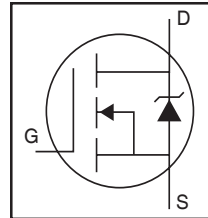International **IƆR** Rectifier
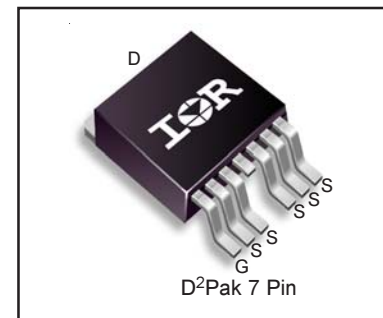
IRFS4010-7PPbF

HEXFET® Power MOSFET

Applications
- High Efficiency Synchronous Rectification in SMPS
- Uninterruptible Power Supply
- High Speed Power Switching
- Hard Switched and High Frequency Circuits

Benefits
- Improved Gate, Avalanche and Dynamic dV/dt Ruggedness
- Fully Characterized Capacitance and Avalanche SOA
- Enhanced body diode dV/dt and dI/dt Capability
- Lead-Free

V_{DSS}		100V
$R_{DS(on)}$	typ.	3.3mΩ
	max.	4.0mΩ
I_D		190A

D²Pak 7 Pin

G	D	S
Gate	Drain	Source

Absolute Maximum Ratings

Symbol	Parameter	Max.	Units
I_D @ T_C = 25°C	Continuous Drain Current, V_{GS} @ 10V	190	
I_D @ T_C = 100°C	Continuous Drain Current, V_{GS} @ 10V	130	A
I_{DM}	Pulsed Drain Current ①	740	
P_D @T_C = 25°C	Maximum Power Dissipation	380	W
	Linear Derating Factor	2.5	W/°C
V_{GS}	Gate-to-Source Voltage	± 20	V
dv/dt	Peak Diode Recovery ③	26	V/ns
T_J	Operating Junction and	-55 to + 175	°C
T_{STG}	Storage Temperature Range		
	Soldering Temperature, for 10 seconds (1.6mm from case)	300	
	Mounting torque, 6-32 or M3 screw	10lb·in (1.1N·m)	

Avalanche Characteristics

$E_{AS\ (Thermally\ limited)}$	Single Pulse Avalanche Energy ②	330	mJ
I_{AR}	Avalanche Current ①	See Fig. 14, 15, 22a, 22b,	A
E_{AR}	Repetitive Avalanche Energy ④		mJ

Thermal Resistance

Symbol	Parameter	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case ⑧⑨	——	0.40	°C/W
$R_{\theta JA}$	Junction-to-Ambient (PCB Mount) ⑦⑧	——	40	

1

International
IƏR Rectifier

Static @ T$_J$ = 25°C (unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Units	Conditions
V$_{(BR)DSS}$	Drain-to-Source Breakdown Voltage	100	——	——	V	V$_{GS}$ = 0V, I$_D$ = 250µA
ΔV$_{(BR)DSS}$/ΔT$_J$	Breakdown Voltage Temp. Coefficient	——	0.11	——	V/°C	Reference to 25°C, I$_D$ = 5mA①
R$_{DS(on)}$	Static Drain-to-Source On-Resistance	——	3.3	4.0	mΩ	V$_{GS}$ = 10V, I$_D$ = 110A ④
V$_{GS(th)}$	Gate Threshold Voltage	2.0	——	4.0	V	V$_{DS}$ = V$_{GS}$, I$_D$ = 250µA
I$_{DSS}$	Drain-to-Source Leakage Current	——	——	20	µA	V$_{DS}$ = 100V, V$_{GS}$ = 0V
		——	——	250		V$_{DS}$ = 100V, V$_{GS}$ = 0V, T$_J$ = 125°C
I$_{GSS}$	Gate-to-Source Forward Leakage	——	——	100	nA	V$_{GS}$ = 20V
	Gate-to-Source Reverse Leakage	——	——	-100		V$_{GS}$ = -20V
R$_{G(int)}$	Internal Gate Resistance	——	2.1	——	Ω	

Dynamic @ T$_J$ = 25°C (unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Units	Conditions
gfs	Forward Transconductance	210	——	——	S	V$_{DS}$ = 25V, I$_D$ = 110A
Q$_g$	Total Gate Charge	——	150	230	nC	I$_D$ = 110A
Q$_{gs}$	Gate-to-Source Charge	——	36	——		V$_{DS}$ = 50V
Q$_{gd}$	Gate-to-Drain ("Miller") Charge	——	48	——		V$_{GS}$ = 10V ④
Q$_{sync}$	Total Gate Charge Sync. (Q$_g$ - Q$_{gd}$)	——	102	——		I$_D$ = 110A, V$_{DS}$ =0V, V$_{GS}$ = 10V
t$_{d(on)}$	Turn-On Delay Time	——	19	——	ns	V$_{DD}$ = 65V
t$_r$	Rise Time	——	56	——		I$_D$ = 110A
t$_{d(off)}$	Turn-Off Delay Time	——	100	——		R$_G$ = 2.7Ω
t$_f$	Fall Time	——	48	——		V$_{GS}$ = 10V ④
C$_{iss}$	Input Capacitance	——	9830	——		V$_{GS}$ = 0V
C$_{oss}$	Output Capacitance	——	650	——		V$_{DS}$ = 50V
C$_{rss}$	Reverse Transfer Capacitance	——	260	——	pF	f = 1.0MHz
C$_{oss}$ eff. (ER)	Effective Output Capacitance (Energy Related)⑥	——	730	——		V$_{GS}$ = 0V, V$_{DS}$ = 0V to 80V ⑥
C$_{oss}$ eff. (TR)	Effective Output Capacitance (Time Related)⑤	——	740	——		V$_{GS}$ = 0V, V$_{DS}$ = 0V to 80V ⑤

