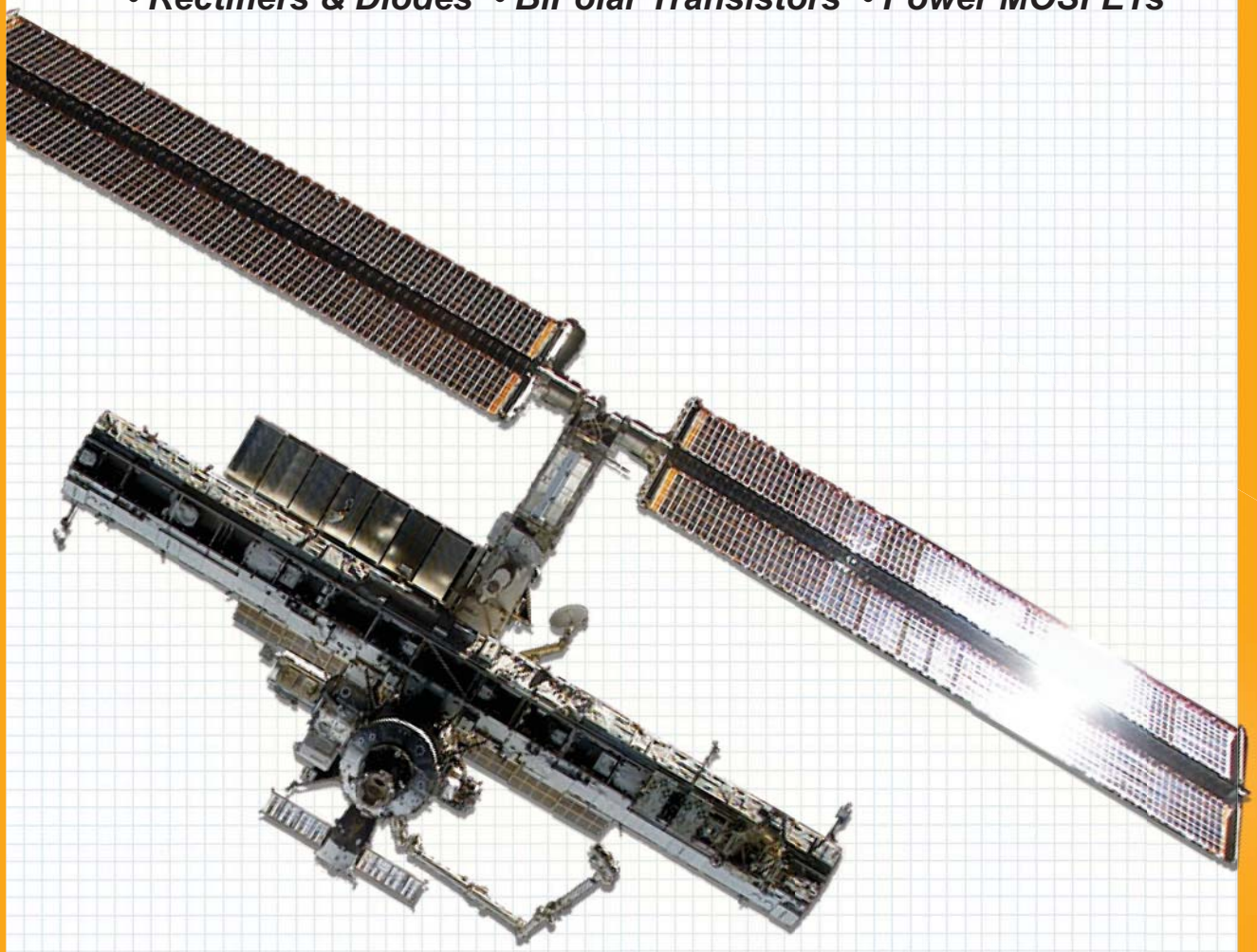
High Reliability Radiation Hardened Semiconductors

• Rectifiers & Diodes • BiPolar Transistors • Power MOSFETs



HiREL Product Guide

Microsemi

Contents

Leader in Radiation Hardened Products

Microsemi Corporation (MSCC) is the world's leading supplier of High Reliability Discrete Semiconductors. Microsemi was the first diode manufacturer selected by the U.S. military services as a source of supply to qualify product to the highest specified reliability level—JANS. Our heritage in supplying space compliant semiconductor products in accordance with MIL-PRF-19500 extends over 30 years. Microsemi has expanded its space product offering to include a wide variety of hermetic diodes, transistors, and MOSFETs.

