

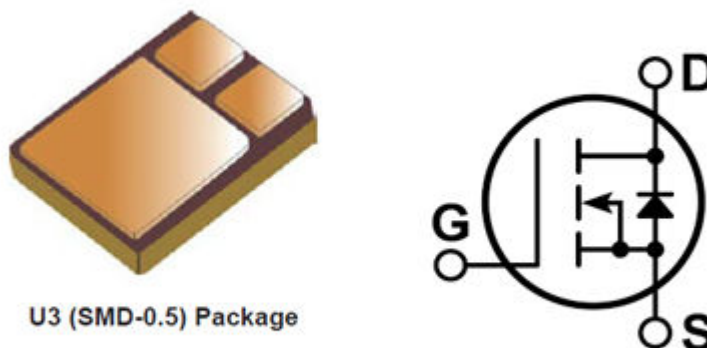
## Product Overview

Microchip's new M6™ technology has been developed to provide extreme reliability and enhanced radiation hardness for hermetic power MOSFETs targeted for space and military applications. Microchip rad-hard MOSFETs feature low  $R_{DS(on)}$  and low total gate charge. The devices have been developed for total dose and single-event environments (SEE). M6 will perform in extreme-environment applications and will remain within specification in radiation environments greater than 300Krad total ionizing dose (TID).

**Table 1.** JANSR2N7593U3/MRH25N12U3SR

Part Number	Radiation Level	$R_{DS(on)}$	$I_D$	QPL Part Number
MRH25N12U3SR	100Krad (Si)	0.210 $\Omega$	12A	JANSR2N7593U3
MRH25N12U3SF	300Krad (Si)	0.210 $\Omega$	12A	—

**Figure 1.** JANSR2N7593U3/MRH25N12U3SR



## Features

The following are key features of the JANSR2N7593U3/MRH25N12U3SR device:

- Low  $R_{DS(on)}$
- Fast Switching
- Single-Event Hardened
- Low Gate Charge
- Simple Drive
- Ease of Paralleling
- Hermetically Sealed

- Surface-Mount Design
- Ceramic Package
- ESD Rating: Class 3B MIL-STD-750, TM 1020

## Applications

The JANSR2N7593U3/MRH25N12U3SR device is designed for the following applications:

- DC-DC Converters
- Motor Control
- Switch Mode Power Supplies

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## 1. Electrical Performance

This section shows the electrical specifications of the JANSR2N7593U3/MRH25N12U3SR device.

### 1.1 Absolute Maximum Ratings

The following table shows the absolute maximum ratings of the JANSR2N7593U3/MRH25N12U3SR device.

**Table 1-1.** Absolute Maximum Ratings

Symbol	Parameter	Ratings	Unit
$V_{DSS}$	Drain-source voltage	250	V
$I_D$	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 <sup>1</sup>	49.6	
$V_{GS}$	Gate-source voltage	$\pm 20$	V
dv/dt	Peak diode recovery	5.0	V/ns
$P_D$	Max. power dissipation at $T_C = 25\text{ }^\circ\text{C}$	75	W
	Linear derating factor	0.60	W/ $^\circ\text{C}$
$T_J, T_{STG}$	Operating junction and storage temperature range	$-55$ to $+150$	$^\circ\text{C}$
$T_L$	Soldering temperature for 5 seconds (1.6 mm from case)	300	
$W_T$	Package weight	1.0 (Typical)	g

**Note:**

1. Repetitive rating; pulse width and case temperature limited by maximum junction temperature.

### 1.2 Electrical Performance

The following table shows the static characteristics of the JANSR2N7593U3/MRH25N12U3SR device.

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

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
$V_{BR(DSS)}$	Drain-source breakdown voltage	$V_{GS} = 0V, I_D = 1.0\text{ mA}$	250	—	—	V
$R_{DS(on)}$	Drain-source on resistance <sup>1</sup>	$V_{GS} = 12V, I_D = 7.8A$	—	—	0.210	$\Omega$
$V_{GS(th)}$	Gate-source threshold voltage	$V_{GS} = V_{DS}, I_D = 1.0\text{ mA}$	2.0	—	4.0	V
$g_{fs}$	Forward transconductance	$V_{DS} = 15V, I_{DS} = 7.8A$	8.8	—	—	S
$I_{DSS}$	Zero-gate voltage drain current	$V_{DS} = 200V$ $V_{GS} = 0V$	—	—	10	$\mu\text{A}$
		$T_A = 125\text{ }^\circ\text{C}$	—	—	25	
$I_{GSS}$	Gate-source leakage current	$V_{GS} = \pm 20V$	—	—	$\pm 100$	nA

**Note:**

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

The following table shows the dynamic characteristics of the JANSR2N7593U3/MRH25N12U3SR device.