Diode Characteristics

Symbol	Parameter	Min.	Typ.	Max.	Units	Conditions
I$_S$	Continuous Source Current (Body Diode)	——	——	186	A	MOSFET symbol showing the integral reverse p-n junction diode.
I$_{SM}$	Pulsed Source Current (Body Diode) ①	——	——	740		
V$_{SD}$	Diode Forward Voltage	——	——	1.3	V	T$_J$ = 25°C, I$_S$ = 110A, V$_{GS}$ = 0V ④
t$_{rr}$	Reverse Recovery Time	——	60	——	ns	T$_J$ = 25°C V$_R$ = 85V,
		——	67	——		T$_J$ = 125°C I$_F$ = 110A
Q$_{rr}$	Reverse Recovery Charge	——	150	——	nC	T$_J$ = 25°C di/dt = 100A/µs ④
		——	180	——		T$_J$ = 125°C
I$_{RRM}$	Reverse Recovery Current	——	4.7	——	A	T$_J$ = 25°C
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.

② Limited by T$_{Jmax}$, starting T$_J$ = 25°C, L = 0.052mH
R$_G$ = 25Ω, I$_{AS}$ = 110A, V$_{GS}$ =10V. Part not recommended for use above this value .

③ I$_{SD}$ ≤ 110A, di/dt ≤ 1310A/µs, V$_{DD}$ ≤ V$_{(BR)DSS}$, T$_J$ ≤ 175°C.

④ Pulse width ≤ 400µs; duty cycle ≤ 2%.

⑤ C$_{oss}$ eff. (TR) is a fixed capacitance that gives the same charging time as C$_{oss}$ while V$_{DS}$ is rising from 0 to 80% V$_{DSS}$.

⑥ C$_{oss}$ eff. (ER) is a fixed capacitance that gives the same energy as C$_{oss}$ while V$_{DS}$ is rising from 0 to 80% V$_{DSS}$.

⑦ When mounted on 1" square PCB (FR-4 or G-10 Material). For recom mended footprint and soldering techniques refer to application note #AN-994.

⑧ R$_θ$ is measured at T$_J$ approximately 90°C.

⑨ R$_{θJC}$ value shown is at time zero.
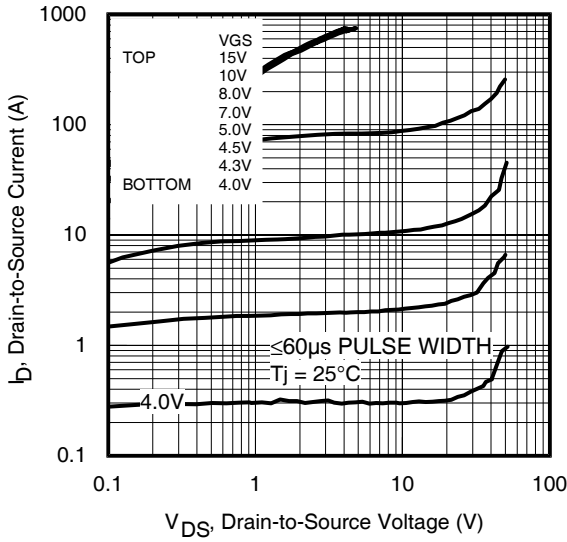
www.irf.com

Fig 1. Typical Output Characteristics
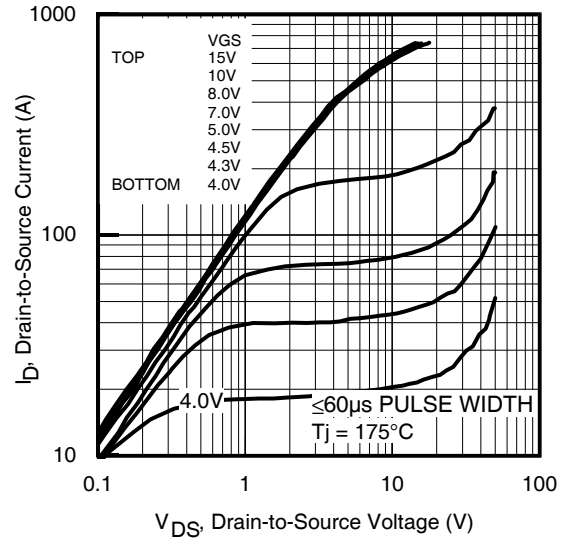

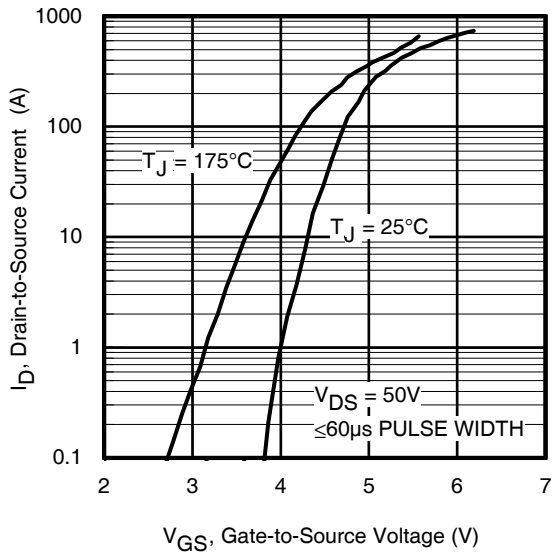**Fig 2.** Typical Output Characteristics

