

250V, 12A N-Channel Radiation-Hardened MOSFET

Qualified to MIL-PRF-19500/746 for space applications

JANSR2N7593U3/MRH25N12U3



Product Overview

Developed on Microchip's new M6™ technology, the JANSR2N7593U3/MRH25N12U3 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	$R_{DS(ON)}$, max	$I_{DS, DC}$ max	Q_G , max	Package	TID Level
MRH25N12U3	Commercial	0.210Ω	12.4A	50nC	SMD-0.5	N/A
JANSR2N7593U3	JANS	0.210Ω	12.4A	50nC	SMD-0.5	100 krad(Si)
JANSF2N7593U3	JANS	0.210Ω	12.4A	50nC	SMD-0.5	300 krad(Si)
2C25N12-F5	Commercial	0.210Ω	12.4A	50nC	Die	N/A
JANKCBR2N7593	JANKC	0.210Ω	12.4A	50nC	Die	100 krad(Si)
JANKCBF2N7593	JANKC	0.210Ω	12.4A	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
- Hermetically 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 Descriptions

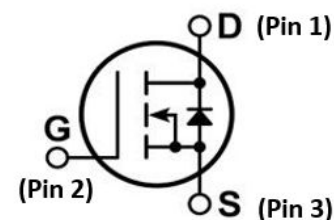
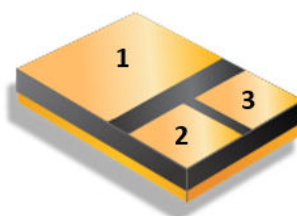


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1. Electrical Specifications

1.1. Absolute Maximum Ratings

Table 1-1. Absolute Maximum Ratings Pre-Irradiation

Symbol	Parameter	Ratings	Unit
I_{DS}	Continuous Drain Current at $T_C = 25\text{ }^{\circ}\text{C}$	12.4	A
	Continuous Drain Current at $T_C = 100\text{ }^{\circ}\text{C}$	7.8	
I_{DM}	Pulsed Drain Current ¹	49.6	
V_{GS}	Gate-Source Voltage	± 20	V
d_v/d_t	Peak Diode Recovery ²	5.0	V/ns
P_D	Total Power Dissipation at $T_C = 25\text{ }^{\circ}\text{C}$	75	W
	Linear Derating Factor	0.60	
T_J, T_{STG}	Operating and Storage Junction Temperature Range	-55 to 150	$^{\circ}\text{C}$
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	56	mJ
I_{AR}	Avalanche Current ³	12.4	A

Notes:

1. Repetitive Rating: Pulse width limited by maximum junction temperature
2. $I_{DS} \leq -12.4\text{A}$, $di/dt \leq 100\text{ A}/\mu\text{s}$, $V_{DD} \leq 30\text{V}$, $T_J \leq 150\text{ }^{\circ}\text{C}$
3. $V_{DD} = 50\text{V}$, starting $T_J = 25\text{ }^{\circ}\text{C}$, $L = 600\text{ }\mu\text{H}$, Peak $I_L = 12.4\text{A}$, $V_{GS} = 12\text{V}$

1.2. Electrical Performance

Table 1-2. Static Characteristics Pre-Irradiation ($T_A = 25\text{ }^{\circ}\text{C}$) unless otherwise noted

Symbol	Parameter	Test Conditions	Ratings			Unit
			Min	Typ	Max	
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	$V_{GS} = 0\text{V}$, $I_{DS} = 1.0\text{ mA}$	250	—	—	V
$R_{DS(ON)}$	Drain-Source On Resistance ¹	$V_{GS} = 12\text{V}$, $I_{DS} = 7.8\text{A}$	—	—	0.210	Ω
$V_{GS(TH)}$	Gate-Source Threshold Voltage	$V_{GS} \leq V_{DS}$, $I_{DS} = 1.0\text{ mA}$	2.0	—	4.0	V
G_{FS}	Forward Transconductance ¹	$V_{DD} = 15\text{V}$, $I_{DS} = 7.8\text{A}$	8.8	—	—	S
I_{GSS}	Gate-Source Leakage Current	$V_{GS} = \pm 20\text{V}$	—	—	± 100	nA
I_{DSS}	Zero-Gate Voltage Drain Current	$V_{DS} = 200\text{V}$ $V_{GS} = 0\text{V}$ $T_A = 25\text{ }^{\circ}\text{C}$	—	—	10	μA
		$T_A = 125\text{ }^{\circ}\text{C}$	—	—	25	

Note:

1. Pulse test: pulse width $< 300\text{ }\mu\text{s}$, duty cycle $< 2\%$.

Table 1-3. Dynamic Characteristics Pre-Irradiation ($T_A = +25\text{ }^{\circ}\text{C}$)

