

**Features**

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

**Description**

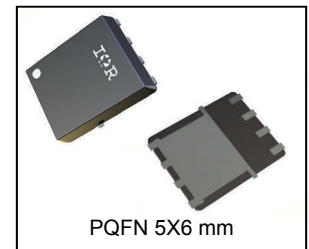
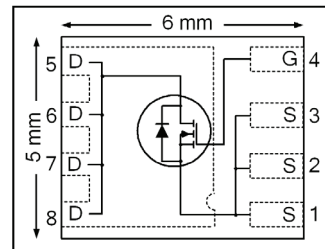
Specifically designed for Automotive applications, this HEXFET® Power MOSFET utilizes the latest processing techniques to achieve extremely low on-resistance per silicon area. Additional features of this design are a 175°C junction operating temperature, fast switching speed and improved repetitive avalanche 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
- DC-DC Converter

HEXFET® POWER MOSFET

<b>V<sub>DSS</sub></b>	<b>40V</b>
<b>R<sub>DS(on)</sub> typ.</b>	<b>1.6mΩ</b>
<b>max</b>	<b>2.0mΩ</b>
<b>I<sub>D</sub> (Silicon Limited)</b>	<b>187A<sup>①</sup></b>
<b>I<sub>D</sub> (Package Limited)</b>	<b>95A</b>



G	D	S
Gate	Drain	Source

Base Part Number	Package Type	Standard Pack		Orderable Part Number
		Form	Quantity	
AUIRFN8405	PQFN 5mm x 6mm	Tape and Reel	4000	AUIRFN8405TR

**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 (TA) is 25°C, unless otherwise specified.

	Parameter	Max.	Units
I <sub>D</sub> @ T <sub>C(Bottom)</sub> = 25°C	Continuous Drain Current, V <sub>GS</sub> @ 10V (Silicon Limited)	187 <sup>①</sup>	A
I <sub>D</sub> @ T <sub>C(Bottom)</sub> = 100°C	Continuous Drain Current, V <sub>GS</sub> @ 10V (Silicon Limited)	132 <sup>①</sup>	
I <sub>D</sub> @ T <sub>C</sub> = 25°C	Continuous Drain Current, V <sub>GS</sub> @ 10V (Package Limited)	95	
I <sub>DM</sub>	Pulsed Drain Current <sup>②</sup>	670 <sup>②</sup>	
P <sub>D</sub> @ T <sub>A</sub> = 25°C	Power Dissipation	3.3	W
P <sub>D</sub> @ T <sub>C(Bottom)</sub> = 25°C	Power Dissipation	136	
	Linear Derating Factor	0.022	W/°C
V <sub>GS</sub>	Gate-to-Source Voltage	± 20	V
T <sub>J</sub> T <sub>STG</sub>	Operating Junction and Storage Temperature Range	-55 to + 175	°C

**Avalanche Characteristics**

E <sub>AS</sub> (Thermally Limited)	Single Pulse Avalanche Energy <sup>③</sup>	190	mJ
E <sub>AS</sub> (Tested)	Single Pulse Avalanche Energy	365	
I <sub>AR</sub>	Avalanche Current <sup>②</sup>	See Fig. 14, 15, 22a, 22b	A
E <sub>AR</sub>	Repetitive Avalanche Energy <sup>②</sup>		mJ

HEXFET® is a registered trademark of International Rectifier.

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

**Thermal Resistance**

Symbol	Parameter	Typ.	Max.	Units
$R_{\theta JC}$ (Bottom)	Junction-to-Case ⑨	—	1.1	°C/W
$R_{\theta JC}$ (Top)	Junction-to-Case ⑨	—	30	
$R_{\theta JA}$	Junction-to-Ambient ⑧	—	44	
$R_{\theta JA}$ (<10s)	Junction-to-Ambient ⑧	—	28	

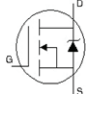
**Static Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)**

