



**Features**

- Advanced Process Technology
- New Ultra Low On-Resistance
- 175°C Operating Temperature
- Fast Switching
- Repetitive Avalanche Allowed up to Tjmax
- Lead-Free, RoHS Compliant
- Automotive Qualified \*

HEXFET® Power MOSFET

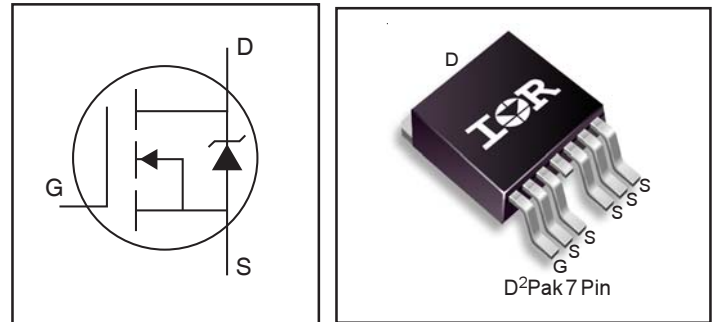
<b>V<sub>DSS</sub></b>	<b>40V</b>
<b>R<sub>DS(on)</sub> typ.</b>	<b>0.55mΩ</b>
<b>max.</b>	<b>0.75mΩ</b>
<b>I<sub>D</sub> (Silicon Limited)</b>	<b>522A<sup>①</sup></b>
<b>I<sub>D</sub> (Package Limited)</b>	<b>240A</b>

**Description**

Specifically designed for Automotive applications, 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 product an extremely efficient and reliable device for use in Automotive and wide variety of other applications.

**Applications**

- Electric Power Steering (EPS)
- Battery Switch
- Start/Stop Micro Hybrid
- Heavy Loads
- SMPS



<b>G</b>	<b>D</b>	<b>S</b>
Gate	Drain	Source

**Ordering Information**

Base part number	Package Type	Standard Pack		Complete Part Number
		Form	Quantity	
AUIRFS8409-7P	D²Pak 7 Pin	Tube	50	AUIRFS8409-7P
		Tape and Reel Left	800	AUIRFS8409-7TRL
		Tape and Reel Right	800	AUIRFS8409-7TRR

**Absolute Maximum Ratings**

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only; and functional operation of the device at these or any other condition beyond those indicated in the specifications is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability. The thermal resistance and power dissipation ratings are measured under board mounted and still air conditions. Ambient temperature (T<sub>A</sub>) is 25°C, unless otherwise specified.

Symbol	Parameter	Max.	Units
I <sub>D</sub> @ T <sub>C</sub> = 25°C	Continuous Drain Current, V <sub>GS</sub> @ 10V (Silicon Limited)	522 <sup>①</sup>	A
I <sub>D</sub> @ T <sub>C</sub> = 100°C	Continuous Drain Current, V <sub>GS</sub> @ 10V (Silicon Limited)	369 <sup>①</sup>	
I <sub>D</sub> @ T <sub>C</sub> = 25°C	Continuous Drain Current, V <sub>GS</sub> @ 10V (Package Limited)	240	
I <sub>DM</sub>	Pulsed Drain Current <sup>②</sup>	1200 <sup>②</sup>	
P <sub>D</sub> @ T <sub>C</sub> = 25°C	Maximum Power Dissipation	375	W
	Linear Derating Factor	2.5	W/°C
V <sub>GS</sub>	Gate-to-Source Voltage	± 20	V
T <sub>J</sub>	Operating Junction and	-55 to + 175	°C
T <sub>STG</sub>	Storage Temperature Range		
	Soldering Temperature, for 10 seconds (1.6mm from case)	300	

**Avalanche Characteristics**

E <sub>AS</sub> (Thermally limited)	Single Pulse Avalanche Energy <sup>③</sup>	764	mJ
E <sub>AS</sub> (tested)	Single Pulse Avalanche Energy Tested Value <sup>③</sup>	1485	
I <sub>AR</sub>	Avalanche Current <sup>②</sup>	See Fig. 14, 15, 24a, 24b	A
E <sub>AR</sub>	Repetitive Avalanche Energy <sup>②</sup>		mJ

**Thermal Resistance**

Symbol	Parameter	Typ.	Max.	Units
R <sub>θJC</sub>	Junction-to-Case <sup>④</sup>	—	0.4	°C/W
R <sub>θJA</sub>	Junction-to-Ambient (PCB Mount) <sup>④</sup>	—	40	

HEXFET® is a registered trademark of International Rectifier.

\*Qualification standards can be found at <http://www.irf.com/>

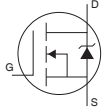
**Static @ T<sub>J</sub> = 25°C (unless otherwise specified)**

Symbol	Parameter	Min.	Typ.	Max.	Units	Conditions
V <sub>(BR)DSS</sub>	Drain-to-Source Breakdown Voltage	40	—	—	V	V <sub>GS</sub> = 0V, I <sub>D</sub> = 250μA
ΔV <sub>(BR)DSS</sub> /ΔT <sub>J</sub>	Breakdown Voltage Temp. Coefficient	—	0.026	—	V/°C	Reference to 25°C, I <sub>D</sub> = 2mA <sup>②</sup>
R <sub>DS(on)</sub>	Static Drain-to-Source On-Resistance	—	0.55	0.75	mΩ	V <sub>GS</sub> = 10V, I <sub>D</sub> = 100A <sup>⑤</sup>
V <sub>GS(th)</sub>	Gate Threshold Voltage	2.2	3.0	3.9	V	V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250μA
I <sub>DSS</sub>	Drain-to-Source Leakage Current	—	—	1.0	μA	V <sub>DS</sub> = 40V, V <sub>GS</sub> = 0V
		—	—	150		V <sub>DS</sub> = 40V, V <sub>GS</sub> = 0V, T <sub>J</sub> = 125°C
I <sub>GSS</sub>	Gate-to-Source Forward Leakage	—	—	100	nA	V <sub>GS</sub> = 20V
	Gate-to-Source Reverse Leakage	—	—	-100		V <sub>GS</sub> = -20V
R <sub>G</sub>	Internal Gate Resistance	—	2.2	—	Ω	