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

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
$C_{iss}$	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	$V_{GS} = 12V$ $I_D = 12.4A$ $V_{DS} = 125V$	—	30	50	nC
$Q_{gs}$	Gate-source charge		—	11	15	
$Q_{gd}$	Gate-drain ("Miller") charge		—	3	20	

The following table shows the switching characteristics of the JANSR2N7593U3/MRH25N12U3SR device.

**Table 1-4.** Switching Characteristics

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
$t_{d(on)}$	Time-on delay time	$V_{GS} = 12V$ $I_D = 12.4A$	—	18	25	ns
$t_r$	Voltage rise time		—	3	30	
$t_{d(off)}$	Time-off delay time	$V_{DS} = 125V$ $R_{G(ext)} = 8\Omega^1$	—	37	60	
$t_f$	Voltage fall time		—	4	30	

**Note:**

- $R_G$  is the external gate resistance excluding internal gate driver impedance.

The following table shows the source-drain characteristics of the JANSR2N7593U3/MRH25N12U3SR device.

**Table 1-5.** Source-Drain Characteristics ( $T_A = +25\text{ }^\circ\text{C}$ )

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
$I_S$	Continuous source current (body diode)	Integral reverse P-N junction diode	—	—	12.4	A
$I_{SM}$	Pulsed source current (body diode) <sup>1</sup>		—	—	49.6	
$V_{SD}$	Diode forward voltage <sup>2</sup>	$I_{SD} = 12.4A$ $T_A = 25\text{ }^\circ\text{C}$ $V_{GS} = 0V$	—	—	1.2	V
ESR	Gate equivalent source resistance	$f = 1\text{ MHz}$ Level = 25 mV drain short	—	1.67	—	$\Omega$
$t_{rr}$	Reverse recovery time	$I_F = 12.4A$ $di/dt \leq 100\text{ A}/\mu\text{s}$ $V_{DD} \leq 50V$	—	—	350	ns

**Notes:**

- Repetitive rating: pulse width and case temperature limited by maximum junction temperature.
- Pulse test: pulse width < 300  $\mu\text{s}$ , duty cycle < 2%.

The following table shows the thermal resistance of the JANSR2N7593U3/MRH25N12U3SR device.

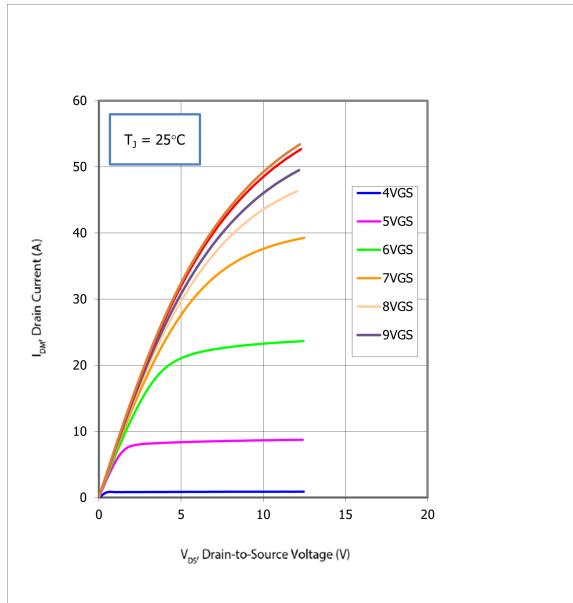
**Table 1-6.** Thermal Resistance

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
$R_{\theta jc}$	Junction-to-case thermal resistance	—	—	0.56	1.67	$^\circ\text{C}/\text{W}$

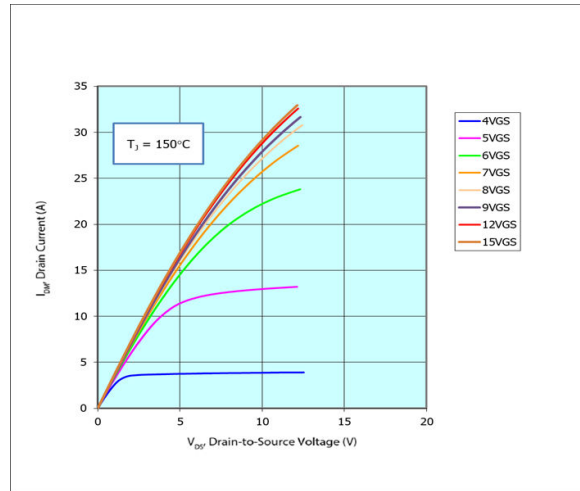
### 1.3 Typical Performance Curves

This section shows the typical performance curves of the JANSR2N7593U3/MRH25N12U3SR device.

