltage

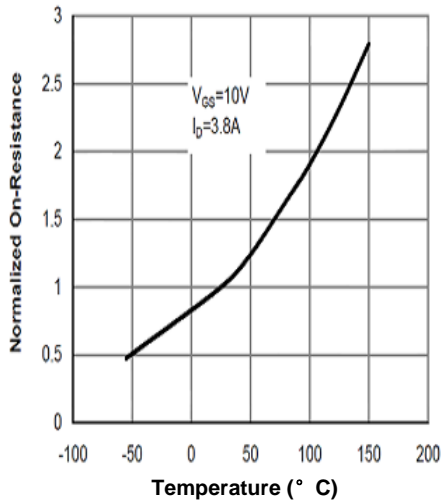


Figure 5: On-Resistance vs. Junction Temperature

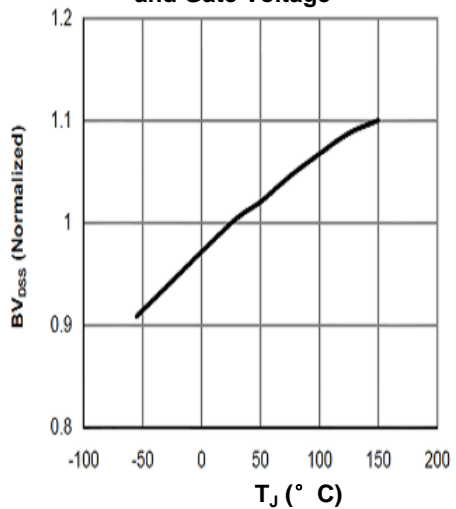


Figure 6: Break Down vs. Junction Temperature

## Typical Performance Characteristics

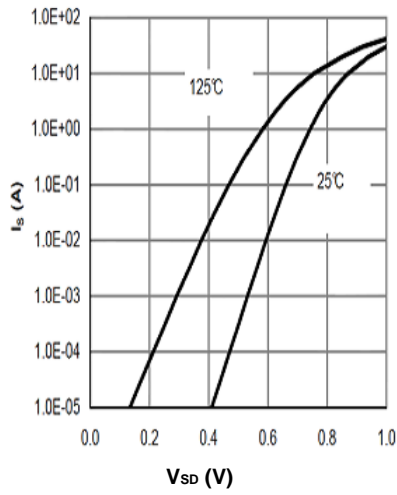


Figure 7: Body-Diode Characteristics