**Dynamic @ T<sub>J</sub> = 25°C (unless otherwise specified)**

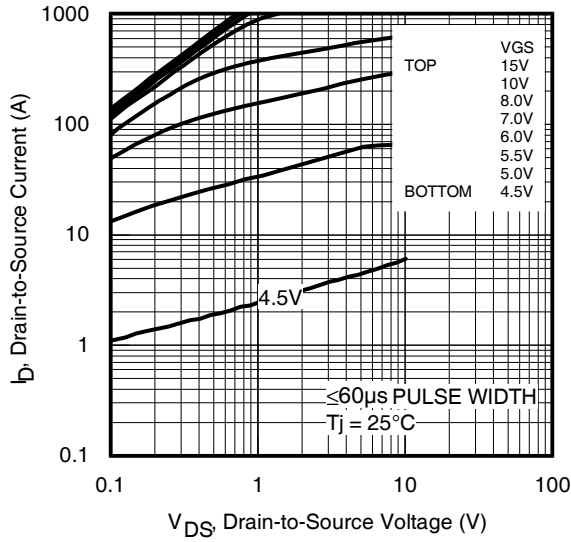
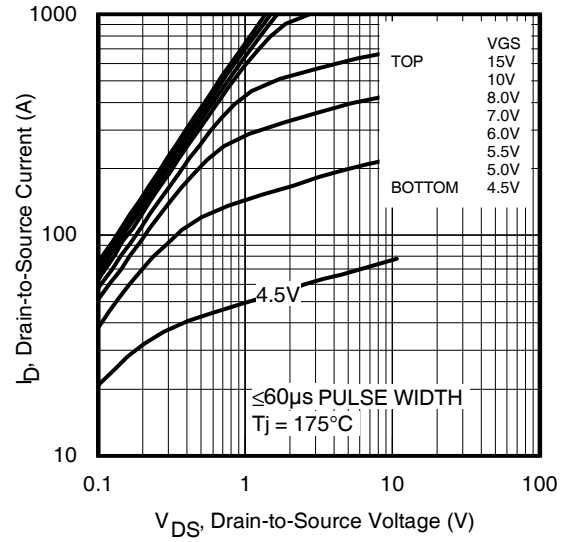
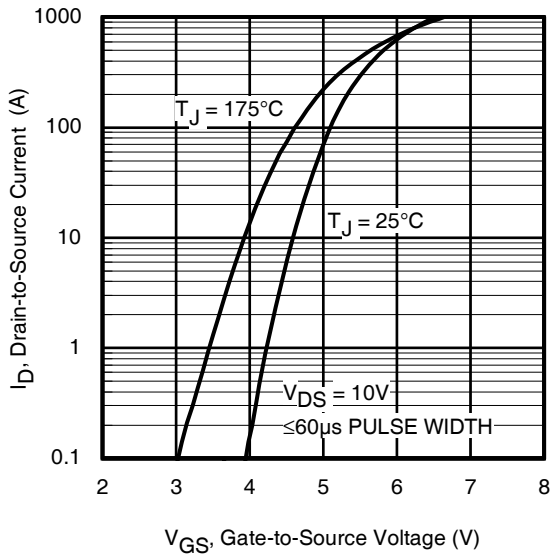
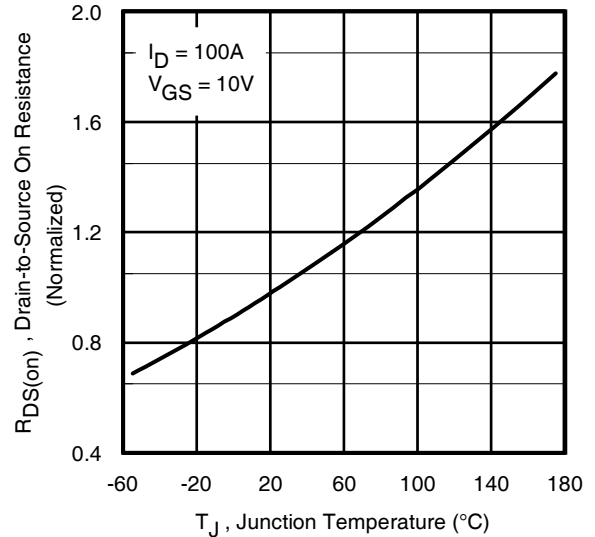
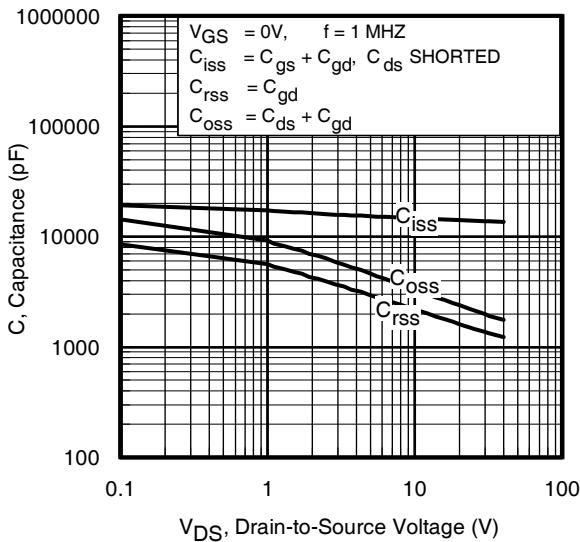
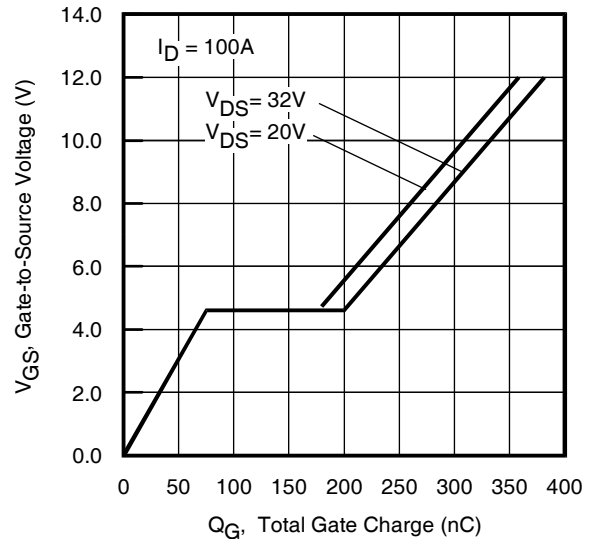
Symbol	Parameter	Min.	Typ.	Max.	Units	Conditions
g <sub>fs</sub>	Forward Transconductance	176	—	—	S	V <sub>DS</sub> = 10V, I <sub>D</sub> = 100A
Q <sub>g</sub>	Total Gate Charge	—	305	460	nC	I <sub>D</sub> = 100A
Q <sub>gs</sub>	Gate-to-Source Charge	—	84	—		V <sub>DS</sub> = 20V
Q <sub>gd</sub>	Gate-to-Drain ("Miller") Charge	—	96	—		V <sub>GS</sub> = 10V <sup>⑤</sup>
Q <sub>sync</sub>	Total Gate Charge Sync. (Q <sub>g</sub> - Q <sub>gd</sub> )	—	209	—		I <sub>D</sub> = 100A, V <sub>DS</sub> = 0V, V <sub>GS</sub> = 10V
t <sub>d(on)</sub>	Turn-On Delay Time	—	32	—	ns	V <sub>DD</sub> = 20V
t <sub>r</sub>	Rise Time	—	148	—		I <sub>D</sub> = 100A
t <sub>d(off)</sub>	Turn-Off Delay Time	—	149	—		R <sub>G</sub> = 2.7Ω
t <sub>f</sub>	Fall Time	—	107	—		V <sub>GS</sub> = 10V <sup>⑤</sup>
C <sub>iss</sub>	Input Capacitance	—	13975	—	pF	V <sub>GS</sub> = 0V
C <sub>oss</sub>	Output Capacitance	—	2140	—		V <sub>DS</sub> = 25V
C <sub>rss</sub>	Reverse Transfer Capacitance	—	1438	—		f = 1.0 MHz, See Fig. 5
C <sub>oss</sub> eff. (ER)	Effective Output Capacitance (Energy Related)	—	2620	—		V <sub>GS</sub> = 0V, V <sub>DS</sub> = 0V to 32V <sup>⑦</sup> , See Fig. 11
C <sub>oss</sub> eff. (TR)	Effective Output Capacitance (Time Related)	—	3306	—		V <sub>GS</sub> = 0V, V <sub>DS</sub> = 0V to 32V <sup>⑧</sup>

