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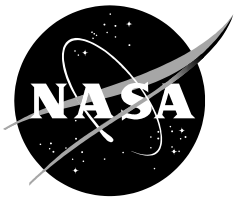

Single-Event Effects Test Report Analog Devices MAX881R Low-Noise Bias Supply

Thomas A. Carstens

Anthony M. Phan

August 2024

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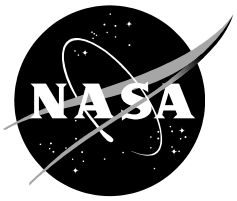

Single-Event Effects Test Report Analog Devices MAX881R Low-Noise Bias Supply

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Science Systems and Applications, Inc., Lanham MD

Test Date: 8/28/2024
Report Date: 9/23/2024

National Aeronautics and
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Goddard Space Flight Center
Greenbelt, MD 20771

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1. Introduction and Purpose

The purpose of this test is to characterize the single-event effects (SEE) and susceptibility of Analog Devices' MAX881R low-noise inverting power supply. These parts were irradiated with the 16 MeV/amu heavy ion cocktail at the Berkeley Accelerator Space Effects (BASE) Facility at the Lawrence Berkeley National Laboratory (LBNL). The test date was August 28-29, 2024.

2. Test Result Summary

The MAX881R did not experience any destructive single-event effects during heavy ion irradiation up to a LET of 52.8 MeVcm^2/mg (Xe) done at normal incident. During the irradiation, the input voltage was set to 5.5V and the temperature of the DUT was set to 125°C. Each run used a fluence of 1x10^7/cm^2.

3. Device Description

The MAX881R is an inverting power supply designed for biasing GaAs FET power amplifiers. Eight devices were prepared for testing by de-lidding the ceramic package. The device is provided in a 10 µMAX package.

Table I. Part Description

REAG ID	24-014
Part Number	MAX881R
Manufacturer	Analog Devices, Inc.
Lot Date Code	N/A
Quantity Tested	8, plus 2 controls
Part Function	Inverting Power Supply
Part Technology	CMOS
Package	10 µMAX

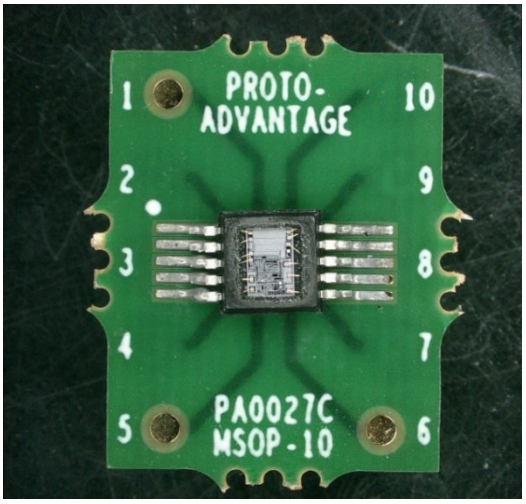

Figure 1. De-lidded Die

4. Test Setup

The test setup requires only power supplies and data logging equipment (see section 9). The power supplies were in the irradiation cave, while the data logging equipment was in the control room. Each test board had a single device under test, with new samples switched by hand.