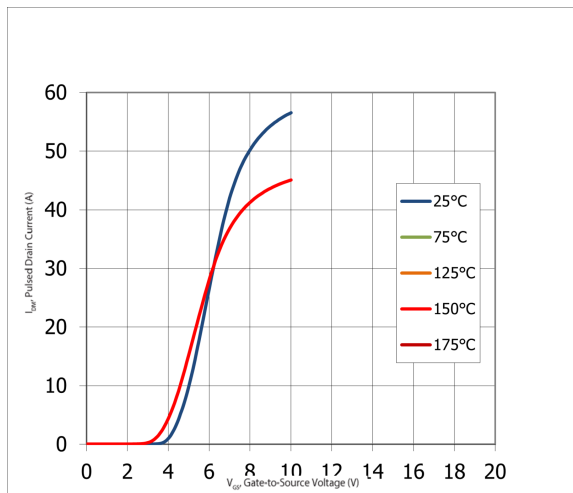
**Figure 1-1. Output Characteristics at 25 °C**



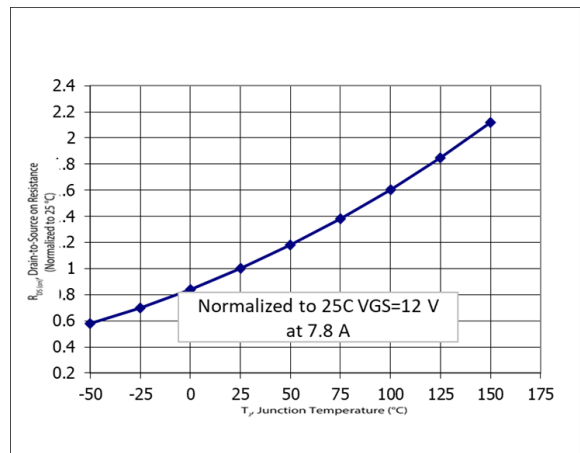
**Figure 1-2. Output Characteristics at 150 °C**



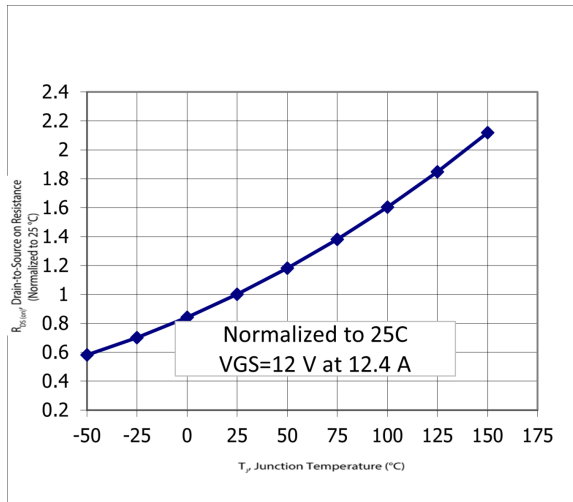
**Figure 1-3.  $I_{DM}$  vs.  $V_{GS}$  at 25 °C and 150 °C**



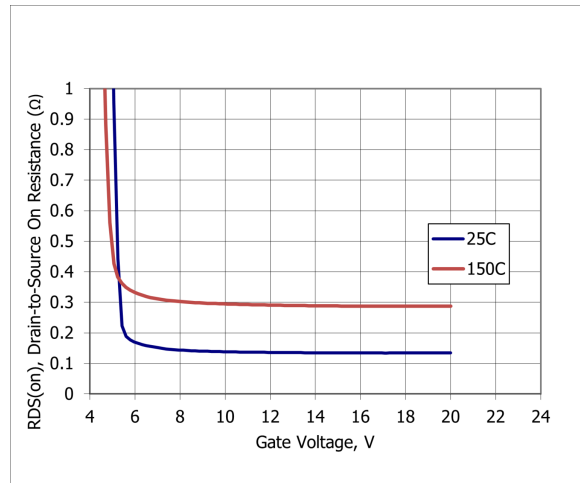
**Figure 1-4.  $R_{DS(on)}$  vs. Junction Temperature, 7.8 A**