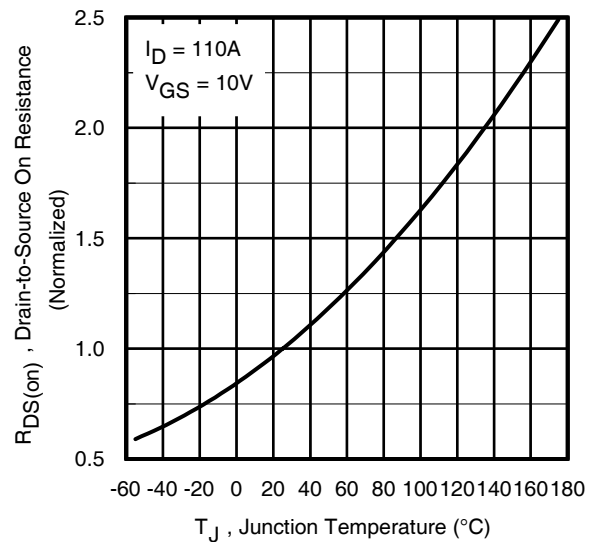
Fig 3. Typical Transfer Characteristics
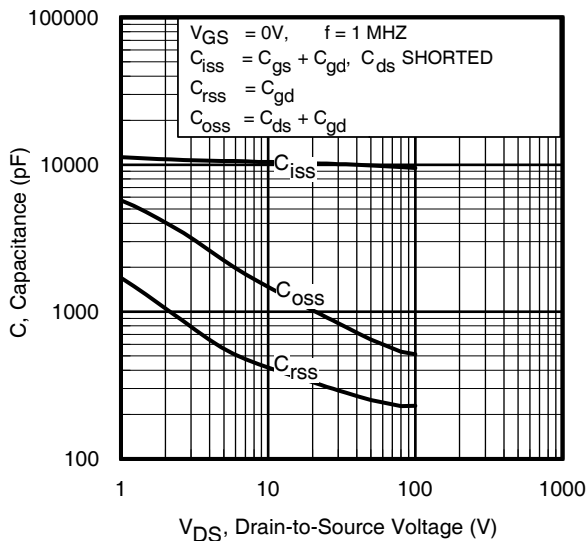

Fig 4. Normalized On-Resistance vs. Temperature

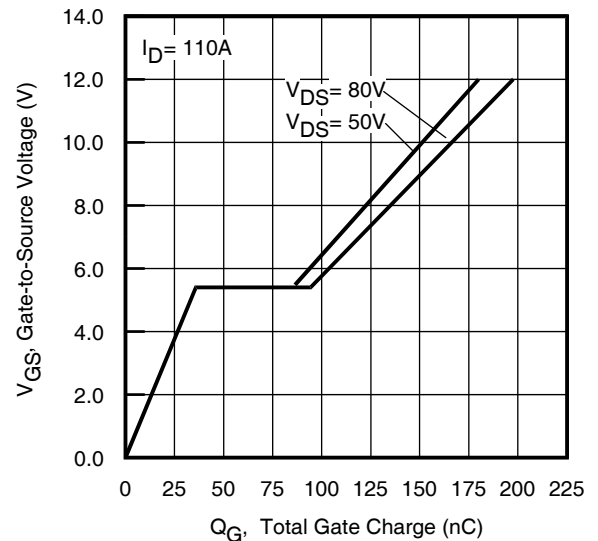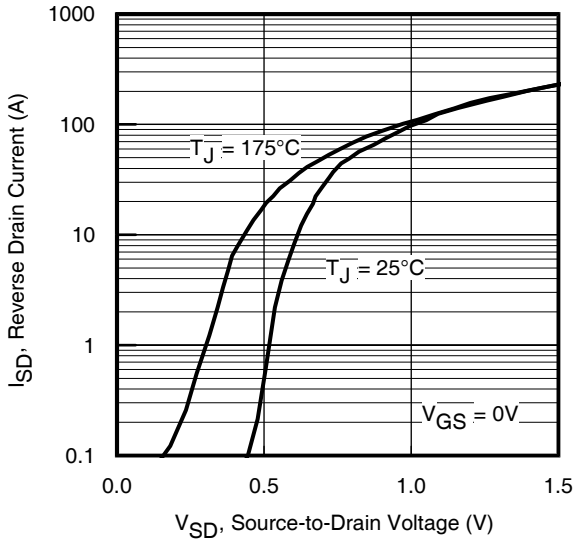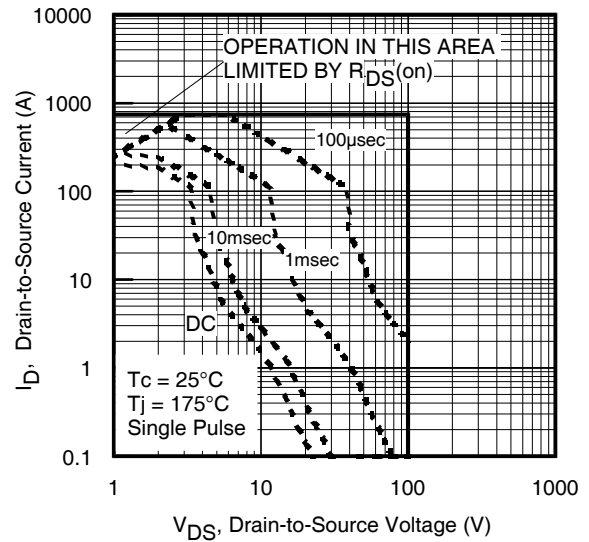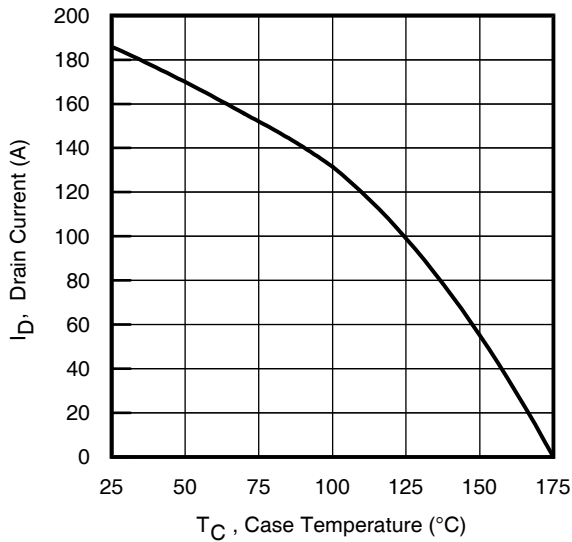**Fig 5.** Typical Capacitance vs. Drain-to-Source Voltage