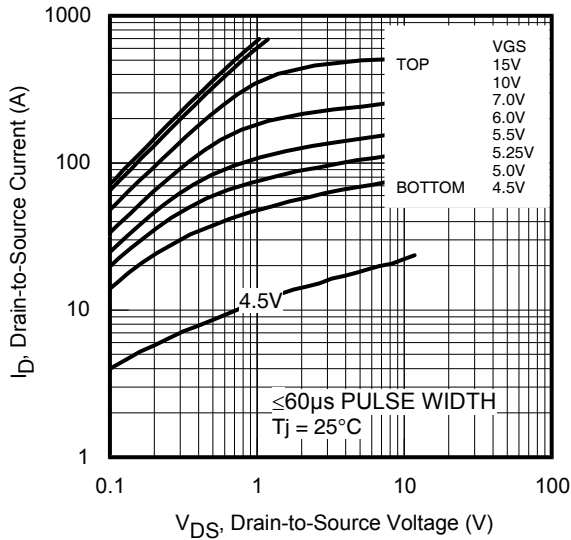
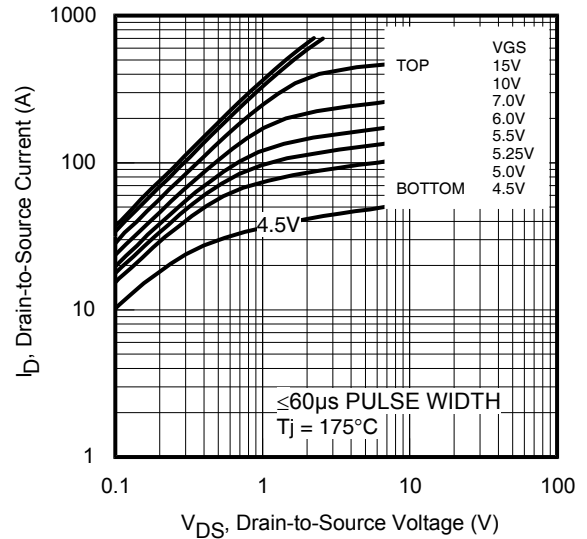
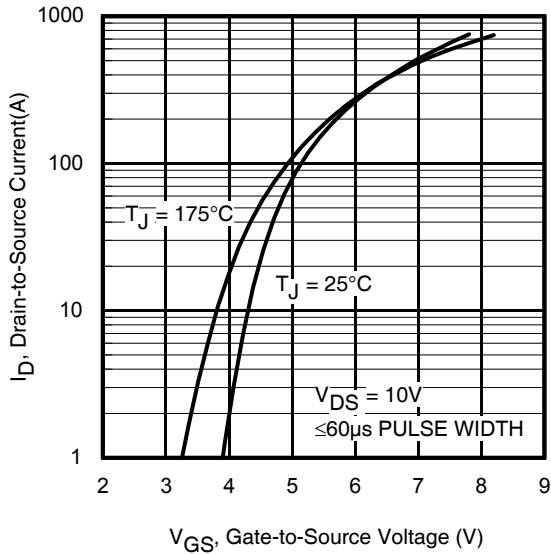
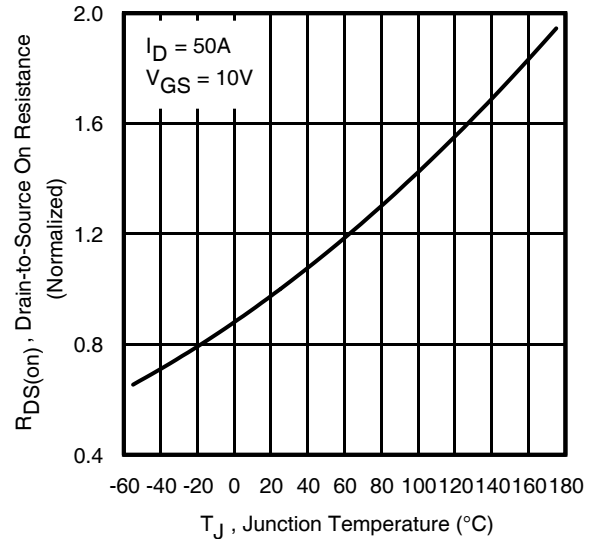
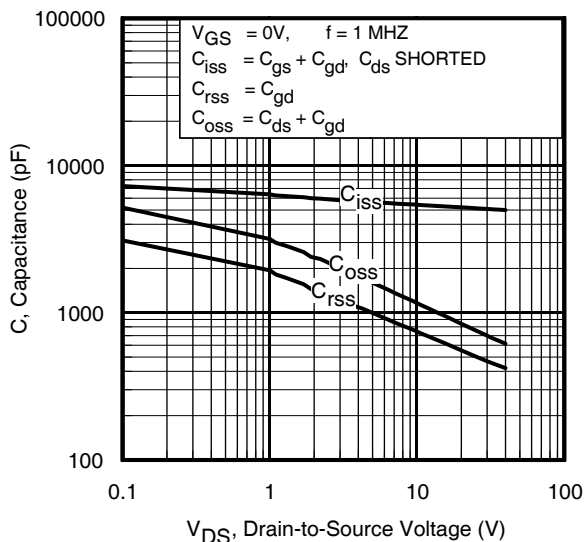
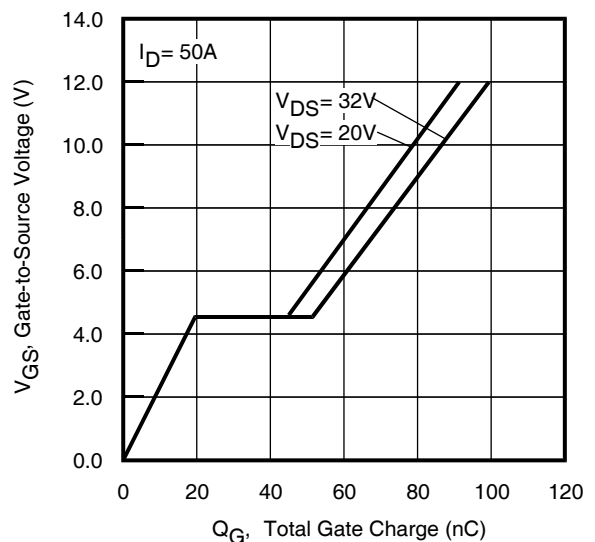
Symbol	Parameter	Min.	Typ.	Max.	Units	Conditions
$V_{(BR)DSS}$	Drain-to-Source Breakdown Voltage	40	—	—	V	$V_{GS} = 0V, I_D = 250\mu A$
$\Delta V_{(BR)DSS}/\Delta T_J$	Breakdown Voltage Temp. Coefficient	—	37	—	mV/°C	Reference to $25^\circ\text{C}, I_D = 1.0\text{mA}$ ⑤
$R_{DS(on)}$	Static Drain-to-Source On-Resistance	—	1.6	2.0	mΩ	$V_{GS} = 10V, I_D = 50A$
$V_{GS(th)}$	Gate Threshold Voltage	2.2	—	3.9	V	$V_{DS} = V_{GS}, I_D = 100\mu A$
$I_{DSS}$	Drain-to-Source Leakage Current	—	—	1.0	μA	$V_{DS} = 40V, V_{GS} = 0V$
		—	—	150		$V_{DS} = 40V, V_{GS} = 0V, T_J = 125^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	—	—	100	Ω	$V_{GS} = 20V$
	Gate-to-Source Reverse Leakage	—	—	-100		$V_{GS} = -20V$
$R_G$	Internal Gate Resistance	—	2.4	—		