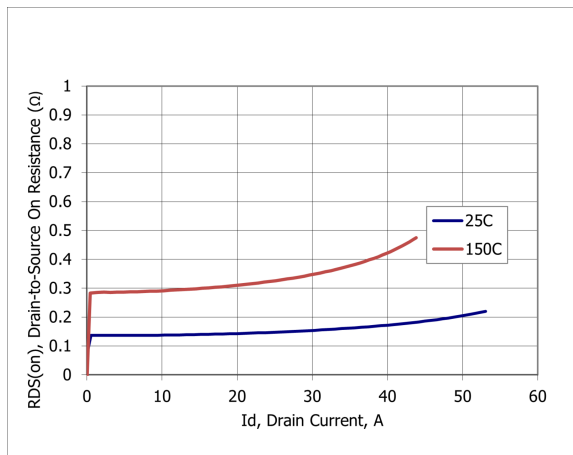
**Figure 1-5.**  $R_{DS(on)}$  vs. Junction Temperature, 12.4 A



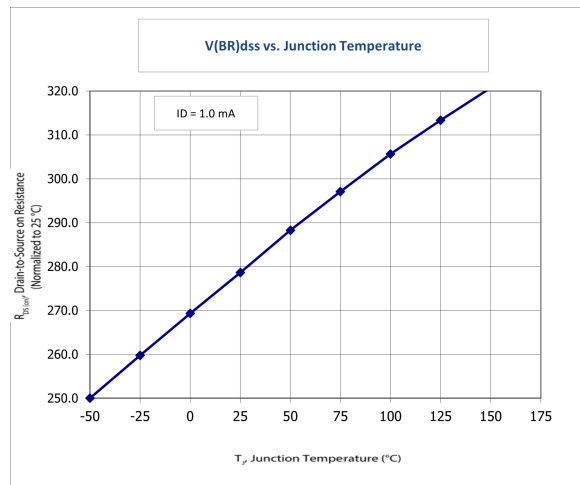
**Figure 1-6.**  $R_{DS(on)}$  vs.  $V_{GS}$  at 25 °C and 150 °C



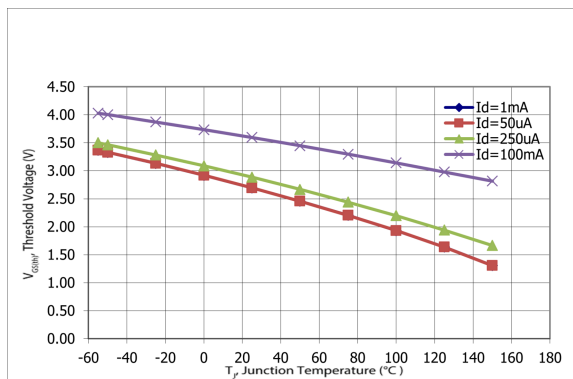
**Figure 1-7.**  $R_{DS(on)}$  vs.  $I_D$  at 25 °C and 150 °C



