Total dose testing of the IS-1009RH Voltage Reference

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1. Introduction

This report documents the results of a low and high dose rate total dose test of the IS-1009RH voltage reference. The test was conducted in order to determine the sensitivity of the part to the total dose environment and to determine if dose rate and bias sensitivity exist.

2. Reference Documents

MIL-STD-883G test method 1019.7
IS-1009RH data sheet
DSCC Standard Microcircuit Drawing (SMD) 5962-00523

3: Part Description

The IS-1009RH is a shunt voltage reference designed to provide an accurate 2.5V reference voltage over a wide current range. The device is stable over a wide current range and is designed to maintain stability over the full military temperature range and over time. It operates and is specified at a lower minimum current than other 1009 types. The 0.2% reference tolerance is achieved by on-chip trimming. An adjustment terminal is provided to allow for the calibration of system errors. The use of this terminal to adjust the reference voltage does not affect the temperature coefficient.

Constructed in the Intersil dielectrically isolated EBHF process, these devices are immune to single event latchup (and indeed immune to latchup from any source) and have been specifically designed to provide reliable performance in harsh radiation environments.

Specifications for Rad Hard QML devices are controlled by the Defense Supply Center in Columbus (DSCC). The SMD numbers listed here must be used when ordering. Detailed Electrical Specifications for the device are contained in SMD 5962-00523. A "hot-link" is provided on the Intersil homepage for downloading.

The IS-1009RH block diagram is not shown as the equivalent circuit of the part is a simple Zener diode, refer to Figure 1.

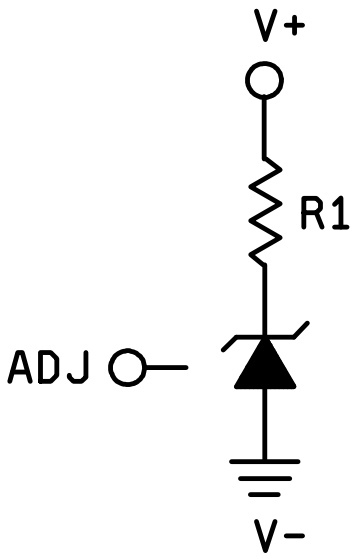
4: Test Description

4.1 Irradiation Facilities

High dose rate testing was performed using a Gammacell 220 ^{60}Co irradiator located in the Palm Bay, Florida Intersil facility. Low dose rate testing was performed on a subcontract basis at White Sands Missile Range (WSMR) Survivability, Vulnerability and Assessment Directorate (SVAD), White Sands, NM, using a vault-type ^{60}Co irradiator. The high dose rate irradiations were done at 55rad(Si)/s and the low dose rate work was performed at 0.010rad(Si)/s, both per MIL-STD-883 Method 1019.7. Dosimetry for the low dose rate test was performed using Far West Technology radiochromic dosimeters and readout equipment.

4.2 Test Fixturing

Fig. 1 shows the configuration used for biased irradiation at both high and low dose rate. This bias configuration is in conformance with the SMD 5962-00523 configuration.



NOTES:

V+ = +5 V ±0.5 V
V- = GND
ADJ = Open
R1 = 2.5 kΩ, 5 %, 1/4 W

Fig. 1: Irradiation bias configuration for the IS-1009RH per Standard Microcircuit Drawing (SMD) 5962-00523.

4.3 Characterization equipment and procedures

All electrical testing was performed outside the irradiator using the production automated test equipment (ATE) with datalogging at each downpoint. Downpoint electrical testing was performed at room temperature. Performing low dose rate testing at a remote site introduces some challenges, and shipping was performed using a foam container with a frozen Gelpack™ along with a strip chart temperature recorder in order to insure compliance with the transit temperature limits imposed by MIL-STD-883 Test Method 1019.7. Close coordination between the two organizations is required, and outstanding support by WSMR is gratefully acknowledged.