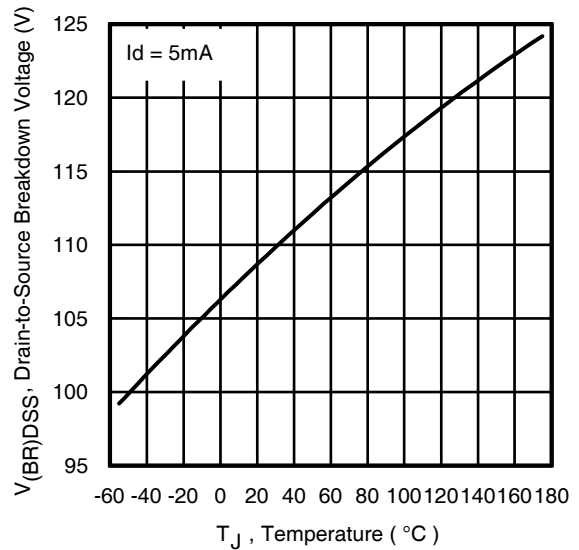**Fig 6.** Typical Gate Charge vs. Gate-to-Source Voltage

Fig 7. Typical Source-Drain Diode
Forward Voltage

Fig 8. Maximum Safe Operating Area
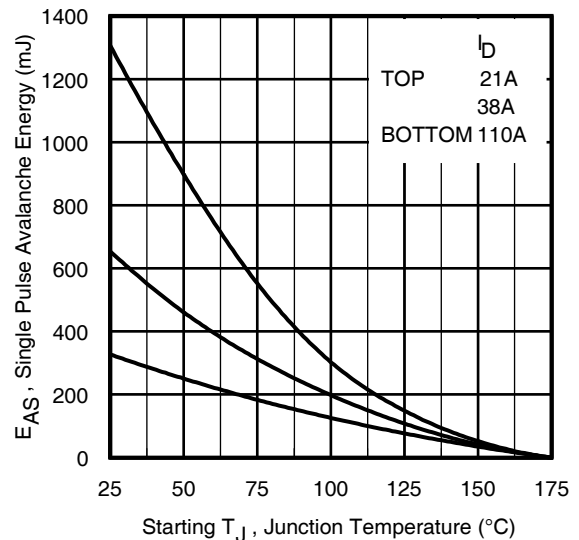

Fig 9. Maximum Drain Current vs.
Case Temperature

Fig 10. Drain-to-Source Breakdown Voltage

Fig 11. Typical C_{OSS} Stored Energy
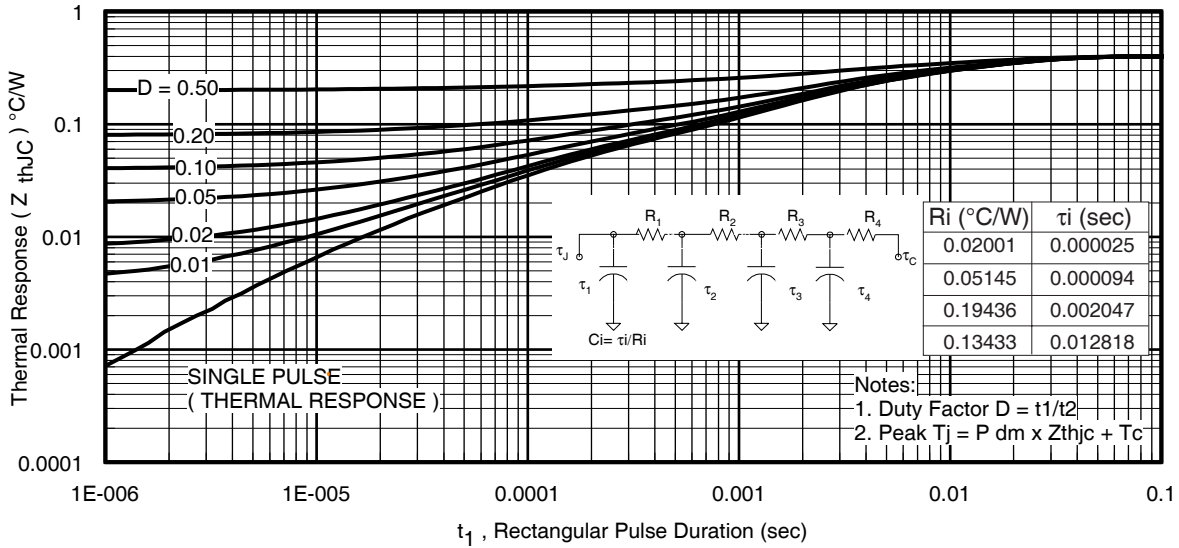

Fig 12. Maximum Avalanche Energy vs. Drain Current

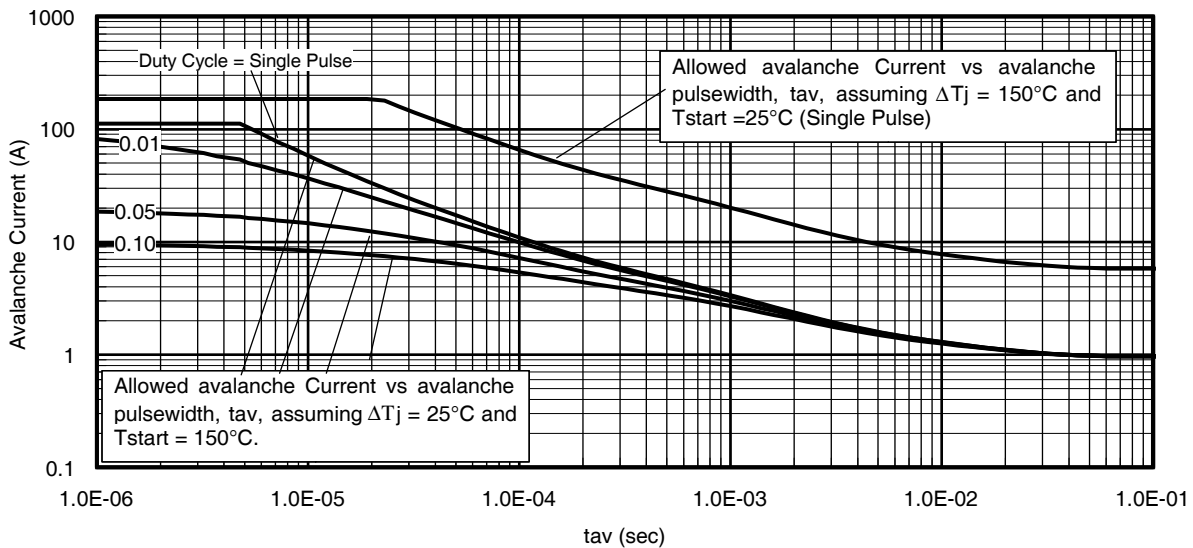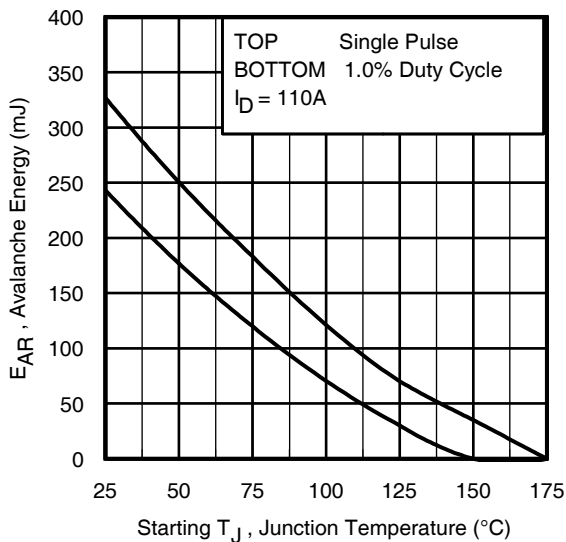**Fig 13.** Maximum Effective Transient Thermal Impedance, Junction-to-Case

Fig 14. Typical Avalanche Current vs.Pulsewidth

