

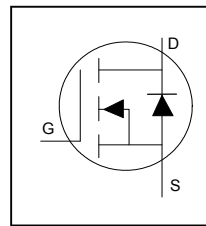
### Application

- Brushed Motor drive applications
- BLDC Motor drive applications
- Battery powered circuits
- Half-bridge and full-bridge topologies
- Synchronous rectifier applications
- Resonant mode power supplies
- DC/DC and AC/DC converters
- DC/AC Inverters

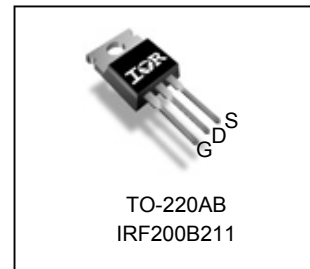
### Benefits

- 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\*, RoHS Compliant, Halogen-Free

HEXFET® Power MOSFET



<b>V<sub>DSS</sub></b>	<b>200V</b>
<b>R<sub>DS(on)</sub> typ.</b>	<b>135mΩ</b>
	<b>max</b>
<b>I<sub>D</sub> (Silicon Limited)</b>	<b>12A</b>



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

Base part number	Package Type	Standard Pack		Orderable Part Number
		Form	Quantity	
IRF200B211	TO-220	Tube	50	IRF200B211

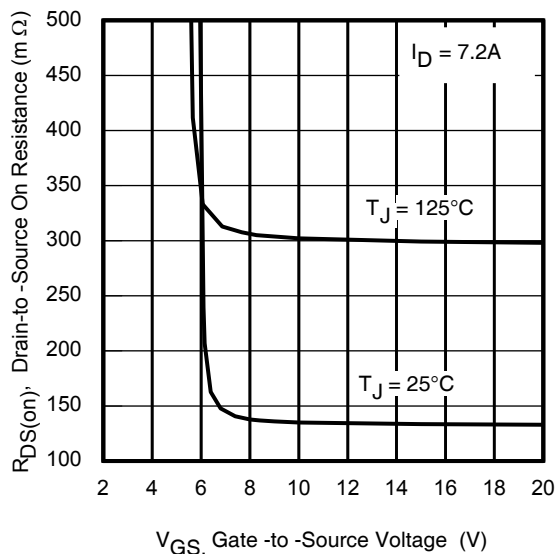


Fig 1. Typical On-Resistance vs. Gate Voltage

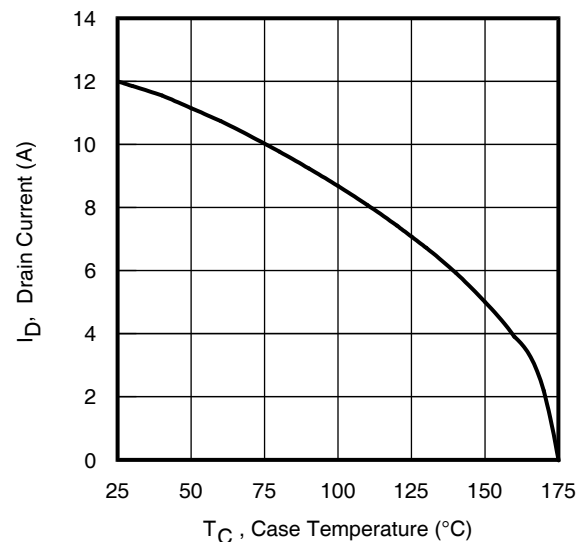


Fig 2. Maximum Drain Current vs. Case Temperature

**Absolute Maximum Rating**

Symbol	Parameter	Max.	Units
$I_D @ T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS} @ 10\text{V}$ (Silicon Limited)	12	A
$I_D @ T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS} @ 10\text{V}$ (Silicon Limited)	9.0	
$I_{DM}$	Pulsed Drain Current ②	34	
$P_D @ T_C = 25^\circ\text{C}$	Maximum Power Dissipation	80	W
	Linear Derating Factor	0.53	W/°C
$V_{GS}$	Gate-to-Source Voltage	$\pm 20$	V
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to + 175	°C
	Soldering Temperature, for 10 seconds (1.6mm from case)	300	
	Mounting Torque, 6-32 or M3 Screw	10 lbf-in (1.1 N-m)	

**Avalanche Characteristics**

$E_{AS}$ (Thermally limited)	Single Pulse Avalanche Energy ②	88	mJ
$E_{AS}$ (Thermally limited)	Single Pulse Avalanche Energy ⑧	72	
$E_{AS}$ (tested)	Single Pulse Avalanche Energy Tested Value ⑨	98	
$I_{AR}$	Avalanche Current ①	See Fig 15, 16, 23a, 23b	A
$E_{AR}$	Repetitive Avalanche Energy ①		mJ

**Thermal Resistance**

Symbol	Parameter	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case ⑦	—	1.88	°C/W
$R_{\theta CS}$	Case-to-Sink, Flat Greased Surface	0.50	—	
$R_{\theta JA}$	Junction-to-Ambient	—	62	

