200V, 16A N-Channel Radiation Hardened MOSFET Qualified to MIL-PRF-19500/746 for space applications

JANSR2N7591U3/MRH20N16U3

Product Overview

Developed on Microchip's new M6™ technology, the JANSR2N7591U3/MRH20N16U3 radiation hardened N-channel MOSFET provides high performance and radiation tolerance for space and defense applications. The proprietary M6 technology is designed to perform in extreme-environment applications and has shown to remain within specification in radiation environments greater than 300 krad(Si) total ionizing dose (TID). Low $R_{DS(ON)}$, high current capability, and improved safe operating area (SOA) make this device ideal for DC-DC converters, power distribution, and motor control.

Table 1. Ordering Options

Part Number	Screening Level	$R_{DS(ON)}$	I_D	Q_G	Package	TID Level
MRH20N16U3	Commercial	0.130Ω	16A	50nC	SMD-0.5	N/A
JANSR2N7591U3	JANS	0.130Ω	16A	50nC	SMD-0.5	100 krad(Si)
JANSF2N7591U3	JANS	0.130Ω	16A	50nC	SMD-0.5	300 krad(Si)
2C20N16-F5	Commercial	0.130Ω	16A	50nC	Die	N/A
JANKCBR2N7591	JANKC	0.130Ω	16A	50nC	Die	100 krad(Si)
JANKCBF2N7591	JANKC	0.130Ω	16A	50nC	Die	300 krad(Si)

Features

- Single Event Effect (SEE) hardened to 90 MeV·cm²/mg per MIL-STD-750 TM 1080
- TID measured performance according to MIL-STD-750 TM 1019 Condition A
- ESD Rating: Class 3B MIL-STD-750, TM 1020
- PIND tested per MIL-STD-750 TM 2052
- Isolated lid from rest of package frame
- Hermatically sealed with lid brazed to body
- Rugged design with measured SOA and single pulse avalanche characterization
- Simple voltage control drive requirements

Applications

- Satellites, Deep Space Probes
- Nuclear Facilities
- Isolated/Non-isolated DC-DC Converters
- Motor Control
- Power Distribution/Protection

Figure 1. Package and Pin Description



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1. Electrical Specifications

1.1. Absolute Maximum Ratings

Table 1-1. Absolute Maximum Ratings Pre-Irradiation

Symbol	Parameter	Ratings	Unit
I_{DS}	Continuous Drain Current at T_C = 25 °C	16	A
	Continuous Drain Current at T_C = 100 °C	10	
I_{DM}	Pulsed Drain Current [1]	64	
V_{GS}	Gate-Source Voltage	±20	V
d_v/d_t	Peak Diode Recovery[2]	5	V/ns
P_D	Max Power Dissipation at T_C = 25 °C	75	W
	Linear Derating Factor	0.6	W/°C
T_J, T_{STG}	Operating and Storage Junction Temperature Range	–55 to 150	°C
T_L	Soldering Temperature for 5 Seconds (1.6 mm from case)	300	
W_T	Typical Package Mass	1.0	g
E_{AS}	Single Pulse Avalanche Energy[3]	60	mJ
I_{AR}	Avalanche Current[1]	16	A

Note:

1. Repetative Rating: Pulse width limited by maximum junction temperature
2. I_{DS} ≤ –16A, di/dt ≤ 100A/µs, V_{DD} ≤ 30V, T_J ≤ 150 °C
3. V_{DD} = 25V, starting T_J = 25 °C, L ≥ 400 µH, Peak I_L = 16A, V_{GS} = 12V

1.2. Electrical Performance

Table 1-2. Static Characteristics Pre-Irradiation, (T_A = +25 °C) unless otherwise noted

Symbol	Parameter	Test Conditions		Ratings			Unit
				Min	Typ	Max	
$V_{BR(DSS)}$	Drain-Source Breakdown Voltage	V_{GS} = 0V, I_{DS} = 1.0 mA		200	—	—	V
$R_{DS(ON)}$	Drain-Source On Resistance [1]	V_{GS} = 12V, I_{DS} = 10A		—	—	0.130	Ω
$V_{GS(TH)}$	Gate-Source Threshold Voltage	V_{GS} ≤ V_{DS}, I_{DS} = 1.0 mA		2.0	—	4.0	V
G_{FS}	Forward Transconductance[1]	V_{DD} = 15V, I_{DS} = 10A		10	—	—	S
I_{GSS}	Gate-Source Leakage Current	V_{GS} = ±20V		—	—	±100	nA
I_{DSS}	Zero-Gate Voltage Drain Current	V_{DS} = 160V	T_A = 25 °C	—	—	10	µA
		V_{GS} = 0V	T_A = 125 °C	—	—	25	

Note:

1. Pulse test: pulse width < 300 µs, duty cycle <2%.

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Table 1-3. Dynamic Characteristics Pre-Irradiation (T_A = +25 °C)