Microsemi has been involved in numerous military and commercial space programs involving radiation hardened product specifications with stringent performance requirements. This now includes the largest selection of JANS qualified products in the world; a portfolio that has become predominant in satellite and launch vehicle programs. With recent design trends, the ability to assemble in a variety of packaging styles has become essential. This includes surface mount packaging options for virtually any product, as well as chips for hybrid use.

- Diodes
- Power Mosfets
- Rectifiers
- Schottkys
- Transistors
- Zeners

Key Application Specific Products

- Thermally activated battery bypass switches for satellites
- Solar cell bypass diodes for bypassing faulty solar cells
- Zero temperature coefficient radiation hardened compensated zener diodes

Custom Products

- Complete solutions from die selection and screening through module assembly
- Custom test, environmental and screening capabilities
- Full range of Total Dose, ELDRs and Single Event Effects (SEE) characterizations available

Radiation Services

MIL-PRF-19500 is the General Performance Specification for Semiconductor Devices. This specification is maintained by the Defense Logistics Agency (DLA) to provide the supplier requirements for manufacturing high reliability semiconductors. MIL-PRF-19500, along with the detailed part requirements found in related slashsheets, and MIL-STD-750 ("Test Methods for Semiconductor Devices" published by the United States Department of Defense) combine to fully specify the scope of Radiation test requirements for discrete semiconductor part types. The following is a brief description of the key radiation tests detailed in these documents.

Radiation Tests Services Available

Microsemi is capable of performing all the methods listed below and offers these test services to our customers. Please contact Microsemi Sales for a review of your unique radiation test requirements.

RHA Prefix	*Total Ionizing Dose Level*
M	3K RADS
D	10K RADS
P	30K RADS
L	50K RADS
R	100K RADS
F	300K RADS
G	500K RADS
H	1000K RADS

Example:	JANSR2N2222A (100K RADS) JANSF2N7261 (300K RADS)

Total Ionizing Dose (TID) or Gamma Irradiation

Per Mil-Std-750 Method 1019
Dose rate 50-200RAD(Si)/s nominal 100RAD(Si)/s
Typically 3kRAD(Si) to 1MRAD(Si) or 300Gy(Si) to 10000Gy(Si)
Note Gy = Gray where 100RAD = Gray

ELDRS (Enhanced Low Dose Rate Sensitivity)

Reference Mil-Std-833 Method 1019
Dose rate either 0.01RAD(Si)/s to 0.020RAD(Si)/s
Typically 10kRAD(Si) which takes 7 days at 0.020RAD(Si)/s

Neutron Irradiation (Fast Neutrons)

Per Mil-Std-750 Method 1017
Typically 1E12 n/cm^2 to 1E15n/cm^2
Large 12 x 12 x 12 inch Target Chamber (can test small systems)

Single Event Effects (SEE) with Heavy Ions

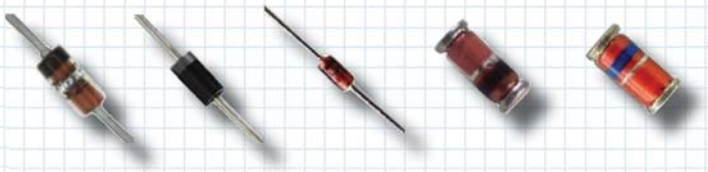
Per Mil-Std-750 Method 1080
Single Event Gate Response (SEGR)
Single Event Burnout (SEB)
K500 Cyclotron with a wide variety of LETs and Ranges

Radiation Services Available

Microsemi is capable of performing all of the radiation test methods listed above and offers these test services to our customers. Please contact the Microsemi Sales department for review of your unique radiation test requirements.

High Reliability Radiation Hardened

Rectifier & Diode Products



Most Microsemi Space-level rectifier and diode products are inherently radiation hardened. This fact has been understood by our major customers for many years. As a result, our heritage of usage in space programs is unsurpassed in the industry.