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

Symbol	Parameter	Min.	Typ.	Max.	Units	Conditions
$V_{(BR)DSS}$	Drain-to-Source Breakdown Voltage	200	—	—	V	$V_{GS} = 0\text{V}, I_D = 250\mu\text{A}$
$\Delta V_{(BR)DSS}/\Delta T_J$	Breakdown Voltage Temp. Coefficient	—	0.21	—	V/°C	Reference to $25^\circ\text{C}, I_D = 1\text{mA}$ ①
$R_{DS(on)}$	Static Drain-to-Source On-Resistance	—	135	170	mΩ	$V_{GS} = 10\text{V}, I_D = 7.2\text{A}$ ④
$V_{GS(th)}$	Gate Threshold Voltage	3.0	—	4.9	V	$V_{DS} = V_{GS}, I_D = 50\mu\text{A}$
$I_{DSS}$	Drain-to-Source Leakage Current	—	—	20	μA	$V_{DS} = 200\text{V}, V_{GS} = 0\text{V}$
		—	—	250		$V_{DS} = 160\text{V}, V_{GS} = 0\text{V}, T_J = 125^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	—	—	100	nA	$V_{GS} = 20\text{V}$
	Gate-to-Source Reverse Leakage	—	—	-100		$V_{GS} = -20\text{V}$
$R_G$	Gate Resistance	—	2.7	—	Ω	

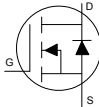
**Notes:**

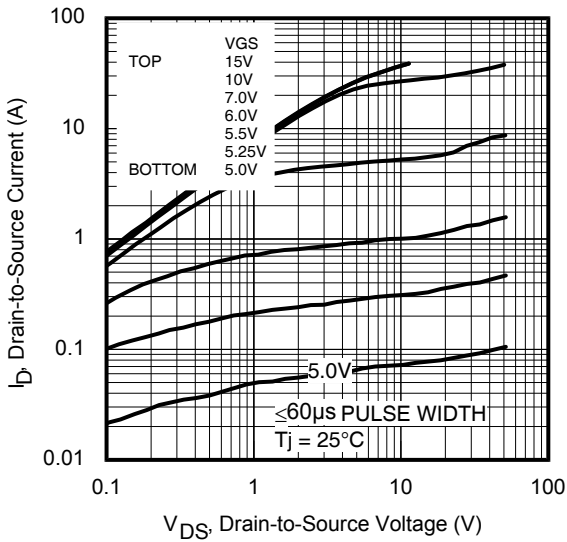
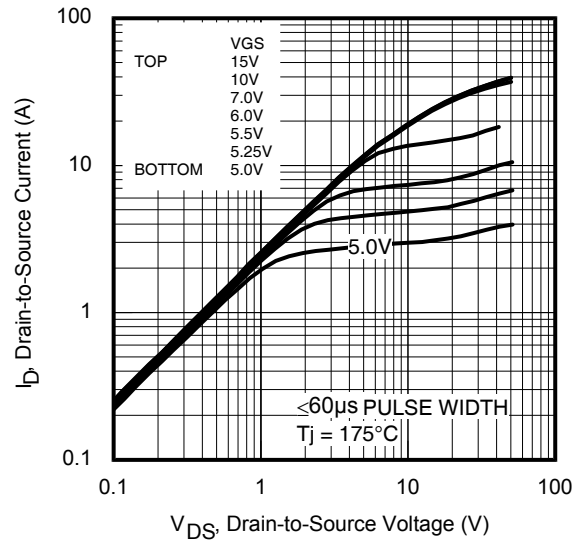
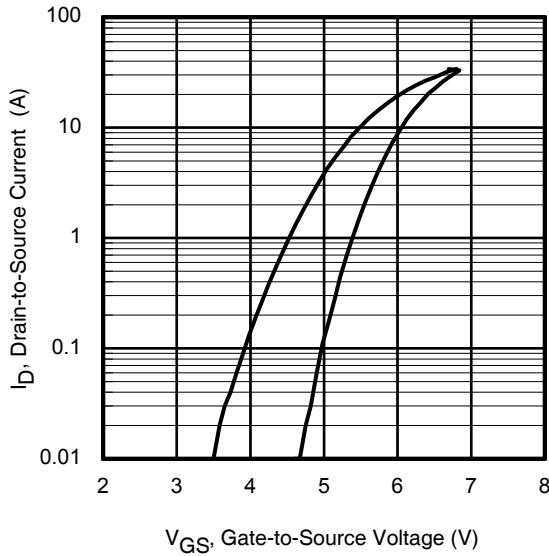
