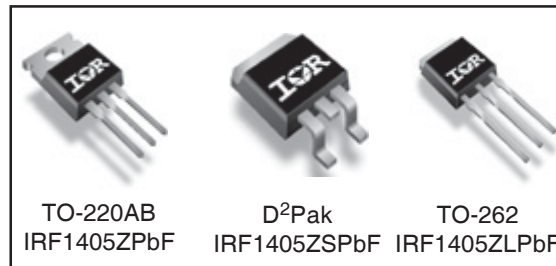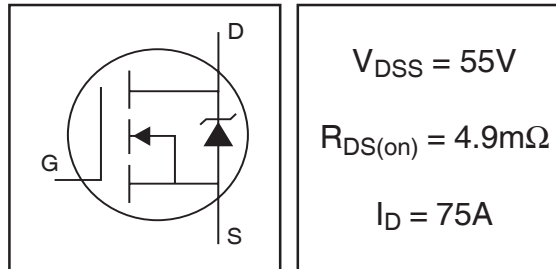# International IOR Rectifier

IRF1405ZPbF
IRF1405ZSPbF
IRF1405ZLPbF

HEXFET® Power MOSFET

Features

- Advanced Process Technology
- Ultra Low On-Resistance
- 175°C Operating Temperature
- Fast Switching
- Repetitive Avalanche Allowed up to Tjmax
- Lead-Free

Description

This HEXFET® Power MOSFET utilizes the latest processing techniques to achieve extremely low on-resistance per silicon area. Additional features of this design are a 175°C junction operating temperature, fast switching speed and improved repetitive avalanche rating. These features combine to make this design an extremely efficient and reliable device for use in a wide variety of applications.

$V_{DSS} = 55V$

$R_{DS(on)} = 4.9m\Omega$

$I_D = 75A$

TO-220AB
IRF1405ZPbF

D²Pak
IRF1405ZSPbF

TO-262
IRF1405ZLPbF

Absolute Maximum Ratings

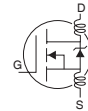|	Parameter	Max.	Units
I_D @ T_C = 25°C	Continuous Drain Current, V_{GS} @ 10V (Silicon Limited)	150	A
I_D @ T_C = 100°C	Continuous Drain Current, V_{GS} @ 10V	110	
I_D @ T_C = 25°C	Continuous Drain Current, V_{GS} @ 10V (Package Limited)	75	
I_{DM}	Pulsed Drain Current ①	600	
P_D @T_C = 25°C	Power Dissipation	230	W
	Linear Derating Factor	1.5	W/°C
V_{GS}	Gate-to-Source Voltage	± 20	V
E_{AS} (Thermally limited)	Single Pulse Avalanche Energy②	270	mJ
E_{AS} (Tested)	Single Pulse Avalanche Energy Tested Value ⑥	420	
I_{AR}	Avalanche Current ①	See Fig.12a, 12b, 15, 16	A
E_{AR}	Repetitive Avalanche Energy ⑤		mJ
T_J	Operating Junction and	-55 to + 175	°C
T_{STG}	Storage Temperature Range		
	Soldering Temperature, for 10 seconds	300 (1.6mm from case)	
	Mounting Torque, 6-32 or M3 screw	10 lbf•in (1.1N•m)	

Thermal Resistance

	Parameter	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	——	0.65	°C/W
$R_{\theta CS}$	Case-to-Sink, Flat, Greased Surface	0.50	——	
$R_{\theta JA}$	Junction-to-Ambient	——	62	
$R_{\theta JA}$	Junction-to-Ambient (PCB Mount, steady state)⑦	——	40	

HEXFET® is a registered trademark of International Rectifier.

IRF1405Z/S/LPbF

Electrical Characteristics @ T_J = 25°C (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Conditions
$V_{(BR)DSS}$	Drain-to-Source Breakdown Voltage	55	——	——	V	V_{GS} = 0V, I_D = 250µA
$\Delta V_{(BR)DSS}/\Delta T_J$	Breakdown Voltage Temp. Coefficient	——	0.049	——	V/°C	Reference to 25°C, I_D = 1mA
$R_{DS(on)}$	Static Drain-to-Source On-Resistance	——	3.7	4.9	mΩ	V_{GS} = 10V, I_D = 75A ③
$V_{GS(th)}$	Gate Threshold Voltage	2.0	——	4.0	V	V_{DS} = V_{GS}, I_D = 250µA
gfs	Forward Transconductance	88	——	——	S	V_{DS} = 25V, I_D = 75A
I_{DSS}	Drain-to-Source Leakage Current	——	——	20	µA	V_{DS} = 55V, V_{GS} = 0V
		——	——	250		V_{DS} = 55V, V_{GS} = 0V, T_J = 125°C
I_{GSS}	Gate-to-Source Forward Leakage	——	——	200	nA	V_{GS} = 20V
	Gate-to-Source Reverse Leakage	——	——	-200		V_{GS} = -20V
Q_g	Total Gate Charge	——	120	180		I_D = 75A
Q_{gs}	Gate-to-Source Charge	——	31	——	nC	V_{DS} = 44V
Q_{gd}	Gate-to-Drain ("Miller") Charge	——	46	——		V_{GS} = 10V ③
$t_{d(on)}$	Turn-On Delay Time	——	18	——		V_{DD} = 25V
t_r	Rise Time	——	110	——		I_D = 75A
$t_{d(off)}$	Turn-Off Delay Time	——	48	——	ns	R_G = 4.4Ω
t_f	Fall Time	——	82	——		V_{GS} = 10V ③
L_D	Internal Drain Inductance	——	4.5	——		Between lead,
					nH	6mm (0.25in.)
L_S	Internal Source Inductance	——	7.5	——		from package
						and center of die contact
C_{iss}	Input Capacitance	——	4780	——		V_{GS} = 0V
C_{oss}	Output Capacitance	——	770	——		V_{DS} = 25V
C_{rss}	Reverse Transfer Capacitance	——	410	——	pF	f = 1.0MHz
C_{oss}	Output Capacitance	——	2730	——		V_{GS} = 0V, V_{DS} = 1.0V, f = 1.0MHz
C_{oss}	Output Capacitance	——	600	——		V_{GS} = 0V, V_{DS} = 44V, f = 1.0MHz
C_{oss} eff.	Effective Output Capacitance	——	910	——		V_{GS} = 0V, V_{DS} = 0V to 44V ④