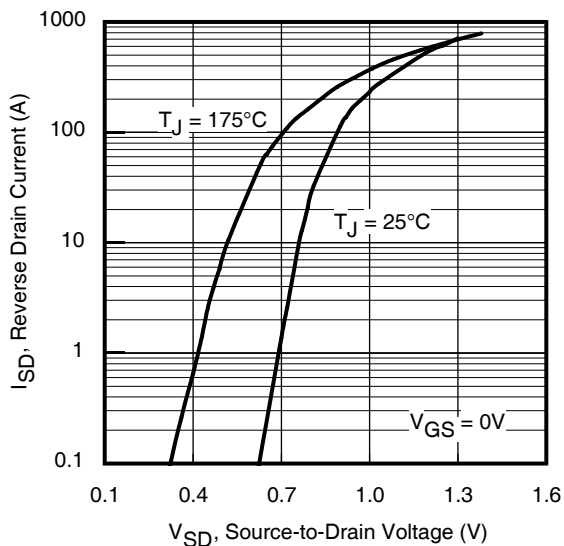
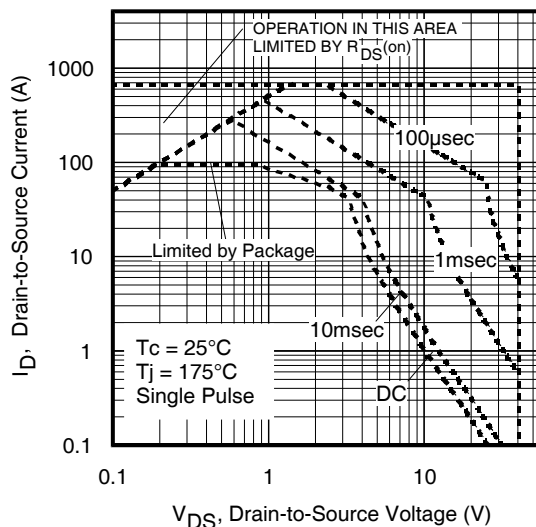
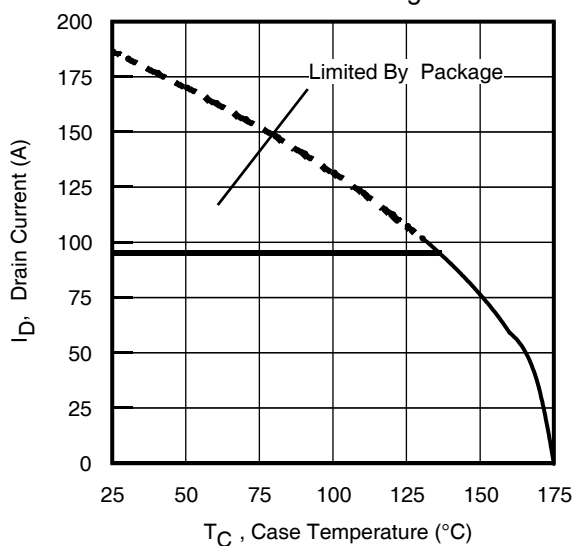
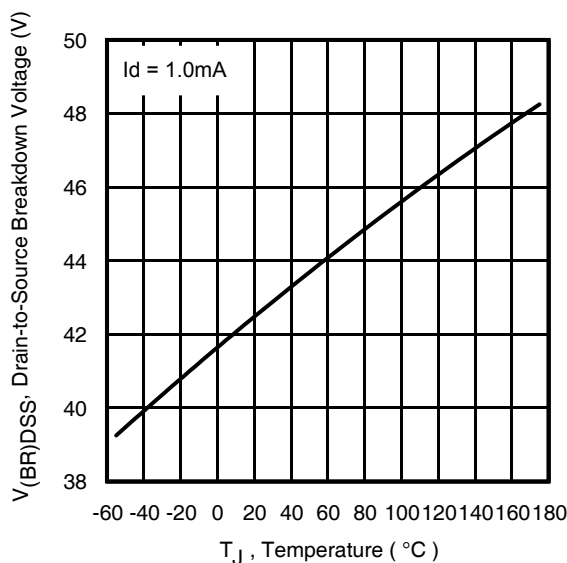
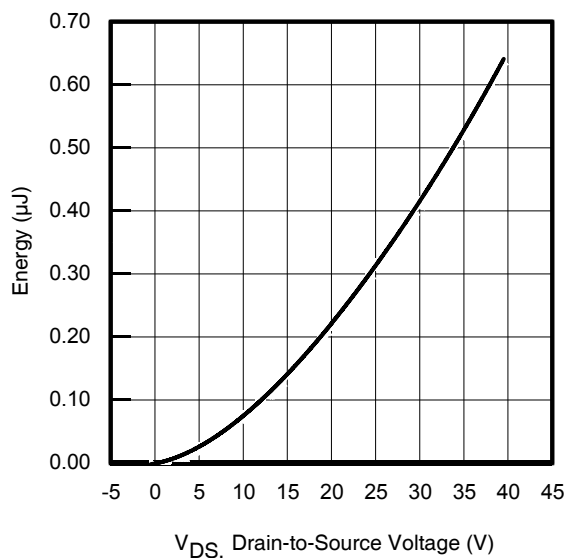
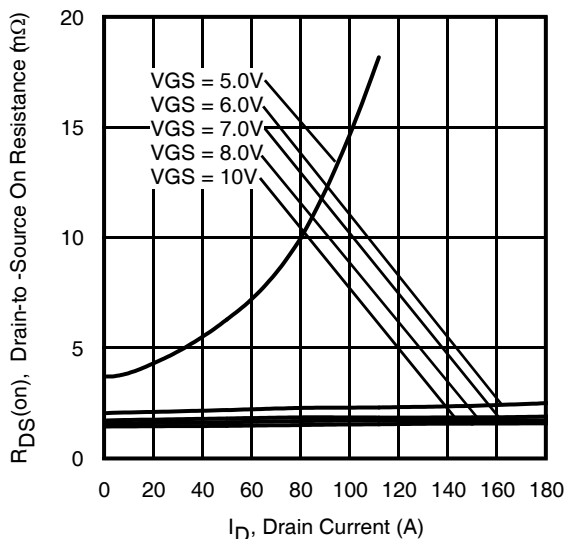
**Dynamic Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)**