Symbol	Parameter	Test Conditions	Ratings			Unit
			Min	Typ	Max	
C_{ISS}	Input Capacitance	$V_{GS} = 0V$ $V_{DS} = 25V$ $f = 1\text{ MHz}$	—	1980	—	pF
C_{RSS}	Reverse Transfer Capacitance		—	6	—	
C_{OSS}	Output Capacitance		—	260	—	
Q_G	Total Gate Charge	$V_{GS} = 12V$ $I_{DS} = 12.4A$ $V_{DD} = 125V$	—	30	50	nC
Q_{GS}	Gate-Source Charge		—	11	15	
Q_{GD}	Gate-Drain ("Miller") Charge		—	3	20	
$t_{D(ON)}$	Time-On Delay Time	$V_{GS} = 12V$, $I_{DS} = 12.4A$, $V_{DD} = 125V$ $R_{G(EXT)} = 7.5\Omega$	—	18	25	ns
t_R	Voltage Rise Time		—	3	30	
$t_{D(OFF)}$	Turn-Off Delay Time		—	37	60	
t_F	Voltage Fall Time		—	4	30	

Table 1-4. Source-Drain Characteristics Pre-Irradiation ($T_A = +25\text{ }^{\circ}\text{C}$)

Symbol	Parameter	Test Conditions	Ratings			Unit
			Min	Typ	Max	
I_S	Continuous Source Current (Body Diode)	—	—	—	12.4	A
I_{SM}	Pulsed Source Current (Body Diode) ¹		—	—	49.6	
V_{SD}	Diode Forward Voltage	$I_{SD} = 12.4A$ $V_{GS} = 0V$	—	0.9	1.2	V
t_{RR}	Reverse recovery time ²	$I_{DS} = -12.4A$, $di/dt \leq 100\text{ A}/\mu\text{s}$, $V_{DD} \leq 50V$	—	272	450	ns
Q_{RR}	Reverse recovery charge ²		—	3.0	—	μC

Notes:

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

Table 1-5. Package Inductance

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

1.3. Typical Performance Curves Pre-Irradiation

Figure 1-1. Typical Output Characteristics

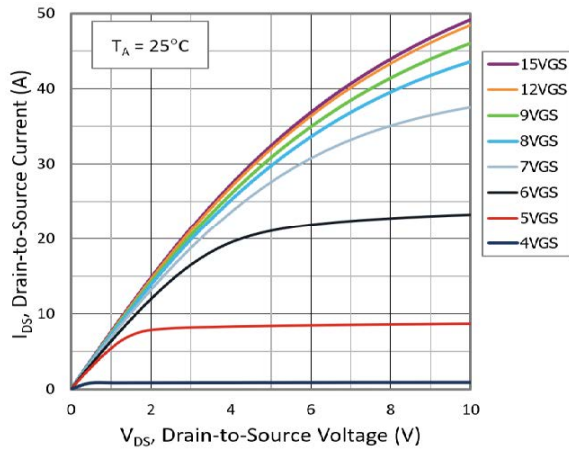


Figure 1-2. Typical Output Characteristics

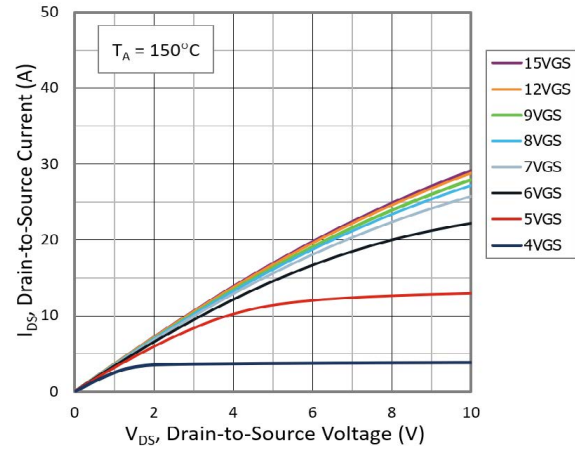


Figure 1-3. Typical Transfer Characteristics

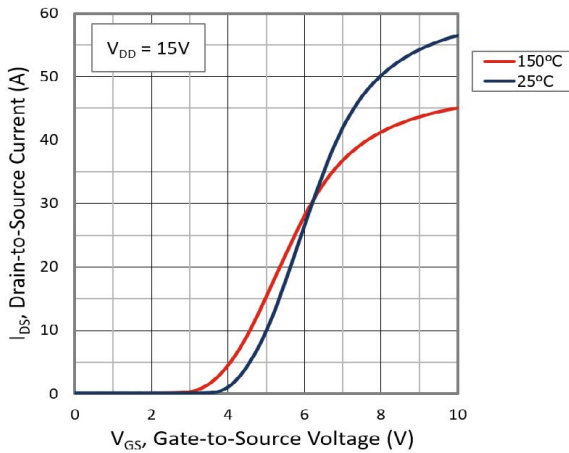


Figure 1-4. Typical $V_{GS(TH)}$ vs T_J

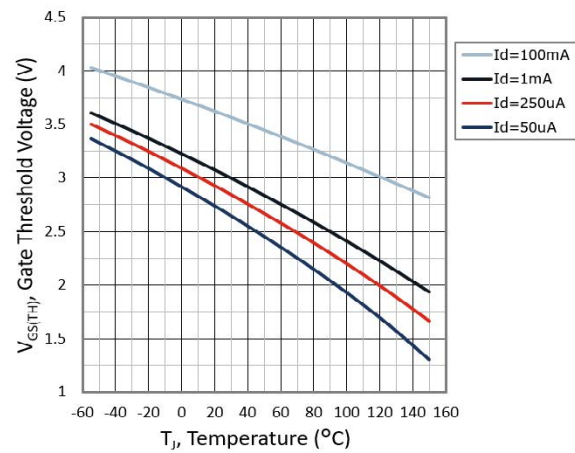


Figure 1-5. Typical $R_{DS(ON)}$ vs V_{GS}