Source-Drain Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Conditions
I_S	Continuous Source Current (Body Diode)	——	——	75	A	MOSFET symbol showing the integral reverse p-n junction diode.
I_{SM}	Pulsed Source Current (Body Diode) ①	——	——	600		
V_{SD}	Diode Forward Voltage	——	——	1.3	V	T_J = 25°C, I_S = 75A, V_{GS} = 0V ③
t_{rr}	Reverse Recovery Time	——	30	46	ns	T_J = 25°C, I_F = 75A, V_{DD} = 25V
Q_{rr}	Reverse Recovery Charge	——	30	45	nC	di/dt = 100A/µs ③
t_{on}	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by LS+LD)				

Notes:

① Repetitive rating; pulse width limited by
   max. junction temperature. (See fig. 11).

② Limited by T_{Jmax}, starting T_J = 25°C, L = 0.10mH
   R_G = 25Ω, I_{AS} = 75A, V_{GS} =10V. Part not
   recommended for use above this value.

③ Pulse width ≤ 1.0ms; duty cycle ≤ 2%.

④ C_{oss} eff. is a fixed capacitance that gives the same
   charging time as C_{oss} while V_{DS} is rising from 0 to 80%
   V_{DSS} .

⑤ Limited by T_{Jmax} , see Fig.12a, 12b, 15, 16 for typical
   repetitive avalanche performance.

⑥ This value determined from sample failure population.
   100% tested to this value in production.

⑦ This is applied to D²Pak, when mounted on 1" square PCB
   (FR-4 or G-10 Material). For recommended footprint and
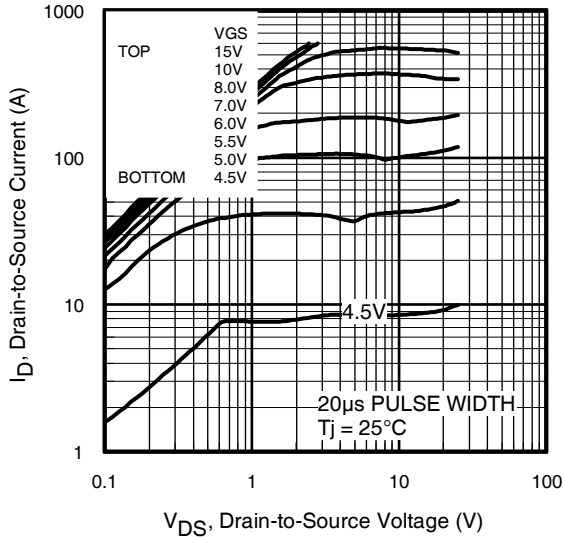   soldering techniques refer to application note #AN-994.

International IOR Rectifier

IRF1405Z/S/LPbF

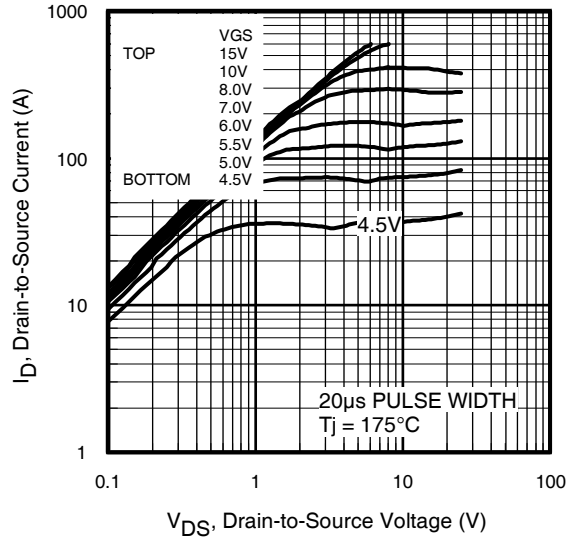**Fig 1.** Typical Output Characteristics