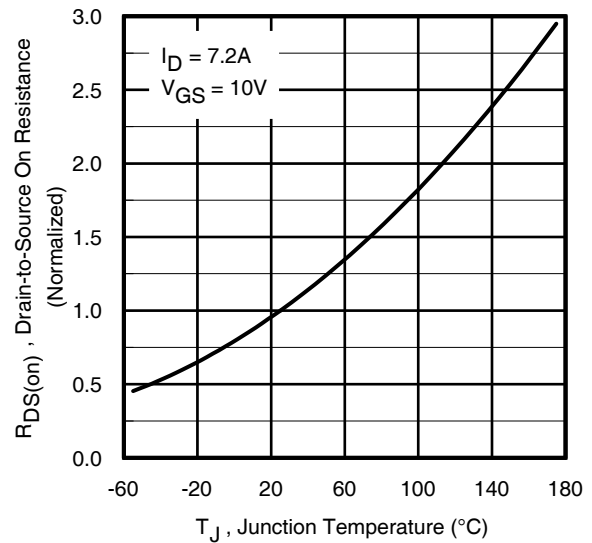
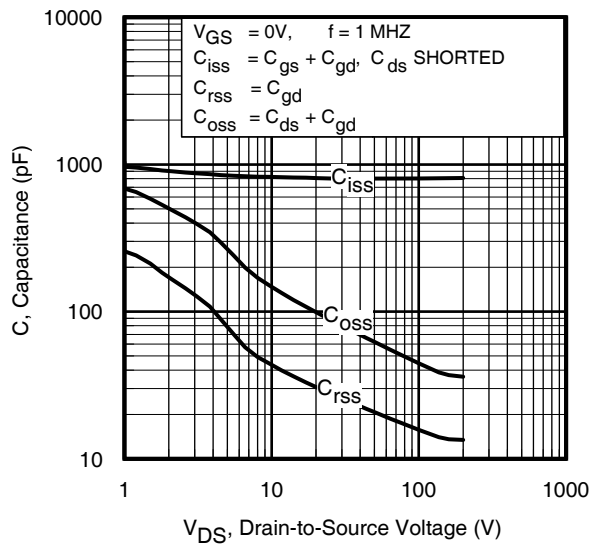
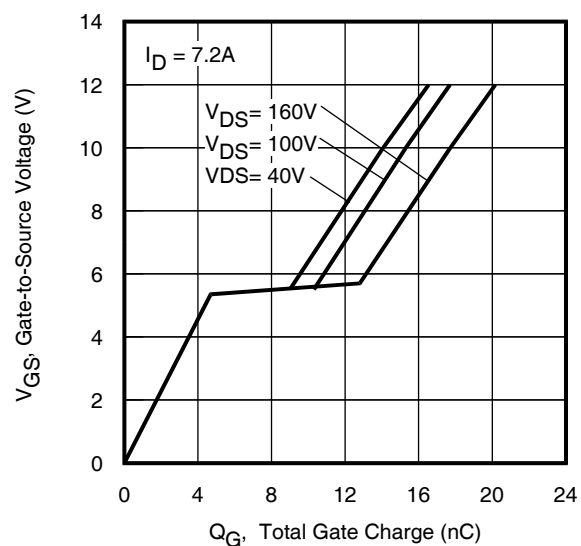
- ① Repetitive rating; pulse width limited by max. junction temperature.
- ② Limited by  $T_{Jmax}$ , starting  $T_J = 25^\circ\text{C}$ ,  $L = 3.4\text{mH}$ ,  $R_G = 50\Omega$ ,  $I_{AS} = 7.2\text{A}$ ,  $V_{GS} = 10\text{V}$ .
- ③  $I_{SD} \leq 7.2\text{A}$ ,  $di/dt \leq 1184\text{A}/\mu\text{s}$ ,  $V_{DD} \leq V_{(BR)DSS}$ ,  $T_J \leq 175^\circ\text{C}$ .
- ④ Pulse width  $\leq 400\mu\text{s}$ ; duty cycle  $\leq 2\%$ .
- 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  $R_\theta$  is measured at  $T_J$  approximately  $90^\circ\text{C}$ .
- ⑧ Limited by  $T_{Jmax}$ , starting  $T_J = 25^\circ\text{C}$ ,  $L = 1.0\text{mH}$ ,  $R_G = 50\Omega$ ,  $I_{AS} = 11.5\text{A}$ ,  $V_{GS} = 10\text{V}$ .
- ⑨ This value determined from sample failure population, starting  $T_J = 25^\circ\text{C}$ ,  $L = 3.4\text{mH}$ ,  $R_G = 50\Omega$ ,  $I_{AS} = 7.2\text{A}$ ,  $V_{GS} = 10\text{V}$ .