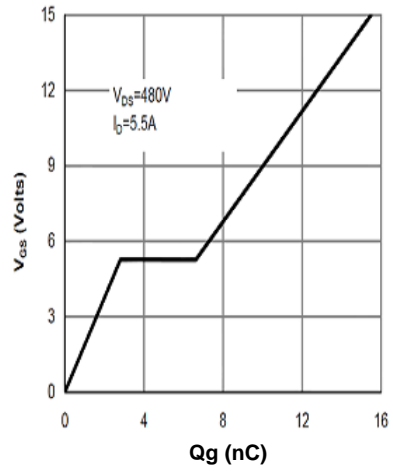


Figure 8: Gate-Charge Characteristics

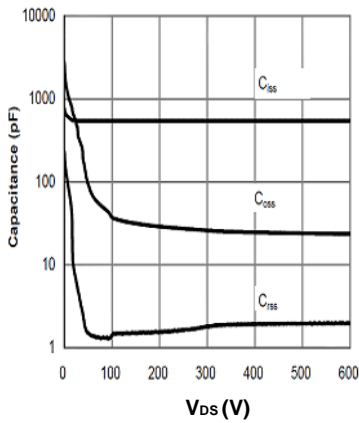


Figure 9: Capacitance Characteristics

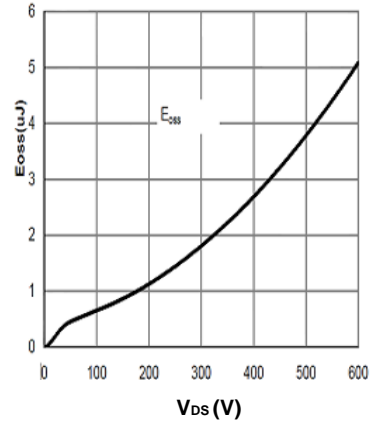


Figure 10:  $C_{oss}$  stored Energy

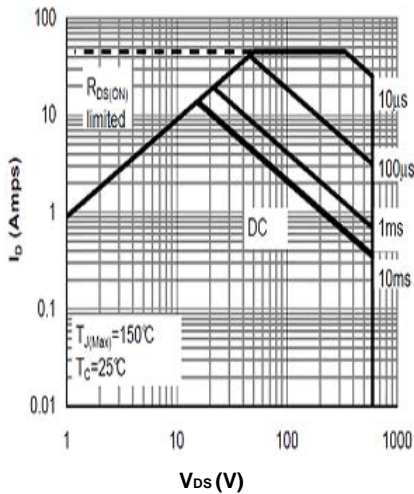


Figure 11: Maximum Forward Biased Safe Operating Area