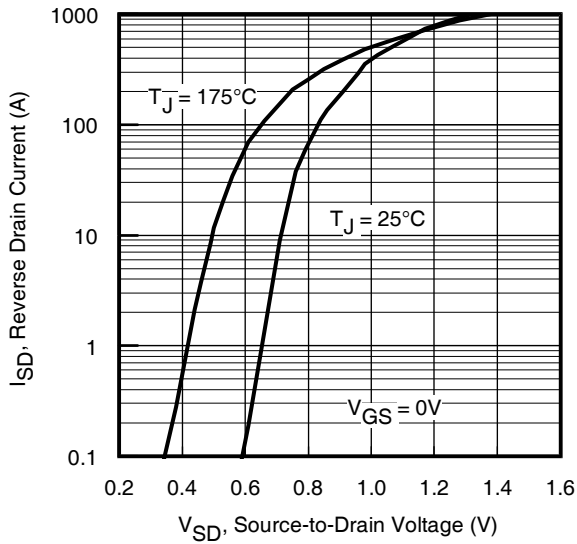
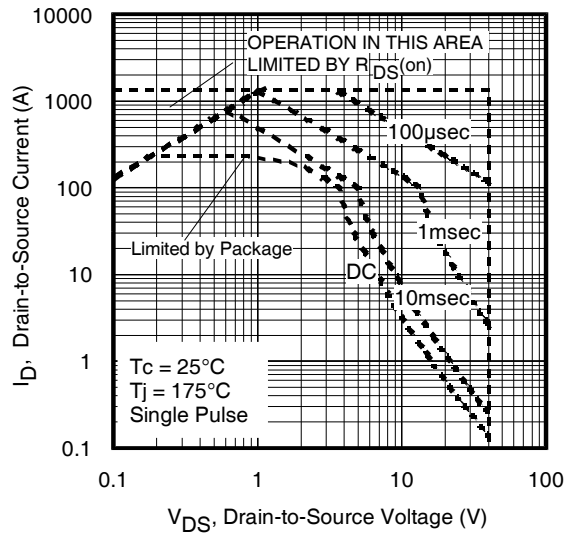
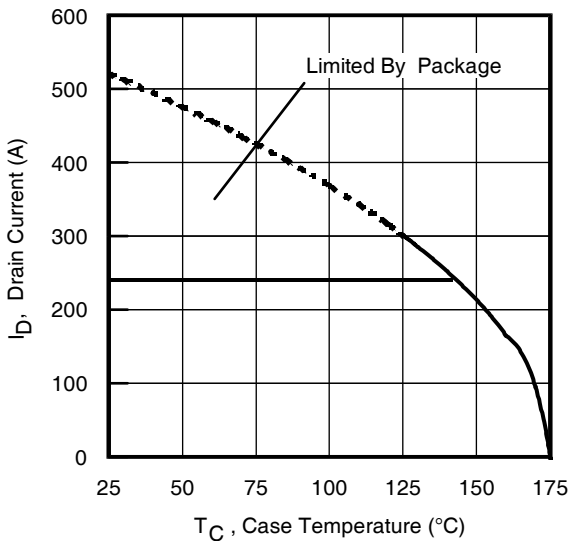
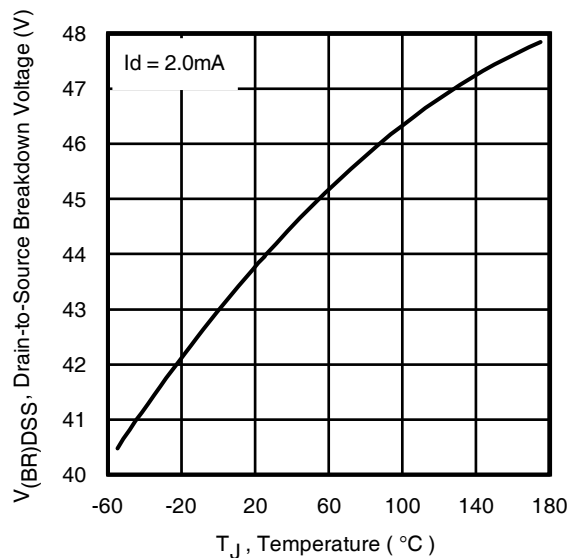
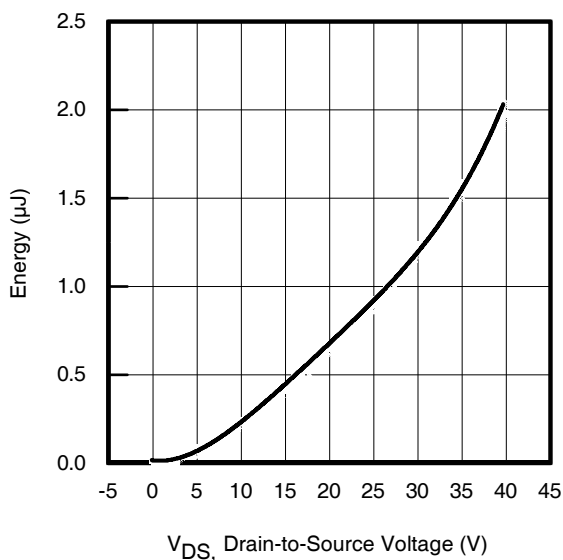
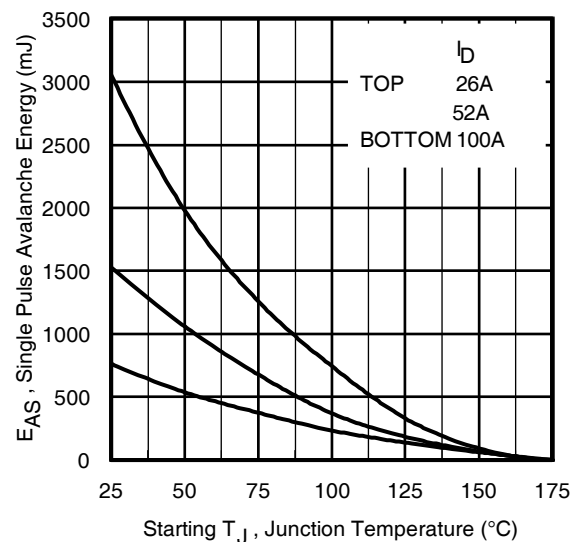
**Diode Characteristics**