Fig 2. Typical Output Characteristics

Fig 3. Typical Transfer Characteristics

Fig 4. Typical Forward Transconductance
vs. Drain Current

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3

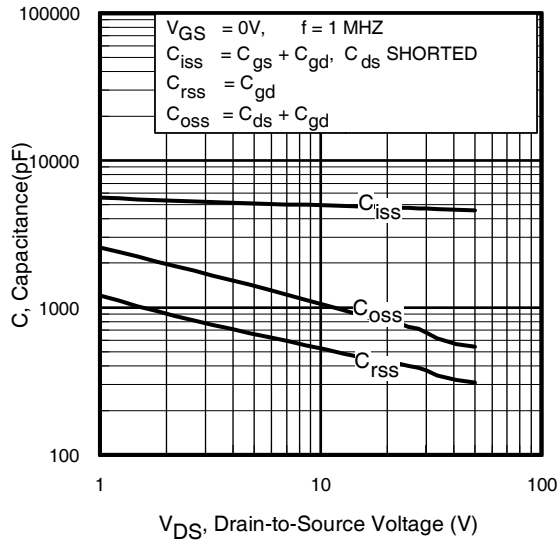# IRF1405Z/S/LPbF

International
IR Rectifier

Fig 5. Typical Capacitance vs.
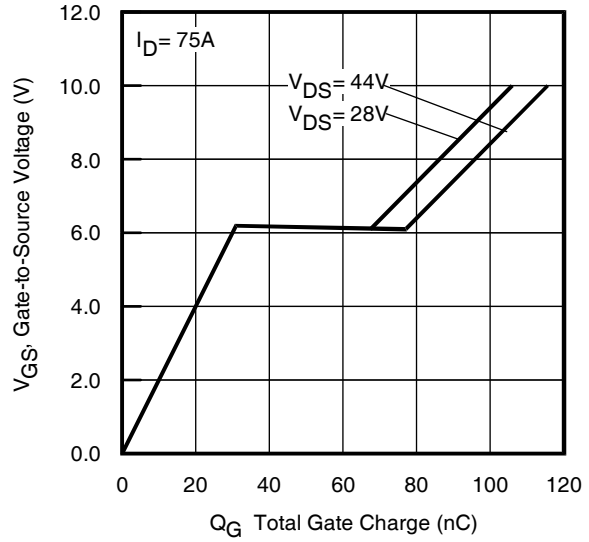Drain-to-Source Voltage

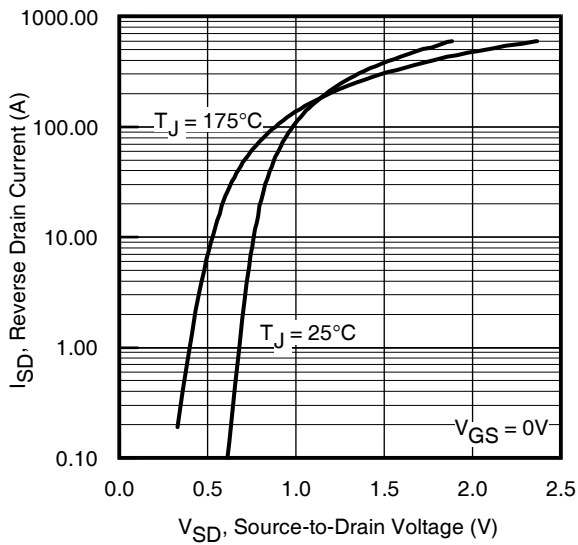Fig 6. Typical Gate Charge vs.
Gate-to-Source Voltage

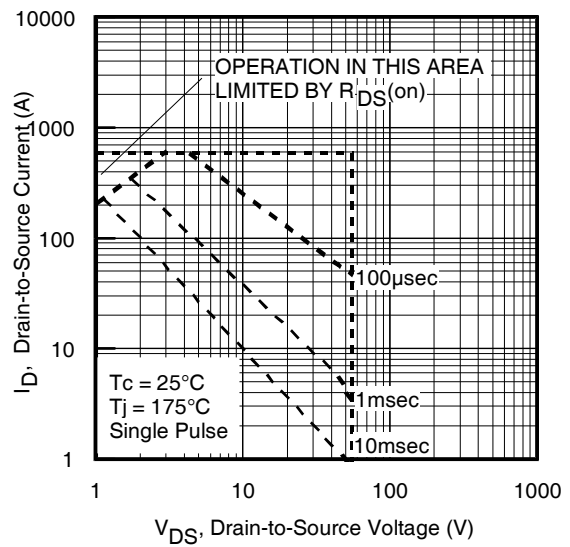Fig 7. Typical Source-Drain Diode
Forward Voltage

Fig 8. Maximum Safe Operating Area

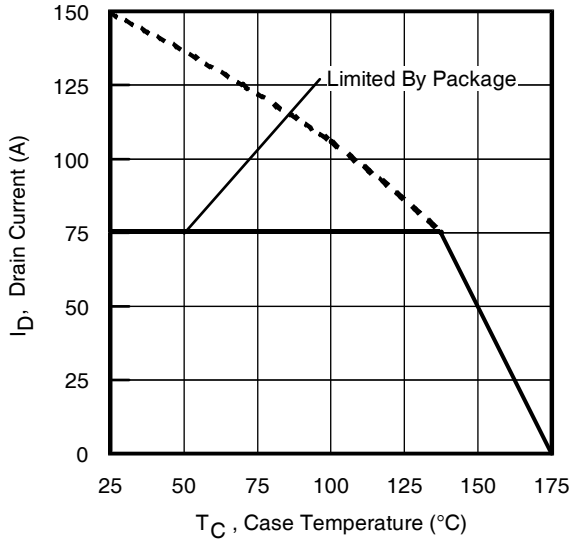**Fig 9.** Maximum Drain Current vs.
Case Temperature