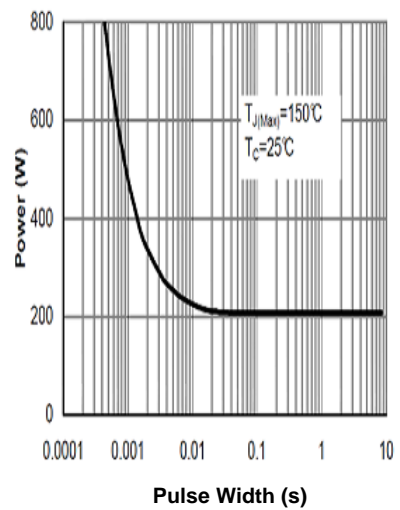


Figure 12: Single Pulse Power Rating Junction to Case

### Typical Performance Characteristics

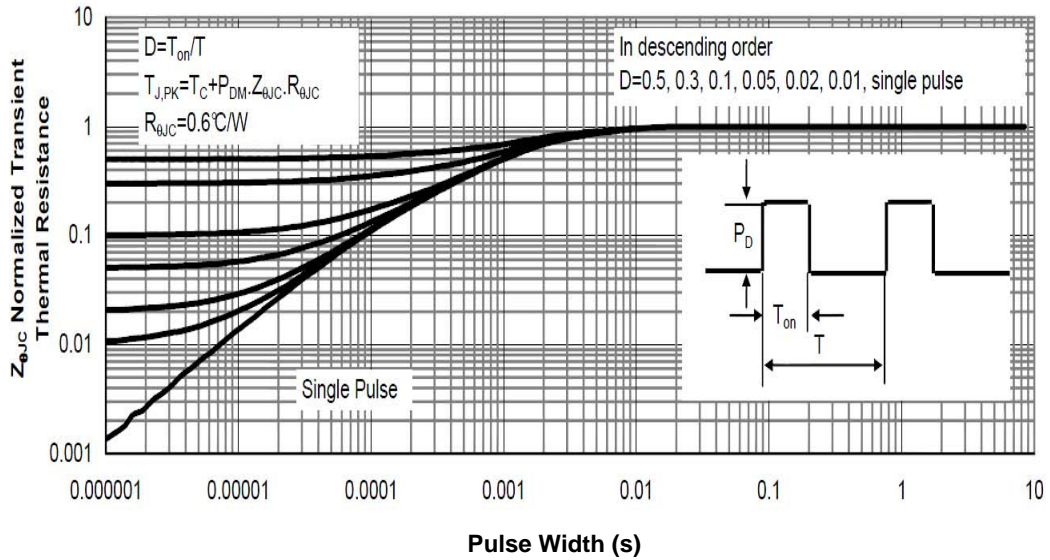


Figure 12: Normalized Maximum Transient Thermal Impedance

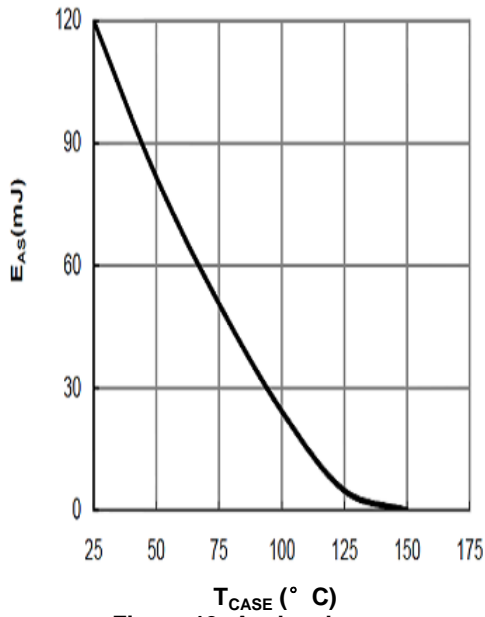