**Figure 1-8.**  $V_{(BR)dss}$  vs. Junction Temperature



**Figure 1-9.**  $V_{GS(th)}$  vs. Junction Temperature



**Figure 1-10.** Capacitance vs. Drain-to-Source Voltage

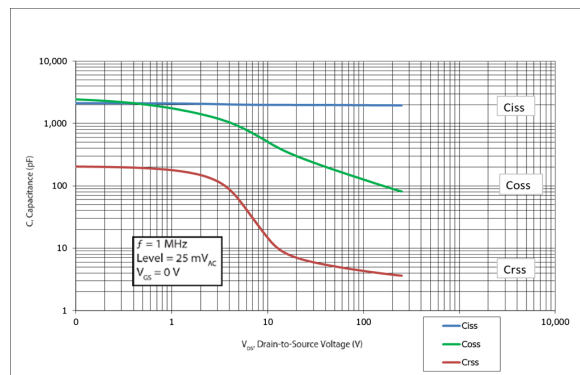


Figure 1-11. Forward Safe Operating Area

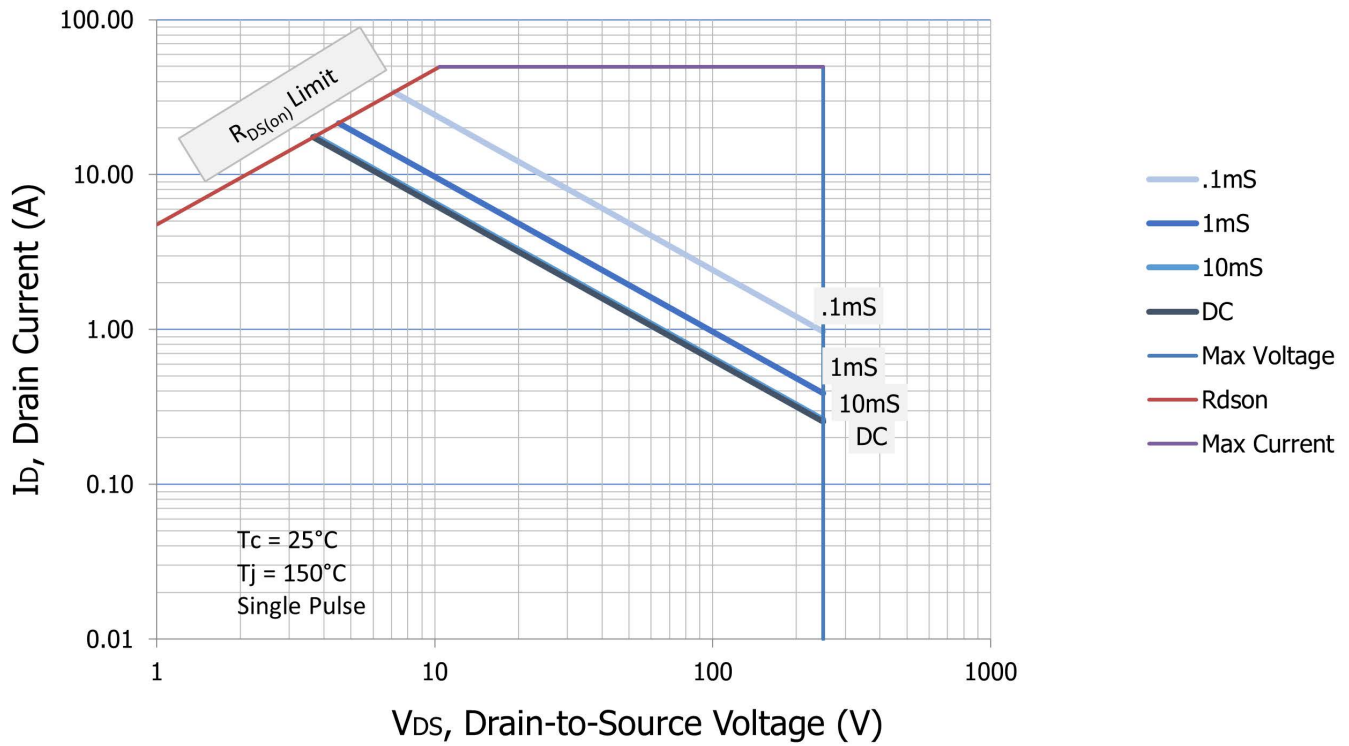
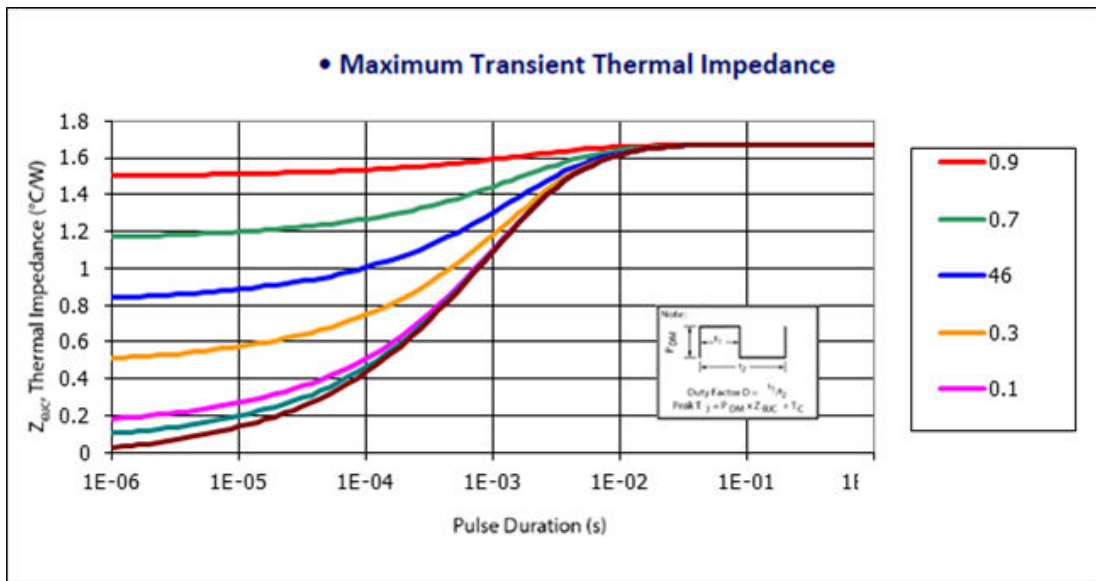


