

## REPETITIVE AVALANCHE AND $dv/dt$ RATED HEXFET<sup>®</sup> TRANSISTOR

## IRHN2C50SE IRHN7C50SE

### N-CHANNEL SINGLE EVENT EFFECT (SEE) RAD HARD

#### 600 Volt, 0.60 $\Omega$ , (SEE) RAD HARD HEXFET

International Rectifier's (SEE) RAD HARD technology HEXFETs demonstrate virtual immunity to SEE failure. Additionally, under **identical** pre- and post-radiation test conditions, International Rectifier's RAD HARD HEXFETs retain **identical** electrical specifications up to  $1 \times 10^5$  Rads (Si) total dose. No compensation in gate drive circuitry is required. These devices are also capable of surviving transient ionization pulses as high as  $1 \times 10^{12}$  Rads (Si)/Sec, and return to normal operation within a few microseconds. Since the SEE process utilizes International Rectifier's patented HEXFET technology, the user can expect the highest quality and reliability in the industry.

RAD HARD HEXFET transistors also feature all of the well-established advantages of MOSFETs, such as voltage control, very fast switching, ease of paralleling and temperature stability of the electrical parameters.

They are well-suited for applications such as switching power supplies, motor controls, inverters, choppers, audio amplifiers and high-energy pulse circuits in space and weapons environments.

#### Product Summary

Part Number	BV <sub>DSS</sub>	R <sub>DS(on)</sub>	I <sub>D</sub>
IRHN2C50SE	600V	0.60 $\Omega$	10.4A
IRHN7C50SE			

#### Features:

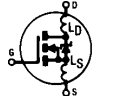
- Radiation Hardened up to  $1 \times 10^5$  Rads (Si)
- Single Event Burnout (SEB) Hardened
- Single Event Gate Rupture (SEGR) Hardened
- Gamma Dot (Flash X-Ray) Hardened
- Neutron Tolerant
- Identical Pre- and Post-Electrical Test Conditions
- Repetitive Avalanche Rating
- Dynamic  $dv/dt$  Rating
- Simple Drive Requirements
- Ease of Paralleling
- Hermetically Sealed
- Surface Mount
- Light-Weight

#### Absolute Maximum Ratings

#### Pre-Radiation

	Parameter	IRHN2C50SE, IRHN7C50SE	Units
I <sub>D</sub> @ V <sub>GS</sub> = 12V, T <sub>C</sub> = 25°C	Continuous Drain Current	10.4	A
I <sub>D</sub> @ V <sub>GS</sub> = 12V, T <sub>C</sub> = 100°C	Continuous Drain Current	6.5	
I <sub>DM</sub>	Pulsed Drain Current ①	41.6	
P <sub>D</sub> @ T <sub>C</sub> = 25°C	Max. Power Dissipation	150	W
	Linear Derating Factor	1.2	W/K ⑤
V <sub>GS</sub>	Gate-to-Source Voltage	±20	V
EAS	Single Pulse Avalanche Energy ②	500	mJ
I <sub>AR</sub>	Avalanche Current ①	10.4	A
EAR	Repetitive Avalanche Energy ①	15	mJ
dv/dt	Peak Diode Recovery dv/dt ③	3.0	V/ns
T <sub>J</sub>	Operating Junction	-55 to 150	°C
T <sub>STG</sub>	Storage Temperature Range		
	Package Mounting Surface Temperature	300 (for 5 seconds)	
	Weight	2.6 (typical)	g