Due to the inherent capability of rectifiers and diodes, MIL-PRF-19500 in general does not specify radiation hardness levels for this product family (some exceptions do exist).

Microsemi's portfolio of JANS qualified rectifiers and diodes is far too extensive to list in this shortfom catalog. The following provides a broad overview of the radiation hardened performance of our core space level diode families. For specific performance information, please visit our website at *www.microsemi.com* or Microsemi Sales.

Rectifiers are naturally radiation hard up to 10^6 or 10^7 RAD(Si) and 10^{14} n/cm^2. This depends heavily on breakdown voltage (VBR), lifetime (switching speed), etc. with forward voltage (VF) and reverse leakage current (IR) being the affected parameters. The "fast" and "ultrafast" recovery rectifiers (FRR and UFR) will have much less effect from high radiation.

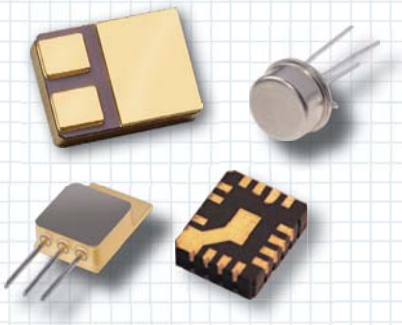
Zeners and Transient Voltage Suppressors (TVS) are naturally very radiation hard as they employ majority carrier avalanche breakdown. These easily perform up to 10^7 RAD(Si) and 10^{14} n/cm^2 for products up to 200 volts. Below 100 volts, they exceed 10^8 RAD(Si) and 10^{15} n/cm^2.

Schottky Rectifiers also operate on a majority carrier principle with natural radiation-hard performance and are comparable to zeners less than 100 volts described above. Typically, reverse leakage current (IR) is affected although not enough to affect performance. Exposure of 10^6 RAD(Si) is considered acceptable as well as 10^{13} n/cm^2 or higher.

Temperature Compensated Zeners (TCZ) are manufactured with process to improve stability and this process makes these parts naturally radiation hard. These reference diodes are capable of performance up to 10^6 RAD and 10^{14} n/cm^2.

High Reliability Radiation Hardened

Bipolar Transistors



SMD-0.5 (Surface Mount)

Part Number	V(BR) CEO	IC	Max TID Rating	MIL-PRF-19500
NPN Power				
JANSF2N5152U3	80V	10.0A	300K RAD	/544
JANSF2N5154U3	80V	10.0A	300K RAD	/544
PNP Power				
JANSF2N5151U3	80V	10.0A	300K RAD	/545
JANSF2N5153U3	80V	10.0A	300K RAD	/545

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Part Number	V(BR) CEO	IC	Max TID Rating	MIL-PRF-19500
NPN Silicon Switcher				
JANSH2N2221A	50V	0.8A	1 MEG RAD	/255
JANSH2N2221AL	50V	0.8A	1 MEG RAD	/255
JANSH2N2222A	50V	0.8A	1 MEG RAD	/255
JANSH2N2222AL	50V	0.8A	1 MEG RAD	/255
JANSF2N2369A	15V	0.1A	300K RAD	/317
JANSR2N3700	80V	1.0A	100K RAD	/391
JANSF2N4449	15V	0.1A	300K RAD	/317
PNP Silicon Switcher				
JANSR2N2906A	60V	0.6A	100K RAD	/291
JANSR2N2906AL	60V	0.6A	100K RAD	/291
JANSR2N2907A	60V	0.6A	100K RAD	/291
JANSR2N2907AL	60V	0.6A	100K RAD	/291