Figure 1-12. Maximum Transient Thermal Impedance



## 2. Single-Event Effects

The Microchip JANSR2N7593U3/MRH25N12U3SR device has been characterized for heavy ion responses at the Texas A&M cyclotron. Devices have been characterized up to  $V_{DS} = 250V$  and  $V_{GS} = -20V$ . The following single-event effects (SEE) safe-operating area profile has been established using the ions, linear energy transfer (LET), range, and total energy conditions shown.

**Table 2-1.** Safe-Operating Area Profile

Parameter	Description	Environment	$V_{DS}$ (V)					
				$V_{GS} = 0V$	$V_{GS} = 5V$	$V_{GS} = 10V$	$V_{GS} = 15V$	$V_{GS} = 20V$
Ion species	Typical LET (MeV/(mg/cm <sup>2</sup> ))	Typ Energy (MeV)	Typ Range (μm)					
Ag	44.9 (44 ±5%)	1267 (1350 ±5%)	111.2 (125 ±10%)	250	250	250	250	40
Xe	63 (61 ±5%)	1007 (825 ±5%)	74.3 (66 ±7.5%)	250	250	250	50	
Au	90 (90 ±5%)	1489 (1489 ±5%)	83.2 (80 ±5%)	250	250			

The following figure shows the safe-operating area of the JANSR2N7593U3/MRH25N12U3 device.