4.4 Experimental matrix

The experimental matrix consisted of five samples irradiated at high dose rate with all pins grounded, five samples irradiated at high dose rate under bias, five samples irradiated at low dose rate with all pins grounded and five samples irradiated at low dose rate under bias. One control unit was used.

Samples of the IS-1009RH die were drawn from production lot DPM0LG and were packaged in the 3-pad hermetic SMD.5 ceramic chip carrier production package. Samples were processed

through the standard burnin cycle before irradiation, as required by MIL-STD-883, and were screened to the SMD 5962-00523 limits at room, low and high temperatures prior to the test.

4.5 Downpoints

Downpoints were 0, 10, 25, 50, 100 and 150krad(Si) for the high and low dose rate tests.

5: Results

5.1 Test results

The current test was undertaken to determine the response of current production parts to high and low dose rate irradiation. Testing at both dose rates of the IS-1009RH is complete through 150krad(Si) at both dose rates. All monitored parameters remained within the SMD post-irradiation specifications.

Referring to Figure 5, note that the unbiased cases for both low and high dose rate represent the worst case drift of the delta VZ parameter, which is similar to a load regulation measurement in that it evaluates reference stability over a given load current range. The biased low dose rate case is observed to be best case. This response is different from the expected RSG performance, in which low dose rate, grounded irradiation has been shown to be worst-case for a number of parts.

The IS-1009RH is implemented in the Intersil EBHF process. The EBHF process uses nitride passivation. Passivation structure, composition and deposition process have been shown to strongly affect the hydrogen transport dynamics and hence the low and high dose rate response of the resulting parts. This result is in disagreement with data for Intersil RSG parts, which uses single-layer Silox passivation. In these parts the grounded low dose rate condition was generally found to be worst case.

These results are consistent, however, with the HS-OP470ARH data obtained earlier and reported on the Intersil Web site. This EBHF part showed little, if any, low dose rate or bias sensitivity, with the low dose rate biased condition marginally worst-case for some parameters.

The IS-1009RH is considered moderately low dose rate sensitive but remains within the SMD post-irradiation limits to a maximum of 150krad(Si) in this environment.

5.2 Variables data

The plots in Figs. 2 through 5 show variables data at all downpoints. The plots show the median of key parameters as a function of total dose for each of the four irradiation conditions. We chose to plot the median for these parameters due to the relatively small sample sizes.