Figure 13: Avalanche energy

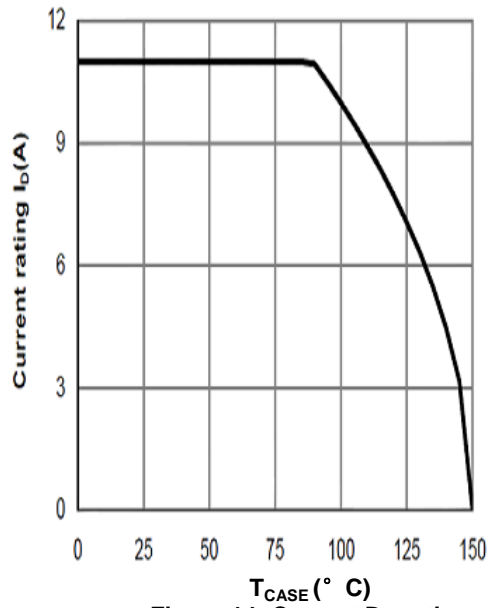


Figure 14: Current De-rating

Typical Performance Characteristics

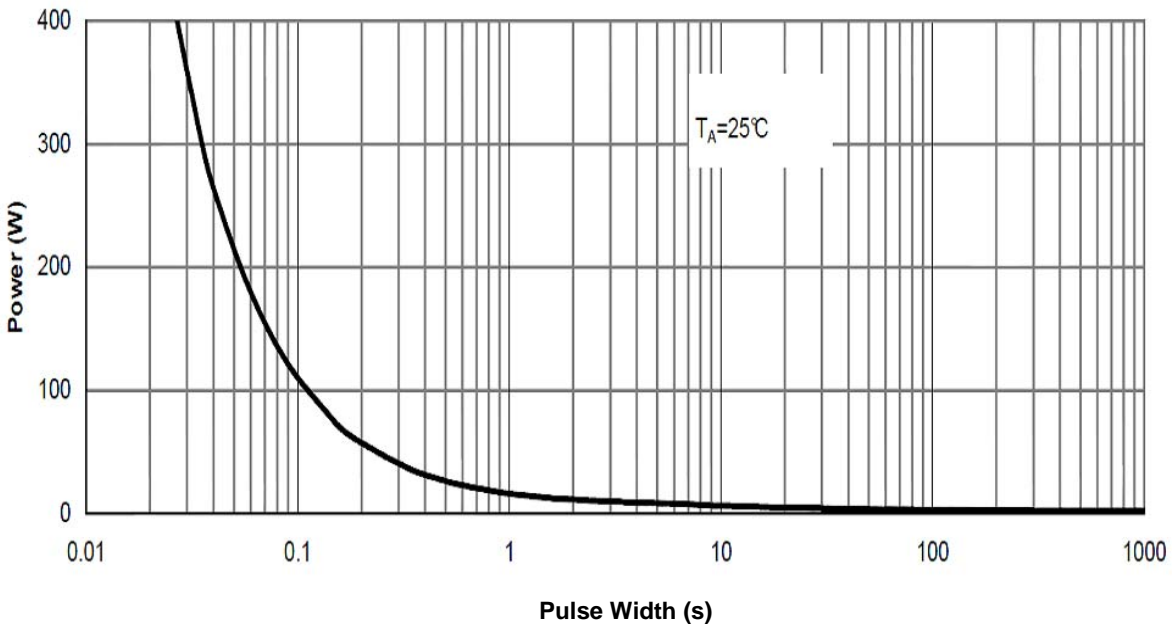


Figure 15: Single Pulse Power Rating Junction-Ambient

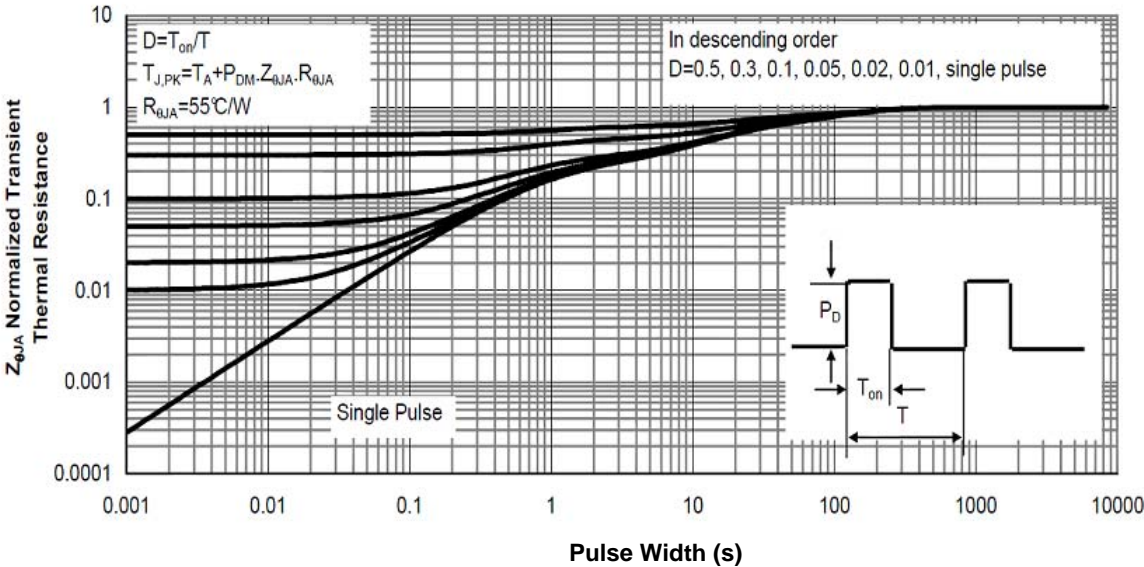
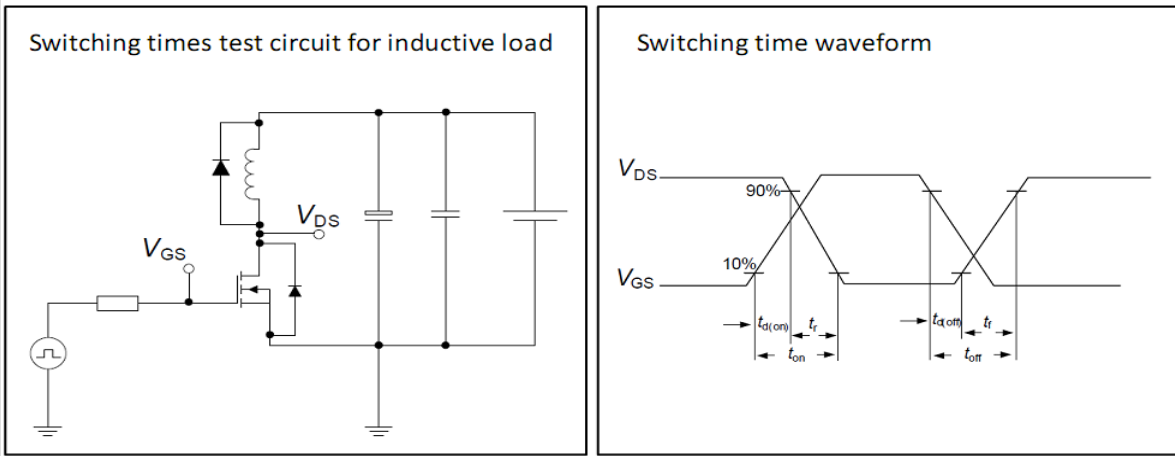