Fig 15. Maximum Avalanche Energy vs. Temperature

Notes on Repetitive Avalanche Curves , Figures 14, 15:
(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 as T_{jmax} is not exceeded.
3. Equation below based on circuit and waveforms shown in Figures 16a, 16b.
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 14, 15).
   t_{av} = Average time in avalanche.
   D = Duty cycle in avalanche = $t_{av} \cdot f$
   $Z_{thJC}(D, t_{av})$ = Transient thermal resistance, see Figures 13)

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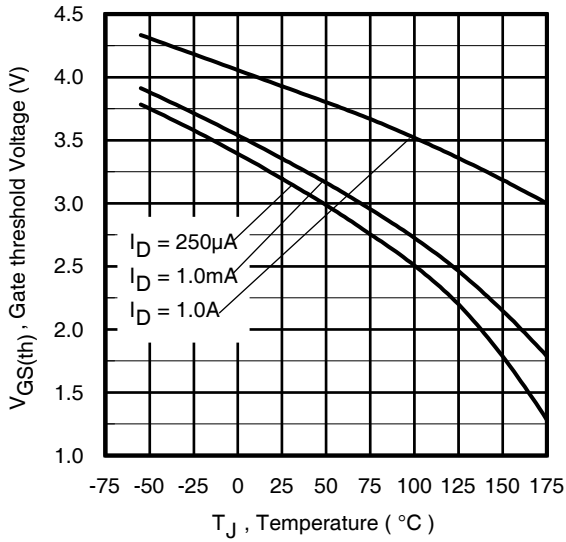$$E_{AS\,(AR)} = P_{D\,(ave)} \cdot t_{av}$$