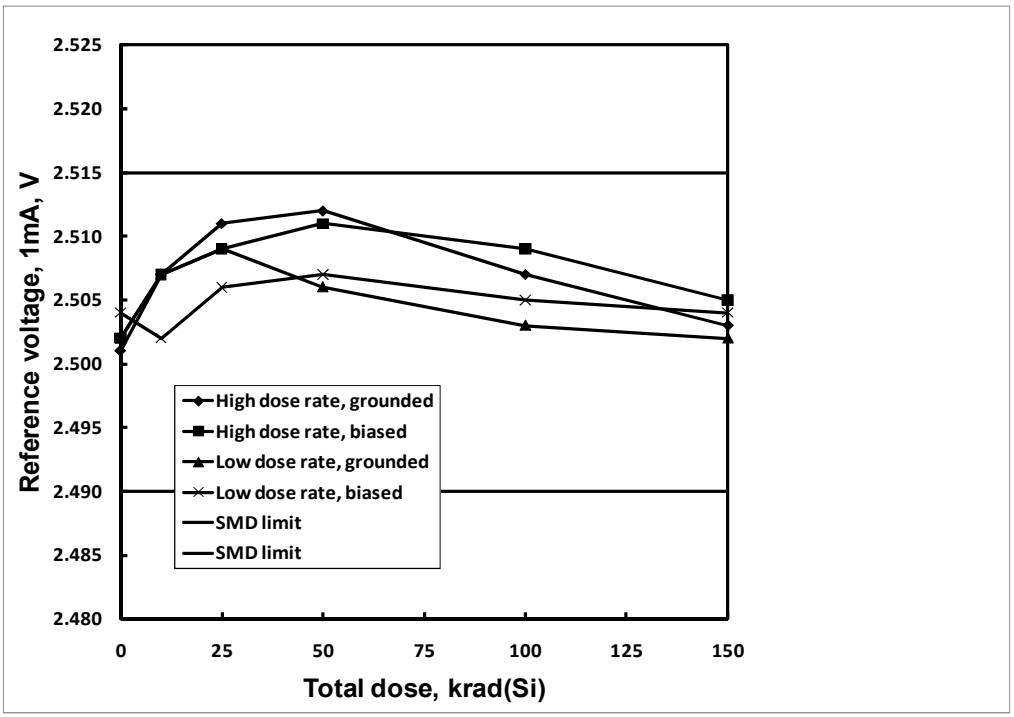


Fig. 2: IS-1009RH reference output voltage at 1mA as a function of total dose irradiation at low and high dose rate for the unbiased (all pins grounded) and the biased (per Fig. 1) cases. The low dose rate was 0.01rad(Si)/s and the high dose rate 55rad(Si)/s. Sample size for each cell was 5. The post-irradiation SMD limits are 2.490V to 2.515V.

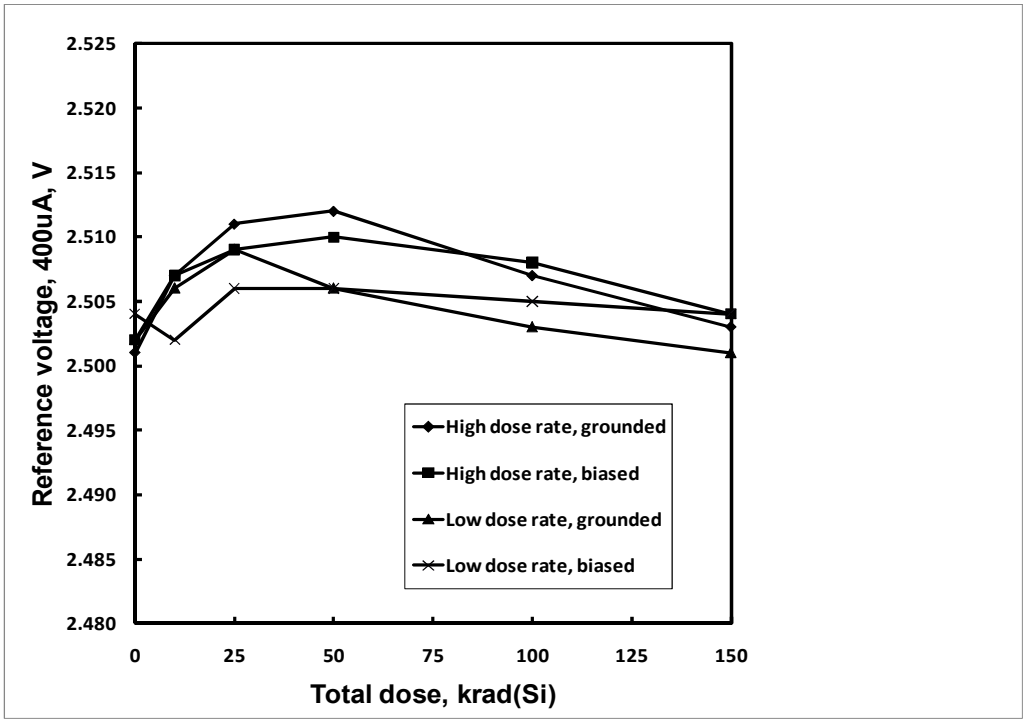


Fig. 3: IS-1009RH reference voltage at 400µA as a function of total dose irradiation at low and high dose rate for the unbiased and biased cases. This parameter is for information only and is not specified in the SMD.