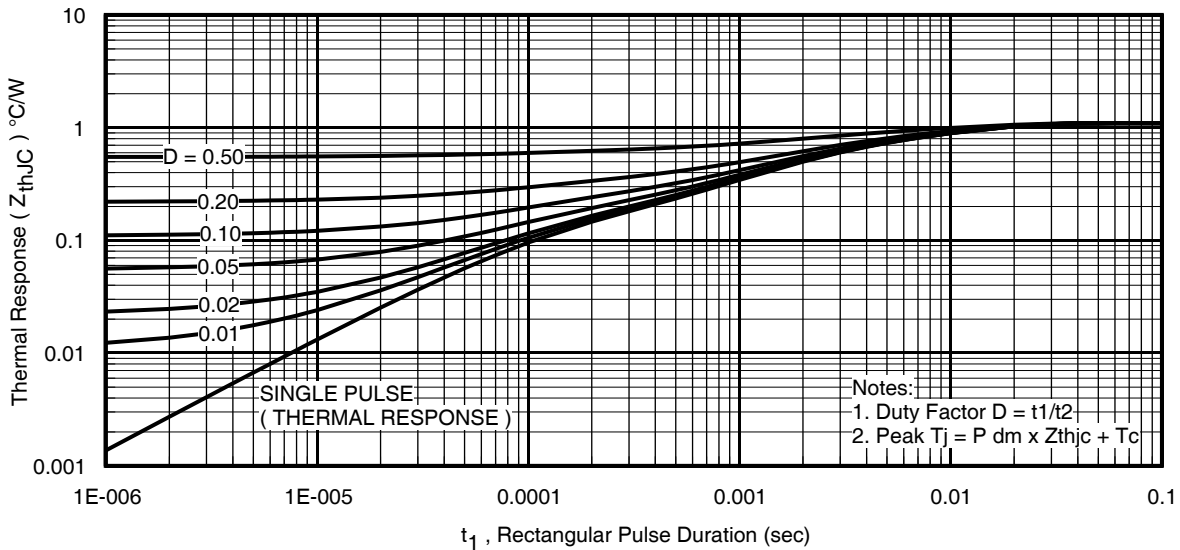
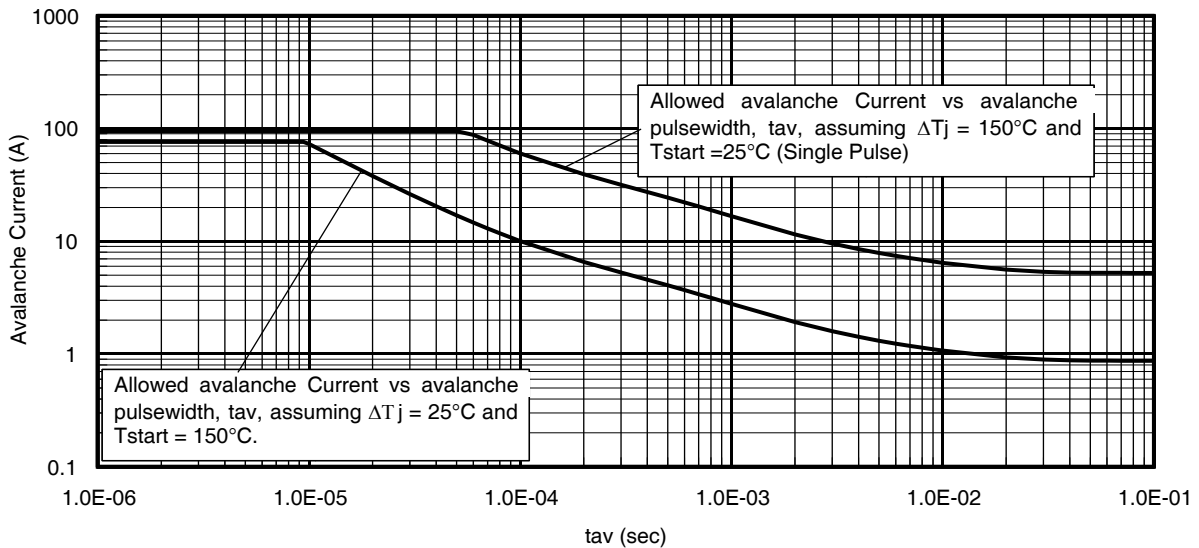
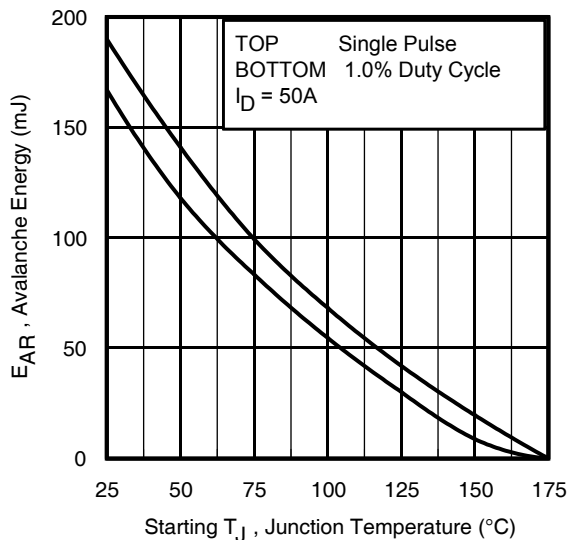
Symbol	Parameter	Min.	Typ.	Max.	Units	Conditions
$g_{fs}$	Forward Transconductance	145	—	—	S	$V_{DS} = 10V, I_D = 50A$
$Q_g$	Total Gate Charge	—	78	117	nC	$I_D = 50A$ $V_{DS} = 20V$ $V_{GS} = 10V$ ⑤
$Q_{gs}$	Gate-to-Source Charge	—	21	—		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	—	25	—		
$Q_{sync}$	Total Gate Charge Sync. ( $Q_g - Q_{gd}$ )	—	53	—		
$t_{d(on)}$	Turn-On Delay Time	—	9.5	—	ns	$V_{DD} = 20V$ $I_D = 50A$ $R_G = 2.7\Omega$ $V_{GS} = 10V$ ⑤
$t_r$	Rise Time	—	30	—		
$t_{d(off)}$	Turn-Off Delay Time	—	58	—		
$t_f$	Fall Time	—	33	—		
$C_{iss}$	Input Capacitance	—	5142	—	pF	$V_{GS} = 0V$ $V_{DS} = 25V$ $f = 1.0\text{MHz}$
$C_{oss}$	Output Capacitance	—	758	—		
$C_{riss}$	Reverse Transfer Capacitance	—	501	—		
$C_{oss\text{ eff. (ER)}}$	Effective Output Capacitance (Energy Related)	—	900	—		
$C_{oss\text{ eff. (TR)}}$	Effective Output Capacitance (Time Related)	—	1094	—		