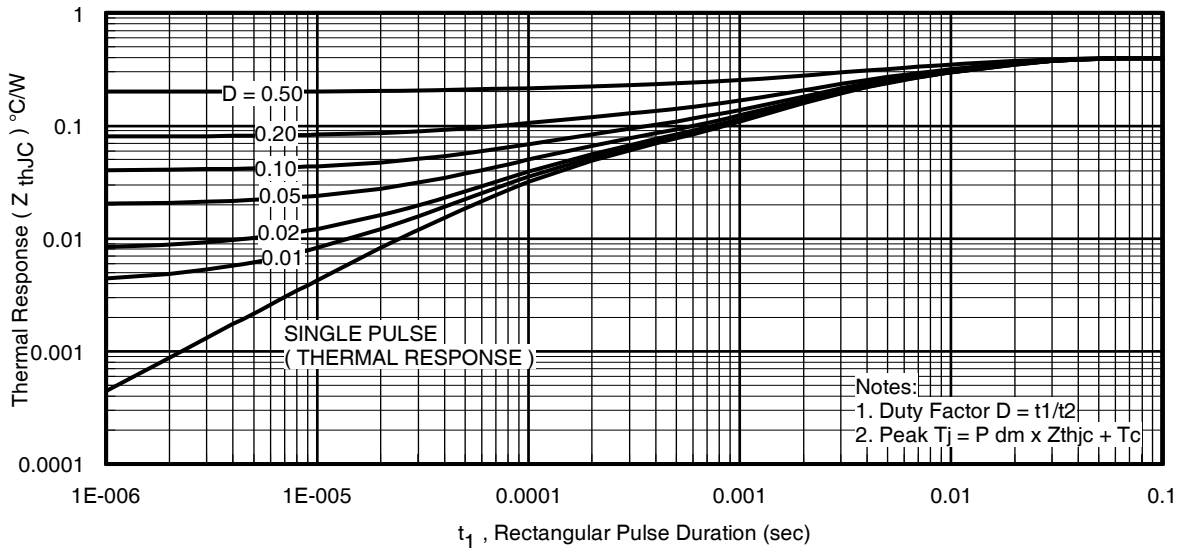
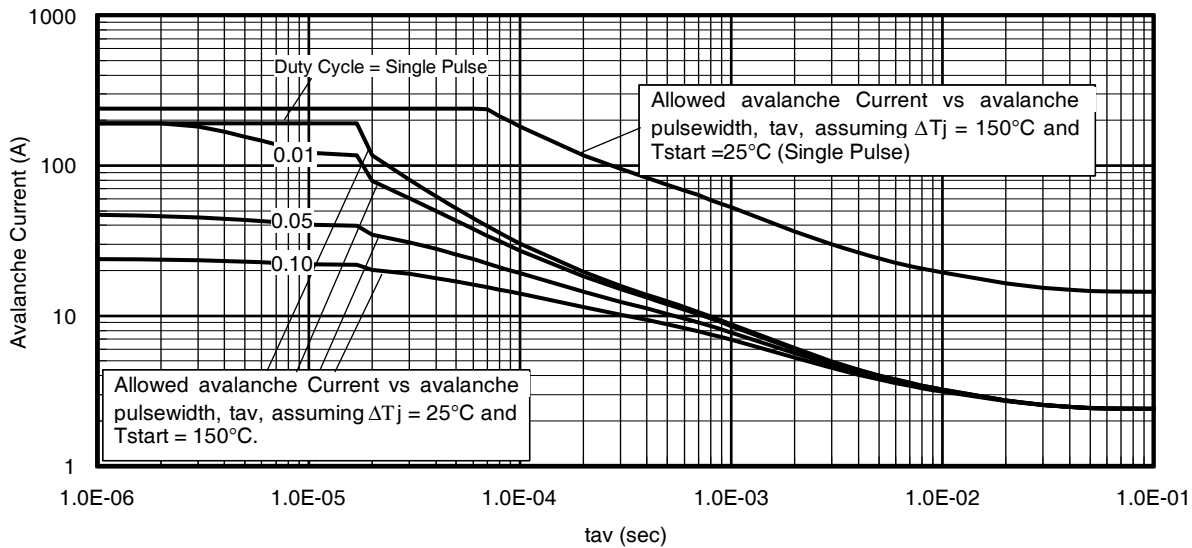
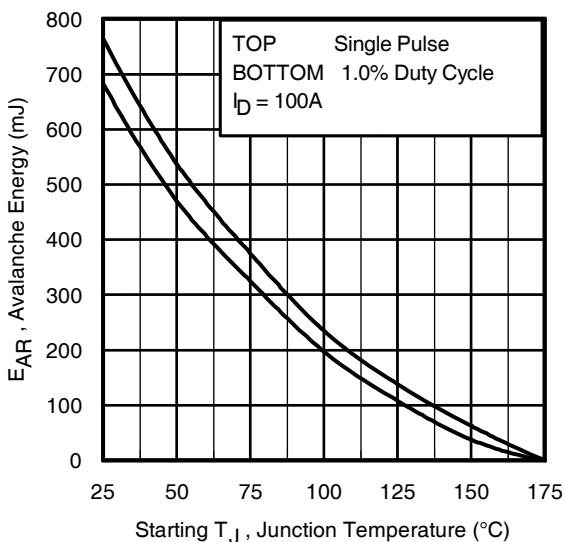
Symbol	Parameter	Min.	Typ.	Max.	Units	Conditions
I <sub>S</sub>	Continuous Source Current (Body Diode)	—	—	522 <sup>①</sup>	A	MOSFET symbol showing the integral reverse p-n junction diode. 
I <sub>SM</sub>	Pulsed Source Current (Body Diode) <sup>②</sup>	—	—	1200 <sup>⑩</sup>		
V <sub>SD</sub>	Diode Forward Voltage	—	0.8	1.2	V	T <sub>J</sub> = 25°C, I <sub>S</sub> = 100A, V <sub>GS</sub> = 0V <sup>⑤</sup>
dv/dt	Peak Diode Recovery <sup>④</sup>	—	1.6	—	V/ns	T <sub>J</sub> = 175°C, I <sub>S</sub> = 100A, V <sub>DS</sub> = 40V
t <sub>rr</sub>	Reverse Recovery Time	—	50	—	ns	T <sub>J</sub> = 25°C V <sub>R</sub> = 34V,
		—	58	—		T <sub>J</sub> = 125°C I <sub>F</sub> = 100A
Q <sub>rr</sub>	Reverse Recovery Charge	—	59	—	nC	T <sub>J</sub> = 25°C di/dt = 100A/μs <sup>⑤</sup>
		—	72	—		T <sub>J</sub> = 125°C
I <sub>RRM</sub>	Reverse Recovery Current	—	2.2	—	A	T <sub>J</sub> = 25°C