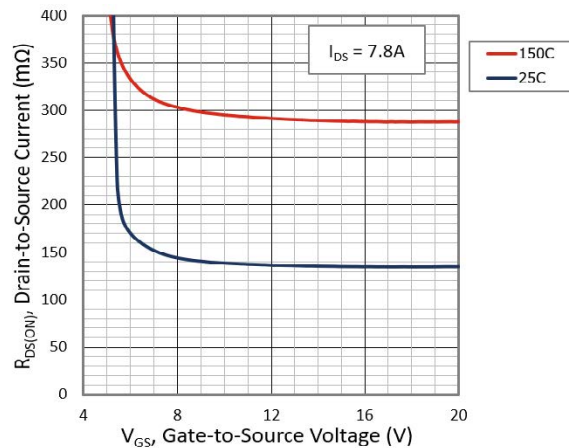


Figure 1-6. Typical $R_{DS(ON)}$ vs I_{DS}

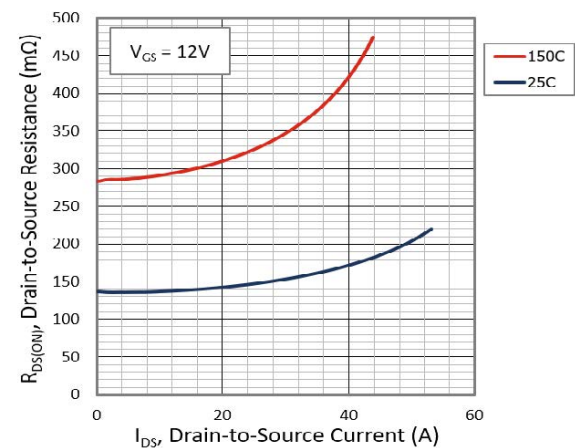


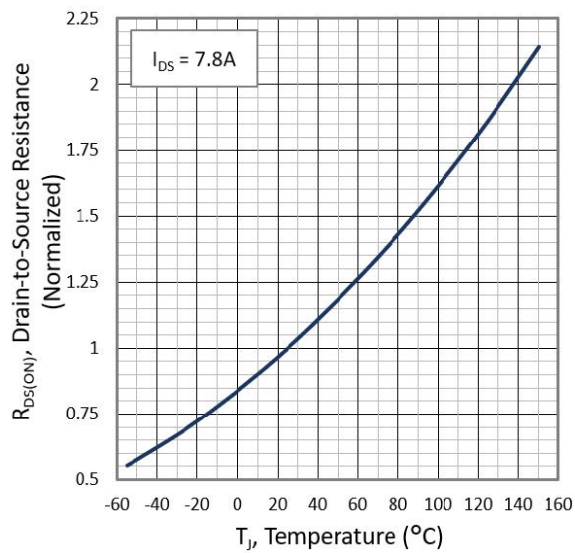
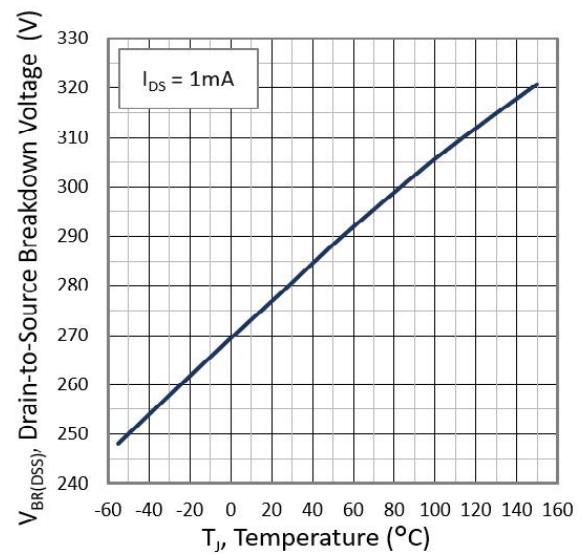
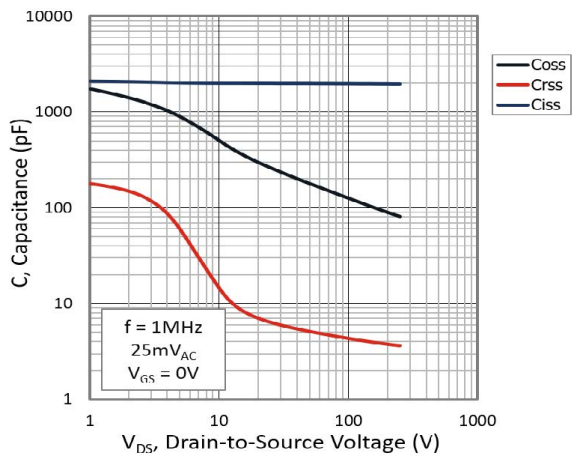
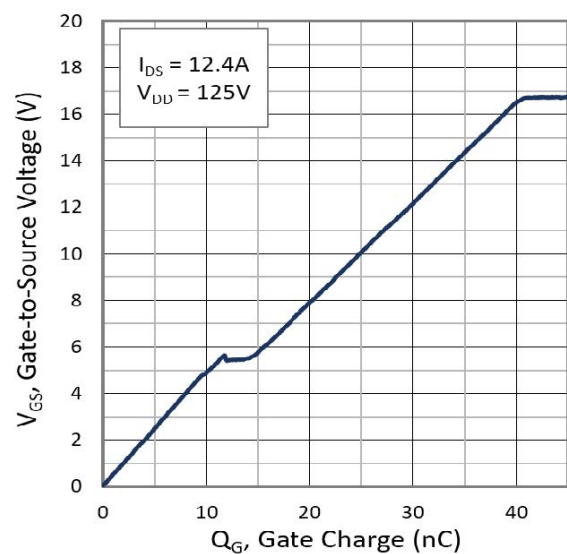
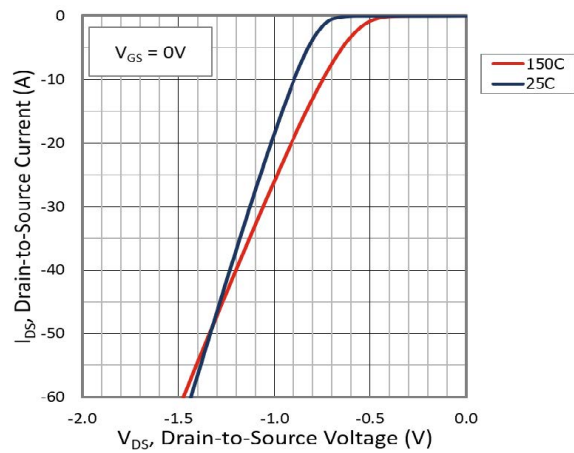
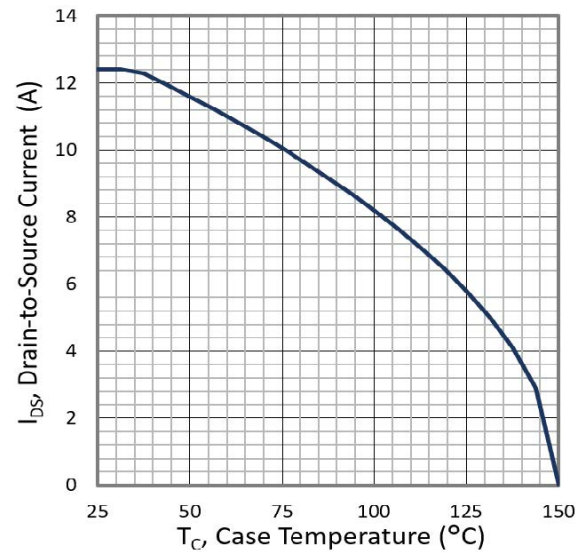
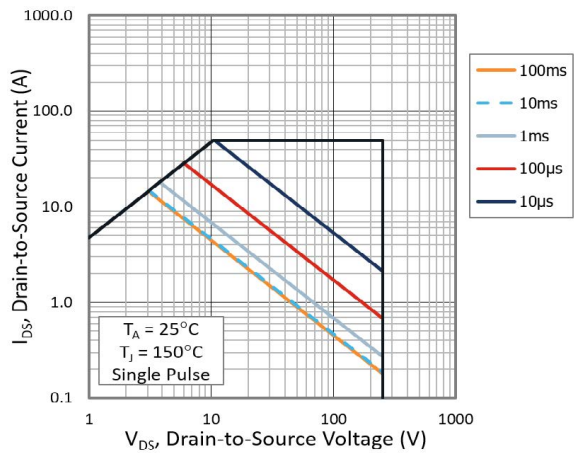
Figure 1-7. Normalized $R_{DS(ON)}$ vs T_J **Figure 1-8.** $V_{(BR)DSS}$ vs T_J **Figure 1-9.** Typical Capacitance vs V_{DS} **Figure 1-10.** Typical V_{GS} vs Q_G 