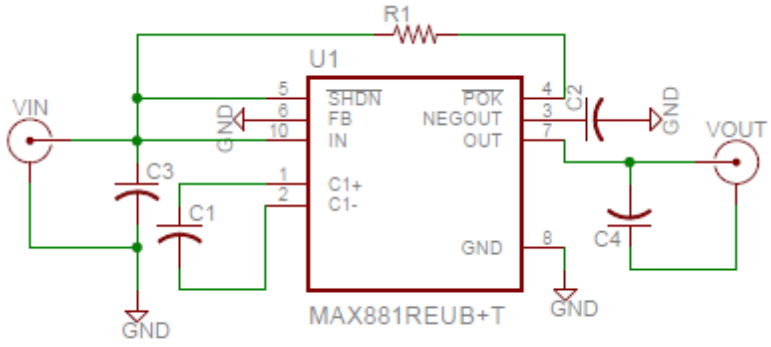

Figure 2. Circuit Diagram

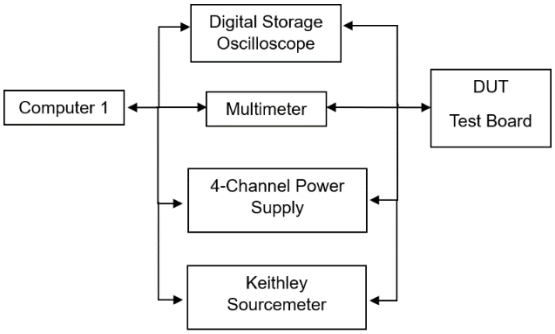

Figure 3. Block Diagram

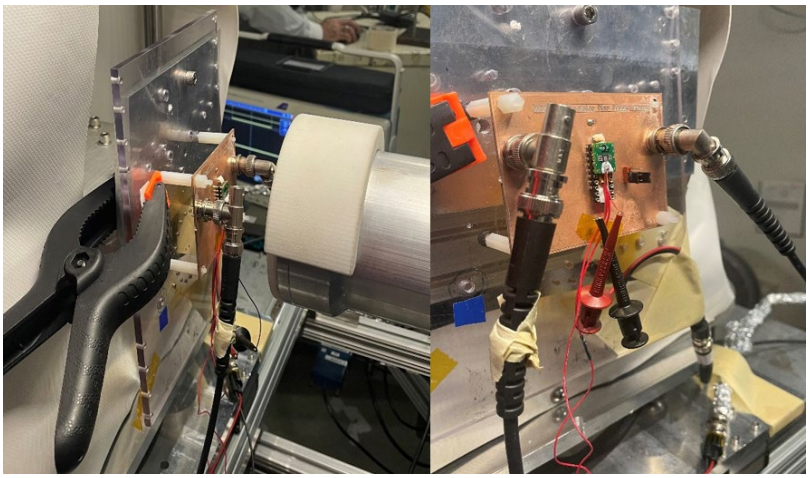

Figure 4. Part in Beam Line

5. Test Facility

SEE testing was done by exposing a decapsulated die to heavy ions to see the radiation response over varied Linear Energy Transfer (LET). This was done by utilizing different species of ions, one at a time to capture the cross section of that device at each LET to characterize the device.

Facility:	Lawerence Berkeley National Laboratory (LBNL) Berkeley Accelerator Space Effects (BASE) Facility 88" Cyclotron
Type of Radiation:	Heavy ions
Facility Configuration:	16 MeV/amu tune
Flux:	$1x10^3$ to $1x10^5$ particles/cm^2/s.
Fluence:	All tests will be run to a fluence of $1x10^7$ ions/cm^2 or until a latch up event was observed
Ion Species:	Shows the surface-incident beam properties.

Table II: Notional Energy, Range, and LET* Estimates for Accelerated Ions at 16 MeV/amu**

Ion	Tilt Angle (°)	Air Gap (cm)	Energy (MeV)	Range (µm)	Nominal Incident LET (MeV-cm2/mg)
^{23}V	0	6	607	114.5	13.2
^{29}Cu	0	6	692	115.9	20.3
^{36}Kr	0	6	879	109.5	30.6
^{47}Ag	0	6	987	85.6	49.0
^{54}Xe	0	4	1416	111.7	52.8

* LET: Linear Energy Transfer (MeV/mg/cm^2)

** LET calculated using Seuss assuming 2 mils of mylar and stated air gap in Table II

The air gap was changed to ensure that the Xe ions had sufficient range.

6. Test Conditions

Temperature: 80°C and 125°C

In-Air or Vacuum: In-air

Supply Voltages: 5.5V

7. Test Methods and Procedures

Personnel present at the test were Anthony Phan (Science Systems and Application Inc) Lead Test Engineer, and Tom Carstens (NASA/GSFC), Principal Investigator.

The DUT was heated to 80°C or 125°C (worst-case temperature) with a strip heater and monitored with a thermistor. A test was stopped if an SEL is seen or if the effective fluence reached $1x10^7$ ions/cm^2. If latch up was seen, the test would be repeated three to seven times with the same DUT with a smaller flux to more accurately determine the fluence. The testing started with Vanadium (lowest LET particle) and continued to Xenon (highest LET particle). The ions required are listed in Table II.

The supply current limit was set to 1mA. The scope captured events greater than the nominal current supply. When a latch up occurred, the beam was turned off and the runtime and fluence were recorded.

8. Test Results

The MAX881R was irradiated with multiple ions and one tune, 16 MeV/amu. Xe was the highest LET particle used with a corresponding nominal LET of 52.8 MeVcm^2/mg. All irradiations occurred at normal incidence. The device temperature was approximately 125°C. The device was irradiated with an input voltage of 5.5V. The worst-case testing conditions and results are listed below:

Table III: Selected Test Conditions and Results

DUT ID#	Input Voltage (V)	Temperature (°C)	LET (MeVcm^2/mg)	Fluence (/cm^2)	Result
2	5.5	125	52.8	1E7	No destructive events
4	5.5	125	52.8	1E7	No destructive events
5	5.5	125	52.8	1E7	No destructive events
6	5.5	125	52.8	1E7	No destructive events
7	5.5	125	52.8	1E7	No destructive events
8	5.5	125	52.8	1E7	No destructive events

No testing ever caused a destructive failure. All parts tested survived at least $1x10^7$/cm^2 fluence with a LET of 52.8 MeVcm^2/mg at normal incidence, with an input voltage of 5.5V, and at an elevated temperature of 125°C.