Electrical Characteristics @ T<sub>j</sub> = 25°C (Unless Otherwise Specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
BV <sub>DSS</sub>	Drain-to-Source Breakdown Voltage	600	—	—	V	V <sub>GS</sub> = 0V, I <sub>D</sub> = 1.0 mA
ΔBV <sub>DSS</sub> /ΔT <sub>J</sub>	Temperature Coefficient of Breakdown Voltage	—	0.45	—	V/°C	Reference to 25°C, I <sub>D</sub> = 1.0 mA
RDS(on)	Static Drain-to-Source	—	—	0.60	Ω	V <sub>GS</sub> = 12V, I <sub>D</sub> = 6.5A V <sub>GS</sub> = 12V, I <sub>D</sub> = 10.4A ④
	On-State Resistance	—	—	0.65		
VGS(th)	Gate Threshold Voltage	2.5	—	4.5	V	V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 1.0 mA
g <sub>fs</sub>	Forward Transconductance	3.0	—	—	S (r̄)	V <sub>DS</sub> > 15V, I <sub>DS</sub> = 6.5A ④
IDSS	Zero Gate Voltage Drain Current	—	—	50	μA	V <sub>DS</sub> = 0.8 x Max Rating, V <sub>GS</sub> = 0V V <sub>DS</sub> = 0.8 x Max Rating V <sub>GS</sub> = 0V, T <sub>J</sub> = 125°C
		—	—	250		
IGSS	Gate-to-Source Leakage Forward	—	—	100	nA	V <sub>GS</sub> = 20V
IGSS	Gate-to-Source Leakage Reverse	—	—	-100	nA	V <sub>GS</sub> = -20V
Q <sub>g</sub>	Total Gate Charge	—	—	150	nC	V <sub>GS</sub> = 12V, I <sub>D</sub> = 10.4A V <sub>DS</sub> = Max. Rating x 0.5
Q <sub>gs</sub>	Gate-to-Source Charge	—	—	30		
Q <sub>gd</sub>	Gate-to-Drain ("Miller") Charge	—	—	75		
t <sub>d(on)</sub>	Turn-On Delay Time	—	—	55	ns	V <sub>DD</sub> = 300V, I <sub>D</sub> = 10.4A, R <sub>G</sub> = 2.35Ω
t <sub>r</sub>	Rise Time	—	—	190		
t <sub>d(off)</sub>	Turn-Off Delay Time	—	—	210		
t <sub>f</sub>	Fall Time	—	—	130		
LD	Internal Drain Inductance	—	2.0	—	nH	<p>Measured from the drain lead, 6mm (0.25 in.) from package to center of die.</p> <p>Modified MOSFET symbol showing the internal inductances.</p> 
LS	Internal Source Inductance	—	6.5	—		
C <sub>iss</sub>	Input Capacitance	—	2700	—	pF	V <sub>GS</sub> = 0V, V <sub>DS</sub> = 25V f = 1.0 MHz
C <sub>oss</sub>	Output Capacitance	—	300	—		
C <sub>rss</sub>	Reverse Transfer Capacitance	—	61	—		

## Source-Drain Diode Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
I <sub>S</sub>	Continuous Source Current (Body Diode)	—	—	10.4	A	Modified MOSFET symbol showing the integral reverse p-n junction rectifier.
I <sub>SM</sub>	Pulse Source Current (Body Diode) ①	—	—	41.6		
V <sub>SD</sub>	Diode Forward Voltage	—	—	1.62	V	T <sub>j</sub> = 25°C, I <sub>S</sub> = 10.4A, V <sub>GS</sub> = 0V ④
t <sub>rr</sub>	Reverse Recovery Time	—	—	1200	ns	T <sub>j</sub> = 25°C, I <sub>F</sub> = 10.4A, di/dt ≤ 100A/μs V <sub>DD</sub> ≤ 50V ④
Q <sub>RR</sub>	Reverse Recovery Charge	—	—	16	μC	
t <sub>on</sub>	Forward Turn-On Time	Intrinsic turn-on time is negligible. Turn-on speed is substantially controlled by L <sub>S</sub> + L <sub>D</sub> .				

## Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
R <sub>thJC</sub>	Junction-to-Case	—	—	0.83	K/W <sup>⑤</sup>	soldered to a copper-clad PC board
R <sub>thJ-PCB</sub>	Junction-to-PC board	—	TBD	—		

**Radiation Performance of Rad Hard HEXFETs**

International Rectifier Radiation Hardened HEX-FETs are tested to verify their hardness capability. The hardness assurance program at International Rectifier uses two radiation environments.