**Figure 2-1.** SEE Safe-Operating Area

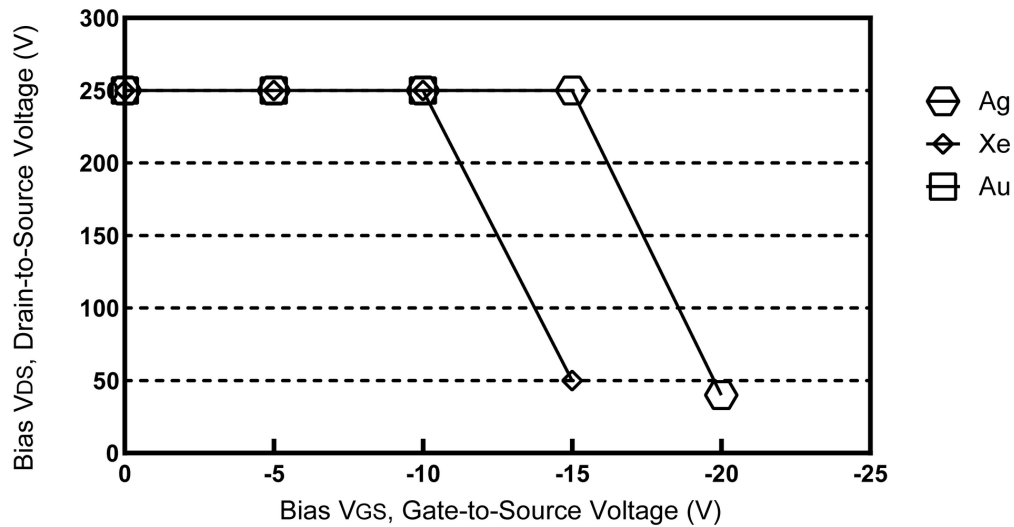
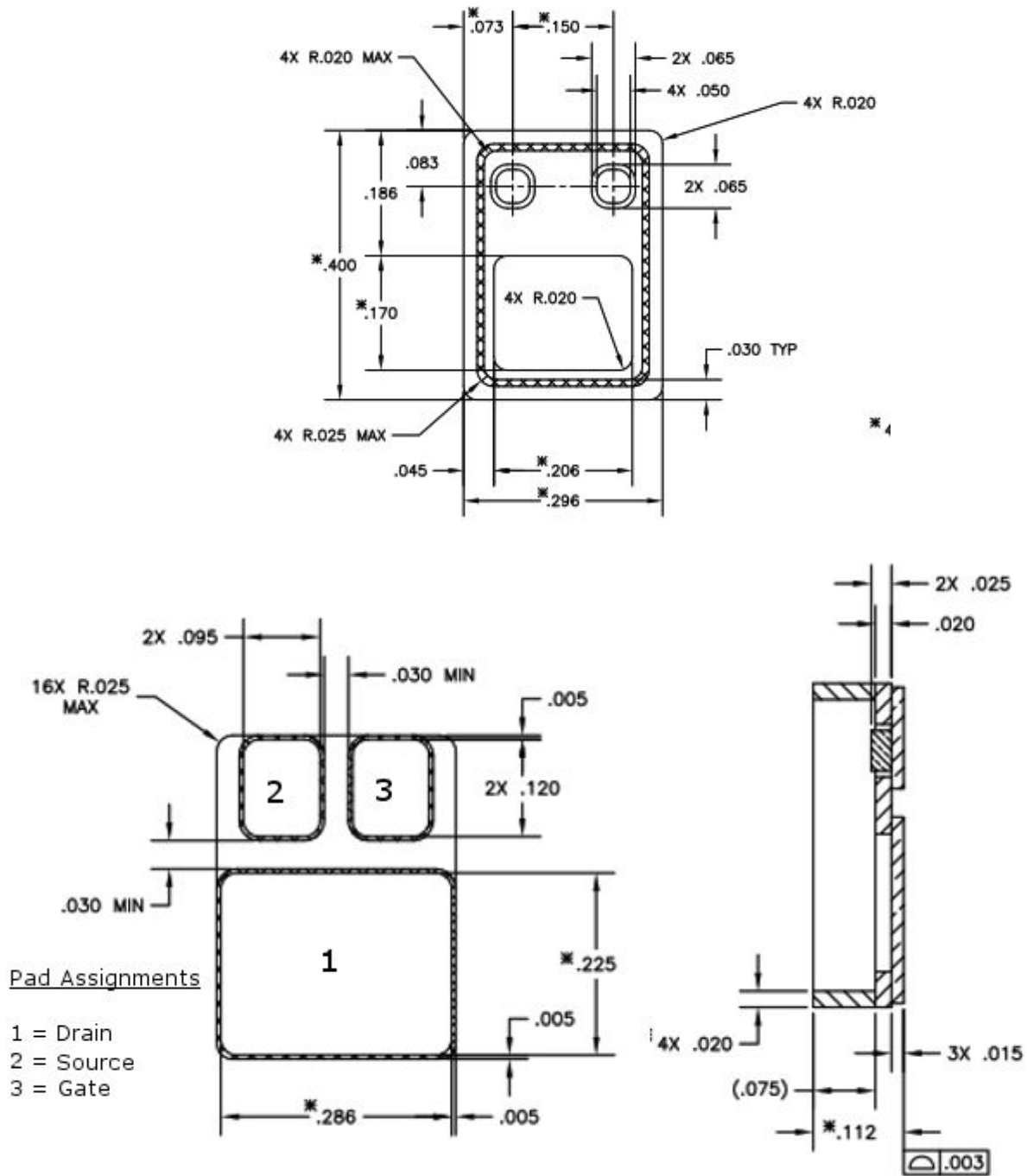


Figure 2-2. SMD.0 Case Outline and Dimensions



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/cm<sup>2</sup> 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.