9. Equipment List

Table IIV. Equipment List

Manufacturer and P/N	Function	S/N or ECN
Tektronix DPO 5204B	Digital Phosphor Oscilloscope	5070157
Agilent N6072A	4 channel Power Supply	
Keithley 2425	100W Sourcemeter	
HP 34401A	Multimeter	
Dell Precision	Laptop computer	2332208
Molex 2152793607	NTC EPOXY - 4035 100MM 10K 1%	
USB, BNC, and GPIB cable		

10. References

[1] Analog Devices, “Low-Noise Bias Supply in µMAX with Power-OK for GaAsFET PA”, MAX881R datasheet, January 2004.

11. Appendix

Test Facility:	LBNL		1ma cut off																	
Test Date:	8/29/2024																			
Device:	MAX881R																			
Device ID:	24-014																			
Test Personnel:	Tom Carstens and Anthony Phan																			
RUN INFO						**BEAM DIAGNOSTICS:**												**Irradiation Results**		
Run	**DUT**	**Time**	**Temperature**	**Air or Vacuum**	**Input Voltage**	**Ion**	**Energy [MeV/u]**	**Energy [MeV]**	**Angle (Degrees)**	**air gap (cm)**	**Range (um)**	**LET [MeV-cm²/mg]**	**Eff. Fluence [/cm²]**	**Cum Fluence [/cm²]**	**run time (sec)**	**Flux [/(cm²-s)]**	**Dose [rad(Si)]**	**Cum. Dose (rad(Si))**	**# Acquisitins**	**Cross Section (cm-2)**	**Notes**
1,55	**1**	18:21	80	**Air**	**5.5**	V	16.0	607	0	6	144.5	13.2	1.00E+07	1.00E+07	1.64E+03	6094.43943	2.11E+03	2.112E+03			no events, next run increase flux
2	**1**	18:57	80	**Air**	**5.5**	Cu	16.0	692	0	6	115.9	20.3	1.00E+07	2.00E+07	3.48E+02	28773.6663	3.25E+03	5.360E+03			no events (no latch ups)
3	**1**	19:08	80	**Air**	**5.5**	Kr	16.0	879	0	6	109.5	30.6	1.00E+07	3.00E+07	8.23E+02	12154.3604	4.90E+03	1.026E+04			no events (no latch ups)
4	**1**		80	**Air**	**5.5**	Ag	16.0	987	0	6	85.6	49.0	1.00E+07	4.00E+07	5.51E+02	18164.3144	7.84E+03	1.810E+04			no events (no latch ups)
5	**1**		80	**Air**	**5.5**	Xe	16.0	1416	0	4	111.7	52.8	1.00E+07	5.00E+07	6.44E+02	15526.2627	8.45E+03	2.654E+04			no events (no latch ups)
6	**2**	20:55	85	**air**	**5.5**	Xe	16.0	1416	0	4	111.7	52.8	1.00E+07		6.58E+02	1.52E+04	8.45E+03				increased to 90 during test, no events
7	**2**	21:07	85-90	**air**	**6**	Xe	16.0	1416	0	4	111.7	52.8	1.00E+07		6.60E+02	1.51E+04	8.45E+03				no events (no latch ups)
8	**2**	21:41	109	**air**	**5.5**	Xe	16.0	1416	0	4	111.7	52.8	1.00E+07		6.56E+02	1.52E+04	8.45E+03				no evetns (no latch ups)
9	**2**	21:54	125	**air**	**5.5**	Xe	16.0	1416	0	4	111.7	52.8	1.00E+07		6.69E+02	1.50E+04	8.45E+03				no events (no latch ups)
10	**4**	22:41	125	**air**	**5.5**	Xe	16.0	1416	0	4	111.7	52.8	1.00E+07		6.51E+02	1.54E+04	8.45E+03				no events (no latch ups)
11	**5**	23:06	125	**air**	**5.5**	Xe	16.0	1416	0	4	111.7	52.8	1.00E+07		6.85E+02	1.46E+04	8.45E+03				no events (no latch ups)
12	**6**	23:29	125	**air**	**5.5**	Xe	16.0	1416	0	4	111.7	52.8	1.00E+07		6.82E+02	1.47E+04	8.45E+03				no events (no latch ups)
13	**7**	23:59	125	**air**	**5.5**	Xe	16.0	1416	0	4	111.7	52.8				#DIV/0!	0.00E+00				flux dropped, called control room to fix
14	**7**	0:12	125	**air**	**5.5**	Xe	16.0	1416	0	4	111.7	52.8	1.00E+07		4.89E+02	2.05E+04	8.45E+03				no events (no latch ups)
15	**8**	0:29	125	**air**	**5.5**	Xe	16.0	1416	0	4	111.7	52.8	1.00E+07		4.88E+02	2.05E+04	8.45E+03				no events (no latch ups)
16	**8**		125	**air**	**5.5**	no beam															
17	**8**		125	**air**	**5.5**	no beam															
18	**8**	1:44	125	**air**	**5.5**	Xe	16.0	1416	0	4	111.7	52.8	1.00E+07		5.06E+02						no events (no latch ups)