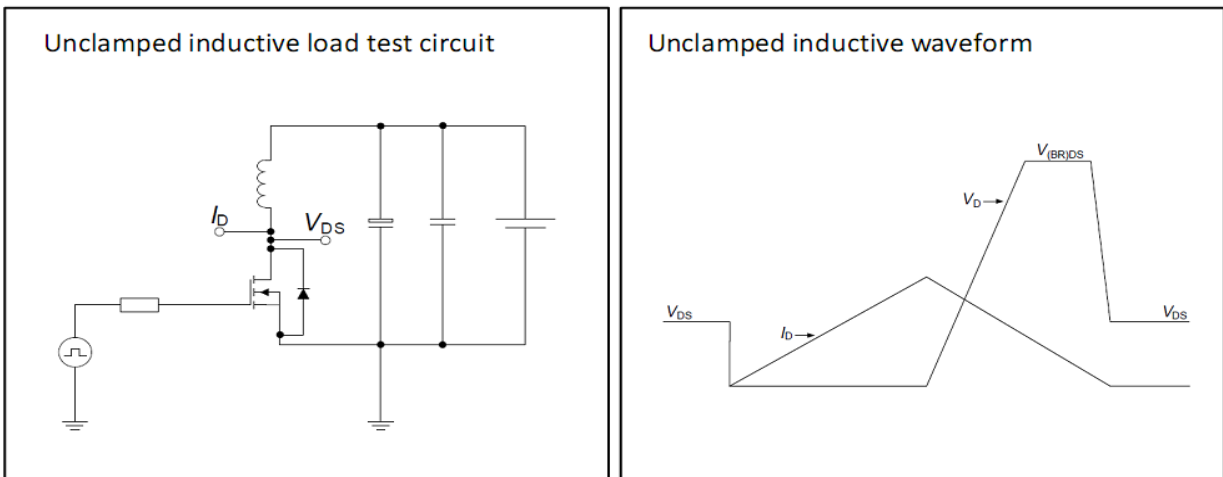
Figure 16: Normalized Maximum Transient Thermal Impedance

## Test circuits

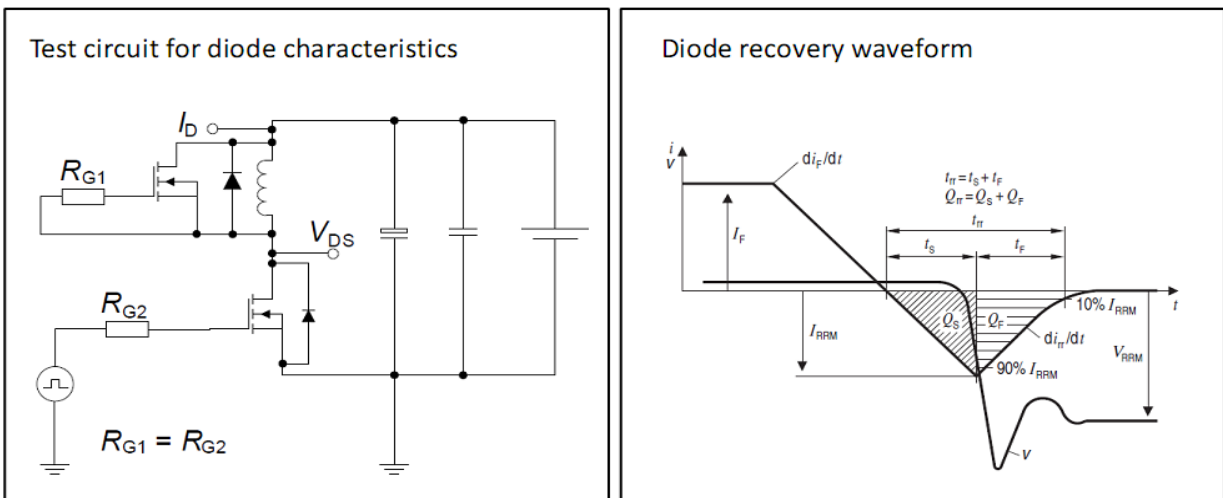
Switching times test circuit and waveform for inductive load