**Diode Characteristics**

Symbol	Parameter	Min.	Typ.	Max.	Units	Conditions
$I_S$	Continuous Source Current (Body Diode)	—	—	187 ①	A	MOSFET symbol showing the integral reverse p-n junction diode. 
$I_{SM}$	Pulsed Source Current (Body Diode) ①	—	—	670 ⑩	A	
$V_{SD}$	Diode Forward Voltage	—	0.9	1.3	V	$T_J = 25^\circ\text{C}, I_S = 50A, V_{GS} = 0V$ ⑤
$dv/dt$	Peak Diode Recovery ④	—	5.2	—	V/ns	$T_J = 175^\circ\text{C}, I_S = 50A, V_{DS} = 40V$
$t_{rr}$	Reverse Recovery Time	—	27	—	ns	$V_R = 34V,$ $I_F = 50A$
		—	28	—		
$Q_{rr}$	Reverse Recovery Charge	—	16	—	nC	$T_J = 25^\circ\text{C}$ $T_J = 125^\circ\text{C}$ $di/dt = 100A/\mu s$ ⑤
		—	18	—		
$I_{RRM}$	Reverse Recovery Current	—	0.92	—	A	$T_J = 25^\circ\text{C}$


**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-to-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 Coss Stored Energy

**Fig 12.** Typical On-Resistance vs. Drain Current

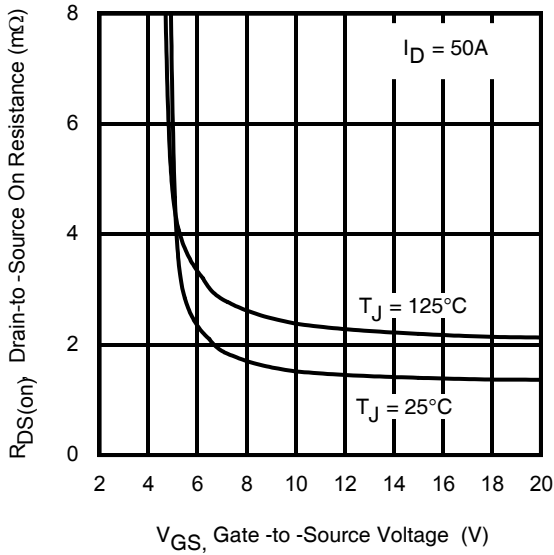
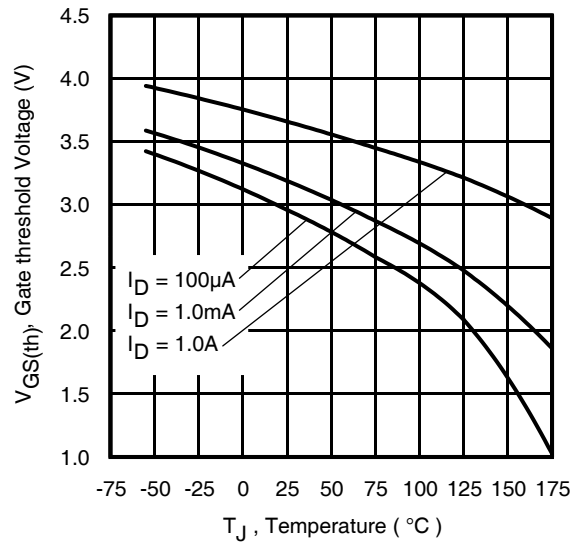
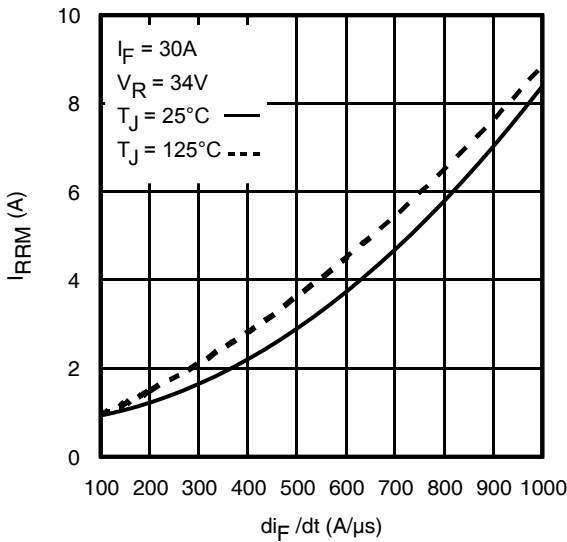
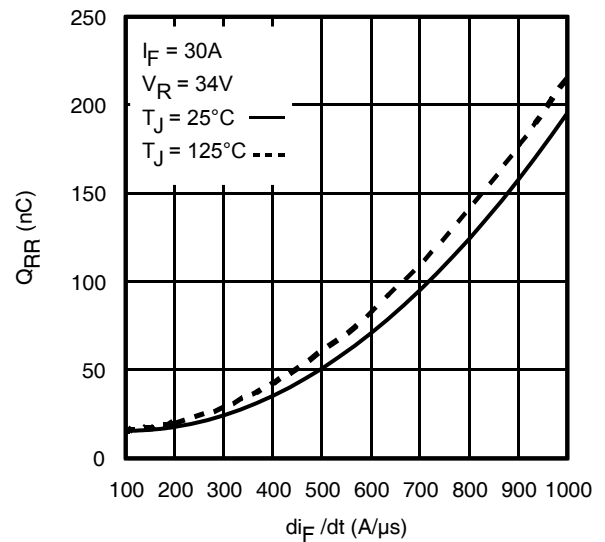
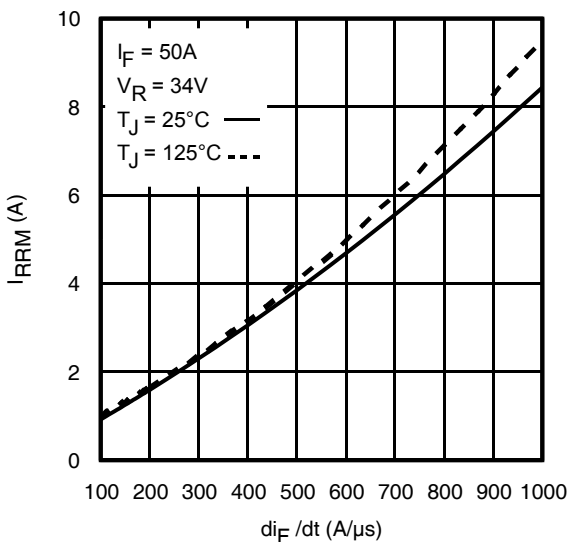
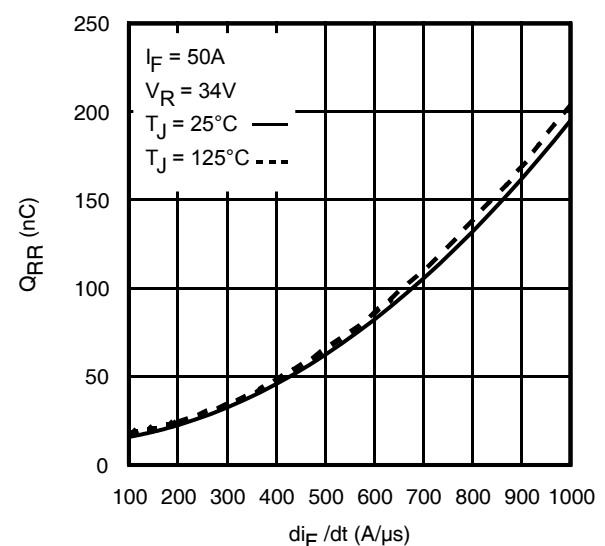