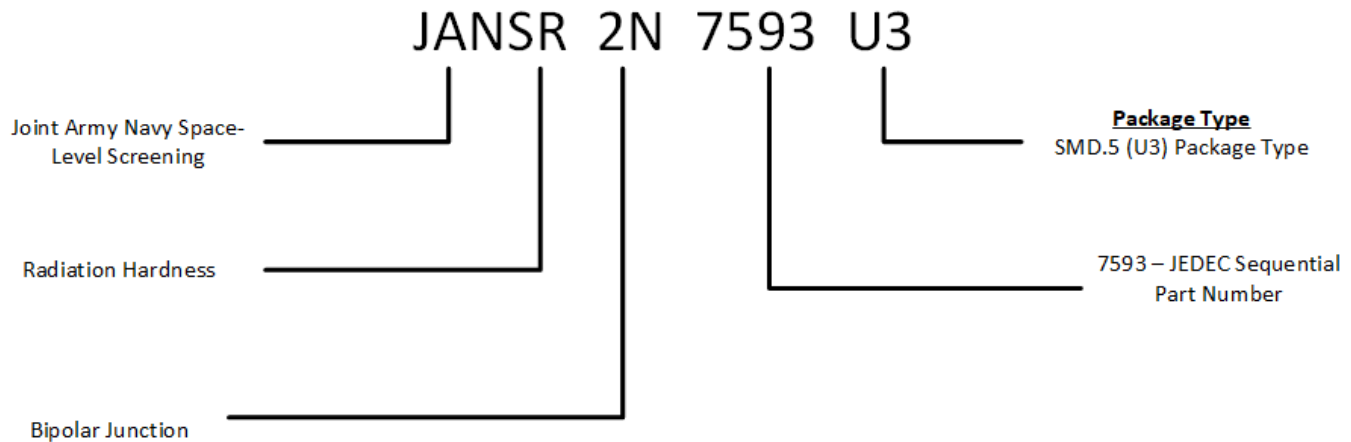
4. Post-exposure IDSS tests continue to pass specification.
5. Post-exposure IGSS tests continue to pass specification.
6. Three randomly selected samples from different production lots are used for observation.

It should be noted that total energy levels are considered to be a factor in SEE characterization. Comparisons to other data sets should not be based on LET alone.

### 3. Part Nomenclature

The following image shows the part nomenclature for the JANSR2N7593U3 device. MRH25N12U3 is the internal part number.

Figure 3-1. Part Nomenclature



- JAN — Joint Army Navy
- S — Space-level screening
- R — Radiation hardness assurance level
- M — Total ionizing dose  $3 \times 10^3$  (RAD(Si)) Neutron fluence  $2 \times 10^{12}$  (N/cm<sup>2</sup>) (unless otherwise specified)
- D — Total ionizing dose  $1 \times 10^4$  (RAD(Si)) Neutron fluence  $2 \times 10^{12}$  (N/cm<sup>2</sup>) (Unless otherwise specified)
- P — Total ionizing dose  $3 \times 10^4$  (RAD(Si)) Neutron fluence  $2 \times 10^{12}$  (N/cm<sup>2</sup>) (Unless otherwise specified)
- L — Total ionizing dose  $5 \times 10^4$  (RAD(Si)) Neutron fluence  $2 \times 10^{12}$  (N/cm<sup>2</sup>) (Unless otherwise specified)
- R — Total ionizing dose  $1 \times 10^5$  (RAD(Si)) Neutron fluence  $2 \times 10^{12}$  (N/cm<sup>2</sup>) (Unless otherwise specified)
- F — Total ionizing dose  $3 \times 10^5$  (RAD(Si)) Neutron fluence  $2 \times 10^{12}$  (N/cm<sup>2</sup>) (Unless otherwise specified)
- G — Total ionizing dose  $5 \times 10^5$  (RAD(Si)) Neutron fluence  $2 \times 10^{12}$  (N/cm<sup>2</sup>) (Unless otherwise specified)
- H — Total ionizing dose  $1 \times 10^6$  (RAD(Si)) Neutron fluence  $2 \times 10^{12}$  (N/cm<sup>2</sup>) (Unless otherwise specified)
- 2N — Bipolar junction
- 7593 — JEDEC sequential part number
- U3 — SMD.5 (U3) package type

## 4. Revision History

Revision Level	Date	Description
D	8/2024	<ul style="list-style-type: none"><li>Updated Product Overview for environments greater than 300 Krad TID</li><li>Added table 1 JANSR2N7593U3/MRH25N12U3SR</li><li>Updated Figure 1 JANSR2N7593U3/MRH25N12U3SR</li><li>Updated Figure 1-11 Forward Safe Operating Area</li></ul>
C	8/2023	Updated Figure 1-11 Forward Safe Operating Area.
B	3/2023	<ul style="list-style-type: none"><li>Updated Part Nomenclature graphic</li><li>Prioritized JANSR2N7593U3 part number throughout document</li><li>Minor grammar and spelling fixes</li></ul>
A	6/2021	Document created.

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