

# Unisys

DATE: April 23, 1998 PPM-98-009  
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SUBJECT: Radiation Report on **OP27 (Analog Devices) (LDC 9721A)**  
PROJECT: GOES (ITT)

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A radiation evaluation was performed on **OP27 Low Noise, Precision Operational Amplifier (Analog Devices)** to determine the total dose tolerance of these parts. The total dose testing was performed using a  $\text{Co}^{60}$  gamma ray source. During the radiation testing, eight parts were irradiated under bias (see Figure 1 for bias configuration) and three parts were used as control samples. The total dose radiation levels were 20.0, 40.0, 60.0, 80.0, 100.0, 150.0, and 200.0 kRads.<sup>1</sup> The dose rate was 1.200 kRads/hour (0.333 Rads/s). See Table II for the radiation schedule and effective dose rate calculation. After the 200.0 kRad irradiation, the parts were annealed under bias at  $25^{\circ}\text{C}$ <sup>2</sup> and tested at 4, 24 and 168 hours. After each radiation exposure and annealing treatment, parts were electrically tested according to the test conditions and the specification limits<sup>3</sup> listed in Table III. An executive summary of the test results is provided below in bold; followed by a detailed summary of the test results at each radiation level and annealing step. For detailed information, refer to Tables I through IV and Figures 1 through 3.

**Four of the eight irradiated parts showed some degradation from the specification limit for VOS with radiation exposures from 20 to 200kRads and all parts showed some degradation from the specification limits for P\_IIB and N\_IIB with radiation exposures from 40 to 200kRads. Figures 2 and 3 show the degradation in the radiation sensitive parameters at increasing radiation levels. All parts passed all other tests. After annealing the parts at  $25^{\circ}\text{C}$  for 4, 24 and 168 hours, no significant recovery was observed in VOS; however, Ibias showed significant recovery. A detailed summary of the test results is provided below.**

Initial electrical measurements were made on 11 samples. Eight samples (SN's 1399, 1400, 1402, 1403, 1404, 1421, 1422, and 1423) were used as radiation samples while SN's 1393 and 1398 were used as control samples. All parts passed all tests during initial electrical measurements.

After the 20.0 kRad irradiation, three parts marginally exceeded the specification limit of  $25\mu\text{V}$  for VOS with readings in the range of 27 to  $33\mu\text{V}$ . **All parts passed all other tests.**

After the 40.0 kRad irradiation, three parts marginally exceeded the specification limit for VOS with readings in the range of 27 to  $57\mu\text{V}$ . Seven parts exceeded the specification limit of 40nA for both P\_IIB and N\_IIB with readings in the range of 51 to 88nA for both. **All parts passed all other tests.**

After the 60.0 kRad irradiation, four parts marginally exceeded the specification limit for VOS with readings in the range of 27 to  $50\mu\text{V}$ . Seven parts exceeded the specification limit for both P\_IIB and N\_IIB with readings in the range of 130 to 180nA for both. **All parts passed all other tests.**

After the 80.0 kRad irradiation, four parts marginally exceeded the specification limit for VOS with readings in the range of 26 to  $96\mu\text{V}$ . Due to an error in the automatic test equipment, there were only four IIB measurements at this level. All four exceeded the specification limit for P\_IIB with readings in the range of 176 to  $207\mu\text{V}$ . **All parts passed all other tests.**

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<sup>1</sup> The term Rads, as used in this document, means Rads (silicon). All radiation levels cited are cumulative.

<sup>2</sup> The temperature  $25^{\circ}\text{C}$  as used in this document implies room temperature.

<sup>3</sup> These are manufacturer's pre-irradiation data specification limits. The manufacturer provided no post-irradiation limits at the time these tests were performed.

After annealing the parts for 72 hours at 25°C, parts showed no significant recovery. Four parts marginally exceeded the specification limit for VOS with readings in the range of 26 to 51µV. All parts exceeded the specification limit for both P\_IIB and N\_IIB with readings in the range of 59 to 136nA for both. **All parts passed all other tests.**

After the 100.0, 150.0 and 200.0 kRad irradiations, four parts marginally exceeded the specification limit for VOS with readings in the range of 25 to 57µV. All parts exceeded the specification limit for both P\_IIB and N\_IIB with readings in the range of 117 to 217nA for both. **All parts passed all other tests.**

After annealing the parts for 4 hours and 24 hours at 25°C, parts showed no significant recovery in any parameter.