Every manufacturing lot is tested in a low dose rate (total dose) environment per MIL-STD-750, test method 1019. International Rectifier has imposed a standard gate voltage of 12 volts per note 6 and a  $V_{DSS}$  bias condition equal to 80% of the device rated voltage per note 7. Pre- and post-radiation limits of the devices irradiated to  $0.5 \times 10^5$  Rads (Si) and  $1 \times 10^5$  Rads (Si) are identical and are presented in Table 1, column 1, IRHN2C50SE and IRHN7C50SE, respectively. The values in Table 1 will be met for either of the two low dose rate test circuits that are used.

Both pre- and post-radiation performance are tested and specified using the same drive circuitry and test conditions in order to provide a direct comparison. It should be noted that at a radiation level of  $1 \times 10^5$  Rads (Si), no change in limits are specified in DC parameters.

High dose rate testing may be done on a special request basis, using a dose rate up to  $1 \times 10^{12}$  Rads (Si)/Sec.

International Rectifier radiation hardened HEXFETs have been characterized in neutron and heavy ion Single Event Effects (SEE) environments. Single Event Effects characterization is shown in Table 3.

**Table 1. Low Dose Rate** ⑥ ⑦

	Parameter	IRHN2C50SE 50K Rads (Si)		Units	Test Conditions ⑩
		IRHN7C50SE 100K Rads (Si)			
		Min.	Max.		
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	600	—	V	$V_{GS} = 0V, I_D = 1.0 \text{ mA}$
$V_{GS(th)}$	Gate Threshold Voltage ④	2.0	4.5		$V_{GS} = V_{DS}, I_D = 1.0 \text{ mA}$
$I_{GSS}$	Gate-to-Source Leakage Forward	—	100	nA	$V_{GS} = 20V$
$I_{GSS}$	Gate-to-Source Leakage Reverse	—	-100		$V_{GS} = -20V$
$I_{DSS}$	Zero Gate Voltage Drain Current	—	50	$\mu A$	$V_{DS} = 0.8 \times \text{Max Rating}, V_{GS} = 0V$
$R_{DS(on)1}$	Static Drain-to-Source ④ On-State Resistance One	—	0.60	$\Omega$	$V_{GS} = 12V, I_D = 6.5A$
$V_{SD}$	Diode Forward Voltage ④	—	1.62	V	$T_C = 25^\circ C, I_S = 10.4A, V_{GS} = 0V$