TO-39

Part Number	V(BR) CEO	IC	Max TID Rating	MIL-PRF-19500
NPN Silicon Switcher				
JANSR2N2218	30V	0.8A	100K RAD	/251
JANSR2N2218A	50V	0.8A	100K RAD	/251
JANSR2N2219	30V	0.8A	100K RAD	/251
JANSR2N2219A	50V	0.8A	100K RAD	/251
JANSR2N3019S	80V	1.0A	100K RAD	/391
JANSR2N3439L	350V	1.0A	100K RAD	/368
JANSR2N3440L	250V	1.0A	100K RAD	/368
JANSR2N3498	100V	0.3A	100K RAD	/366
JANSR2N3499	100V	0.3A	100K RAD	/366
JANSR2N3500	150V	0.3A	100K RAD	/366
JANSR2N3501	150V	0.3A	100K RAD	/366
PNP Silicon Switcher				
JANSR2N3634	140V	1.0A	100K RAD	/357
JANSR2N3635	140V	1.0A	100K RAD	/357
JANSR2N3636	175V	1.0A	100K RAD	/357
JANSR2N3637	175V	1.0A	100K RAD	/357
NPN Power				
JANSF2N5152	80V	10.0A	300K RAD	/544
JANSF2N5154	80V	10.0A	300K RAD	/544
PNP Power				
JANSF2N5151	80V	10.0A	300K RAD	/545
JANSF2N5153	80V	10.0A	300K RAD	/545

TO-5

Part Number	V(BR) CEO	IC	Max TID Rating	MIL-PRF-19500
NPN Silicon Switcher				
JANSR2N2218AL	50V	0.8A	100K RAD	/251
JANSR2N2219AL	50V	0.8A	100K RAD	/251
JANSR2N3019	80V	1.0A	100K RAD	/391
JANSR2N3439	350V	1.0A	100K RAD	/368
JANSR2N3440	250V	1.0A	100K RAD	/368
JANSR2N3498L	100V	0.3A	100K RAD	/366
JANSR2N3499L	100V	0.3A	100K RAD	/366
JANSR2N3500L	150V	0.3A	100K RAD	/366
JANSR2N3501L	150V	0.3A	100K RAD	/366
PNP Silicon Switcher				
JANSR2N3634L	140V	1.0A	100K RAD	/357
JANSR2N3635L	140V	1.0A	100K RAD	/357
JANSR2N3636L	175V	1.0A	100K RAD	/357
JANSR2N3637L	175V	1.0A	100K RAD	/357
NPN Power				
JANSF2N5152L	80V	10.0A	300K RAD	/544
JANSF2N5154L	80V	10.0A	300K RAD	/544
PNP Power				
JANSF2N5151L	80V	10.0A	300K RAD	/545
JANSF2N5153L	80V	10.0A	300K RAD	/545

TO-59

Part Number	V(BR) CEO	IC	Max TID Rating	MIL-PRF-19500
NPN Power				
JANSF2N5002	80V	10.0A	300K RAD	/534
JANSF2N5004	80V	10.0A	300K RAD	/534

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Part Number	V(BR) CEO	IC	Max TID Rating	MIL-PRF-19500
PNP DUAL				
JANSF2N3810	60V	0.1A	300K RAD	/336
JANSF2N3810L	60V	0.1A	300K RAD	/336
JANSF2N3811	60V	0.1A	300K RAD	/336
JANSF2N3811L	60V	0.1A	300K RAD	/336

Products are listed with the highest qualified radiation hardness assurance designation as described on Page 4 of this brochure.

Part Number	V(BR) CEO	IC	Max TID Rating	MIL-PRF-19500

3 Pin LCC (Surface Mount)

NPN Silicon Switcher

JANSH2N2221AUB	50V	0.8A	1 MEG RAD	/255
JANSH2N2221AUBC	50V	0.8A	1 MEG RAD	/255
JANSH2N2222AUB	50V	0.8A	1 MEG RAD	/255
JANSH2N22222AUBC	50V	0.8A	1 MEG RAD	/255
JANSF2N2369AUB	15V	0.1A	300K RAD	/317
JANSF2N2369AUBC	15V	0.1A	300K RAD	/317
JANSR2N3501UB	150V	0.3A	100K RAD	/366
JANSR2N3700UB	80V	1.0A	100K RAD	/391

PNP Silicon Switcher

JANSR2N2906AUB	60V	0.6A	100K RAD	/291
JANSR2N2906AUBC	60V	0.6A	100K RAD	/291
JANSR2N2907AUB	60V	0.6A	100K RAD	/291
JANSR2N2907AUBC	60V	0.6A	100K RAD	/291
JANSR2N3634UB	140V	1.0A	100K RAD	/357
JANSR2N3635UB	140V	1.0A	100K RAD	/357
JANSR2N3636UB	175V	1.0A	100K RAD	/357
JANSR2N3637UB	175V	1.0A	100K RAD	/357