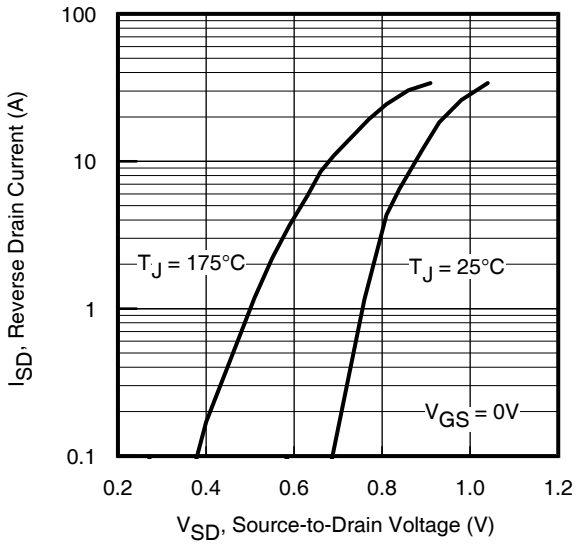
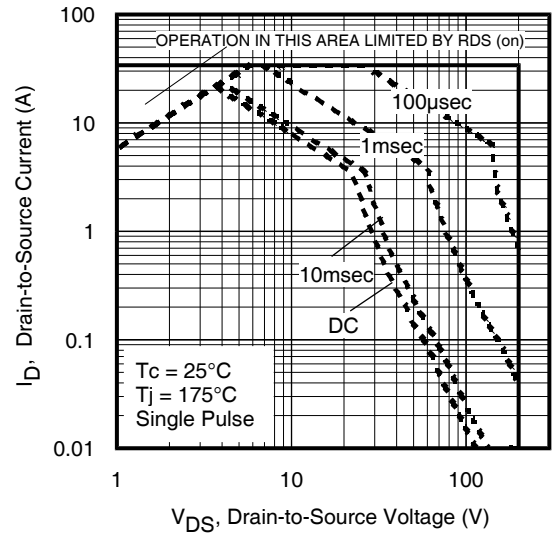
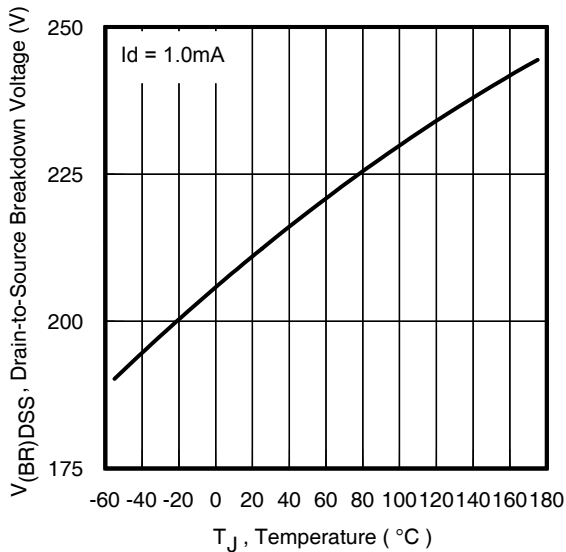
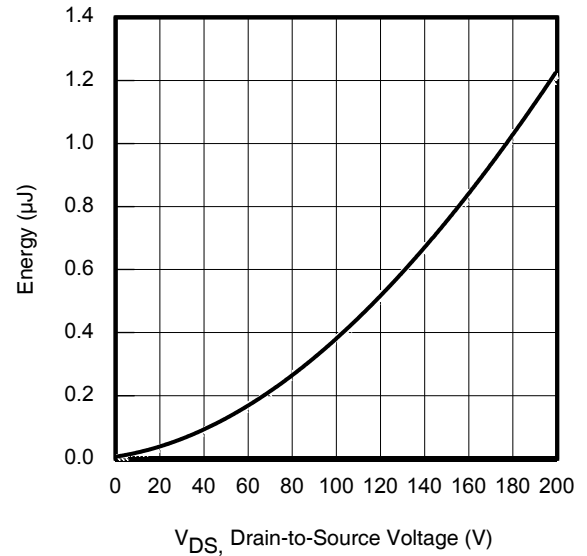
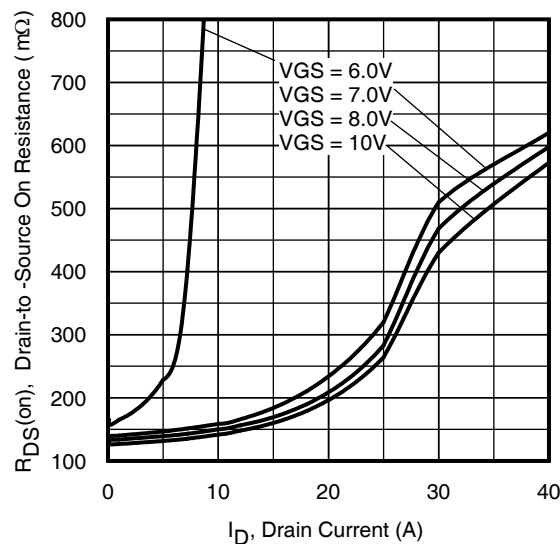
**Dynamic Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)**