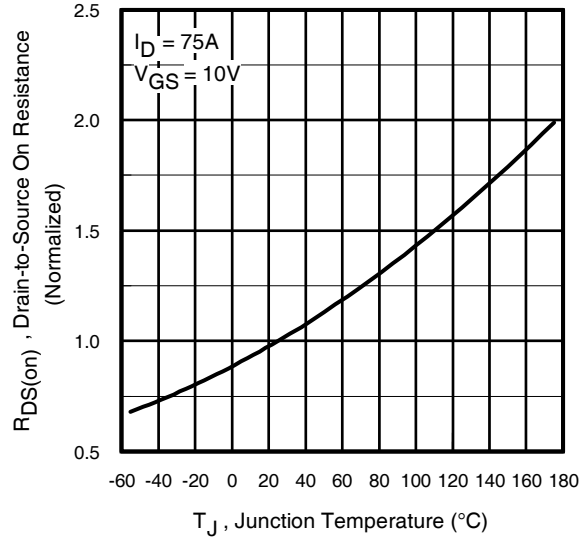**Fig 10.** Normalized On-Resistance
vs. Temperature

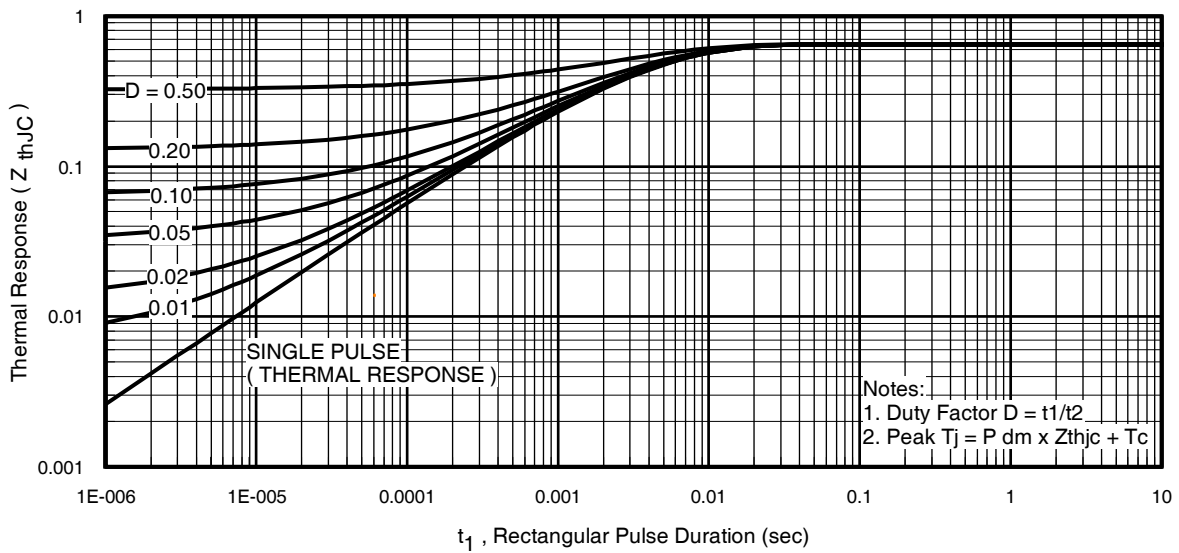**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case