**Notes:**

- ① Calculated continuous current based on maximum allowable junction temperature. Bond wire current limit is 240A by source bonding technology. Note that current limitations arising from heating of the device leads may occur with some lead mounting arrangements. (Refer to AN-1140)
- ② Repetitive rating; pulse width limited by max. junction temperature.
- ③ Limited by T<sub>Jmax</sub>, starting T<sub>J</sub> = 25°C, L = 0.153mH, R<sub>G</sub> = 50Ω, I<sub>AS</sub> = 100A, V<sub>GS</sub> = 10V. Part not recommended for use above this value.
- ④ I<sub>SD</sub> ≤ 100A, di/dt ≤ 1403A/μs, V<sub>DD</sub> ≤ V<sub>(BR)DSS</sub>, T<sub>J</sub> ≤ 175°C.
- ⑤ Pulse width ≤ 400μs; duty cycle ≤ 2%.
- ⑥ C<sub>oss</sub> eff. (TR) is a fixed capacitance that gives the same charging time as C<sub>oss</sub> while V<sub>DS</sub> is rising from 0 to 80% V<sub>DSS</sub>.
- ⑦ C<sub>oss</sub> eff. (ER) is a fixed capacitance that gives the same energy as C<sub>oss</sub> while V<sub>DS</sub> is rising from 0 to 80% V<sub>DSS</sub>.
- ⑧ When mounted on 1" square PCB (FR-4 or G-10 Material). For recommended footprint and soldering techniques refer to application note #AN-994.
- ⑨ R<sub>θ</sub> is measured at T<sub>J</sub> approximately 90°C.
- ⑩ Pulse drain current is limited by source bonding technology.