**Fig 13. Maximum Effective Transient Thermal Impedance, Junction-to-Case**

**Fig 14. Typical Avalanche Current vs. Pulse Width**

**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)**

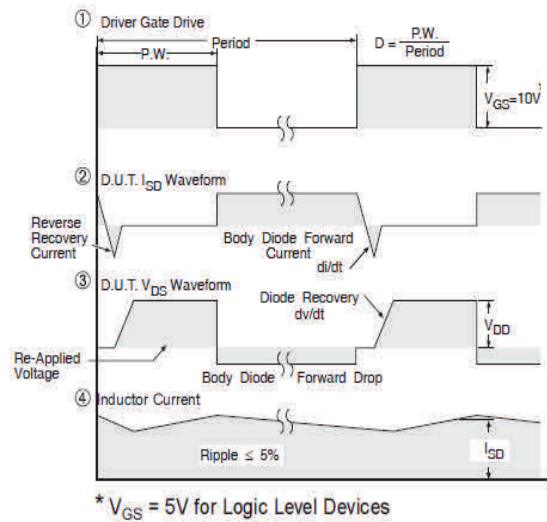
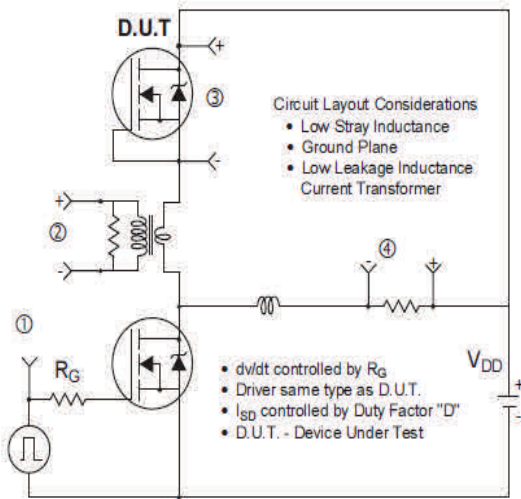
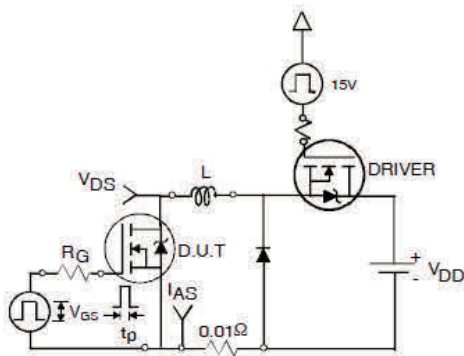
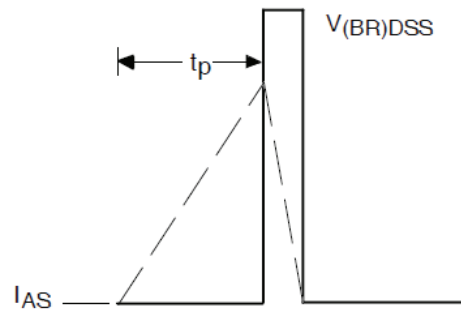
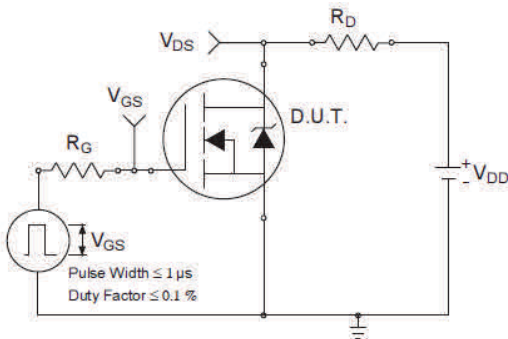
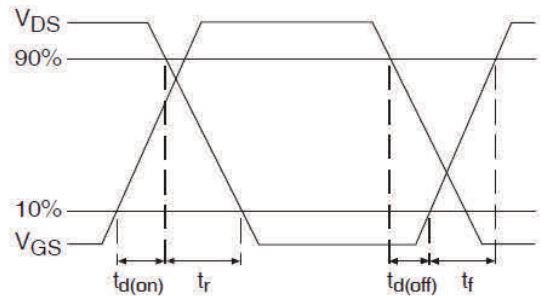
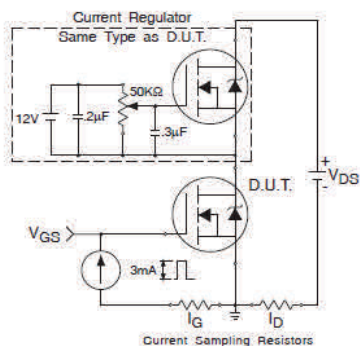
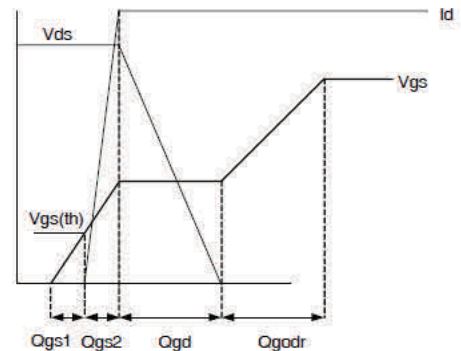
1. Avalanche failures assumption:  
Purely a thermal phenomenon and failure occurs at a temperature far in excess of  $T_{jmax}$ . This is validated for every part type.
2. Safe operation in Avalanche is allowed as long as  $T_{jmax}$  is not exceeded.
3. Equation below based on circuit and waveforms 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.  $\Delta T$  = 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)

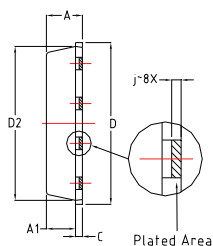
$$P_{D(ave)} = 1/2 ( 1.3 \cdot BV \cdot I_{av} ) = \Delta T / Z_{thJC}$$

$$I_{av} = 2\Delta T / [ 1.3 \cdot BV \cdot Z_{th} ]$$

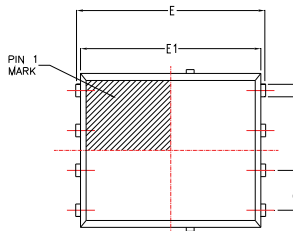
$$E_{AS(AR)} = P_{D(ave)} \cdot t_{av}$$


**Fig 16.** Typical On-Resistance vs. Gate Voltage

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

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

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

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

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


**Fig 22. Peak Diode Recovery dv/dt Test Circuit for N-Channel HEXFET® Power MOSFETs**

**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**

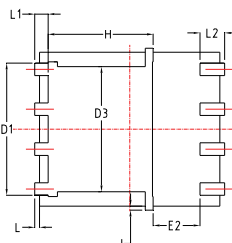
**PQFN 5x6 Outline "E" Package Details**