4 Pin LCC (Surface Mount)

NPN Silicon Switcher

JANSH2N2221AUA	50V	0.8A	1 MEG RAD	/255
JANSH2N22222AUA	50V	0.8A	1 MEG RAD	/255
JANSF2N2369AUA	15V	0.1A	300K RAD	/317
JANSR2N3439UA	350V	1.0A	100K RAD	/368
JANSR2N3440UA	250V	1.0A	100K RAD	/368

PNP Silicon Switcher

JANSR2N2906AUA	60V	0.6A	100K RAD	/291
JANSR2N2907AUA	60V	0.6A	100K RAD	/291

6 Pin LCC (Surface Mount)

NPN Silicon Switcher

JANSF2N2369AU	15V	0.1A	300K RAD	/317
JANSF2N3810U	60V	0.1A	300K RAD	/336

PNP DUAL

JANSF2N3811U	60V	0.1A	300K RAD	/336

TO-254AA

NPN Power

JANSF2N7373	80V	10.0A	300K RAD	/613

TO-46

NPN Silicon Switcher

JANSR2N3057A	80V	1.0A	100K RAD	/391

Total Dose Irradiation Effects on Bipolar Transistors

Ionizing radiation damage in semiconductor devices is mainly the result of charges trapped on or near the surfaces of their insulating layers and interfaces. In bipolar devices, a trapped charge at their surface layers produce inversion layers that expand the effective surface area, hence, modifying the surface potential at the Si-SiO^2 interfaces.

This means that there will be a reduction in the minority carrier life-time and hence a corresponding decrease in the DC current gain (h_{FE}) of the DUT. Therefore, bipolar transistors require special calculations to report their post-irradiation performance:

(a) Delta ($1/h_{FE}$): Let $h_{FE}1$ be the measured h_{FE} at a specific test point (Vce, Ic) prior to irradiation. Let $h_{FE}2$ be the measured h_{FE} post-irradiation at that same test point.

Then: Delta ($1/h_{FE}$) = $\Delta(1/h_{FE})$ = $1/h_{FE}2 - 1/h_{FE}1$ and is unitless as is h_{FE}.

Example: $h_{FE}1$ = 200 before irradiation and at post-irradiation testing it has decreased to $h_{FE}2$ = 125.Then: Δ ($1/h_{FE}$) = 1/125 – 1/200 = 0.00300.

(b) [h_{FE}] calculation is not a directly measured value of h_{FE}, but rather a calculated value used by system analysis engineers. It signifies exactly how well the bipolar transistor will perform in the system after exposure to a radiation fluence. This [h_{FE}] is denoted in square brackets [ ] to delineate it from any measured value of h_{FE} and uses the calculated value of Delta ($1/h_{FE}$) but adds one additional term.

Calculate as follows:

Let h_{FE}(min) be the pre-irradiation spec minimum h_{FE} limit at the same test point in the Delta($1/h_{FE}$) calculation shown above.

Then: [h_{FE}] = inverse { $\Delta(1/h_{FE})$ + $1/h_{FE}$)min}

Example: h_{FE}(min) = 100 and, in accordance with the above expample, $\Delta(1/h_{FE})$ = 0.00300.

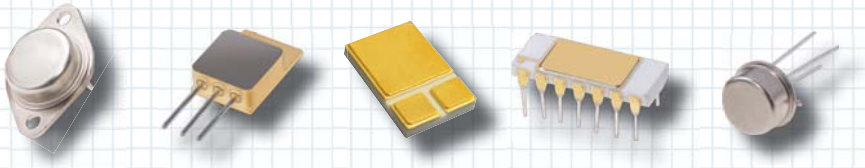
Then: [h_{FE}] = inverse { 0.00300 + 1/100 } = inverse { 0.003 + 0.01 } = 1 / { 0.013} = 76.92.

Note that [h_{FE}] can never exceed h_{FE} (min).

(c) When $\Delta(1/h_{FE})$, [h_{FE}] or both are required by the control specification, these calculations will only be required on the irradiation test samples. The test report shall then contain, in spreadsheet fashion, the appropriate pre and post h_{FE} measurements as well as the required calculation results. Unless otherwise specified, all devices shall adhere to the specification maximum h_{FE} limits that were imposed pre-irradiation.