Symbol	Parameter	Test Conditions	Ratings			Unit
			Min	Typ	Max	
C_{ISS}	Input Capacitance	V_{GS} = 0V, V_{DS} = 25V, ƒ = 1 MHz	—	1715	—	pF
C_{RSS}	Reverse Transfer Capacitance		—	10	—	
C_{OSS}	Output Capacitance		—	276	—	
Q_G	Total Gate Charge	V_{GS} = 12V, I_{DS} = 16A, V_{DD} = 100V	—	27	50	nC
Q_{GS}	Gate-Source Charge		—	9	15	
Q_{GD}	Gate-Drain (“Miller”) Charge		—	4	20	
$t_{D(ON)}$	Turn-On Delay Time	V_{GS} = 12V, I_{DS} = 16A, V_{DD} = 100V, $R_{G(EXT)}$ = 7.5Ω	—	12	25	ns
t_R	Voltage Rise Time		—	2	30	
$t_{D(OFF)}$	Turn-Off Delay Time		—	18	60	
t_F	Voltage Fall Time		—	2	30	

Table 1-4. Source-Drain Characteristics Pre_Irradiation (T_A = +25 °C)

Symbol	Parameter	Test Conditions	Ratings			Unit
			Min	Typ	Max	
I_S	Continuous Source Current (Body Diode)	—	—	—	16	A
I_{SM}	Pulsed Source Current (Body Diode)[1]	—	—	—	64	
V_{SD}	Diode Forward Voltage	I_{DS} = –16A, V_{GS} = 0V	—	0.9	1.2	V
t_{RR}	Reverse Recovery Time[2]	I_{DS} = –16A, di/dt ≤ 100 A/µS, V_{DD} ≤ 50V	—	208	350	ns
Q_{RR}	Reverse Recovery Charge[2]		—	2.1	—	µC

Notes:

1. Repetitive rating: Pulse width and case temperature limited by maxing junction temperature.
2. Pulse test: pulse width < 300 µs, duty cycle < 2%.

Table 1-5. Package Iductance

Symbol	Parameter	Test Conditions	Ratings			Unit
			Min	Typ	Max	
$L_S + L_D$	Total inductance	Measured from the center of drain pad to center of source pad	—	4	—	nH

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1.3. Typical Electrical Performance Curves Pre-Irradiation