Fig 12a. Unclamped Inductive Test Circuit

Fig 12b. Unclamped Inductive Waveforms

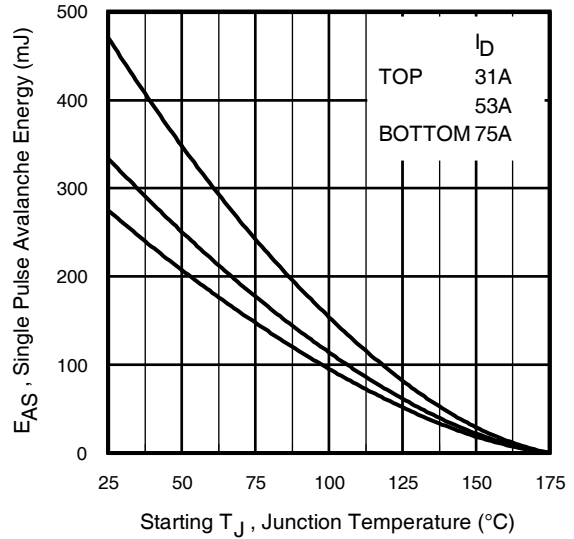**Fig 13a.** Basic Gate Charge Waveform

Fig 13b. Gate Charge Test Circuit
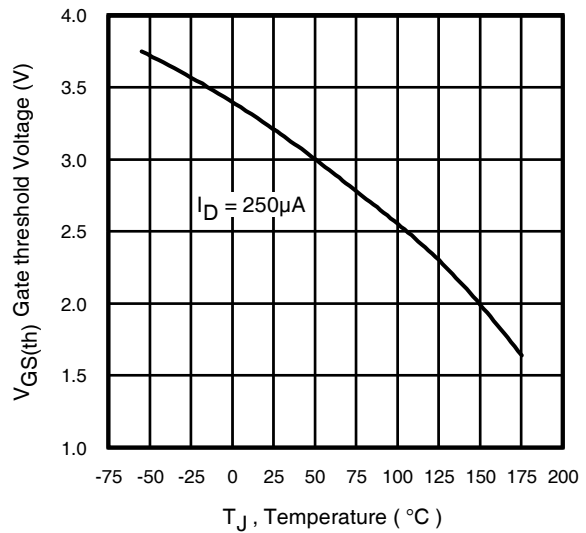

Fig 12c. Maximum Avalanche Energy
vs. Drain Current
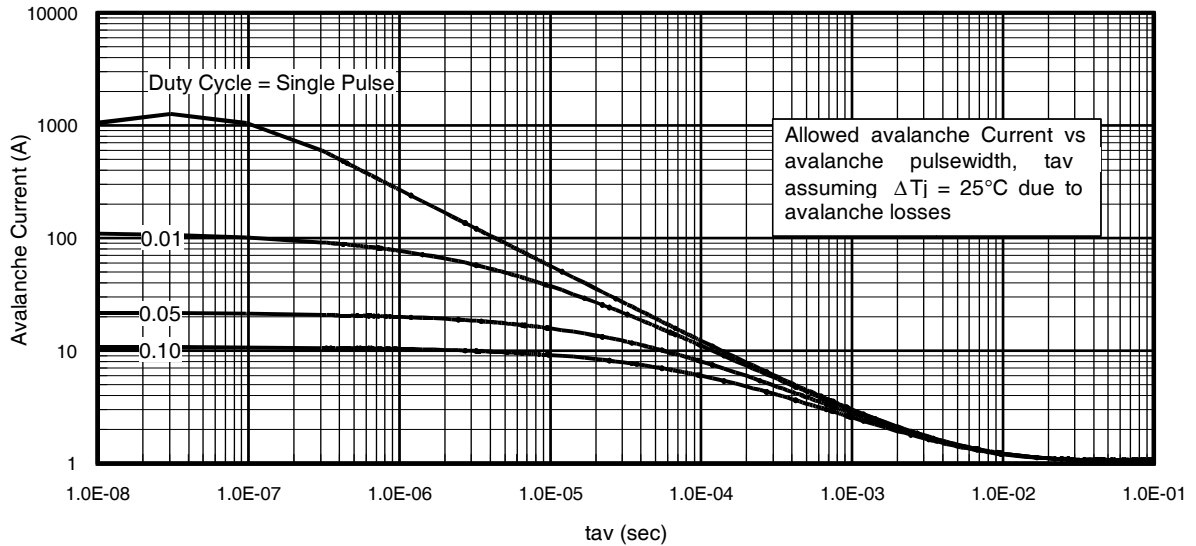

Fig 14. Threshold Voltage vs. Temperature

6

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Duty Cycle = Single Pulse

Allowed avalanche Current vs avalanche pulsewidth, tav assuming $\Delta Tj = 25°C$ due to avalanche losses

0.01

0.05

0.10

Fig 15. Typical Avalanche Current vs.Pulsewidth

TOP   Single Pulse
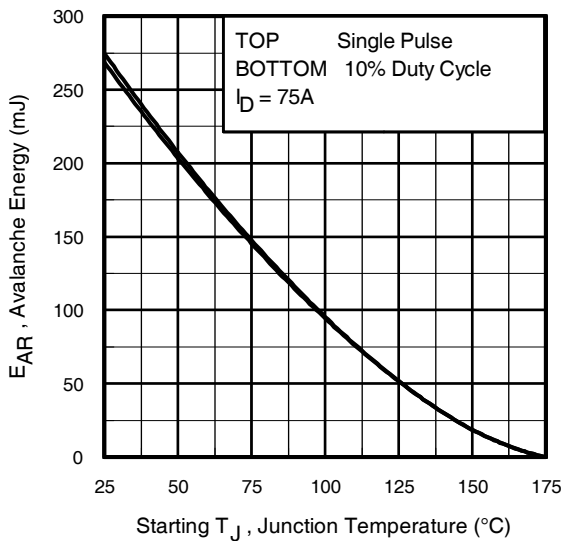BOTTOM   10% Duty Cycle
$I_D = 75A$

Fig 16. Maximum Avalanche Energy vs. Temperature

Notes on Repetitive Avalanche Curves , Figures 15, 16:
(For further info, see AN-1005 at www.irf.com)
1. Avalanche failures assumption:
   Purely a thermal phenomenon and failure occurs at a temperature far in excess of T_{jmax}. This is validated for every part type.
2. Safe operation in Avalanche is allowed as long asT_{jmax} is not exceeded.
3. Equation below based on circuit and waveforms shown in Figures 12a, 12b.
4. $P_{D (ave)}$ = Average power dissipation per single avalanche pulse.
5. BV = Rated breakdown voltage (1.3 factor accounts for voltage increase during avalanche).
6. I_{av} = Allowable avalanche current.
7. ΔT = Allowable rise in junction temperature, not to exceed T_{jmax} (assumed as 25°C in Figure 15, 16).
   $t_{av} =$ Average time in avalanche.
   D = Duty cycle in avalanche = $t_{av} \cdot f$
   $Z_{thJC}(D, t_{av})$ = Transient thermal resistance, see figure 11)

$$P_{D (ave)} = 1/2 (1.3 \cdot BV \cdot I_{av}) = \Delta T/ Z_{thJC}$$
$$I_{av} = 2\Delta T/ [1.3 \cdot BV \cdot Z_{th}]$$
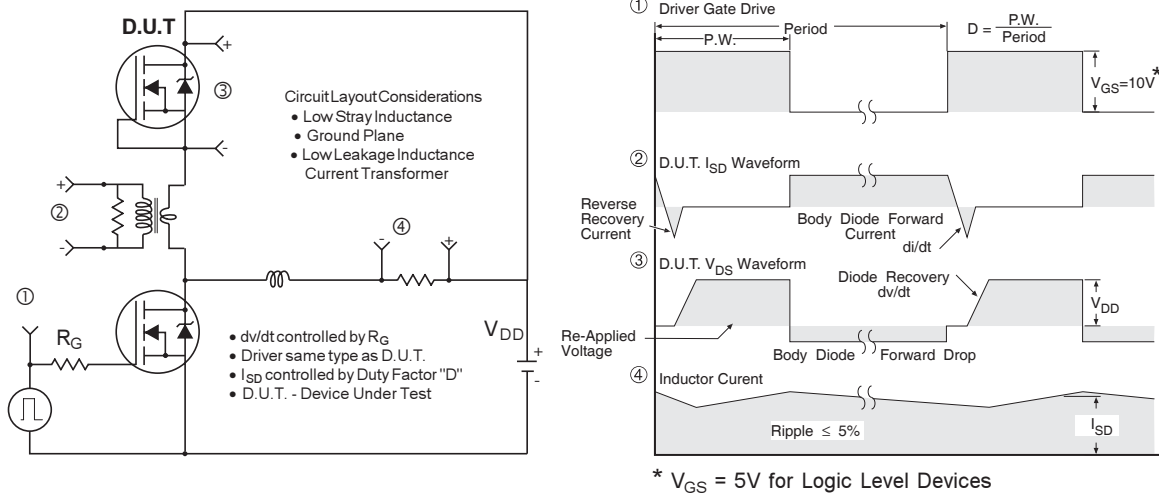$$E_{AS (AR)} = P_{D (ave)} \cdot t_{av}$$