**Table 2. High Dose Rate** ⑧

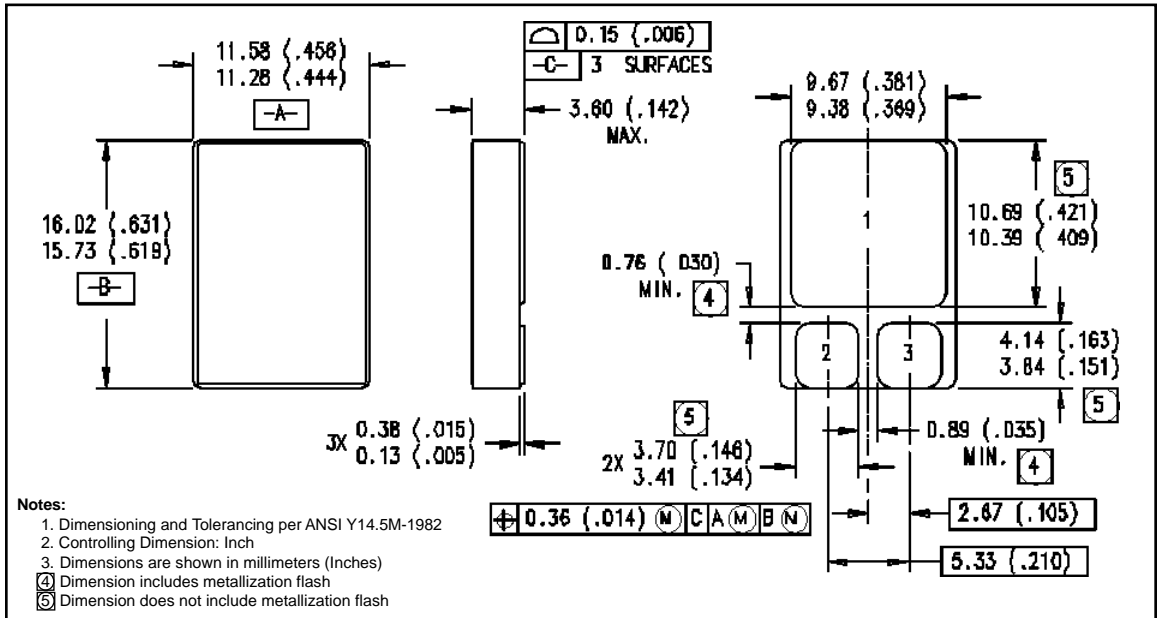
	Parameter	10 <sup>11</sup> Rads (Si)/sec		10 <sup>12</sup> Rads (Si)/sec		Units	Test Conditions		
		Min.	Typ	Max.	Min.			Typ.	Max.
$V_{DSS}$	Drain-to-Source Voltage	—	—	480	—	—	480	V	Applied drain-to-source voltage during gamma-dot
$I_{PP}$		—	6.4	—	—	6.4	—	A	Peak radiation induced photo-current
di/dt		—	—	16	—	—	2.3	A/ $\mu$ sec	Rate of rise of photo-current
L1		20	—	—	137	—	—	$\mu H$	Circuit inductance required to limit di/dt

**Table 3. Single Event Effects** ⑨

Parameter	Typ.	Units	Ion	LET (Si) (MeV/mg/cm <sup>2</sup> )	Fluence (ions/cm <sup>2</sup> )	Range ( $\mu$ m)	$V_{DS}$ Bias (V)	$V_{GS}$ Bias (V)
$BV_{DSS}$	600	V	Ni	28	$1 \times 10^6$	~35	480	-5

- ① Repetitive Rating; Pulse width limited by maximum junction temperature. Refer to current HEXFET reliability report.
- ② @  $V_{DD} = 50V$ , Starting  $T_J = 25^\circ C$ ,  
 $E_{AS} = [0.5 * L * (I_L^2) * [BV_{DSS}/(BV_{DSS}-V_{DD})]]$   
 Peak  $I_L = 10.4A$ ,  $V_{GS} = 12V$ ,  $25 \leq R_G \leq 200\Omega$
- ③  $I_{SD} \leq 10.4A$ ,  $di/dt \leq 130A/\mu s$ ,  
 $V_{DD} \leq BV_{DSS}$ ,  $T_J \leq 150^\circ C$   
 Suggested  $R_G = 2.35\Omega$
- ④ Pulse width  $\leq 300 \mu s$ ; Duty Cycle  $\leq 2\%$
- ⑤  $K/W = ^\circ C/W$   
 $W/K = W/^\circ C$
- ⑥ **Total Dose Irradiation with  $V_{GS}$  Bias.**  
 12 volt  $V_{GS}$  applied and  $V_{DS} = 0$  during irradiation per MIL-STD-750, method 1019.
- ⑦ **Total Dose Irradiation with  $V_{DS}$  Bias.**  
 $V_{DS} = 0.8$  rated  $BV_{DSS}$  (pre-radiation) applied and  $V_{GS} = 0$  during irradiation per MIL-STD-750, method 1019.
- ⑧ This test is performed using a flash x-ray source operated in the e-beam mode (energy  $\sim 2.5$  MeV), 30 nsec pulse.
- ⑨ Process characterized by independent laboratory.
- ⑩ All Pre-Radiation and Post-Radiation test conditions are **identical** to facilitate direct comparison for circuit applications.

Case Outline and Dimensions — SMD-1



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