Figure 1-11. Typical Source-Drain Diode Conduction**Figure 1-12. I_{DS} vs Case Temperature****Figure 1-13. Maximum Safe Operating Area**

2. Thermal Specifications

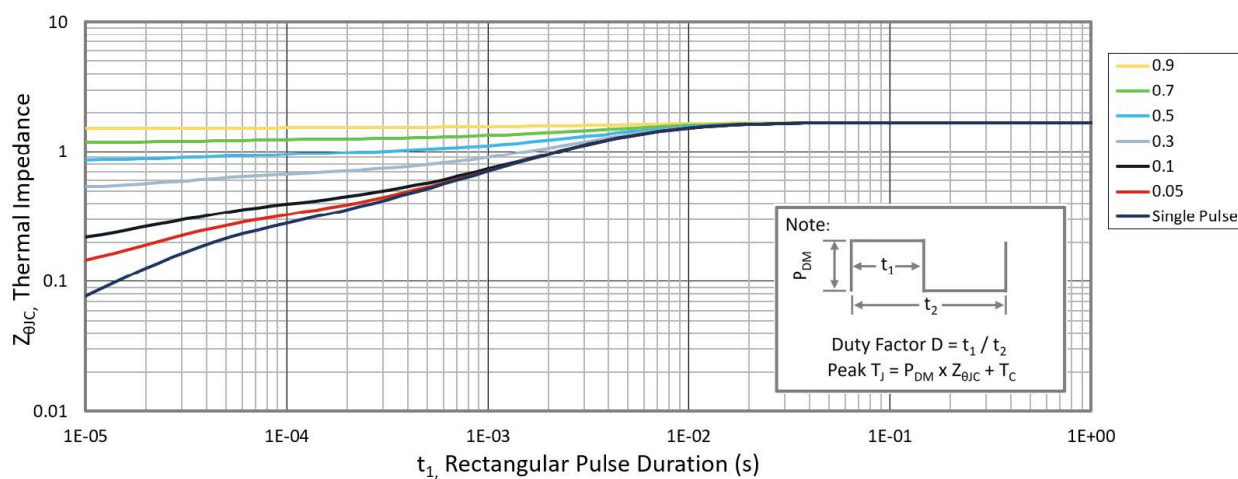
2.1. Thermal Performance

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



3. Radiation Performance

3.1. Post Total Dose Irradiation Electrical Performance

Table 3-1. Static Characteristics $T_A = 25\text{ }^{\circ}\text{C}$, 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	$V_{GS} = 0V$ $I_{DS} = 1.0\text{ mA}$	250	—	—	V
$R_{DS(ON)}$	Drain-Source On Resistance ¹ (SMD-0.5)	$V_{GS} = 12V$ $I_{DS} = 7.8A$	—	—	0.210	Ω
$V_{GS(TH)}$	Gate-Source Threshold Voltage	$V_{GS} \leq V_{DS}$, $I_{DS} = 1.0\text{ mA}$	2.0	—	4.0	V
V_{SD}	Diode Forward Voltage	$I_{SD} = 12.4A$, $V_{GS} = 0V$	—	0.9	1.2	V
I_{GSS}	Gate-Source Leakage Current	$V_{GS} = \pm 20V$	—	—	± 100	nA
I_{DSS}	Zero Gate Voltage Drain Current	$V_{DS} = 200V$, $V_{GS} = 0V$, $T_A = 25\text{ }^{\circ}\text{C}$	—	—	10	μA
		$T_A = 125\text{ }^{\circ}\text{C}$	—	—	25	