High Reliability Radiation Hardened Power MOSFETs

NEW QUALIFICATION



Microsemi has recently qualified its first generation of Radiation Hardened Power MOSFETs. The post irradiation test requirements for MOSFETs are clearly defined in the controlling MIL-PRF-19500 slashsheets. Typically, MOSFETs show movement in threshold voltage (Vth) after exposure to Total Ionizing Dose (TID) Irradiation.

Following is a listing of our current MIL-PRF-19500 radiation hardened qualified devices. Check our website for the latest product offerings as we continue to expand this product portfolio.

TO-205AF (TO-39)

Part Number	Channel	BVDSS MIN	VGS MAX	RDS(on) MAX	ID MAX	PD MAX	MAX TID Rating (K RAD)	MIL-PRF-19500 Spec.
		V	V	mΩ	A	W		
JANSR2N7389	P	-100	±20	300	6.5	25	100	/630
JANSF2N7389	P	-100	±20	300	6.5	25	300	/630
JANSR2N7261	N	100	±20	180	8.0	25	100	/601
JANSF2N7261	N	100	±20	180	8.0	25	300	/601
JANSR2N7262	N	200	±20	350	5.5	25	100	/601
JANSF2N7262	N	200	±20	350	5.5	25	300	/601

TO-257AA

JANSR2N7382	P	-100	±20	300	11.0	75	100	/615
JANSF2N7382	P	-100	±20	300	11.0	75	300	/615
JANSR2N7380	N	100	±20	180	14.4	75	100	/614
JANSF2N7380	N	100	±20	180	14.4	75	300	/614
JANSR2N7381	N	200	±20	400	9.4	75	100	/614
JANSF2N7381	N	200	±20	400	9.4	75	300	/614

18-Pin LCC (Surface Mount)

JANSR2N7389U	P	-100	±20	300	6.5	25	100	/630
JANSF2N7389U	P	-100	±20	300	6.5	25	300	/630
JANSR2N7261U	N	100	±20	180	8.0	25	100	/601
JANSF2N7261U	N	100	±20	180	8.0	25	300	/601
JANSR2N7262U	N	200	±20	350	5.5	25	100	/601
JANSF2N7262U	N	200	±20	350	5.5	25	300	/601

SMD-1 (TO-267AB Surface Mount)

MSR2N7394U**	N	60	±20	27	35	150	100	N/A
MSF2N7394U**	N	60	±20	27	35	150	300	N/A
JANSR2N7394U*	N	60	±20	27	35	150	100	/603
JANSF2N7394U*	N	60	±20	27	35	150	300	/603
JANSR2N7268U	N	100	±20	65	34.0	150	100	/603
JANSF2N7268U	N	100	±20	65	34.0	150	300	/603
JANSR2N7269U	N	200	±20	100	26.0	150	100	/603
JANSF2N7269U	N	200	±20	100	26.0	150	300	/603