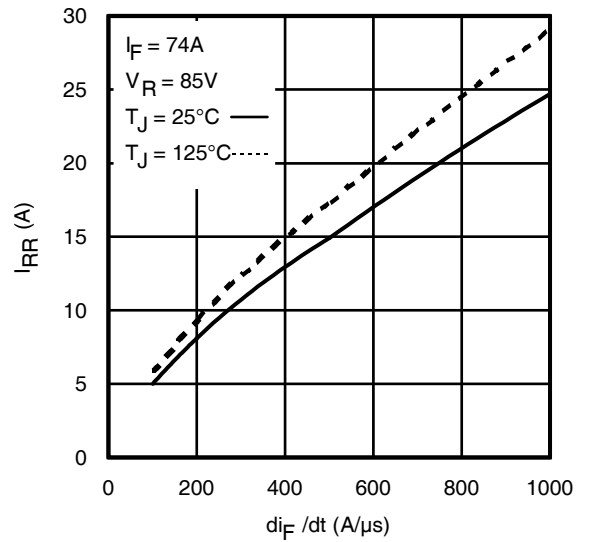**Fig 16.** Threshold Voltage vs. Temperature

Fig. 17 - Typical Recovery Current vs. di$_f$/dt
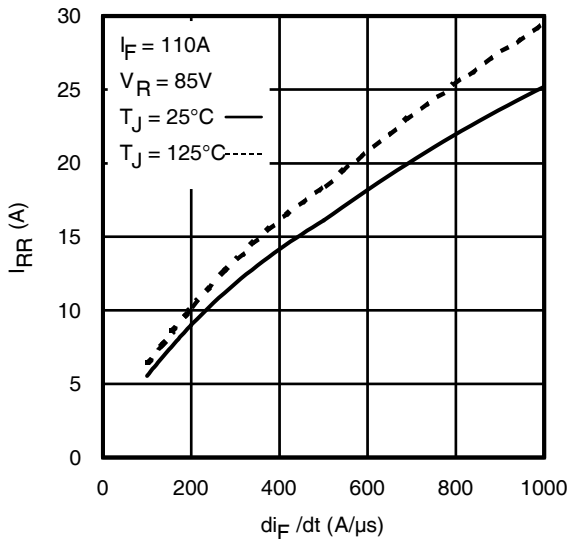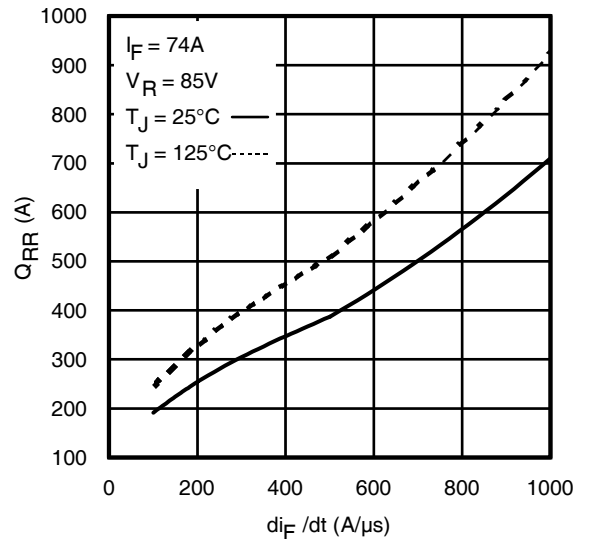

Fig. 18 - Typical Recovery Current vs. di$_f$/dt

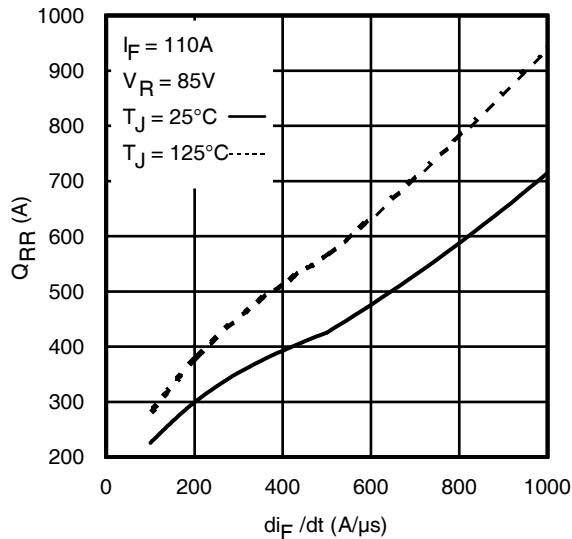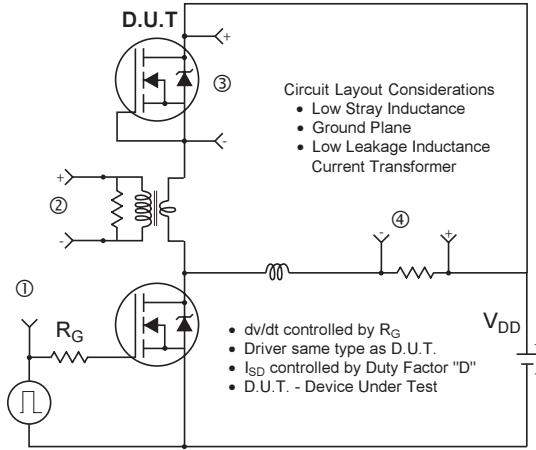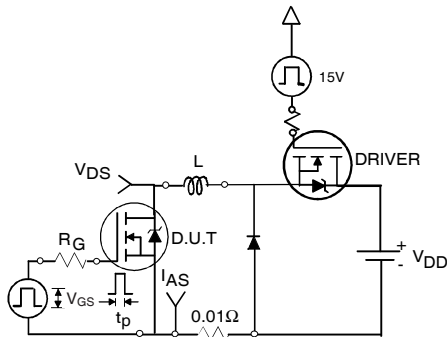**Fig. 19** - Typical Stored Charge vs. di$_f$/dt