Note:

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

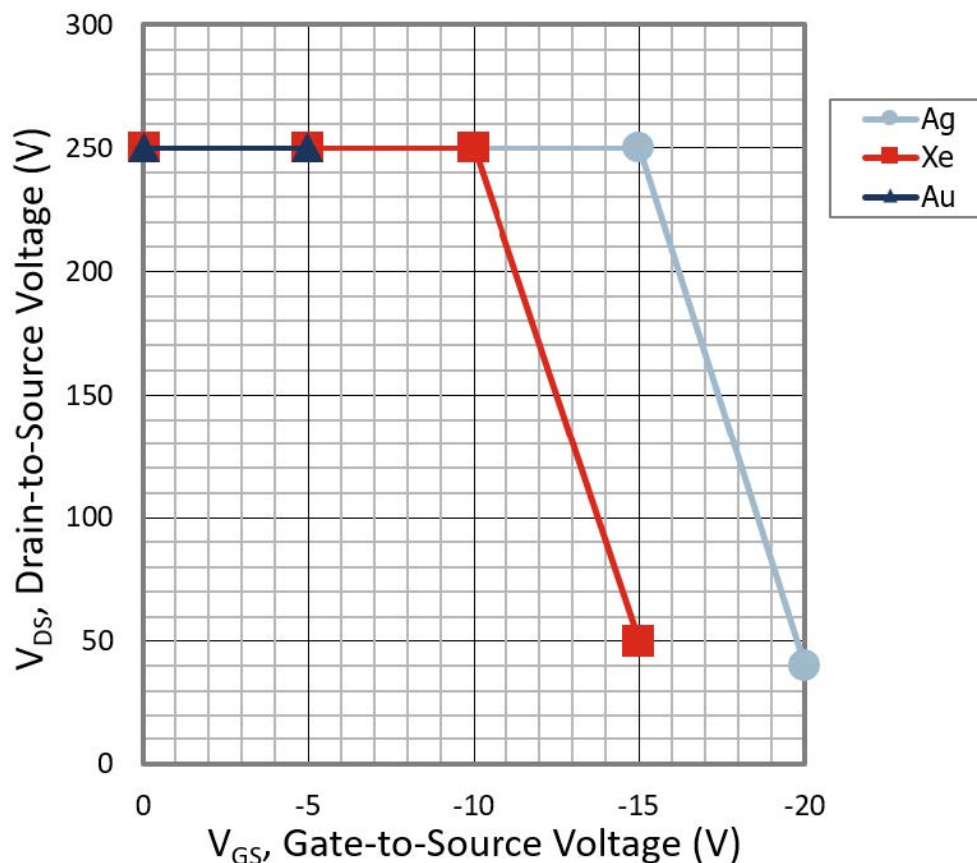
3.2. Single-Event Effects (SEE) Performance

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·cm ² /mg)	Ion Energy (MeV)	Eff. Range (μm)	V_{DS}				
				$V_{GS} = 0V$	$V_{GS} = -5V$	$V_{GS} = -10V$	$V_{GS} = -15V$	$V_{GS} = -20V$
Ag	44 ($\pm 5\%$)	1350 ($\pm 5\%$)	125 ($\pm 10\%$)	250	250	250	250	40
Xe	61.0 ($\pm 5\%$)	825 ($\pm 5\%$)	66 ($\pm 7.5\%$)	250	250	250	50	—
Au	90.0 ($\pm 5\%$)	1470 ($\pm 5\%$)	80 ($\pm 5\%$)	250	250	—	—	—

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.

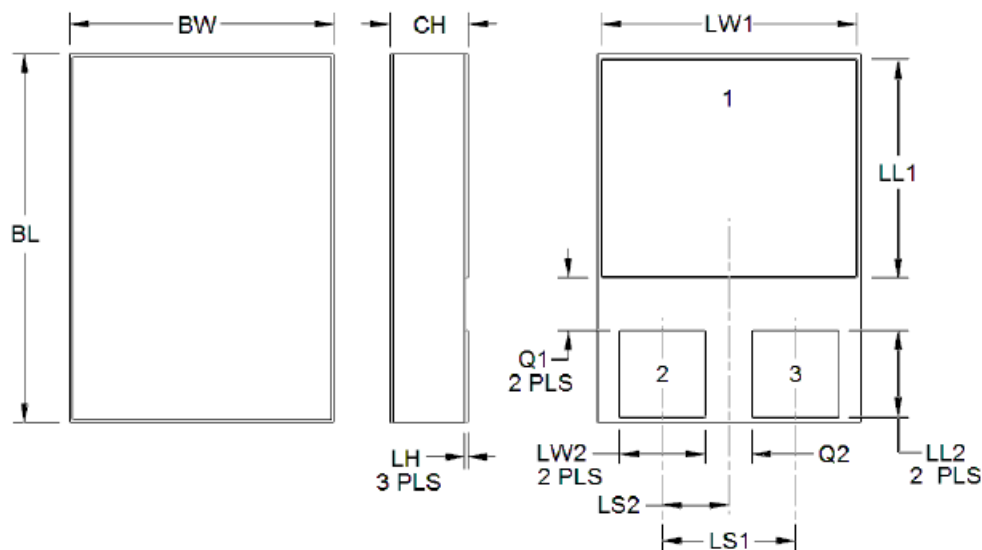
A V_{GS}/V_{DS} point is accepted on the prior plot if all of the following conditions are met:

1. A fluence of $3 \times 10^5 \pm 20\%$ ions/cm² 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.

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 ϕ x symbology.

Table 4-1. Package Dimensions

Symbol	Dimensions			
	Inch		Millimeter	
	Min	Max	Min	Max
BL	0.395	0.405	10.03	10.29
BW	0.291	0.301	7.39	7.65
CH	0.108	0.124	2.74	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			

5. Die Details

5.1. Die Drawing

Figure 5-1. Die Drawing

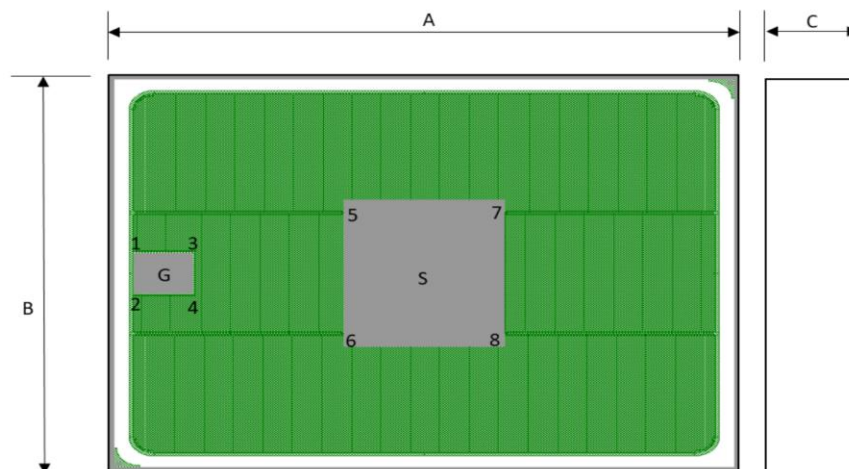


Table 5-1. Die Dimensions

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.

6. Part Nomenclature

6.1. Qualified Packaged Devices¹

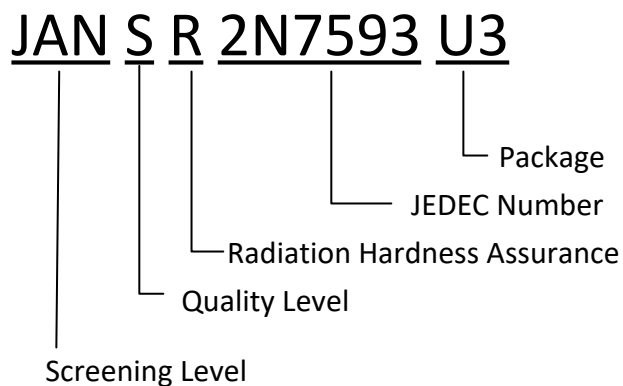


Table 6-1. Qualified Package Devices Description

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	2N7593	
Package	U3	SMD-0.5

Example:

JANSF2N7593U3: Space grade 2N7593 MOSFET with 300 krad(Si) rating in an SMD-0.5 package.

Note:

1. Cage Code: 43611

6.2. Qualified Unencapsulated Devices (Die Version)^{1,2}

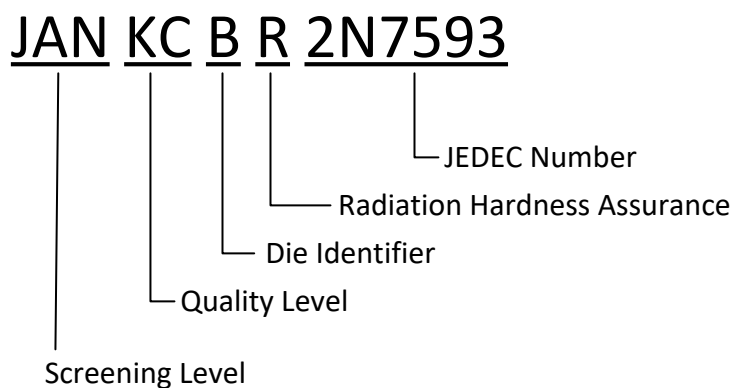


Table 6-2. Qualified Unencapsulated Devices Description

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	2N7593	

Notes:

1. Please refer to slash sheet [MIL-PRF-519500/746](#) page 6 for die information.
2. Cage Code: 43611

6.3. Commercial Packaged Devices^{1,2}

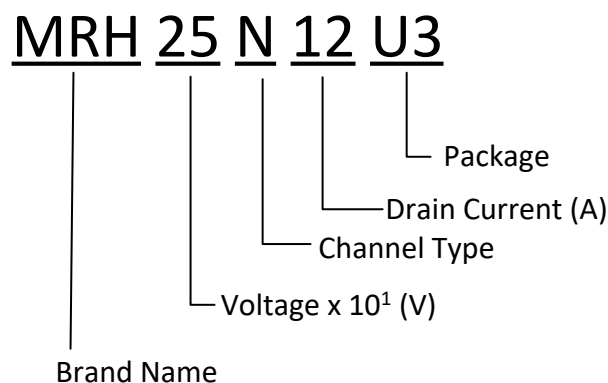


Table 6-3. Commercial Package Devices Description

Term	Initial	Option
Brand Name	MRH	Microchip Radiation Hardened
Voltage (V)	25	$25 \times 10^1 = 250V$
Channel Type	N	N-Channel
Drain Current	12	12.4A
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}2C25N12-F5

└ Ordering part number for the die version of the 2N7593

Table 6-4. Commercial Unencapsulated Devices Description

Term	Initial	Option
	2C	MOSFET Die
Voltage (V)	25	$25 \times 10^1 = 250V$
Channel Type	N	N-Channel
Drain Current	12	12.4A
	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.

7. Additional Product Resources

7.1. Product Webpages

[JANSR2N7593U3-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 JANSR2N7593U3/MRH25N12U3 SPICE model](#)

Official SPICE model for this product

8. Revision History

Revision Level	Date	Description
H	7/2026	- Updated Table 1 Ordering Options - Updated Features - Updated Applications - Updated Table 1-1 Absolute Maximum Ratings Pre-Irradiation and its notes - Updated Table 1-2 Static Characteristics Pre-Irradiation ($T_A = 25\text{ }^{\circ}\text{C}$) unless otherwise noted - Removed Thermal Resistance table - Updated figures in Section 1.3 Typical Performance Curves Pre-Irradiation - Added Section 2 Thermal Specifications - Added Section 2.1 Thermal Performance - Added Section 2.2 Thermal Performance Curves - Updated Table 3-1 Static Characteristics $T_A = 25\text{ }^{\circ}\text{C}$, 300 krad(Si)/s, unless otherwise noted - Updated Table 3-2 SEE Safe-Operating Area - Updated Figure 3-1 SEE Safe-Operating Area - Updated Table 4-1 Package Dimensions - Added Section 5 Die Details - Added Section 5.1 Die Drawing - Added a second note to Section 6.2 Qualified Unencapsulated Devices (Die Version) - Added Table 6-4 Commercial Unencapsulated Devices (Die Version) - Added Section 7 Additional Product Resources - Added Section 7.1 Product Webpages - Added Section 7.2 SPICE Model
G	10/2025	- Updated Figure 1 Package and Pin Description - Updated Features - Updated Table 1-2 Static Characteristics - Updated Table 1-3 Dynamic Characteristics - Added Table 1-6 Package Inductance - Updated Table 2-1 SEE Safe-Operating Area - Updated Section 4 Part Nomenclature
F	7/2025	Removed QPL Part Number from Table 1
E	3/2025	Added QPL Part Number to Table 1
D	11/2024	- Updated Product Overview for environments greater than 300 Krad TID - Added table 1 JANSR2N7593U3/MRH25N12U3SR - Updated Figure 1 JANSR2N7593U3/MRH25N12U3SR - Updated Figure 1-11 Forward Safe Operating Area - Added Section 3 Package Outline Drawing - Updated Part Nomenclature
C	8/2023	Updated Figure 1-11 Forward Safe Operating Area.
B	3/2023	- Updated Part Nomenclature graphic - Prioritized JANSR2N7593U3 part number throughout document - Minor grammar and spelling fixes

Revision History (continued)

Revision Level	Date	Description
A	6/2021	Document created.

Microchip Information

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