IRF1405Z/S/LPbF

Fig 17. Peak Diode Recovery dv/dt Test Circuit for N-Channel
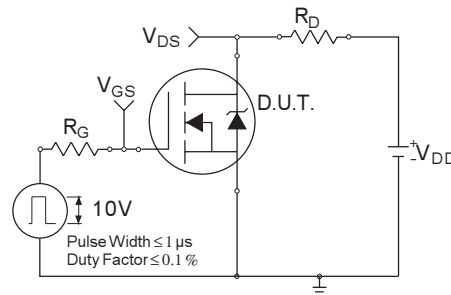HEXFET® Power MOSFETs

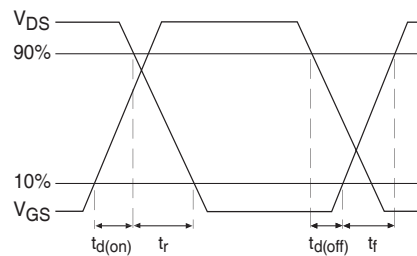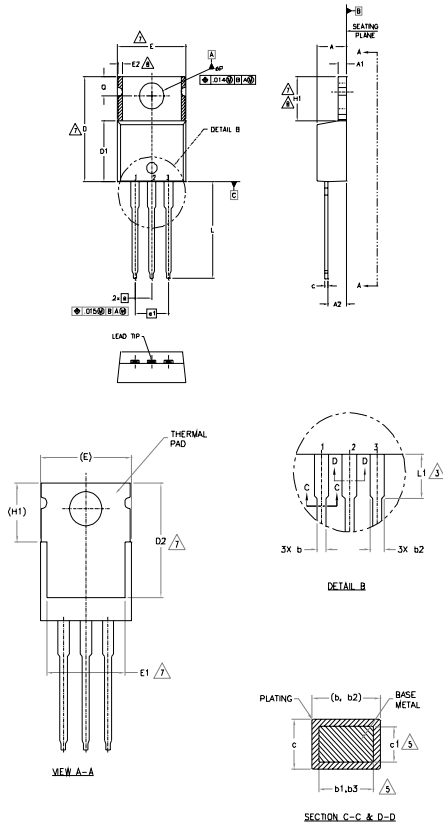**Fig 18a.** Switching Time Test Circuit

Fig 18b. Switching Time Waveforms

TO-220AB Package Outline

Dimensions are shown in millimeters (inches)

NOTES:
1.– DIMENSIONING AND TOLERANCING AS PER ASME Y14.5 M– 1994.
2.– DIMENSIONS ARE SHOWN IN INCHES [MILLIMETERS].
3.– LEAD DIMENSION AND FINISH UNCONTROLLED IN L1.
4.– DIMENSION D, D1 & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED .005" (0.127) PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY.
5.– DIMENSION b1, b3 & c1 APPLY TO BASE METAL ONLY.
6.– CONTROLLING DIMENSION : INCHES.
7.– THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSIONS E,H1,D2 & E1
8.– DIMENSION E2 X H1 DEFINE A ZONE WHERE STAMPING AND SINGULATION IRREGULARITIES ARE ALLOWED.
9.– OUTLINE CONFORMS TO JEDEC TO-220, EXCEPT A2 (max.) AND D2 (min.) WHERE DIMENSIONS ARE DERIVED FROM THE ACTUAL PACKAGE OUTLINE.

| SYMBOL | DIMENSIONS | | | | NOTES |
| | MILLIMETERS | | INCHES | | |
	MIN.	MAX.	MIN.	MAX.	
A	3.56	4.83	.140	.190	
A1	0.51	1.40	.020	.055	
A2	2.03	2.92	.080	.115	
b	0.38	1.01	.015	.040	
b1	0.38	0.97	.015	.038	5
b2	1.14	1.78	.045	.070	
b3	1.14	1.73	.045	.068	5
c	0.36	0.61	.014	.024	
c1	0.36	0.56	.014	.022	5
D	14.22	16.51	.560	.650	4
D1	8.38	9.02	.330	.355	
D2	11.68	12.88	.460	.507	7
E	9.65	10.67	.380	.420	4,7
E1	6.86	8.89	.270	.350	7
E2	–	0.76	–	.030	8
e	2.54 BSC		.100 BSC		
e1	5.08 BSC		.200 BSC		
H1	5.84	6.86	.230	.270	7,8
L	12.70	14.73	.500	.580	
L1	3.56	4.06	.140	.160	3
øP	3.54	4.08	.139	.161	
Q	2.54	3.42	.100	.135	