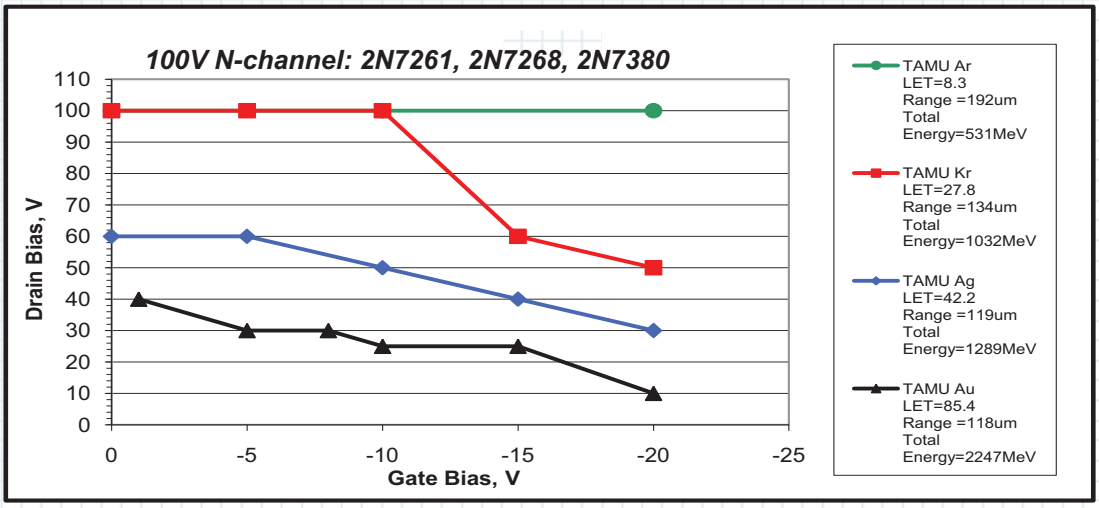
TO-254AA

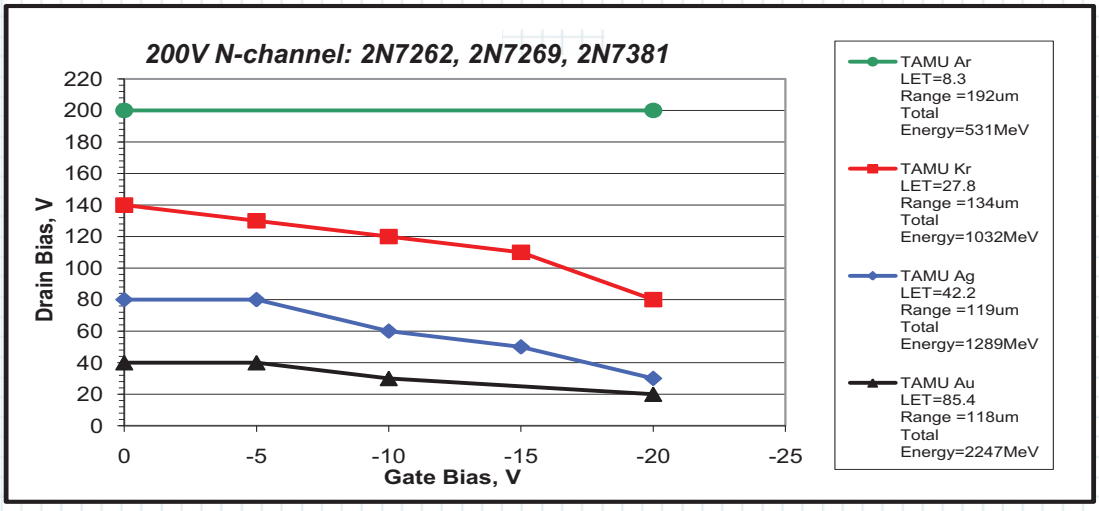
MSR2N7394**	N	60	±20	27	35	150	100	N/A
JANSF2N7394*	N	60	±20	27	35	150	300	/603
JANSR2N7268	N	100	±20	65	34	150	100	/603
JANSF2N7268	N	100	±20	65	34	150	300	/603
JANSR2N7269	N	200	±20	100	26	150	100	/603
JANSF2N7269	N	200	±20	100	26	150	300	/603

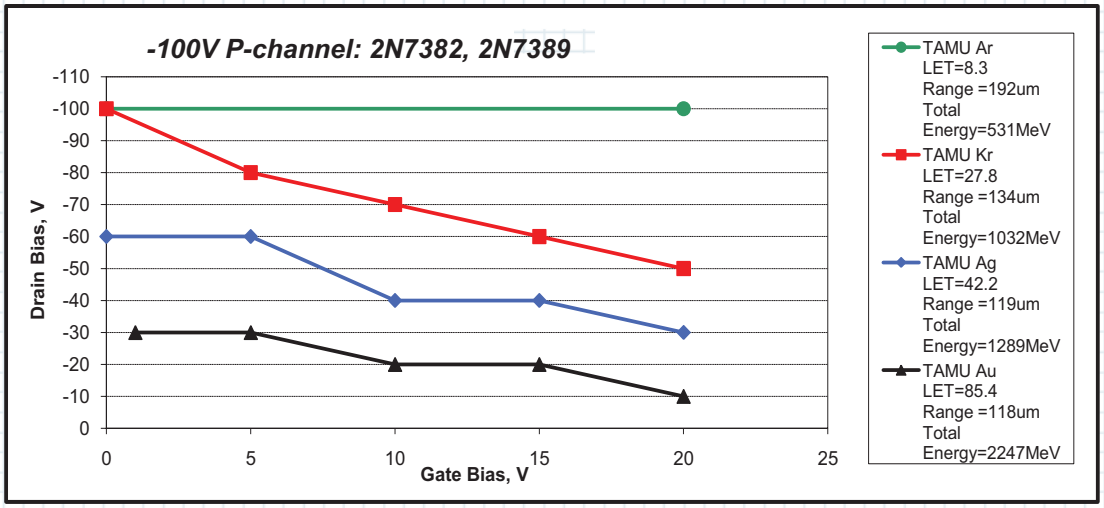
* DLA qualification in progress
** Microsemi qualified part