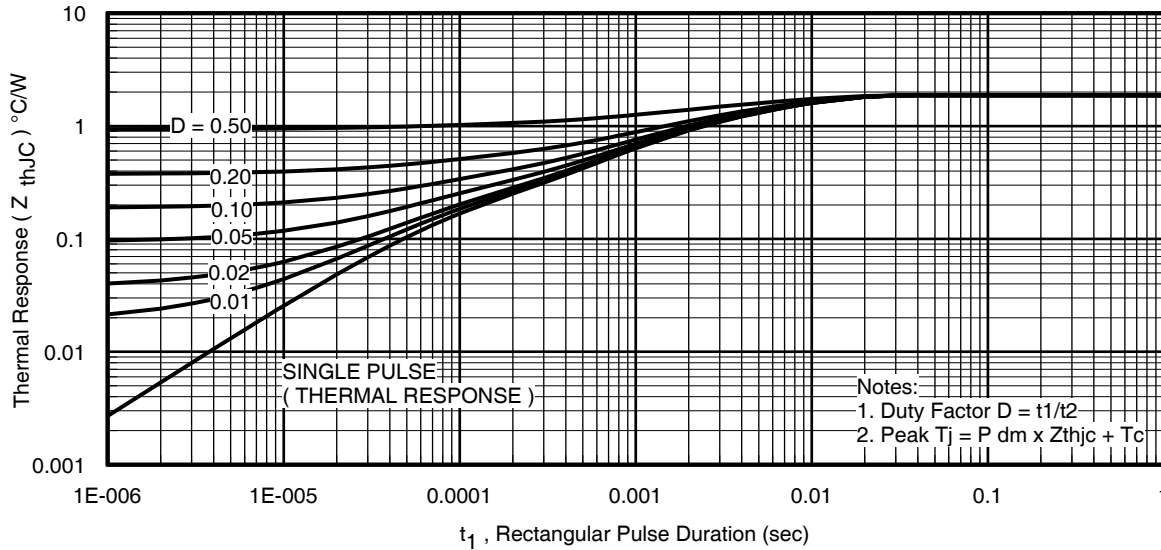
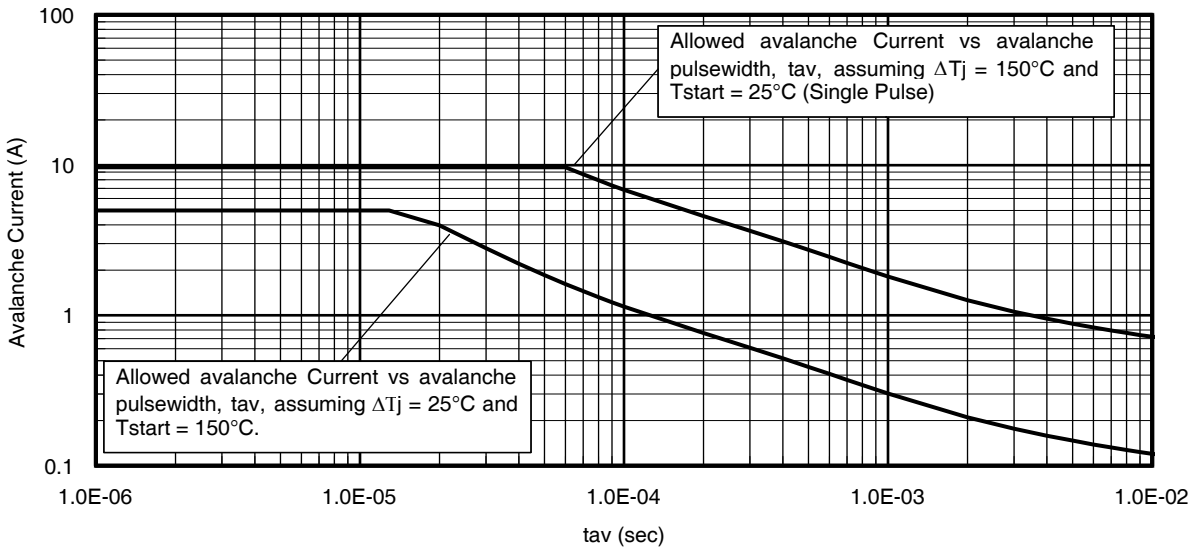
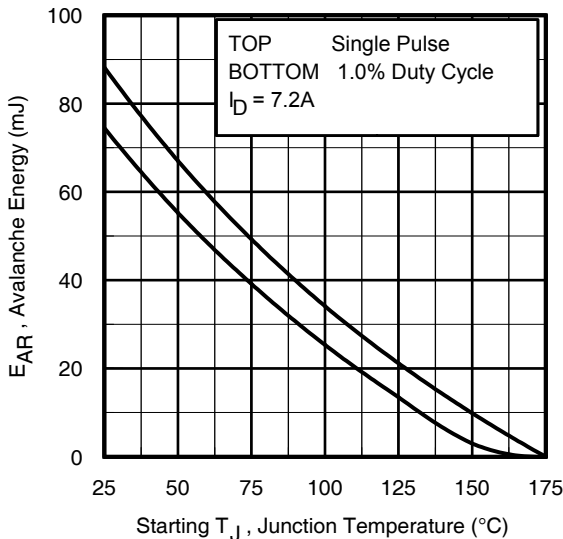
Symbol	Parameter	Min.	Typ.	Max.	Units	Conditions
gfs	Forward Transconductance	13	—	—	S	$V_{DS} = 50\text{V}, I_D = 7.2\text{A}$
$Q_g$	Total Gate Charge	—	15.3	23	nC	$I_D = 7.2\text{A}$ $V_{DS} = 100\text{V}$ $V_{GS} = 10\text{V}^{(4)}$
$Q_{gs}$	Gate-to-Source Charge	—	5.1	—		
$Q_{gd}$	Gate-to-Drain Charge	—	5.6	—		
$Q_{sync}$	Total Gate Charge Sync. ( $Q_g - Q_{gd}$ )	—	10.2	—		
$t_{d(on)}$	Turn-On Delay Time	—	6.5	—	ns	$V_{DD} = 130\text{V}$ $I_D = 7.2\text{A}$ $R_G = 2.7\Omega$ $V_{GS} = 10\text{V}^{(4)}$
$t_r$	Rise Time	—	9.5	—		
$t_{d(off)}$	Turn-Off Delay Time	—	11.3	—		
$t_f$	Fall Time	—	6.5	—		
$C_{iss}$	Input Capacitance	—	790	—	pF	$V_{GS} = 0\text{V}$ $V_{DS} = 50\text{V}$ $f = 1.0\text{MHz}$ , See Fig.TBD
$C_{oss}$	Output Capacitance	—	62	—		
$C_{riss}$	Reverse Transfer Capacitance	—	21	—		
$C_{oss\text{ eff.}(ER)}$	Effective Output Capacitance (Energy Related)	—	66	—		
$C_{oss\text{ eff.}(TR)}$	Output Capacitance (Time Related)	—	83	—		