LEAD ASSIGNMENTS

HEXFET
1.– GATE
2.– DRAIN
3.– SOURCE

IGBTs, CoPACK
1 – GATE
2.– COLLECTOR
3.– EMITTER

DIODES
1.– ANODE
2.– CATHODE
3.– ANODE

TO-220AB Part Marking Information

EXAMPLE: THIS IS AN IRF1010
LOT CODE 1789
ASSEMBLED ON WW 19, 2000
IN THE ASSEMBLY LINE "C"

Note: "P" in assembly line position indicates "Lead - Free"

INTERNATIONAL RECTIFIER LOGO

PART NUMBER

ASSEMBLY LOT CODE

DATE CODE
YEAR 0 = 2000
WEEK 19
LINE C

Notes:
1. **For an Automotive Qualified version of this part please see** http://www.irf.com/product-info/auto/
2. **For the most current drawing please refer to IR website at** http://www.irf.com/package/

D²Pak (TO-263AB) Package Outline

Dimensions are shown in millimeters (inches)

S Y M B O L	DIMENSIONS				N O T E S
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	4.06	4.83	.160	.190	
A1	0.00	0.254	.000	.010	
b	0.51	0.99	.020	.039	
b1	0.51	0.89	.020	.035	5
b2	1.14	1.78	.045	.070	
b3	1.14	1.73	.045	.068	5
c	0.38	0.74	.015	.029	
c1	0.38	0.58	.015	.023	5
c2	1.14	1.65	.045	.065	
D	8.38	9.65	.330	.380	3
D1	6.86	–	.270		4
E	9.65	10.67	.380	.420	3,4
E1	6.22	–	.245		4
e	2.54 BSC		.100 BSC		
H	14.61	15.88	.575	.625	
L	1.78	2.79	.070	.110	
L1	–	1.65	–	.066	4
L2	–	1.78	–	.070	
L3	0.25 BSC		.010 BSC		
L4	4.78	5.28	.188	.208	

LEAD ASSIGNMENTS

DIODES
1.– ANODE (TWO DIE) / OPEN (ONE DIE)
2, 4.– CATHODE
3.– ANODE

HEXFET
1.– GATE
2, 4.– DRAIN
3.– SOURCE

IGBTs, CoPACK
1.– GATE
2, 4.– COLLECTOR
3.– EMITTER

NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M–1994
2. DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
3. DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.127 [.005"] PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY AT DATUM H.
4. THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSION E, L1, D1 & E1.
5. DIMENSION b1 AND c1 APPLY TO BASE METAL ONLY.
6. DATUM A & B TO BE DETERMINED AT DATUM PLANE H.
7. CONTROLLING DIMENSION: INCH.
8. OUTLINE CONFORMS TO JEDEC OUTLINE TO–263AB.

D²Pak (TO-263AB) Part Marking Information

EXAMPLE: THIS IS AN IRF530S WITH
LOT CODE 8024
ASSEMBLED ON WW 02, 2000
IN THE ASSEMBLY LINE "L"

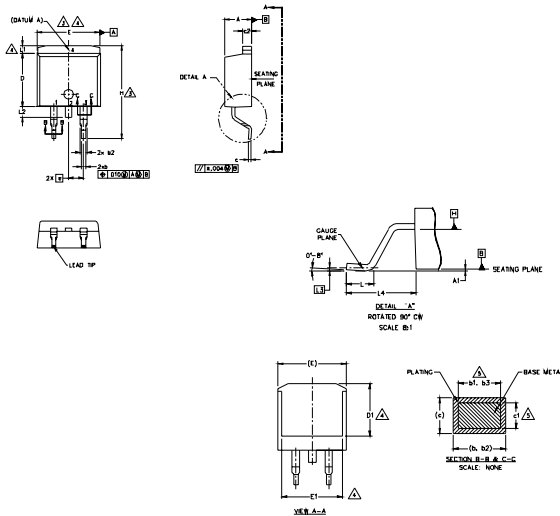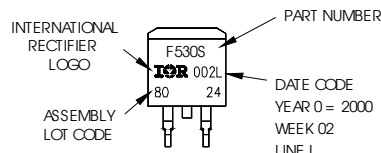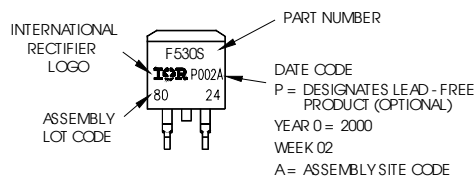Note: "P" in assembly line position
indicates "Lead – Free"

INTERNATIONAL RECTIFIER LOGO
PART NUMBER
ASSEMBLY LOT CODE
DATE CODE
YEAR 0 = 2000
WEEK 02
LINE L

OR

INTERNATIONAL RECTIFIER LOGO
PART NUMBER
ASSEMBLY LOT CODE
DATE CODE
P = DESIGNATES LEAD - FREE PRODUCT (OPTIONAL)
YEAR 0 = 2000
WEEK 02
A = ASSEMBLY SITE CODE

Notes:
1. For an Automotive Qualified version of this part please see http://www.irf.com/product-info/datasheets/data/auirf1405zs.pdf
2. For the most current drawing please refer to IR website at http://www.irf.com/package/

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www.irf.com

International
IΩR Rectifier

TO-262 Package Outline

Dimensions are shown in millimeters (inches)

NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M−1994

2. DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].

3. DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.127 [.005"] PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY.

4. THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSION E, L1, D1 & E1.

5. DIMENSION b1 AND c1 APPLY TO BASE METAL ONLY.

6. CONTROLLING DIMENSION: INCH.

7.− OUTLINE CONFORM TO JEDEC TO−262 EXCEPT A1(max.), b(min.) AND D1(min.) WHERE DIMENSIONS DERIVED THE ACTUAL PACKAGE OUTLINE.

SYMBOL	MILLIMETERS MIN.	MILLIMETERS MAX.	INCHES MIN.	INCHES MAX.	NOTES
A	4.06	4.83	.160	.190	
A1	2.03	3.02	.080	.119	
b	0.51	0.99	.020	.039	
b1	0.51	0.89	.020	.035	5
b2	1.14	1.78	.045	.070	
b3	1.14	1.73	.045	.068	5
c	0.38	0.74	.015	.029	
c1	0.38	0.58	.015	.023	5
c2	1.14	1.65	.045	.065	
D	8.38	9.65	.330	.380	3
D1	6.86	–	.270	–	4
E	9.65	10.67	.380	.420	3,4
E1	6.22	–	.245	–	4
e	2.54 BSC		.100 BSC		
L	13.46	14.10	.530	.555	
L1	–	1.65	–	.065	4
L2	3.56	3.71	.140	.146	

LEAD ASSIGNMENTS

HEXFET

1.− GATE
2.− DRAIN
3.− SOURCE
4.− DRAIN

IGBTs, CoPACK

1.− GATE
2.− COLLECTOR
3.− EMITTER
4.− COLLECTOR

TO-262 Part Marking Information

EXAMPLE: THIS IS AN IRL3103L
LOT CODE 1789
ASSEMBLED ON WW 19, 1997
IN THE ASSEMBLY LINE "C"

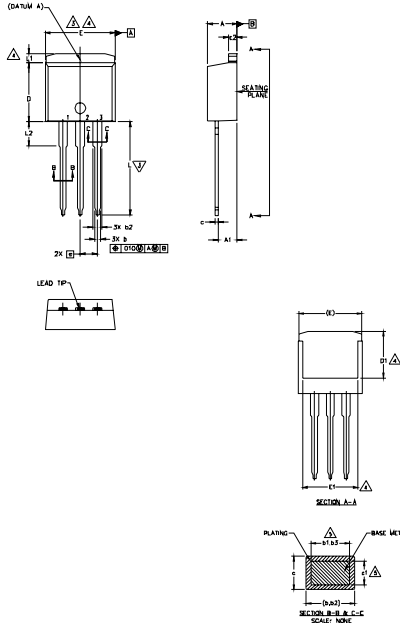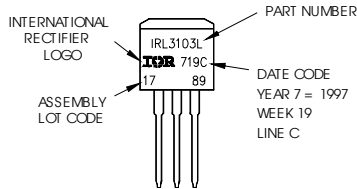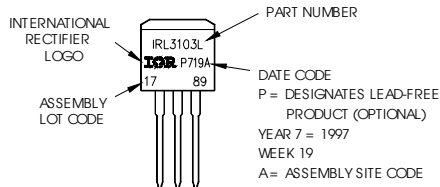Note: "P" in assembly line position indicates "Lead − Free"

INTERNATIONAL RECTIFIER LOGO

PART NUMBER

IRL3103L
IΩR 719C
17   89

DATE CODE
YEAR 7 = 1997
WEEK 19
LINE C

ASSEMBLY LOT CODE

OR

INTERNATIONAL RECTIFIER LOGO

PART NUMBER

IRL3103L
IΩR P719A
17   89

ASSEMBLY LOT CODE

DATE CODE
P = DESIGNATES LEAD-FREE PRODUCT (OPTIONAL)
YEAR 7 = 1997
WEEK 19
A = ASSEMBLY SITE CODE

Notes:

1. For an Automotive Qualified version of this part please see http://www.irf.com/product-info/datasheets/data/auirf1405zs.pdf

2. For the most current drawing please refer to IR website at http://www.irf.com/package/

IRF1405Z/S/LPbF

D²Pak Tape & Reel Information

Dimensions are shown in millimeters (inches)

TRR

FEED DIRECTION

TRL

FEED DIRECTION

1.60 (.063)
1.50 (.059)

4.10 (.161)
3.90 (.153)

1.85 (.073)
1.65 (.065)

⌀ 1.60 (.063)
1.50 (.059)

11.60 (.457)
11.40 (.449)

10.90 (.429)
10.70 (.421)

⌀ 1.75 (.069)
1.25 (.049)

16.10 (.634)
15.90 (.626)

0.368 (.0145)
0.342 (.0135)

15.42 (.609)
15.22 (.601)

24.30 (.957)
23.90 (.941)

4.72 (.136)
4.52 (.178)

13.50 (.532)
⌀ 12.80 (.504)

⌀ 330.00
(14.173)
MAX.

27.40 (1.079)
23.90 (.941)
④

⌀ 60.00 (2.362)
MIN.

30.40 (1.197)
MAX.
④

26.40 (1.039)
24.40 (.961)
③

NOTES :
1. COMFORMS TO EIA-418.
2. CONTROLLING DIMENSION: MILLIMETER.
③ DIMENSION MEASURED @ HUB.
④ INCLUDES FLANGE DISTORTION @ OUTER EDGE.

TO-220AB packages are not recommended for Surface Mount Application.

Data and specifications subject to change without notice.
This product has been designed and qualified for the Industrial market.
Qualification Standards can be found on IR's Web site.

International **I⊕R** Rectifier

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