

INA240-SEP Wide Common-Mode Range, High- and Low-Side, Bidirectional, Zero-Drift, Current-Sense Amplifier TID Report



ABSTRACT

This report covers the radiation characterization results of the INA240-SEP Current-Sense Amplifier. The study was done to determine Total Ionizing Dose (TID) effects under high dose rate (HDR) up to 30 krad(Si) as a one time characterization. The results show that all samples passed within the specified limits up to 30 krad(Si) with 5 minutes of anneal. However, Radiation Lot Acceptance Testing (RLAT) will be performed using 22 units at a dose level of 20 krad(Si) for future wafer lots. Furthermore, the INA240-SEP is packaged in a space enhanced plastic for low outgassing characteristics and is Single Event Latch-Up (SEL) immune up to 43 MeV-cm²/mg making the device suitable for low earth orbit space applications. The device is ideal for application such as power supervision, motor control loop, overcurrent and undercurrent detection.

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1 Device Information

The INA240-SEP device is a voltage-output, current sense amplifier with enhanced PWM rejection that can sense drops across shunt resistors over a wide common-mode voltage range from -4 V to 80 V , independent of the supply voltage.

The negative common-mode voltage allows the device to operate below ground, accommodating the flyback period of typical solenoid applications. This device operates from a single 2.7-V to 5.5-V power supply, drawing a maximum of 2.4 mA of supply current. The fixed gain is 20 V/V. The low offset of the zero-drift architecture enables current sensing with maximum drops across the shunt as low as 10-mV full-scale.

1.1 Device Details

Table 1-1 lists the device information used for TID HDR characterization and qualification.

Table 1-1. Device and Exposure Details

TID HDR Details: up to 30 krad(Si)	
TI Device Number	INA240-SEP
Package	8-pin PW (TSSOP)
Technology	ABCD6
Die Lot Number	7004590
A/T Lot Number / Date Code	1084349/8AD3PDK
Quantity Tested	37 irradiated devices + 3 control
Lot Accept/Reject	Devices passed 3 krad(Si), 10 krad(Si), 20 krad(Si), 30 krad(Si)
HDR Radiation Facility	Texas Instruments SVA Group, Santa Clara, CA
HDR Dose Level	3 krad(Si), 10 krad(Si), 20 krad(Si), 30 krad(Si)
HDR Dose Rate	78 rad(Si)/s
HDR Radiation Source	Gammacell 220 Excel (GC-220E) Co-60
Irradiation Temperature	Ambient, room temperature

2 Total Dose Test Setup

2.1 Test Overview

The INA240-SEP samples were irradiated at a high dose rate of 78 rad(Si)/s up to 30 krad(Si) and then put through full electrical parametric testing on the production Automated Test Equipment (ATE). The samples were functional and passed all electrical parametric tests with readings within data sheet electrical specification limits.

2.2 Test Description and Facilities

The INA240-SEP HDR exposure was performed on biased devices in a Co60 gamma cell at TI SVA facility in Santa Clara, California. The unattenuated dose rate of this cell is 78 rad(Si)/s. After exposure, the devices were packed in dry ice and returned to TI Dallas for a full post irradiation electrical evaluation using Texas Instruments ATE. ATE guard band test limits are set within data sheet electrical specifications to ensure a minimum Cpk and test error margin based on initial qualification and characterization data. Post irradiation measurements were taken within 30 minutes of removal of the devices from the dry ice container. The devices were allowed to reach room temperature prior to electrical post radiation measurements.

2.3 Test Setup Details

The devices were tested in biased conditions as described below:

2.3.1 Biased

Figure 2-1 shows the bias conditions for each pin during irradiation.