Figure 1-1. Typical Output Characteristics

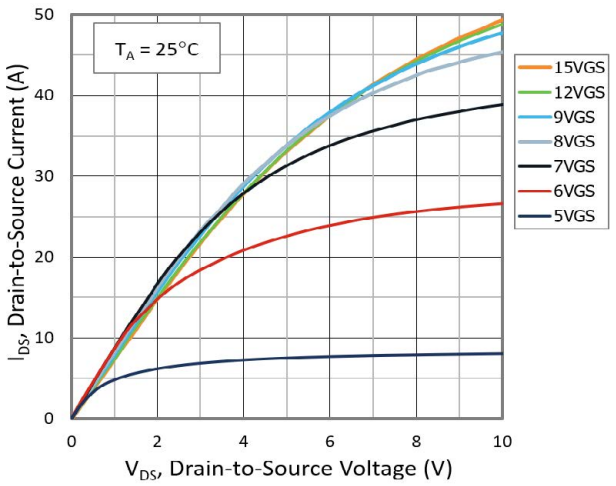


Figure 1-2. Typical Output Characteristics

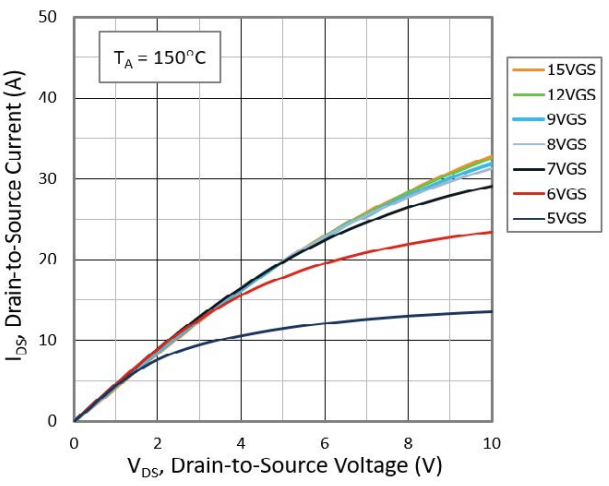


Figure 1-3. Typical Transfer Characteristics

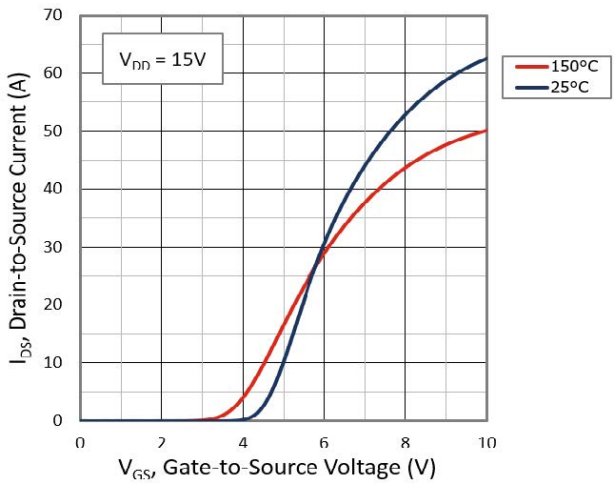
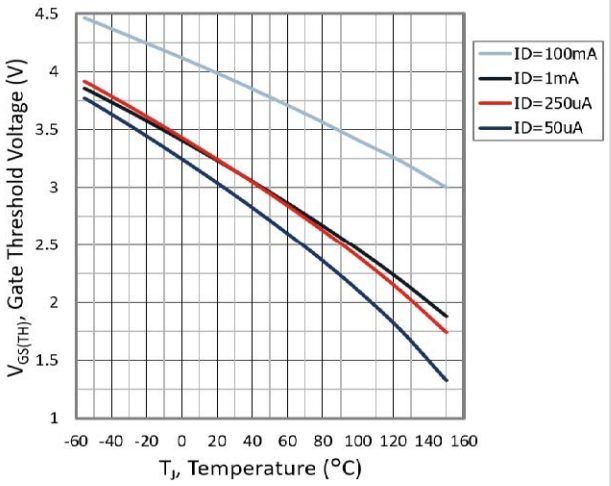


Figure 1-4. Typical $V_{GS(TH)}$ vs T_J



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Figure 1-5. Typical $R_{DS(ON)}$ vs V_{GS}

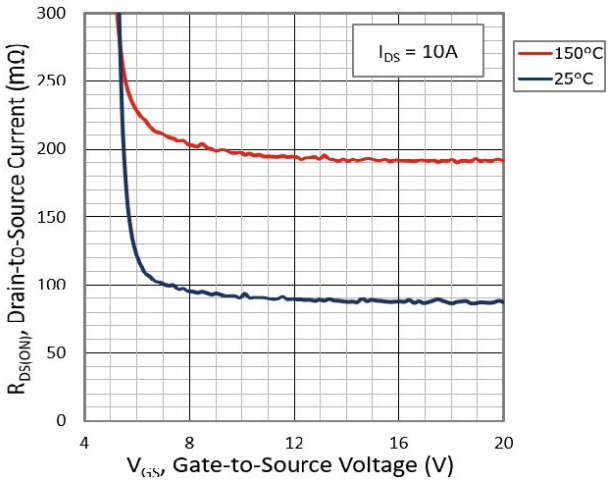


Figure 1-6. Typical $R_{DS(ON)}$ vs I_{DS}

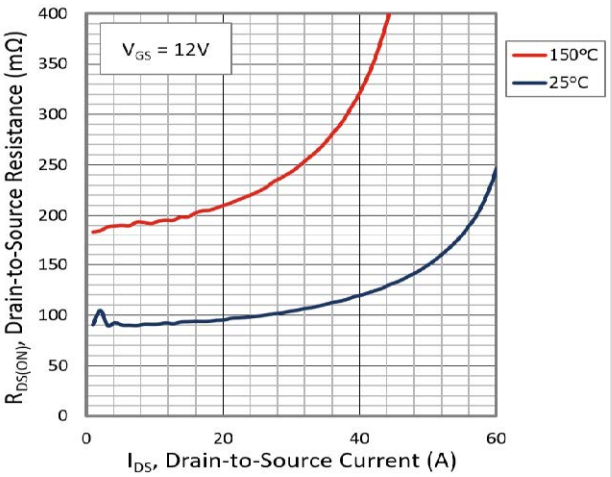


Figure 1-7. Normalized $R_{DS(ON)}$ vs T_J

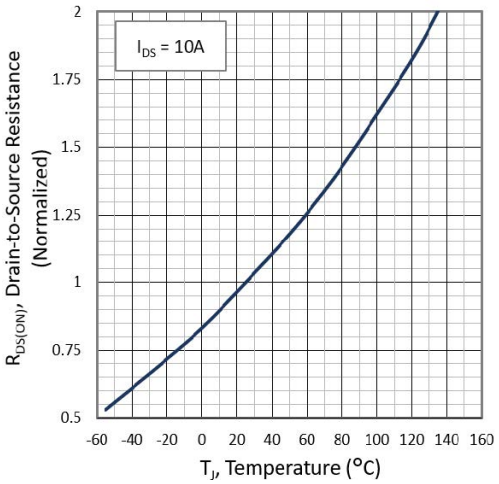
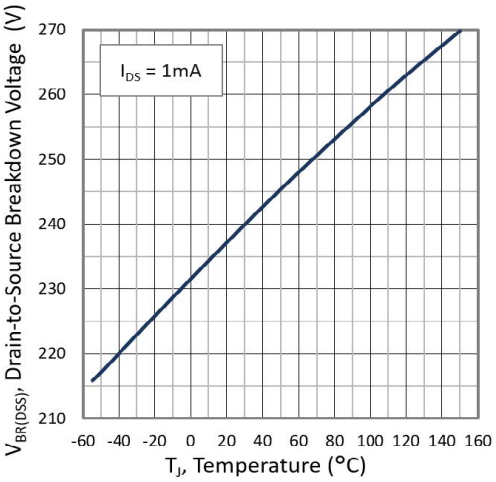