Single Event Capability

In addition to TID, Microsemi routinely performs Single Event Effects (SEE) testing using Heavy Ions. Microsemi MOSFETs are sample tested for Single Event Gate Rupture (SEGR) and Single Event Burnout (SEB). The following graphs summarize the SEE results obtained for each of the MOSFET groups.

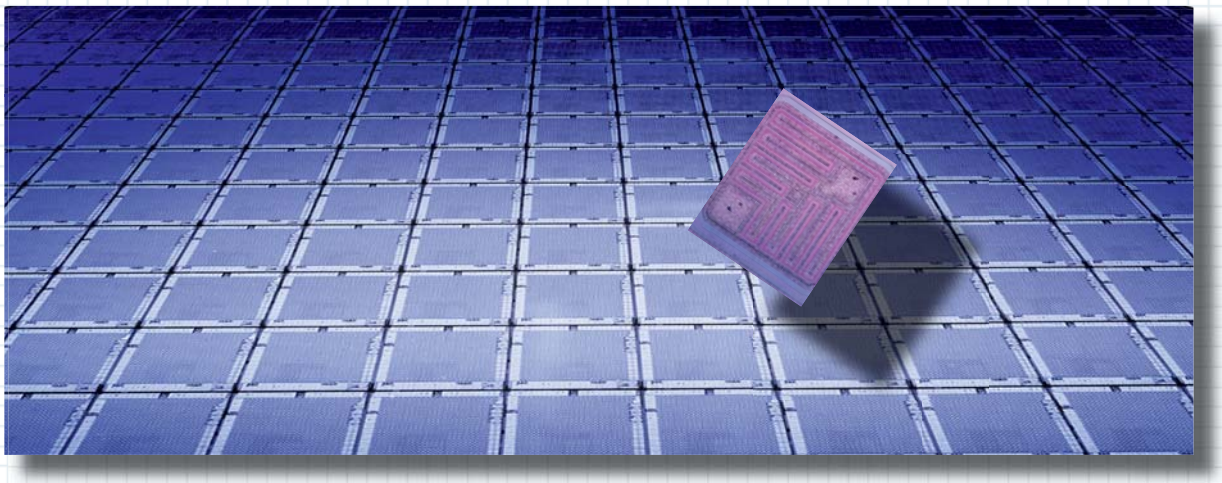






High Reliability Radiation Hardened

Semiconductor Chips

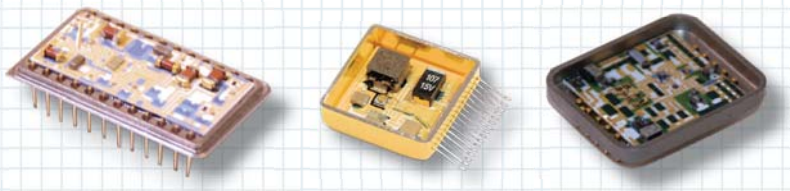


Microsemi Corporation is a leader in the sale of semiconductor chips to the high reliability military and space community for hybrid circuit applications.

We are continuously adding to our qualified product listings.

If you are unable to find the chip you are looking for, please contact our Sales Department for the latest updates.

We also regularly sell commercial chip and JANHC/JANKC equivalents to meet customer specific needs.



Solar Flare

NASA Solar Dynamics Observatory

High Reliability, Radiation Hardened Semiconductors

Microsemi has a team of specialists available to provide application support for you High Reliability requirements. Call for more information or visit our website.

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