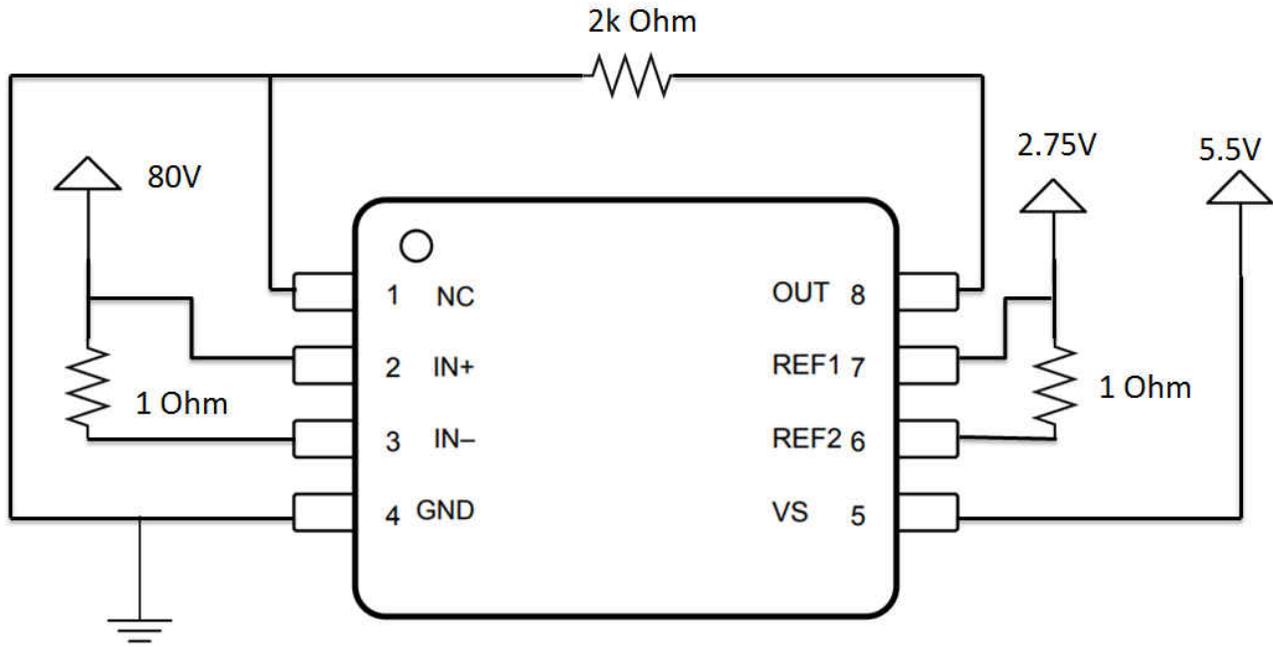


Figure 2-1. INA240-SEP Biased Diagram

2.4 Test Configuration and Condition

A step-stress (3k, 10k, 20k, and 30k) test method was used to determine the TID hardness level. That is, after a predetermined TID level was reached, an electrical test was performed on a given sample of parts to verify that the units are within specified data sheet electrical test limits. From initial feasibility studies the difference between pre and post irradiation was greater for samples that were biased, hence for RLAT 22 sample units were used at the 20-krad(Si) dose level with biased setup conditions and this will be repeated for each wafer lot.

Table 2-1 list the serialized samples used for RHA characterization.

Table 2-1. HDR = 78 rad(Si)/s Biased Device Information

HDR = 78 rad(Si)/s			
Total Samples: 37			
Exposure Levels			
3 krad(Si)	10 krad(Si)	20 krad(Si)	30 krad(Si)
Biased	Biased	Biased	Biased
001, 002, 003, 004, 005	006, 007, 008, 009, 010	011, 012, 013, 014, 015, 016, 017, 018, 019, 020, 021, 022, 023, 024, 025, 026, 027, 028, 029, 030, 031, 032	033, 034, 035, 036, 037

3 Tested Parameters

Table 3-1 links the test numbers for each test condition with the data sheet parameters.