Figure 1-8. $V_{BR(DSS)}$ vs T_J



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Figure 1-9. Typical Capacitance vs V_{DS}

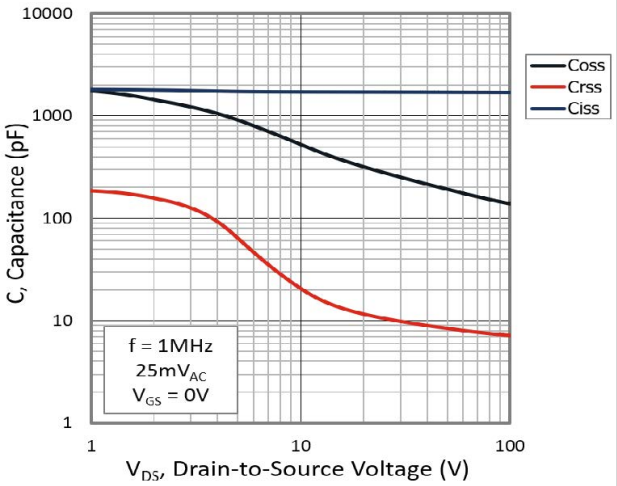


Figure 1-10. Typical V_{GS} vs Q_G

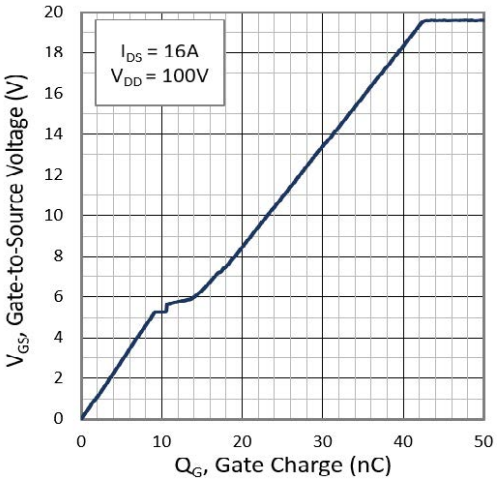


Figure 1-11. Typical Source-Drain Diode Conduction

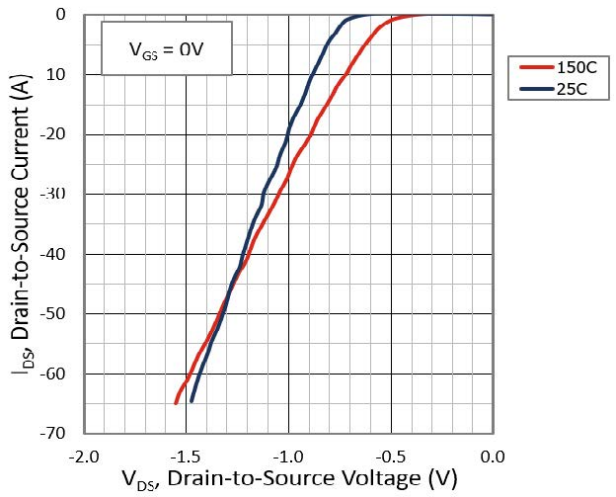
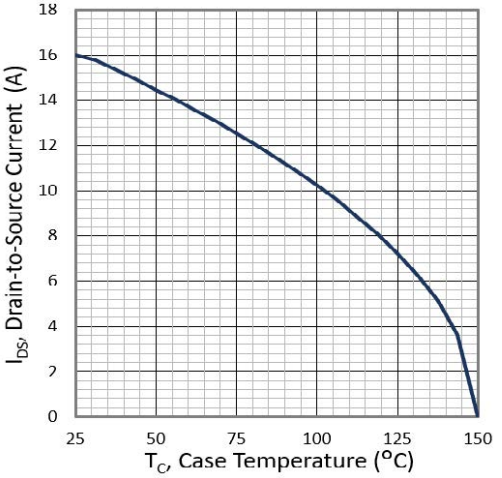
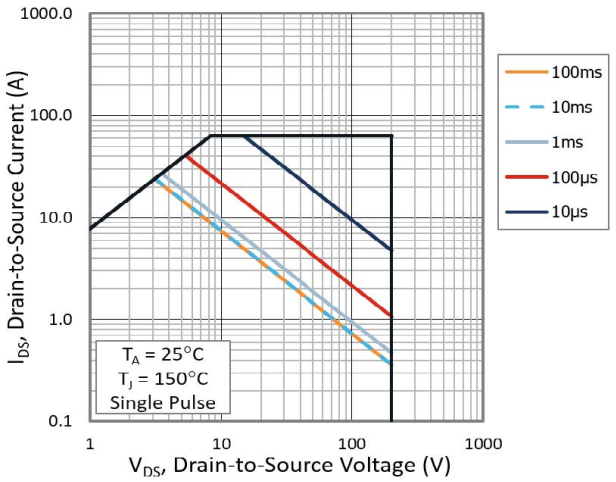