**Diode Characteristics**

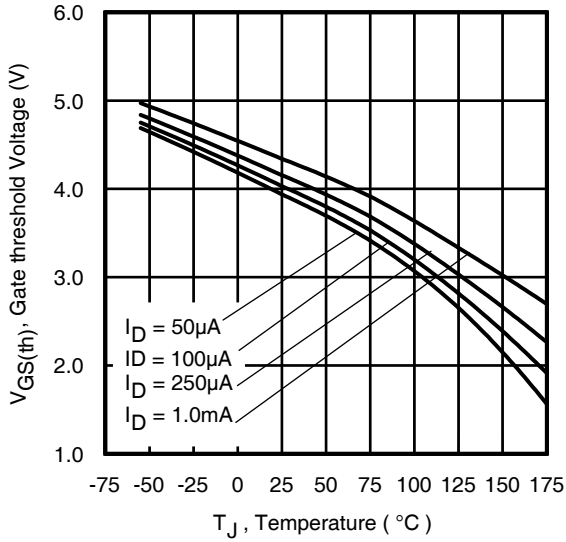
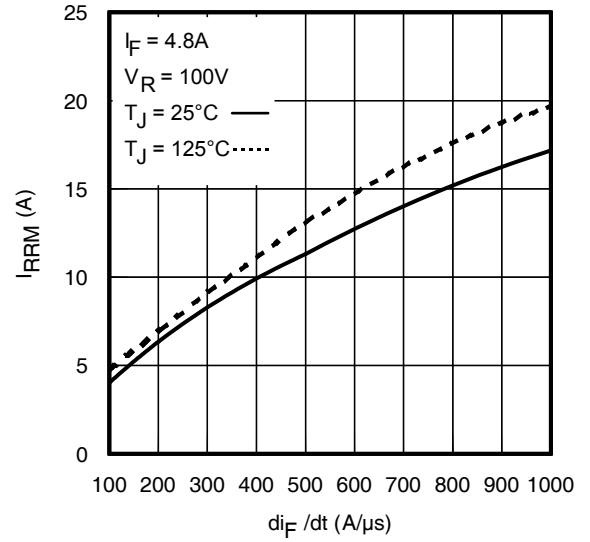
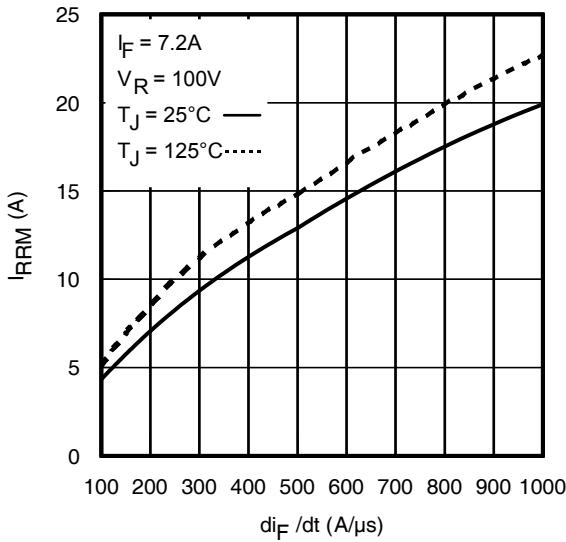
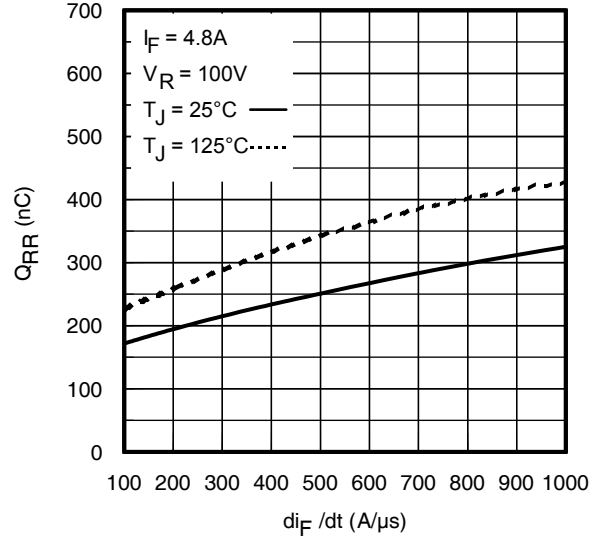
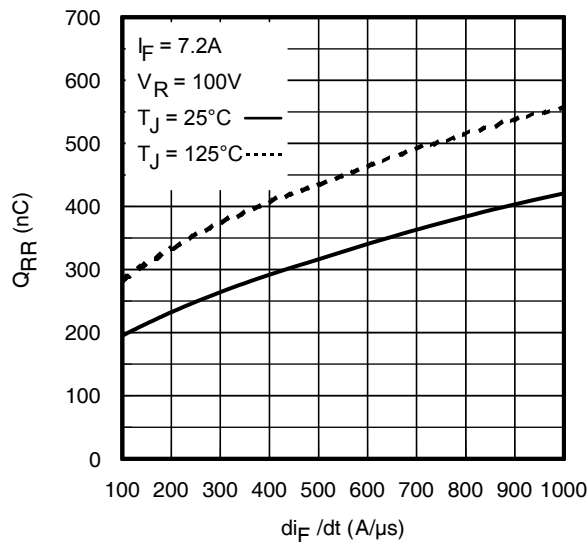
Symbol	Parameter	Min.	Typ.	Max.	Units	Conditions
$I_S$	Continuous Source Current (Body Diode)	—	—	12	A	MOSFET symbol showing the integral reverse p-n junction diode. 
$I_{SM}$	Pulsed Source Current (Body Diode) ①	—	—	34		
$V_{SD}$	Diode Forward Voltage	—	—	1.3	V	$T_J = 25^\circ\text{C}, I_S = 7.2\text{A}, V_{GS} = 0\text{V}^{(4)}$
dv/dt	Peak Diode Recovery dv/dt③	—	32.5	—	V/ns	$T_J = 175^\circ\text{C}, I_S = 7.2\text{A}, V_{DS} = 200\text{V}$
$t_{rr}$	Reverse Recovery Time	—	68	—	ns	$V_{DD} = 100\text{V}$ $I_F = 7.2\text{A}$ , $di/dt = 100\text{A}/\mu\text{s}^{(4)}$
		—	83	—		
$Q_{rr}$	Reverse Recovery Charge	—	195	—	nC	$T_J = 25^\circ\text{C}$ $T_J = 125^\circ\text{C}$
		—	280	—		
$I_{RRM}$	Reverse Recovery Current	—	4.3	—	A	$T_J = 25^\circ\text{C}$