Table 3-1. INA240-SEP Data Sheet Parameters with Test Numbers

PARAMETER	TEST CONDITION	Data sheet Lit# SLVSER5 - November 2018				Test Number	Test Name
		MIN	TYP	MAX	UNIT		
Common-mode rejection ratio	VIN+ = -4 V to 80 V, VSENSE = 0 mV	120	132		dB	1071.3	CMRR test VCM_-4V_-_80V
Offset voltage, input-referred	VSENSE = 0 mV		±5	±25	µV	1081.1	VOS_chopped_test_5.0_2.50_12.00
Power-supply rejection ratio	VS = 2.7 V to 5.5 V, VSENSE = 0 mV		±1	±10	µV/V	1061.3	PSRR_test
Gain error	GND + 50 mV ≤ VOUT ≤ VS - 200 mV		±0.05%	±0.20%		1101.6	GAIN_Error_5.0_2.50_12.00_0.050
Reference divider accuracy	VOUT = (VREF1 - VREF2) / 2 at VSENSE = 0 mV		0.02%	0.1%		1131.6	Accuracy_5.00_5.00_12.00_VOS
Swing to VS power-supply rail	RL = 10 kΩ to GND		VS - 0.05	VS - 0.2	V	1121.1	Swing_test_5.0_2.50_12.00_1.00_10K_V CC-OUT
Swing to GND	RL = 10 kΩ to GND, VSENSE = 0 mV VREF1 = VREF2 = 0 V		VGND + 1	VGND + 10	mV	1121.3	Swing_test_5.0_2.50_12.00_-1.00_10K_O UT-VEE
Quiescent current	VSENSE = 0 mV		1.8	2.4	mA	611.1	IQ_5.0_2.50_12.00_Post_Trim

4 Total Ionizing Dose (RHA) Characterization Test Results

The parametric data for the INA240-SEP is within data sheet limits up to 30 krad(Si) for biased setup conditions.

4.1 Offset Voltage

Offset voltage showed little variation at 30 krad(Si) but is still within data sheet limits. The graphs below show the minimum, average, and maximum data post irradiation for each dose level.