Figure 1-12. I_{DS} vs Case Temperature



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Figure 1-13. Maximum Safe Operating Area



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2. Thermal Specifications

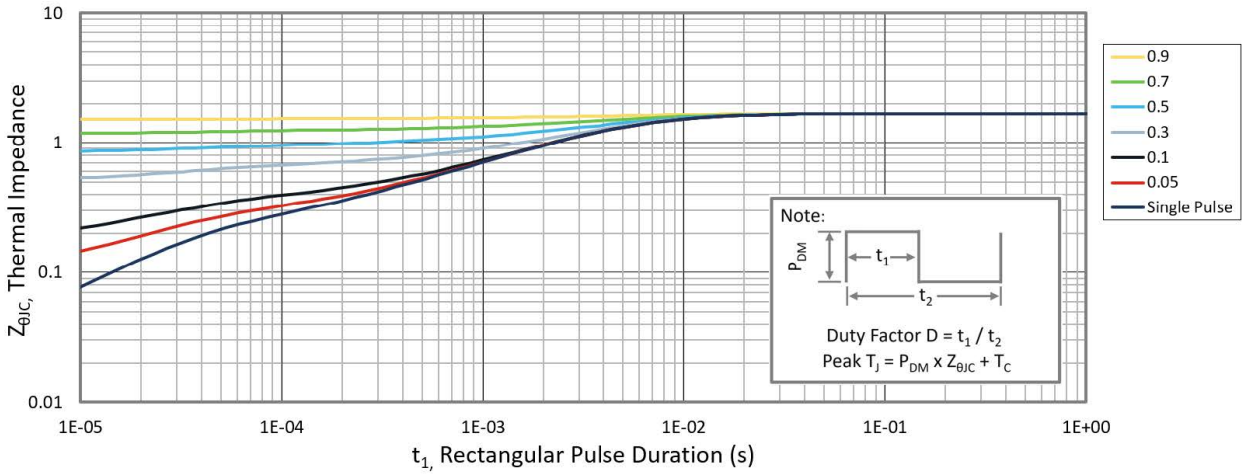
2.1. Thermal Performance

Table 2-1. Thermal Resistance

Symbol	Parameter	Test Conditions	Ratings			Unit
			Min	Typ	Max	
$R_{\theta JC}$	Junction-to-case thermal resistance	—	—	—	1.67	°C/W

2.2. Thermal Performance Curves

Figure 2-1. Maximum Transient Thermal Impedance



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3. Radiation Performance

3.1. Post Total Dose Irradiation Electrical Performance

Table 3-1. Static Characteristics T_A = 25 °C, 300 krad(Si), 50–300 rad(Si)/s, unless otherwise noted

Symbol	Parameter	Test Conditions		Ratings			Unit
				Min	Typ	Max	
$V_{BR(DSS)}$	Drain-Source Breakdown Voltage	V_{GS} = 0V, I_{DS} = 1.0 mA		200	—	—	V
$R_{DS(ON)}$	Drain-Source On Resistance[1] (SMD-0.5)	V_{GS} = 12V, I_{DS} = 10A		—	—	0.130	Ω
$V_{GS(TH)}$	Gate-Source Threshold Voltage	$V_{GS} \le V_{DS}$ I_{DS} = 1.0 mA		2.0	—	4.0	V
V_{SD}	Diode Forward Voltage	I_{SD} = 16A, V_{GS} = 0V		—	0.9	1.2	V
I_{GSS}	Gate-Source Leakage Current	V_{GS} = ±20V		—	—	±100	nA
I_{DSS}	Zero Gate Voltage Drain Current	V_{DS} = 160V	T_A = 25 °C	—	—	10	µA
		V_{GS} = 0V	T_A = 125 °C	—	—	25	

Note:

1. Pulse test: pulse width < 300 µs, duty cycle < 2%

3.2. Single-Event Effects (SEE) Performance

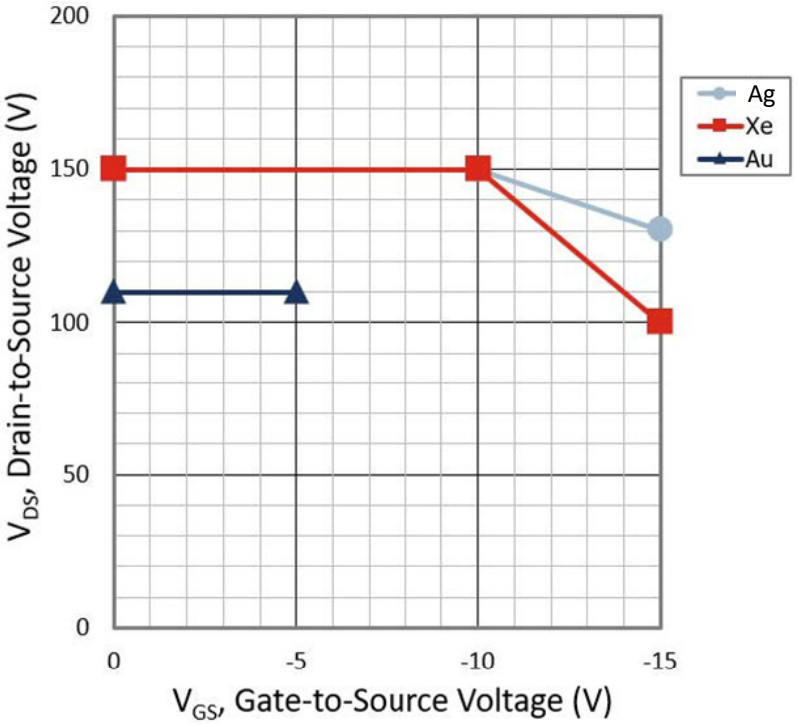
This device has been characterized for SEE with heavy ions. The following SEE safe-operating area profile has been established using the ions, linear energy transfer (LET), range and total energy conditions shown.

Table 3-2. SEE Safe-Operating Area

Ion Species	Eff. Surface LET (MeV·cm²/mg)	ION Energy (MeV)	Eff. Range (µm)	VDS(V)				
				V_{GS} = 0V	V_{GS} = –5V	V_{GS} = –10V	V_{GS} = –15V	V_{GS} = –20V
Ag	44 (±5%)	1330 (±5%)	117.3 (±10%)	150	—	150	130	—
Xe	61.0 (±5%)	1132 (±5%)	83 (±7.5%)	150	150	150	100	—
Au	90.0 (±5%)	1476 (±5%)	82.5 (±5%)	110	110	—	—	—

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Figure 3-1. SEE Safe-Operating Area



Microchip Radiation-Hardened MOSFETs are tested in a manner to provide maximum observability during heavy ion exposure. The filtering circuits of MIL-STD-750F Method 1080 are not used.

A V_{GS}/V_{DS} point is accepted on the prior plot if all of the following conditions are met:

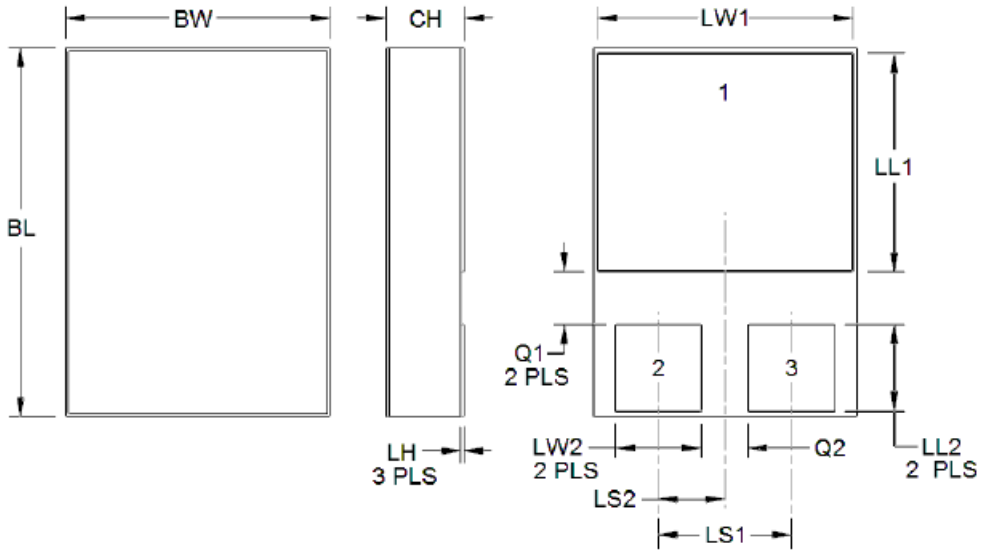
1. A fluence of $3x10^5$ ± 20% ions/cm^2 is delivered to each sample.
2. No Single-Event Burnout is detected via continuous monitoring of the drain current.
3. No Single-Event Gate Rupture is detected via continuous monitoring of the gate current.
4. Post-Exposure I_{DSS} tests continue to pass specification.
5. Post-Exposure I_{GSS} tests continue to pass specification.

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4. Package Details

4.1. Package Outline Drawing

Figure 4-1. Package Outline Drawing



Notes:

1. Controlling dimensions are in inches. Millimeters are given for general information only.
2. In accordance with ASME Y 14.5M, diameters are equivalent to φx symbology.