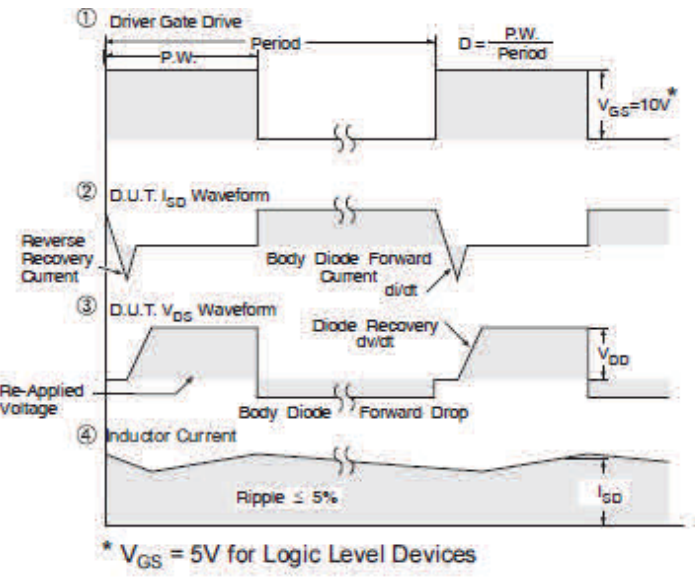
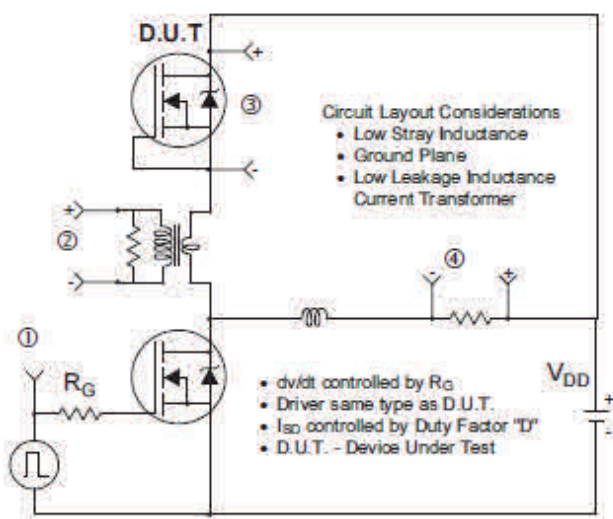

**Fig 3. Typical Output Characteristics**

**Fig 4. Typical Output Characteristics**

**Fig 5. Typical Transfer Characteristics**

**Fig 6. Normalized On-Resistance vs. Temperature**

**Fig 7. Typical Capacitance vs. Drain-to-Source Voltage**

**Fig 8. Typical Gate Charge vs. Gate-to-Source Voltage**


**Fig 9.** Typical Source-Drain Diode Forward Voltage

**Fig 10.** Maximum Safe Operating Area

**Fig 11.** Drain-to-Source Breakdown Voltage

**Fig 12.** Typical  $C_{oss}$  Stored Energy

**Fig 13.** Typical On-Resistance vs. Drain Current

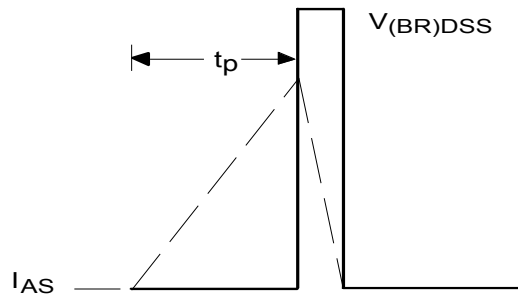
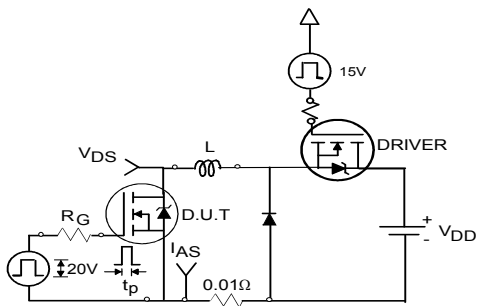

**Fig 14. Maximum Effective Transient Thermal Impedance, Junction-to-Case**

**Fig 15. Avalanche Current vs. Pulse Width**

**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 as  $T_{jmax}$  is not exceeded.
3. Equation below based on circuit and waveforms shown in Figures 23a, 23b.
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 14)  
 $P_{D(ave)} = 1/2 (1.3 \cdot BV \cdot I_{av}) = \Delta T / Z_{thJC}$   
 $I_{av} = 2\Delta T / [1.3 \cdot BV \cdot Z_{th}]$   
 $E_{AS(AR)} = P_{D(ave)} \cdot t_{av}$


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

**Fig 18. Typical Recovery Current vs. dif/dt**

**Fig 19. Typical Recovery Current vs. dif/dt**

**Fig 20. Typical Stored Charge vs. dif/dt**

**Fig 21. Typical Stored Charge vs. dif/dt**

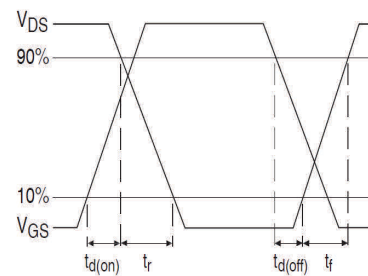
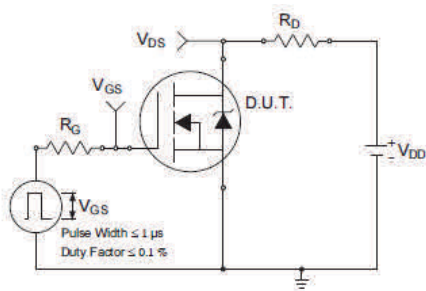