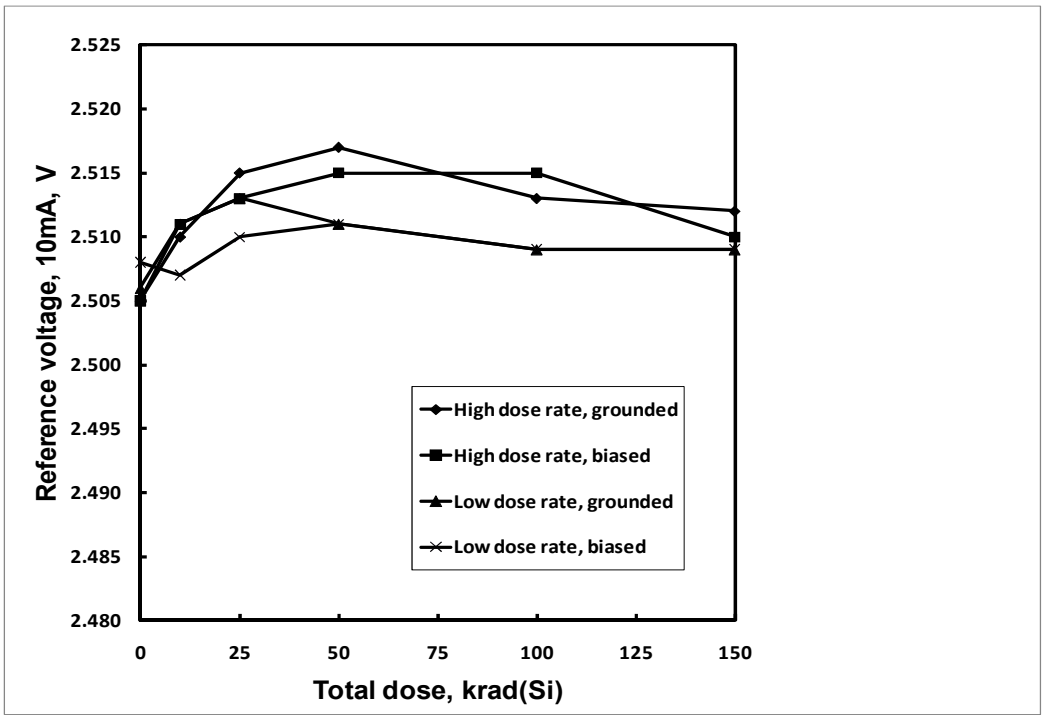


Fig. 4: IS-1009RH reference voltage at 10mA as a function of total dose irradiation at low and high dose rate for the unbiased and biased cases. This parameter is for information only and is not specified in the SMD.