**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

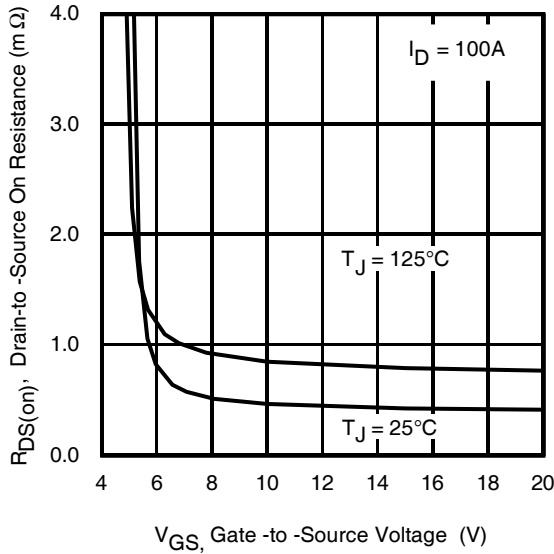
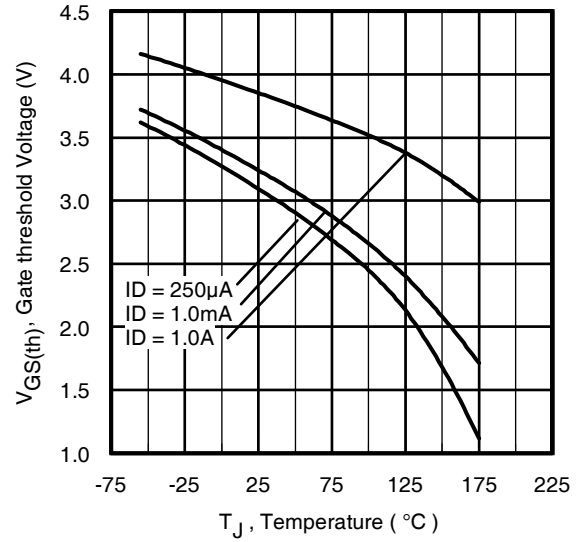
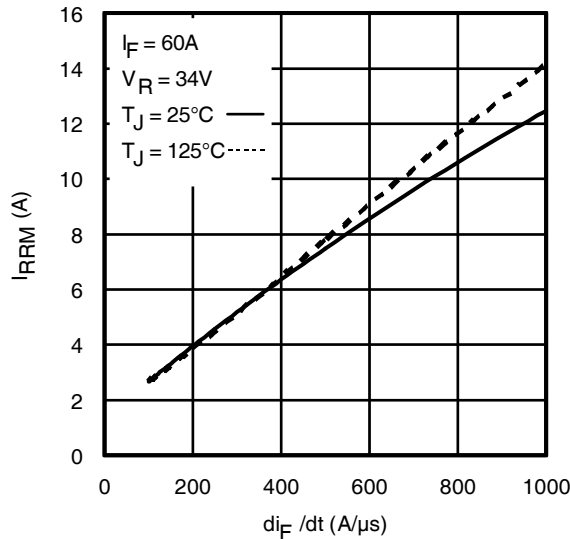
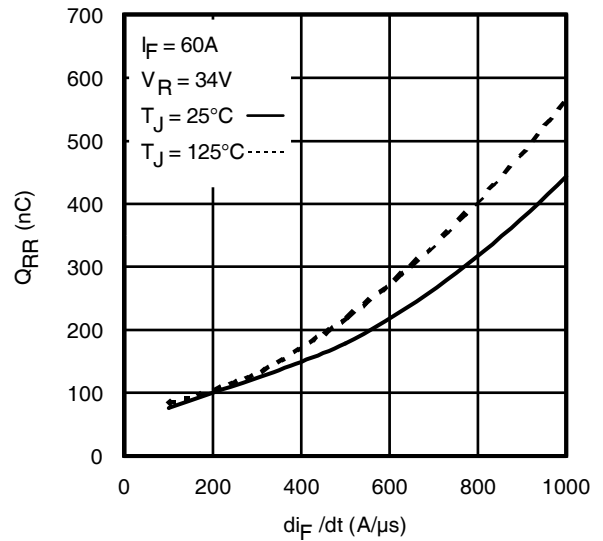
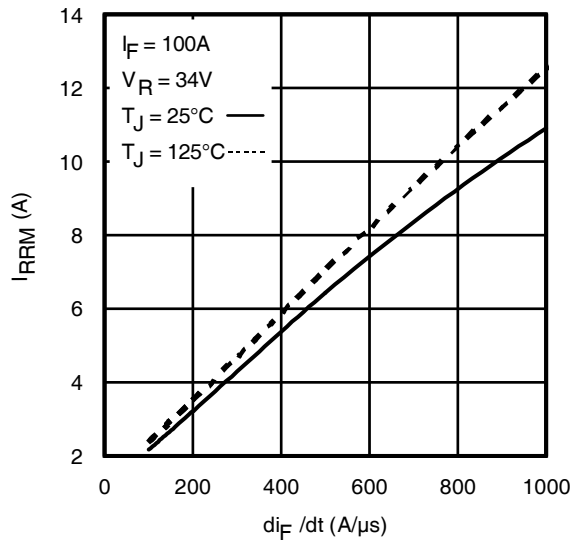
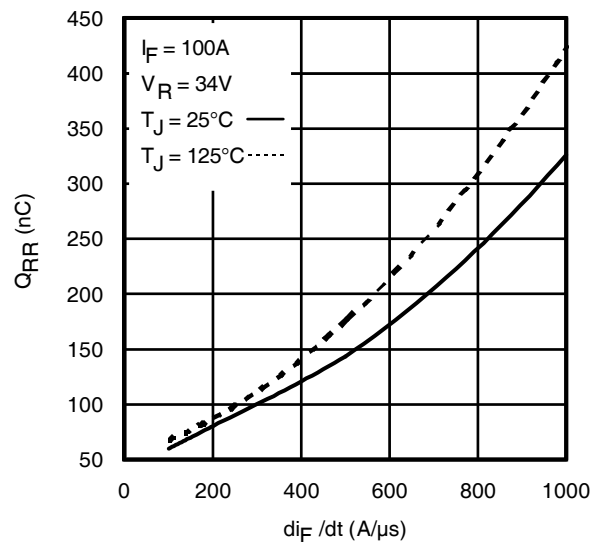

**Fig 13. Maximum Effective Transient Thermal Impedance, Junction-to-Case**

**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 24a, 24b.
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.  $\Delta T$  = 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. On-Resistance vs. Gate Voltage**