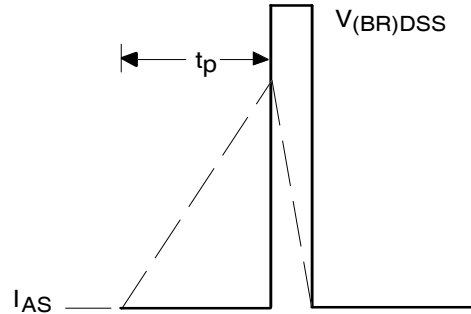**Fig. 20** - Typical Stored Charge vs. di$_f$/dt

Fig 21. Peak Diode Recovery dv/dt Test Circuit for N-Channel HEXFET® Power MOSFETs
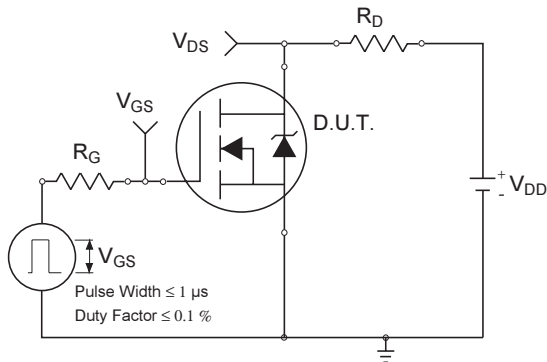
$* V_{GS} = 5V$ for Logic Level Devices
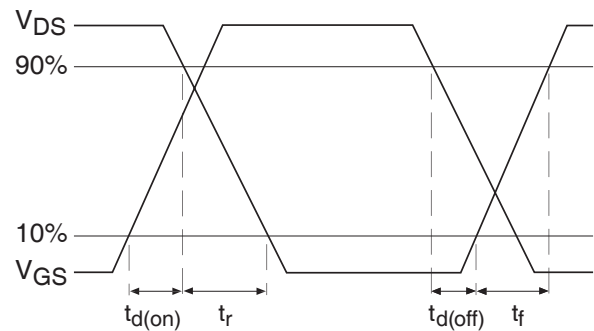

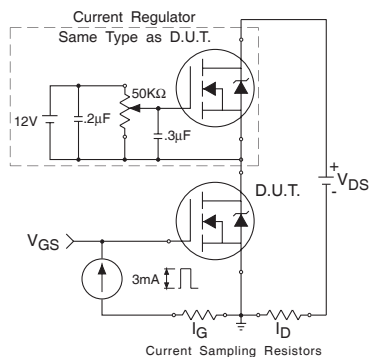**Fig 22a.** Unclamped Inductive Test Circuit

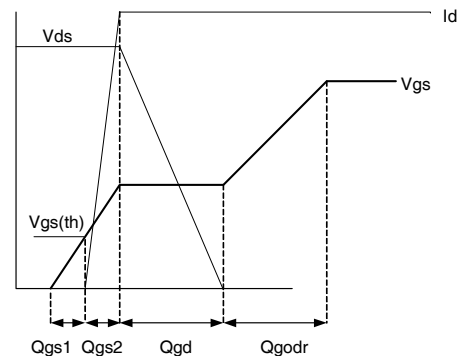**Fig 22b.** Unclamped Inductive Waveforms