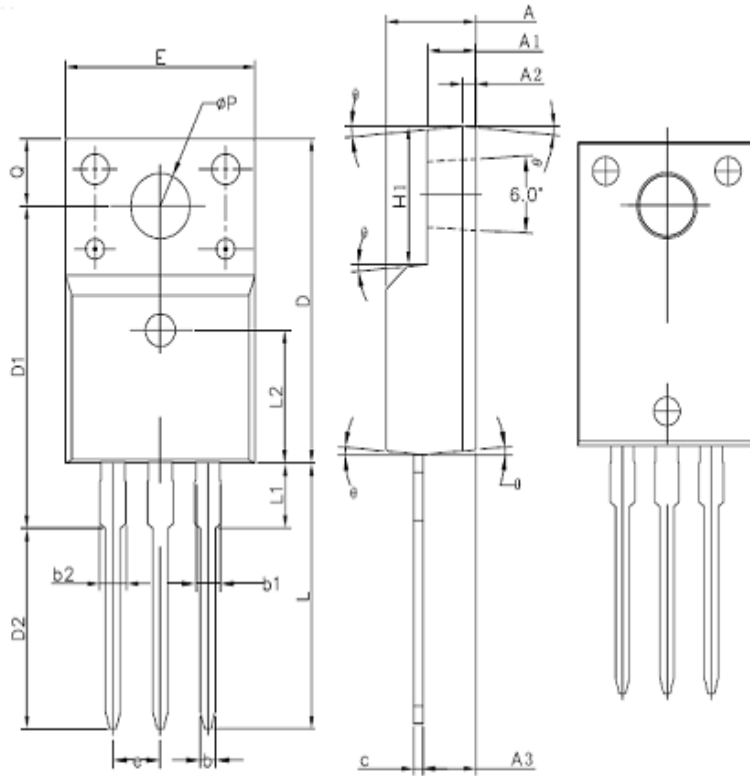
Unclamped inductive load test circuit and waveform



Test circuit and waveform for diode characteristics

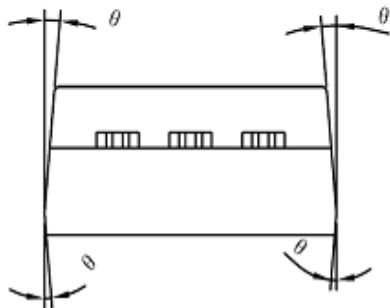


# PKG TO-220F



COMMON DIMENSIONS  
(UNITS OF MEASURE=MILLIMETER)