Table 4-1. Package Dimensions

Symbol	Dimensions			
	Inches		Millimeters	
	Min	Max	Min	Max
BL	0.395	0.405	10.03	10.29
BW	0.291	0.301	7.39	7.65
CH	0.112	0.124	2.84	3.15
LH	0.010	0.020	0.25	0.51
LL1	0.220	0.230	5.59	5.84
LL2	0.115	0.125	2.92	3.18
LS1	0.150 BSC		3.81 BSC	
LS2	0.075 BSC		1.91 BSC	
LW1	0.281	0.291	7.14	7.39
LW2	0.090	0.100	2.29	2.54
Q1	0.030	—	0.76	—
Q2	0.030	—	0.76	—
Pad 1	Drain			
Pad 2	Gate			
Pad 3	Source			

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5. Die Details

5.1. Die Drawing

Figure 5-1. Die Drawing

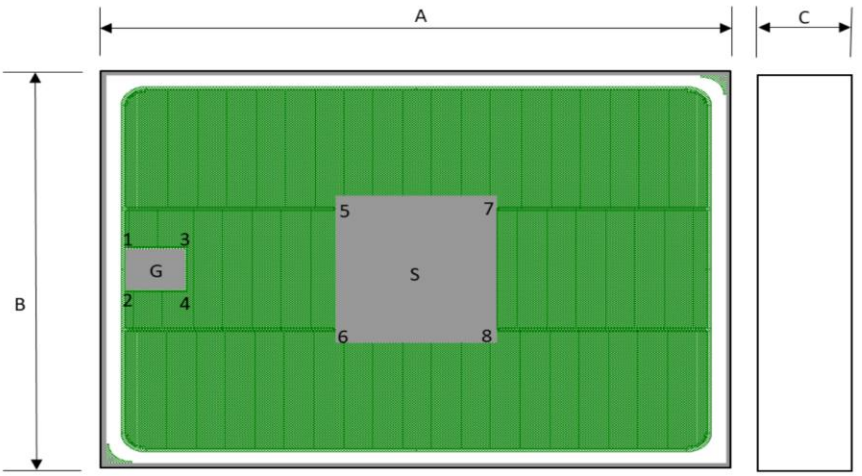


Table 5-1. Die Dimensions

Key	Dimensions					
	Inch	Inch	Micrometer	Micrometer	Tolerance	Tolerance
	X	Y	X	Y	Inch	Micrometer
1	0	0	0	0	±0.0002	±5
2	0.01504	0	382	0	±0.0002	±5
3	0	0.01657	0	421	±0.0002	±5
4	0.01504	0.01657	382	421	±0.0002	±5
5	0.02055	0.06040	522	1534.2	±0.0002	±5
6	0.03559	0.06040	904	1534.2	±0.0002	±5
7	0.02055	0.10631	522	2700.2	±0.0002	±5
8	0.03559	0.10631	904	2700.2	±0.0002	±5
A	0.1843		4682		±0.0079	±200
B	0.1543		3920		±0.0079	±200
C	0.0150		381		±0.0010	±25

Notes:

1. Dimensions are in inches. Micrometers are given for general information only.
2. All dimensions are valid for all radiation hardness levels specified.
3. For sawn die, outline dimensions (A and B) will be reduced by 0.001 (25 µm), due to saw kerf.
4. Die bond pad coordinates are provided for use in automated bonding equipment. Key locations 1 through 4 refer to adjacent gate (G) pad corners. Key locations 5 through 8 refer to adjacent source (S) pad corners.
5. Keys 2 through 8 are relative to Key 1.
6. Top metal: 150V and 250V—Aluminum Copper (0.5%) Silicon (1%), 55,000 Å
7. Back metal: Titanium, Nickel, Silver 700 Å, 3200 Å, 7500 Å thick, respectively
8. Backside metal is the drain connection.

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6. Part Nomenclature

6.1. Packaged Devices[1]

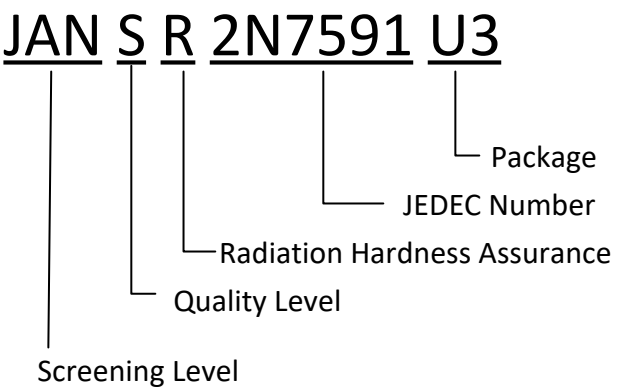


Table 6-1. Qualified Package Devices Description

Term	Initial	Option
Screening Level	JAN	Joint Army Navy
Quality Level	S	Space grade
Radiation Hardness Assurance	R	100 krad(Si)
	F	300 krad(Si)
JEDEC Number	2N7591	
Package	U3	SMD-0.5

Example:

JANSF2N7591U3: Space grade 2N7591 MOSFET with 300 krad(Si) rating in an SMD-0.5 package.