**Fig 17. Threshold Voltage vs. Temperature**

**Fig. 18 - Typical Recovery Current vs.  $di_T/dt$** 

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

**Fig. 20 - Typical Recovery Current vs.  $di_T/dt$** 

**Fig. 21 - Typical Stored Charge vs.  $di_T/dt$**

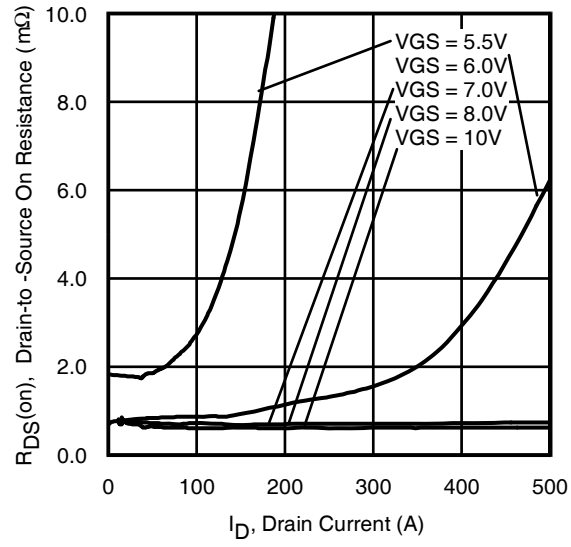
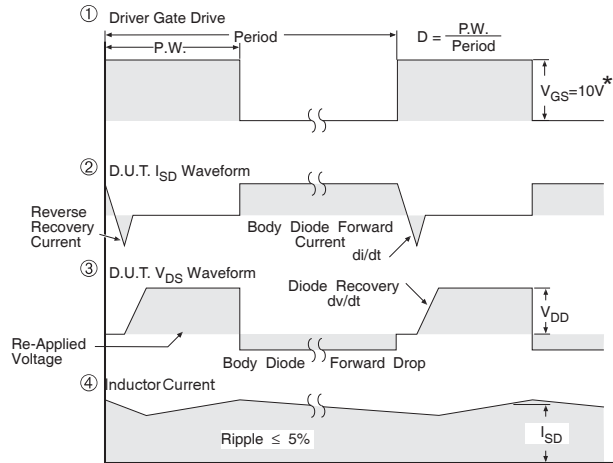
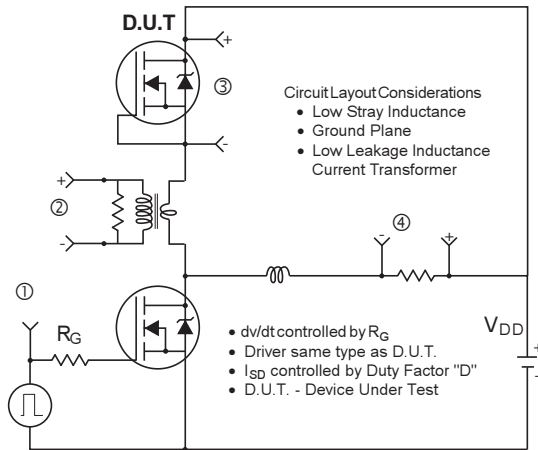
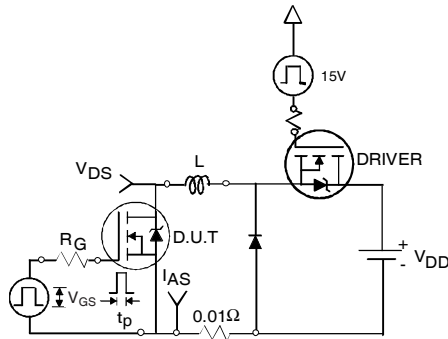


Fig 22. Typical On-Resistance vs. Drain Current

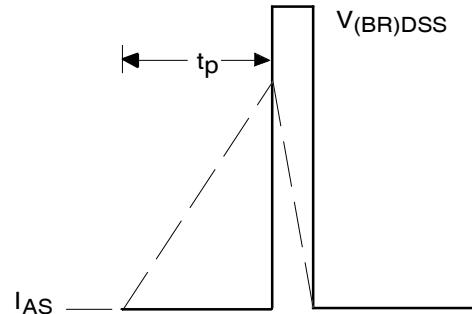


\*  $V_{GS} = 5V$  for Logic Level Devices

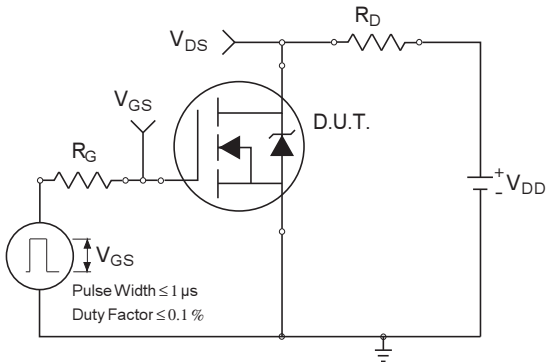
**Fig 23. Peak Diode Recovery  $dv/dt$  Test Circuit for N-Channel HEXFET<sup>®</sup> Power MOSFETs**



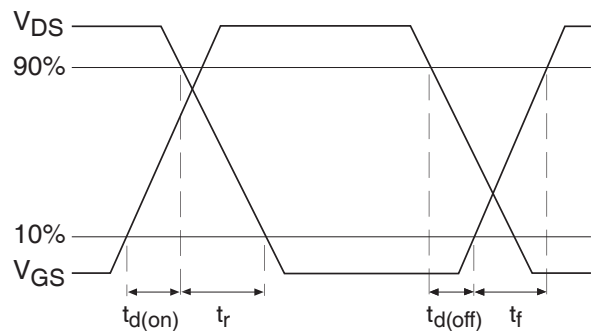
**Fig 24a. Unclamped Inductive Test Circuit**



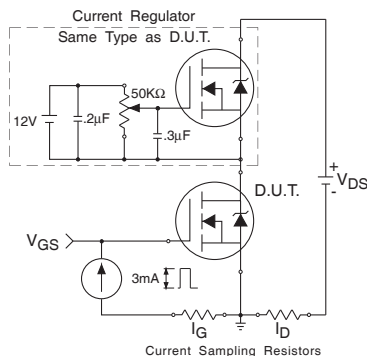
**Fig 24b. Unclamped Inductive Waveforms**



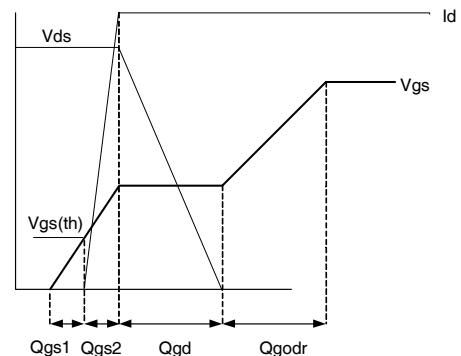
**Fig 25a. Switching Time Test Circuit**