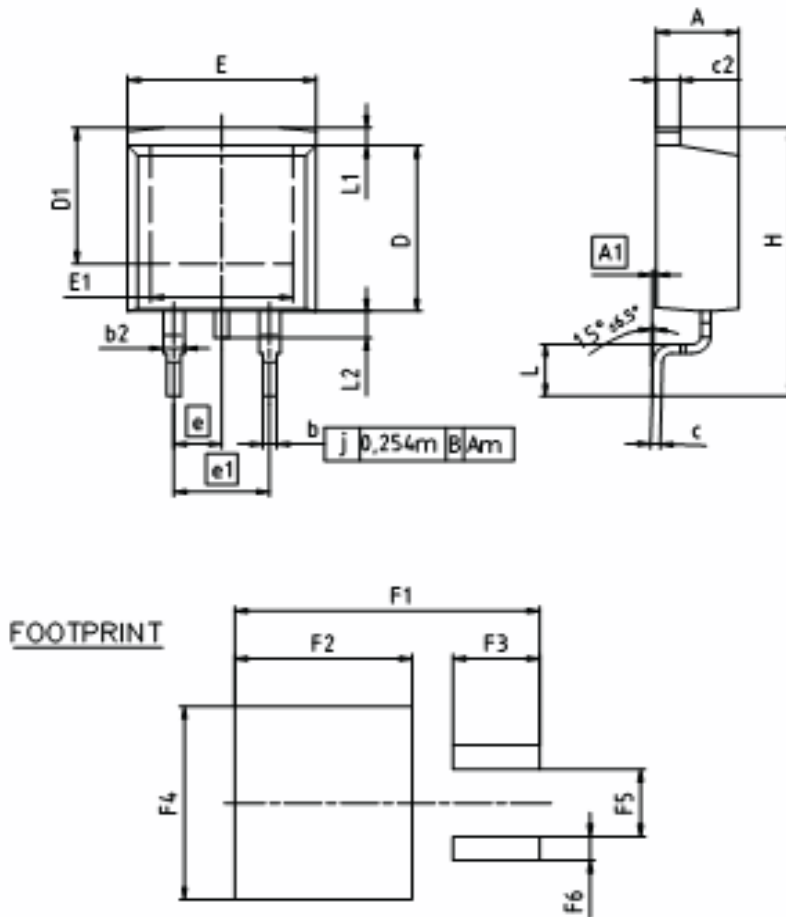
SYMBOL	MIN	NOM	MAX
A	4.50	4.70	4.90
A1	2.34	2.54	2.74
A2	0.70 REF		
A3	2.56	2.76	2.96
b	0.70	-	0.90
b1	1.18	-	1.38
b2	-	-	1.47
c	0.45	0.50	0.60
D	15.67	15.87	16.07
D1	15.55	15.75	15.95
D2	9.60	9.80	10.0
E	9.96	10.16	10.36
e	2.54BSC		
H1	6.48	6.68	6.88
L	12.68	12.98	-
L1	-	-	3.50
L2	6.50REF		
$\phi P$	3.08	3.18	3.28
Q	3.20	-	3.40
$\theta$	3°	5°	7°





# PKG TO-263

TSP10N60S / TSF10N60S/TSB10N60S 600V N-Channel MOSFET



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.30	4.67	0.169	0.180
A1	0.00	0.25	0.000	0.010
b	0.65	0.85	0.026	0.033
b2	0.95	1.15	0.037	0.045
c	0.33	0.65	0.013	0.026
c2	1.17	1.40	0.046	0.055
D	8.51	8.45	0.335	0.372
D1	7.10	7.90	0.280	0.311
E	9.80	10.31	0.389	0.408
E1	6.60	6.60	0.260	0.339
e	2.54		0.100	
e1	5.08		0.200	
N	2		2	
H	14.81	15.88	0.575	0.625
L	2.29	3.00	0.090	0.118
L1	0.70	1.80	0.028	0.083
L2	1.00	1.78	0.039	0.070
F1	18.08	18.25	0.832	0.840
F2	9.30	9.80	0.368	0.374
F3	4.80	4.70	0.177	0.185
F4	10.70	10.90	0.421	0.429
F5	3.65	3.85	0.144	0.152
F6	1.25	1.45	0.049	0.057