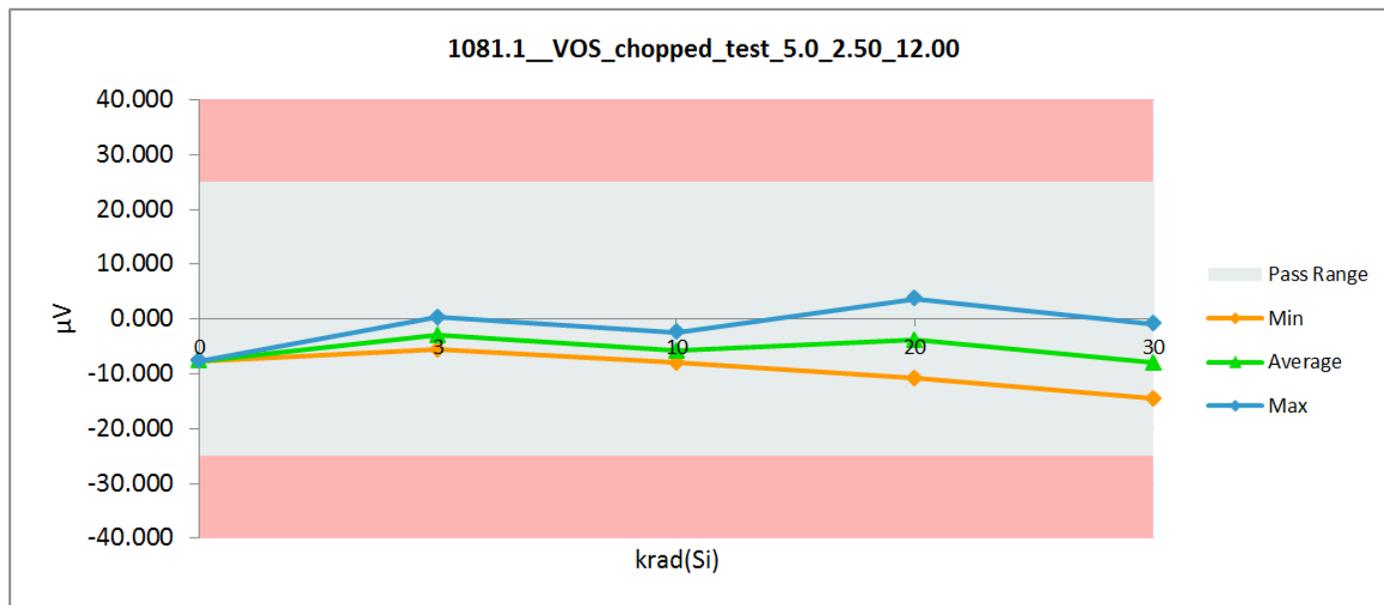


Figure 4-1. Radiation Exposure Effect on Offset Voltage

4.2 Gain Error

Gain Error showed little variation at 30 krad(Si) but is still within data sheet limits. The graphs below show the minimum, average, and maximum data post irradiation for each dose level.

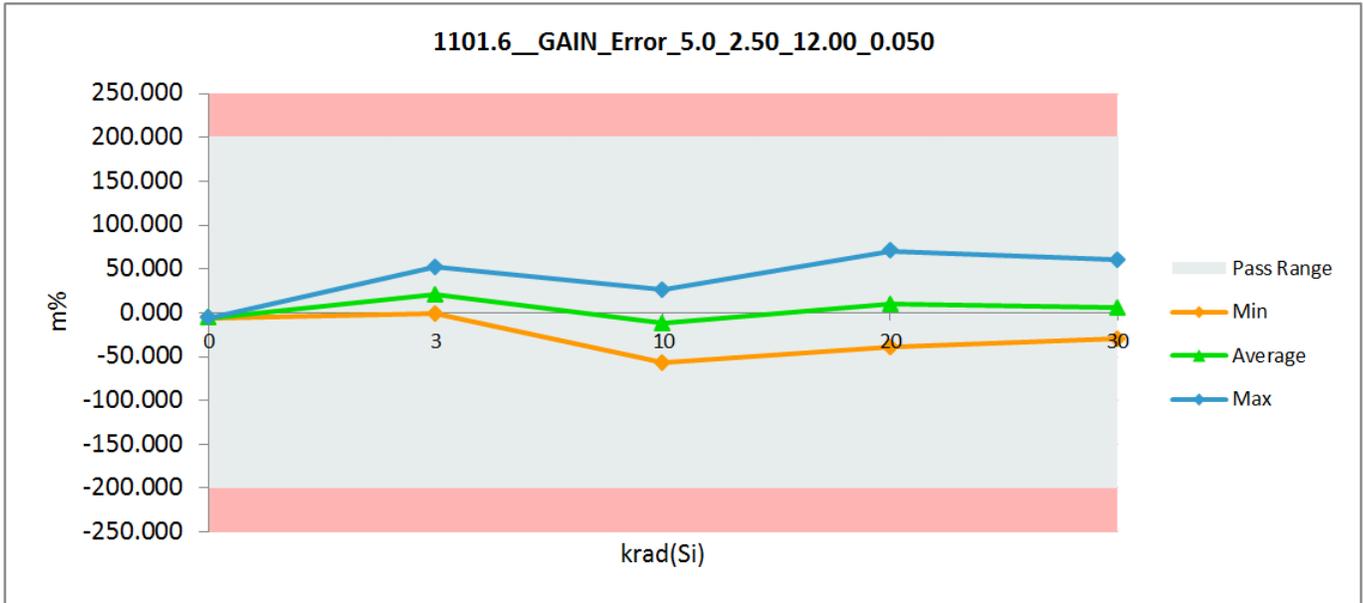


Figure 4-2. Radiation Exposure Effect on Gain Error

A Total Ionizing Dose HDR Report

This appendix provides the INA240-SEP TID HDR report. The report shows the variation for each parameter up to 30 krad(Si).

B Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision * (February 2019) to Revision A (August 2021)	Page
• Updated the numbering format for tables, figures, and cross-references throughout the document.....	2
• Updated the <i>Total Ionizing DOS (RHA) Characterization Test Results</i> sections.....	4

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