**Fig 25b. Switching Time Waveforms**



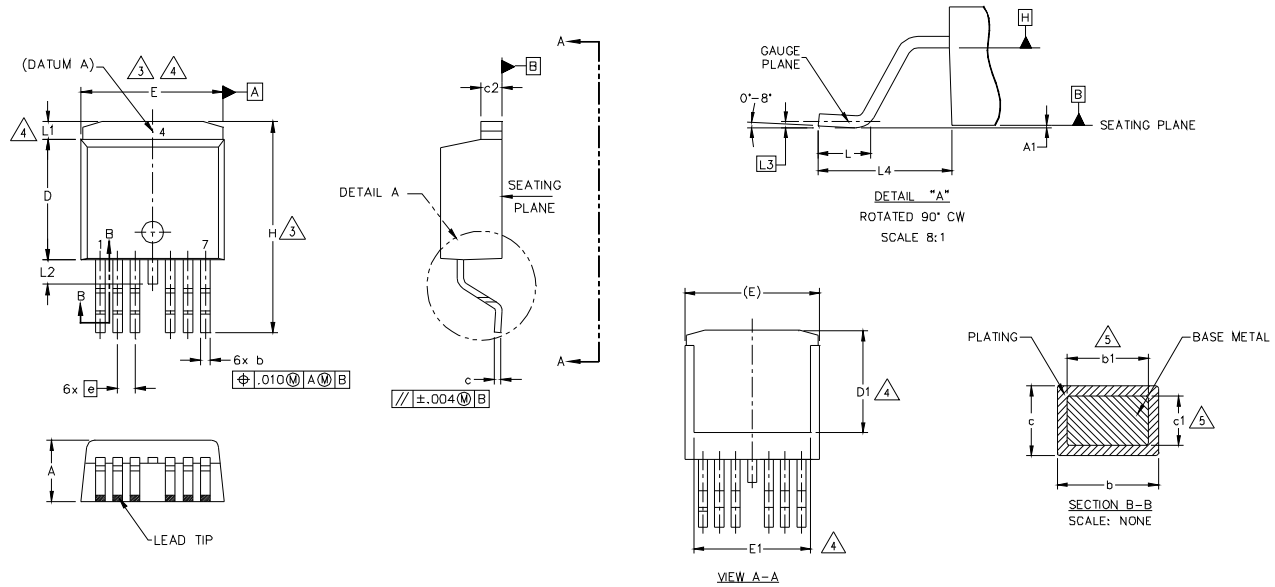
**Fig 26a. Gate Charge Test Circuit**



**Fig 26b. Gate Charge Waveform**

# D<sup>2</sup>Pak - 7 Pin Package Outline

Dimensions are shown in millimeters (inches)



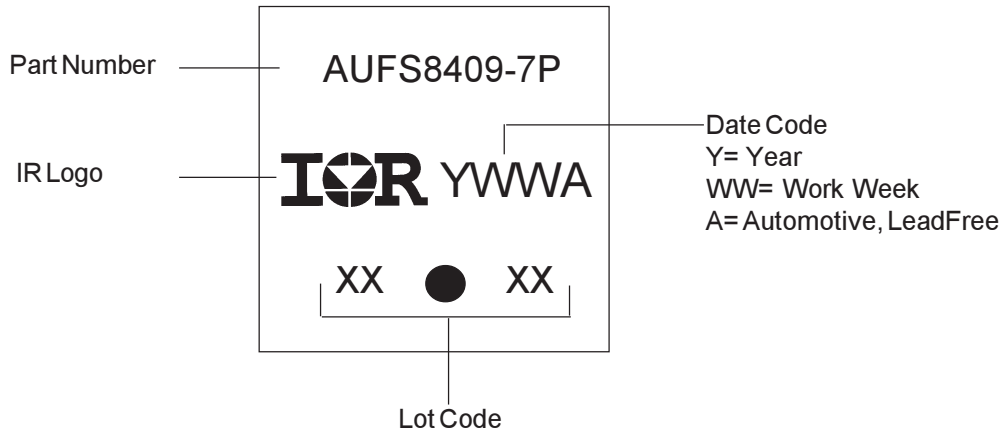
SYMBOL	DIMENSIONS				NOTES	
	MILLIMETERS		INCHES			
	MIN.	MAX.	MIN.	MAX.		
A	4.06	4.83	.160	.190	5	
A1	-	0.254	-	.010		
b	0.51	0.99	.020	.036		
b1	0.51	0.89	.020	.032		
c	0.38	0.74	.015	.029		
c1	0.38	0.58	.015	.023		5
c2	1.14	1.65	.045	.065		
D	8.38	9.65	.330	.380		3
D1	6.86	-	.270	-		4
E	9.65	10.67	.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		4
L1	-	1.68	-	.066		
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 [0.005"] 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/>

## D<sup>2</sup>Pak - 7 Pin Part Marking Information



## D<sup>2</sup>Pak - 7 Pin Tape and Reel

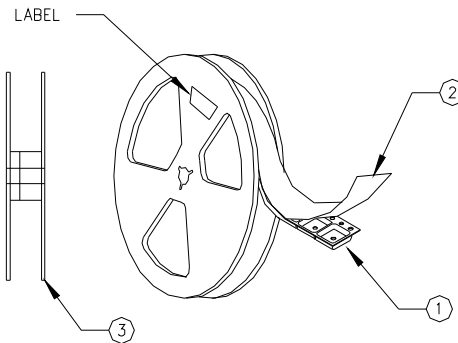
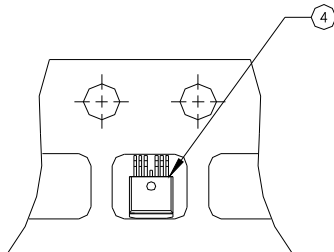
### NOTES, TAPE & REEL, LABELLING:

#### 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/>

**Qualification Information<sup>†</sup>**

<b>Qualification Level</b>		Automotive (per AEC-Q101) <sup>††</sup>	
		Comments: This part number(s) passed Automotive qualification. IR's Industrial and Consumer qualification level is granted by extension of the higher Automotive level.	
		D <sup>2</sup> PAK - 7 Pin	MSL1
<b>ESD</b>	Machine Model	Class M4 (+/- 600) <sup>††</sup> AEC-Q101-002	
	Human Body Model	Class H3A (+/- 6000) <sup>††</sup> AEC-Q101-001	
	Charged Device Model	Class C5 (+/- 2000) <sup>††</sup> AEC-Q101-005	
<b>RoHS Compliant</b>		Yes	

† Qualification standards can be found at International Rectifier's web site: <http://www.irf.com/>

†† Exceptions (if any) to AEC-Q101 requirements are noted in the qualification report.

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