DOCUMENT NO.  
**Z8800003324**

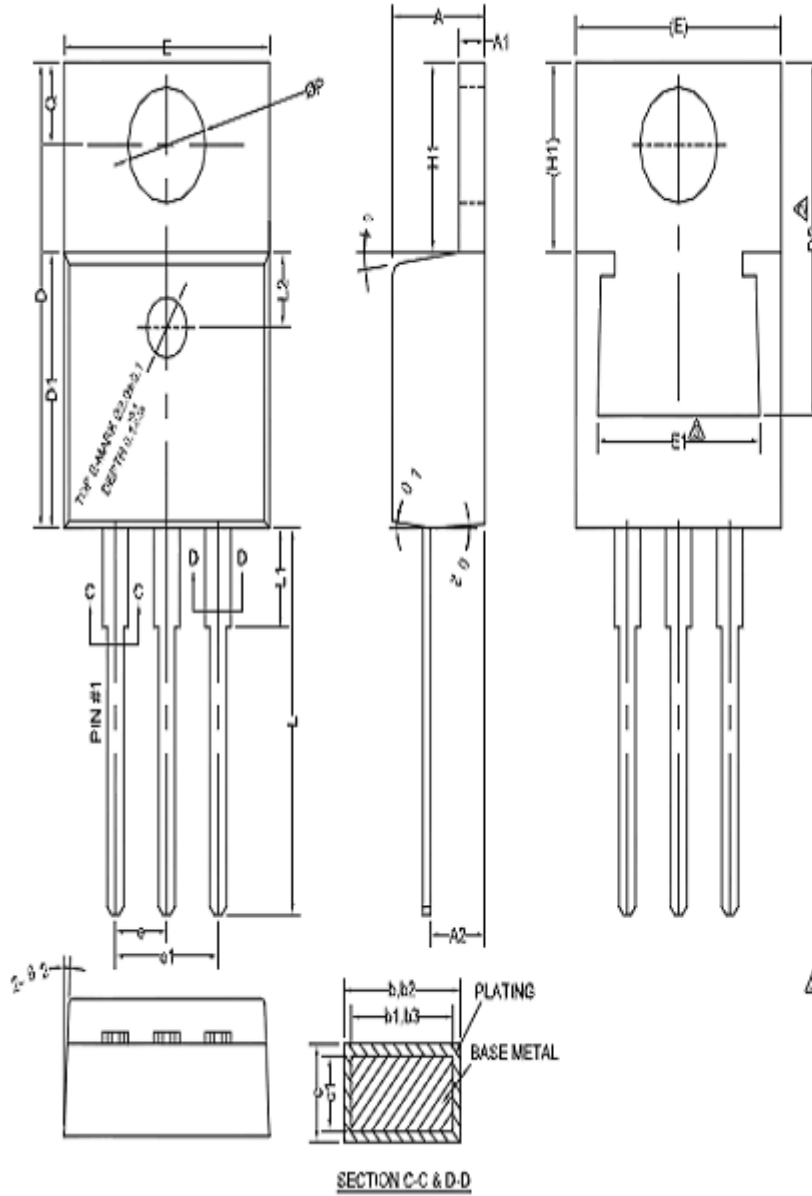
SCALE 7.5mm

EUROPEAN PROJECTION

ISSUE DATE  
**30-08-2007**

REVISION  
**01**

# PKG TO-220



COMMON DIMENSIONS  
(UNITS OF MEASURE=MILLIMETER)

SYMBOL	MIN	NOM	MAX
A	4.40	4.57	4.70
A1	1.22	-	1.32
A2	2.59	2.39	2.79
b	0.77	-	0.90
b1	0.76	0.81	0.83
b2	1.23	-	1.35
b3	1.22	1.27	1.32
c	0.34	-	0.47
c1	0.33	0.38	0.43
D	15.15	15.45	15.75
D1	9.05	9.15	9.25
D2	11.40	-	12.88
E	9.93	10.13	10.33
E1	3.66	-	3.89
a	2.44	2.54	2.64
a1	4.96	5.06	5.1
H1	3.10	3.30	3.50
L	12.70	-	13.12
L1	-	-	3.90
L2	2.50REF		
ØP	3.80	3.84	3.88
q	2.30	-	2.90
Ø 1	5'	7'	9'
Ø 2	1'	3'	5'

**NOTES:**

1. ALL DIMENSIONS REFER TO JEDEC STANDARD TO-220 AB DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.

2. 'D2' AND 'E1' ARE VARIABLES DEPENDING ON DIE PAD SIZES.