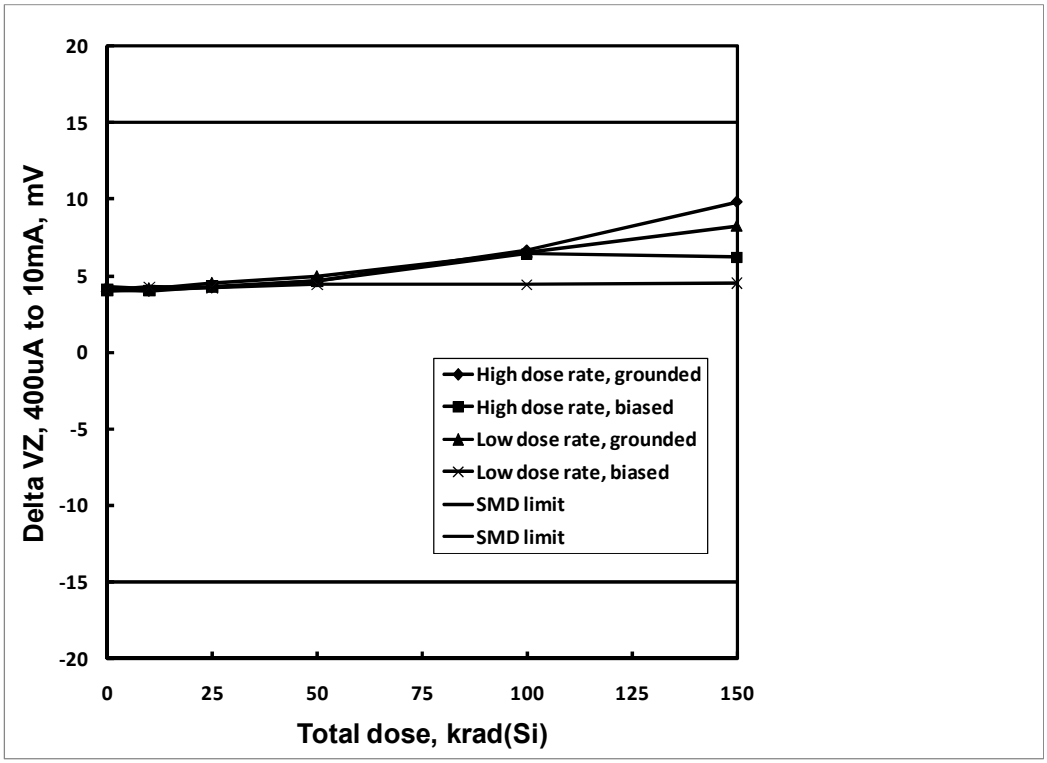


Fig. 5: IS-1009RH total reference voltage variation, 400µA to 10mA output current, as a function of total dose irradiation at low and high dose rate for the unbiased and biased cases. The post-irradiation SMD limits are -15mV to 15mV.

6: Conclusion

Total dose testing of the IS-1009RH is complete through 150krad(Si) at low and high dose rate. All sample parameters remained within the SMD post-irradiation specifications.

The delta VZ parameter showed some drift as a function of total dose. The worst case drift was for the unbiased cases at both low and high dose rate. The delta VZ parameter is somewhat similar to a load regulation measurement in that it evaluates reference stability over a given load current range. The biased low dose rate case was observed to be best case. This response is different from the performance of RSG parts, in which low dose rate, grounded irradiation has been shown to be worst-case for a number of parts.

The IS-1009RH is implemented in the Intersil EBHF process, which uses nitride passivation. Passivation structure, composition and deposition process have been shown to strongly affect the hydrogen transport dynamics and hence the relative low and high dose rate responses of the resulting parts.

This result is in disagreement with data for Intersil RSG parts, which uses single-layer Silox passivation. In these parts the grounded low dose rate condition was generally found to be worst case. This result is also in disagreement with the considerable amount of data for Intersil RSG parts, which uses single-layer Silox passivation. In the RSG parts the grounded low dose rate condition was generally found to be worst case, as has been reported in the literature for many competitive bipolar parts. These results are consistent, however, with the HS-OP470ARH data obtained earlier and reported on the Intersil Web site. This is an EBHF part as well and showed little, if any, low dose rate or bias sensitivity, with the low dose rate biased condition marginally worst-case for some parameters.

The IS-1009RH is considered moderately low dose rate sensitive but remains well within the SMD post-irradiation limits to a maximum of 150krad(Si) in this environment.

7: Appendices

7.1: Reported parameters.

Fig.	Parameter	SMD limit, low	SMD limit, high	Units	Notes
2	Reference voltage	2.490	2.515	V	IZ = 1mA
3	Reference voltage	NA	NA	V	IZ = 400µA
4	Reference voltage	NA	NA	V	IZ = 10mA
5	Load regulation	-15	+15	mV	IZ = 400µA to 10mA

Note 1: Limits are taken from Standard Microcircuit Drawing (SMD) 5962-00523.

Note 2: Parameters shown in Figures 3 and 4 are for information only and are not specified in the SMD.

8: Document revision history

Revision	Date	Pages	Comments
0	January 2011	All	Original issue