Note:

1. Cage Code: 43611

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6.2. Qualified Unencapsulated Devices (Die Version)[1, 2]

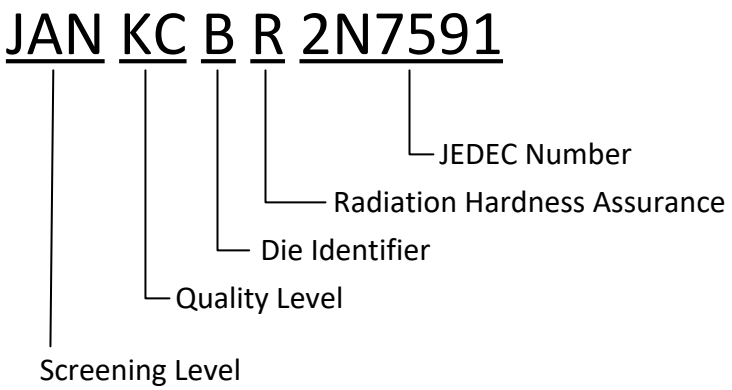


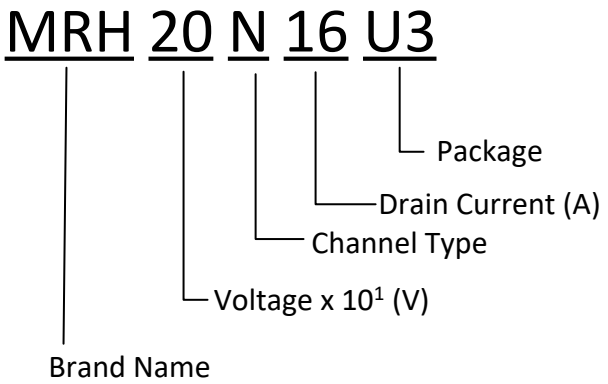
Table 6-2. Qualified Unencapsulated Devices Description

Term	Initial	Option
Screening Level	JAN	Joint Army Navy
Quality Level	KC	Screened per MIL-PRF-19500 Class K for space applications
Die Identifier	B	Microchip die
Radiation Hardness Assurance	R	100 krad(Si)
	F	300 krad(Si)
JEDEC Number	2N7591	

Notes:

1. Please refer to slash sheet MIL-PRF-19500/746 page 6 for die information.
2. Cage Code: 43611

6.3. Commercial Packaged Devices[1, 2]



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Table 6-3. Commercial Package Devices Description

Term	Initial	Option
Brand Name	MRH	Microchip Radiation Hardened
Voltage (V)	20	$20 \times 10^1 = 200V$
Channel Type	N	N-channel
Drain Current	16	16A
Package	U3	SMD-0.5

Notes:

1. Commercial screened devices are intended for engineering evaluation and are not available with any quality levels or radiation hardness assurance.
2. Commercial screened devices are only tested to meet static electrical specifications.

6.4. Commercial Unencapsulated Devices (Die Version)[1, 2, 3]

2C20N16-F5

└ Ordering part number for the die version of the 2N7591

Table 6-4. Commercial Unencapsulated Devices Description

Term	Initial	Option
	2C	MOSFET Die
Voltage (V)	20	$20 \times 10^1 = 200V$
Channel Type	N	N-Channel
Drain Current	16	16A
	F5	Internal Microchip Fabrication Site

Notes:

1. Commercial screened devices are intended for engineering evaluation and are not available with any quality levels or radiation hardness assurance.
2. Commercial screened devices are only tested to meet static electrical specifications.
3. Please refer to slash sheet MIL-PRF-19500/746 page 6 for die information.

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7. Additional Product Resources

7.1. Product Webpages

JANSR2N7591U3-MOSFET | Microchip Technology

Main webpage for this product

Radiation-Hardened Power MOSFETs | Microchip Technology

Main webpage for this product family

7.2. SPICE Model

Download JANSR2N7591U3/MRH20N16U3 SPICE model

Official SPICE model for this product

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8. Revision History

Revision	Date	Description
E	6/2026	• Editorial changes • Added die sales information, die map and dimensions • Reformatted electrical tables • Updated plots for consistency • Added Section 7 Additional Product Resources • Added reverse recovery specification and single pulse avalanche energy
D	9/2025	• Updated Table 1 Ordering Options • Updated Figure 1 Package and Pin Descriptions • Added Table 1-6 Package Inductance • Updated Section 2 Radiation Performance to include Section 2.1 Post Total Dose Irradiation Electrical Performance • Added table to Section 3 Package Outline Drawing • Added Section 4 Part Nomenclature
C	4/2025	• Added QPL Part Number to Table 1
B	2/2025	• Updated Table 1.2 Statis Characteristics (T_A = +25 °C) unless otherwise noted • Updated Table 2.1 Safe-Operating Area Profile • Figure 2.1 SEE Safe-Operating Area added
A	11/2024	Initial Revision

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