Fig 23a. Switching Time Test Circuit
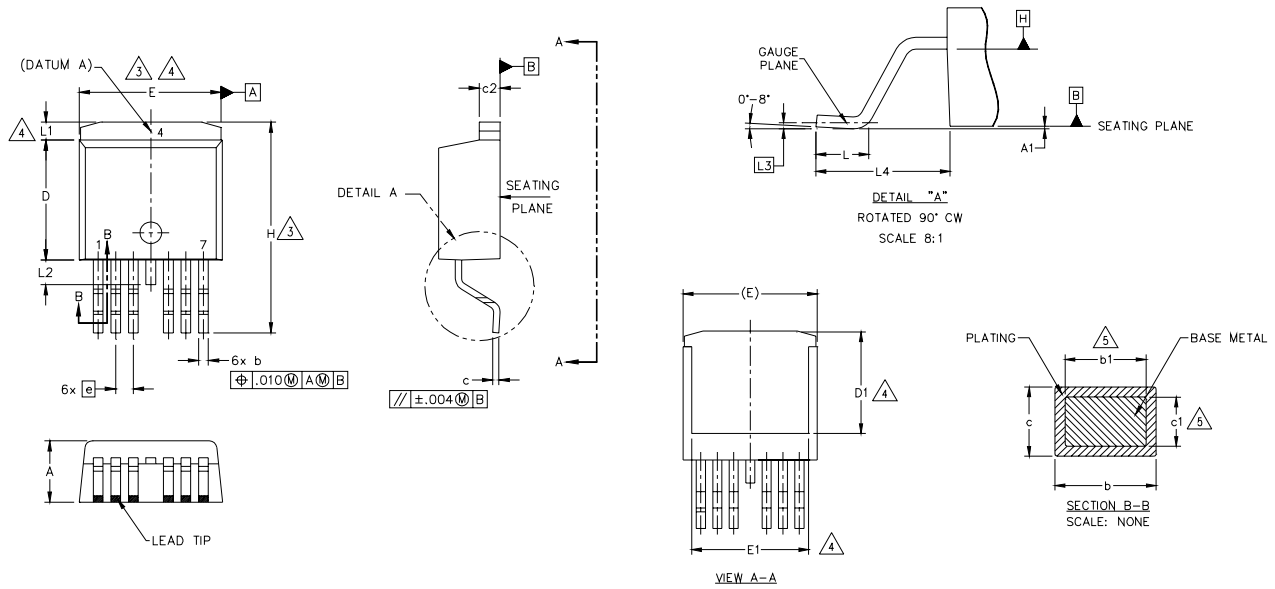

Fig 23b. Switching Time Waveforms

Fig 24a. Gate Charge Test Circuit

Fig 24b. Gate Charge Waveform

D²Pak - 7 Pin 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	–	0.254	–	.010	
b	0.51	0.99	.020	.036	
b1	0.51	0.89	.020	.032	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	1.27 BSC		.050 BSC		
H	14.61	15.88	.575	.625	
L	1.78	2.79	.070	.110	
L1	–	1.68	–	.066	4
L2	–	1.78	–	.070	
L3	0.25 BSC		.010 BSC		
L4	4.78	5.28	.188	.208	

NOTES:

1. DIMENSIONING AND TOLERANCING AS 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.
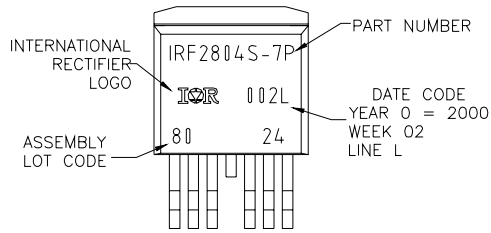
8. OUTLINE CONFORMS TO JEDEC OUTLINE TO−263CB.

Note: For the most current drawing please refer to IR website at http://www.irf.com/package/
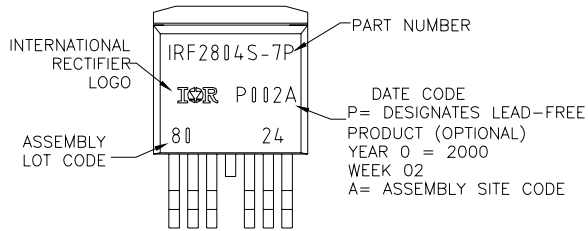
International IRR Rectifier

D²Pak - 7 Pin Part Marking Information

EXAMPLE: THIS IS AN IRF2804S-7P WITH
LOT CODE 8024
ASSEMBLED ON WW02,2000
IN THE ASSEMBLY LINE "L"

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

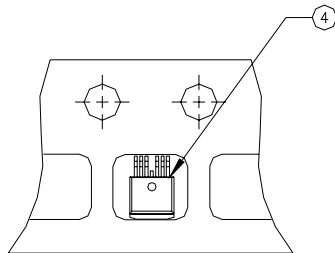PART NUMBER
INTERNATIONAL
RECTIFIER
LOGO
IRF2804S-7P
IRR   002L
80   24
ASSEMBLY
LOT CODE
DATE CODE
YEAR 0 = 2000
WEEK 02
LINE L

OR

PART NUMBER
INTERNATIONAL
RECTIFIER
LOGO
IRF2804S-7P
IRR P002A
80   24
ASSEMBLY
LOT CODE
DATE CODE
P= DESIGNATES LEAD-FREE
PRODUCT (OPTIONAL)
YEAR 0 = 2000
WEEK 02
A= ASSEMBLY SITE CODE

D²Pak - 7 Pin Tape and Reel

NOTES, TAPE & REEL, LABELLING:

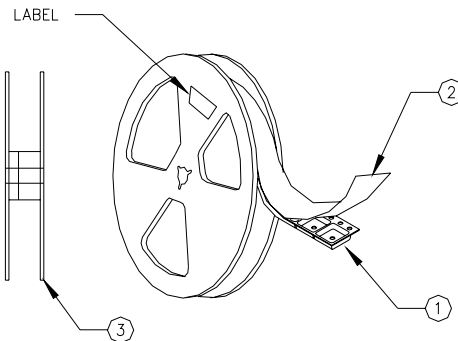1. TAPE AND REEL.
   1.1 REEL SIZE 13 INCH DIAMETER.
   1.2 EACH REEL CONTAINING 800 DEVICES.
   1.3 THERE SHALL BE A MINIMUM OF 42 SEALED POCKETS
       CONTAINED IN THE LEADER AND A MINIMUM OF 15
       SEALED POCKETS IN THE TRAILER.
   1.4 PEEL STRENGTH MUST CONFORM TO THE SPEC. NO.
       71-9667.
   1.5 PART ORIENTATION SHALL BE AS SHOWN BELOW.
   1.6 REEL MAY CONTAIN A MAXIMUM OF TWO UNIQUE
       LOT CODE/DATE CODE COMBINATIONS.
       REWORKED REELS MAY CONTAIN A MAXIMUM OF
       THREE UNIQUE LOT CODE/DATE CODE COMBINATIONS.
       HOWEVER, THE LOT CODES AND DATE CODES WITH THEIR
       RESPECTIVE QUANTITIES SHALL APPEAR ON THE BAR
       CODE LABEL FOR THE AFFECTED REEL.

2. LABELLING (REEL AND SHIPPING BAG).
   2.1 CUST. PART NUMBER (BAR CODE): IRFXXXXSTRL-7P
   2.2 CUST. PART NUMBER (TEXT CODE): IRFXXXXSTRL-7P
   2.3 I.R. PART NUMBER: IRFXXXXSTRL-7P
   2.4 QUANTITY:
   2.5 VENDOR CODE: IR
   2.6 LOT CODE:
   2.7 DATE CODE:

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

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 IRR Rectifier