**Fig 22.** Peak Diode Recovery dv/dt Test Circuit for N-Channel HEXFET® Power MOSFETs



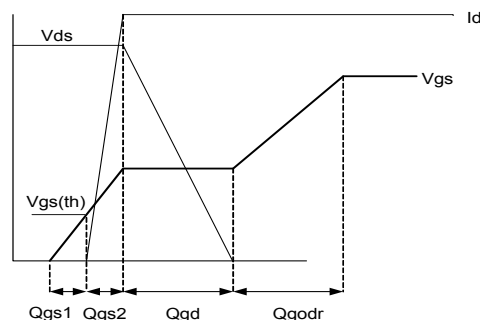
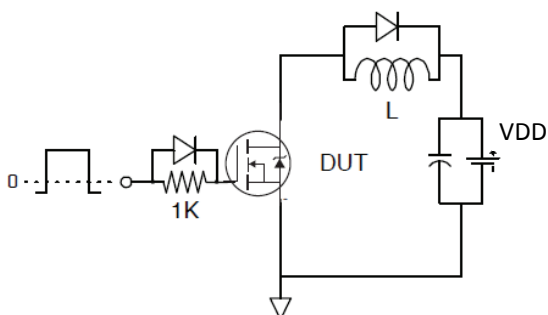
**Fig 23a.** Unclamped Inductive Test Circuit

**Fig 23b.** Unclamped Inductive Waveforms



**Fig 24a.** Switching Time Test Circuit

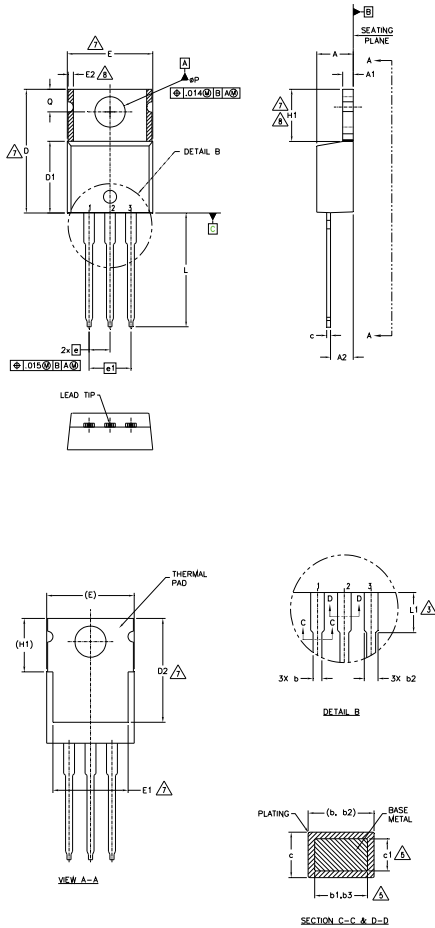
**Fig 24b.** Switching Time Waveforms



**Fig 25a.** Gate Charge Test Circuit

**Fig 25b.** Gate Charge Waveform



**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	1.14	1.40	.045	.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

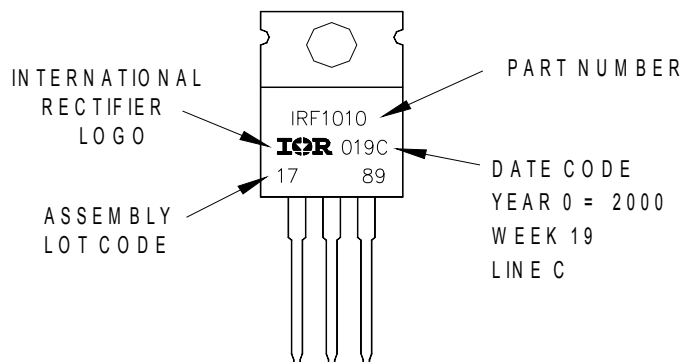
**DIODES**

- 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"



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

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>	Industrial (per JEDEC JESD47F) <sup>††</sup>	
<b>Moisture Sensitivity Level</b>	TO-220	N/A
<b>RoHS Compliant</b>	Yes	

† Qualification standards can be found at International Rectifier’s web site: <http://www.irf.com/product-info/reliability/>

†† Applicable version of JEDEC standard at the time of product release.

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[MIC4420CM-TR](#) [VN1206L](#) [614234A](#) [715780A](#) [NTNS3166NZT5G](#) [SSM6J414TU,LF\(T](#) [751625C](#) [BUK954R8-60E](#) [GROUP A 5962-](#)  
[8877003PA](#) [NTE6400](#) [SQJ402EP-T1-GE3](#) [2SK2614\(TE16L1,Q\)](#) [2N7002KW-FAI](#) [DMN1017UCP3-7](#) [EFC2J004NUZTDG](#) [ECH8691-TL-W](#)  
[FCAB21350L1](#) [P85W28HP2F-7071](#) [DMN1053UCP4-7](#) [NTE221](#) [NTE222](#) [NTE2384](#) [NTE2903](#) [NTE2941](#) [NTE2945](#) [NTE2946](#) [NTE2960](#)  
[NTE2967](#) [NTE2969](#) [NTE2976](#) [NTE6400A](#) [NTE2910](#) [NTE2916](#) [NTE2956](#) [NTE2911](#) [DMN2080UCB4-7](#) [TK10A80W,S4X\(S](#)  
[SSM6P69NU,LF](#) [DMP22D4UFO-7B](#) [DMN1006UCA6-7](#)