SIDE VIEW



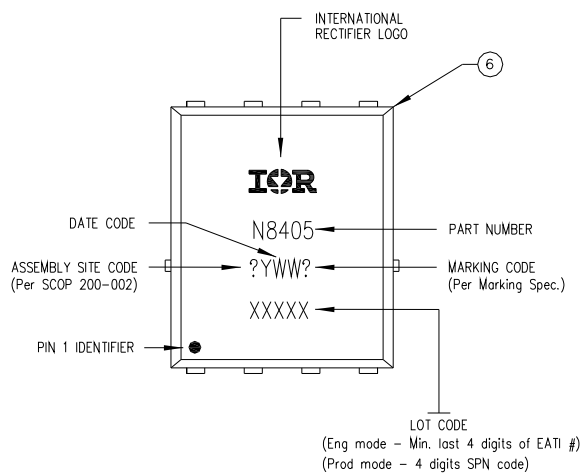
TOP VIEW

DIM	MM		
	MIN	NOM	MAX
A	0.90	1.10	1.17
A1	0.824	0.897	0.97
b	0.33	0.41	0.50
c	0.150	0.20	0.250
D	4.80	4.98	5.15
D1	3.91	4.22	4.36
D2	4.80	4.90	5.00
D3	3.85	4.00	4.15
E	5.90	6.05	6.15
E1	5.65	5.76	5.85
E2	1.10	/	/
e	1.27 BSC		
L	0.05	0.15	0.25
L1	0.38	0.425	0.50
L2	0.51	0.785	0.86
H	3.25	3.35	3.58
I	0	/	0.18
j	0.1015 BSC		



BOTTOM VIEW

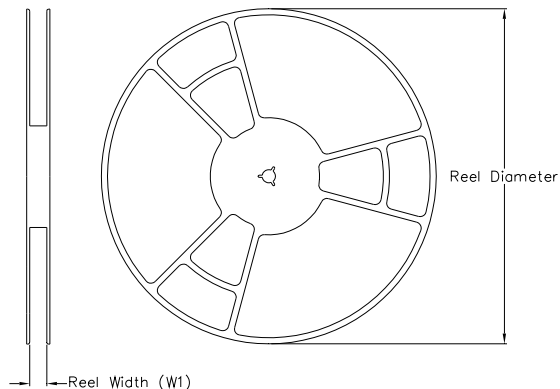
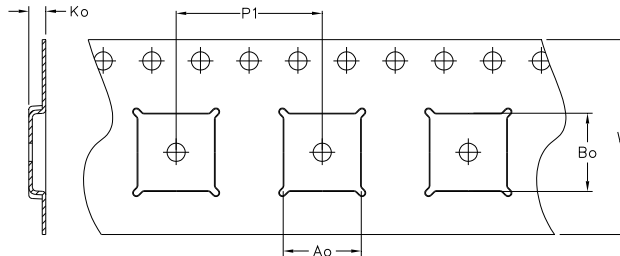
For footprint and stencil design recommendations, please refer to application note AN-1136 at <http://www.irf.com/technical-info/appnotes/an-1136.pdf>  
 For visual inspection recommendations, please refer to application note AN-1154 at <http://www.irf.com/technical-info/appnotes/an-1154.pdf>

**PQFN 5x6 Outline "E" Part Marking**


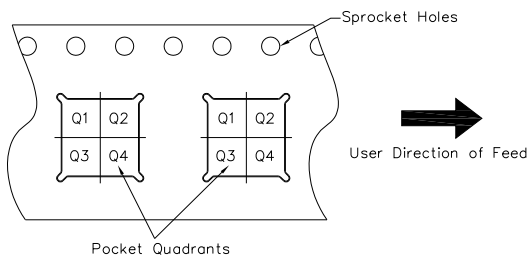
TOP MARKING (LASER)

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



**PQFN 5x6 Outline "E" Tape and Reel**
**REEL DIMENSIONS**

**TAPE DIMENSIONS**


CODE	DESCRIPTION
Ao	Dimension design to accommodate the component width
Bo	Dimension design to accommodate the component length
Ko	Dimension design to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**


Note: All dimension are nominal

Package Type	Reel Diameter (Inch)	QTY	Reel Width W1 (mm)	Ao (mm)	Bo (mm)	Ko (mm)	P1 (mm)	W (mm)	Pin 1 Quadrant
5 X 6 PQFN	13	4000	12.4	6.300	5.300	1.20	8.00	12	Q1

 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)	
		Comments: This part number(s) passed Automotive qualification. IR's Industrial and Consumer qualification level is granted by extension of the higher Automotive level.	
<b>Moisture Sensitivity Level</b>		PQFN 5mm x 6mm	MSL1
<b>ESD</b>	Human Body Model	Class H1C (+/- 2000V) <sup>††</sup>	
		AEC-Q101-001	
	Charged Device Model	Class C5 (+/- 2000V) <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/>

†† Highest passing voltage.

**Notes:**

- ① Calculated continuous current based on maximum allowable junction temperature. Bond wire current limit is 95A. 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 = 0.152mH, R<sub>G</sub> = 50Ω, I<sub>AS</sub> = 50A, V<sub>GS</sub> = 10V.
- ④ I<sub>SD</sub> ≤ 50A, di/dt ≤ 961A/μs, V<sub>DD</sub> ≤ V<sub>(BR)DSS</sub>, T<sub>J</sub> ≤ 175°C.
- ⑤ Pulse width ≤ 400μs; duty cycle ≤ 2%.
- ⑥ Coss eff. (TR) is a fixed capacitance that gives the same charging time as Coss while VDS is rising from 0 to 80%VDSS.
- ⑦ Coss eff. (ER) is a fixed capacitance that gives the same energy as Coss while VDS is rising from 0 to 80% VDSS.
- 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: <http://www.irf.com/technical-info/appnotes/an-994.pdf>
- ⑨ R<sub>θ</sub> is measured at T<sub>J</sub> approximately 90°C.
- ⑩ Pulse drain current is limited at 380A by source bonding technology.

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