After annealing the parts for 168 hours at 25°C, parts showed some recovery in P\_IIB and N\_IIB with readings in the range of 53 to 95nA for both.

Table IV provides a summary of the test results with the mean and standard deviation values for each parameter after each irradiation exposure and annealing step.

Any further details about this evaluation can be obtained upon request. If you have any questions, please call us at (301) 731-8954.

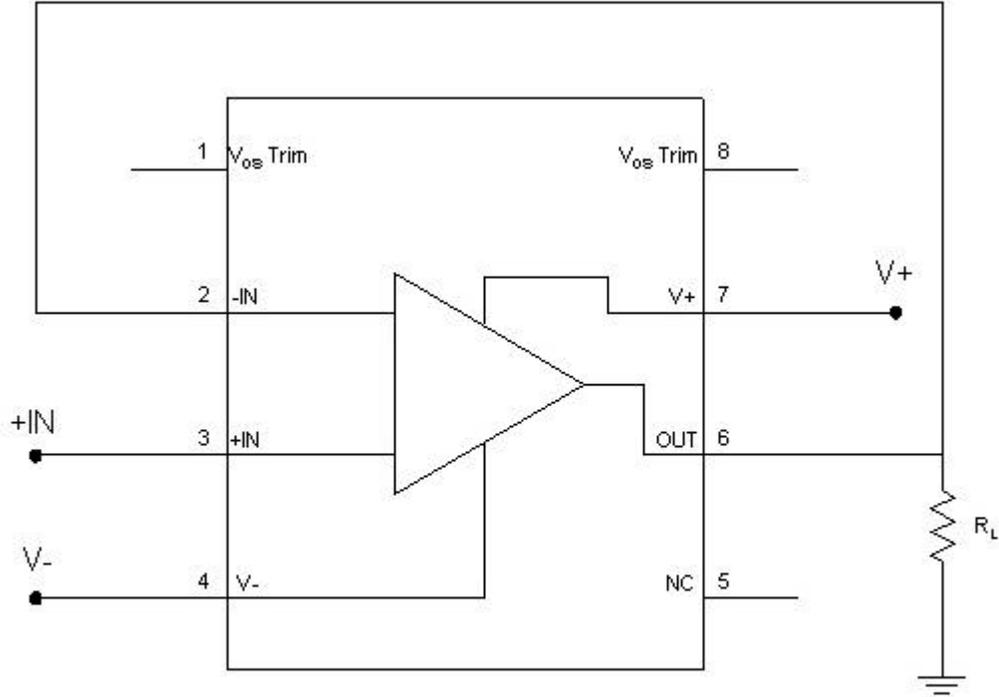
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Figure 1. Radiation Bias Circuit for OP27



Notes:

1.  $R_L = 402\Omega \pm 5\%$ ,  $\frac{1}{2}W$ .
2.  $+IN = 3.0V$ ,  $V+ = +18V$ ,  $V- = -18V$ .

TABLE I. Part Information

Generic Part Number:	OP27
GOES ITT Part Number	OP27
Charge Number:	C80709
Manufacturer:	Analog Devices
Lot Date Code (LDC):	9721A
Quantity Tested:	11
Serial Number of Control Samples:	1393, 1398
Serial Numbers of Radiation Samples:	1399, 1400, 1402, 1403, 1404, 1421, 1422, and 1423
Part Function:	Operational Amplifier
Part Technology:	Bipolar
Package Style:	8-Pin DIP
Test Equipment:	A540
Test Engineer:	S. Archer-Davies

- The manufacturer for this part guaranteed no radiation tolerance/hardness.

TABLE II. Radiation Schedule for OP27

EVENT .....	DATE
1) INITIAL ELECTRICAL MEASUREMENTS.....	03/23/98
2) 20.0 KRAD IRRADIATION (1.200 KRADS/HOUR) .....	03/23/98
POST-20.0 KRAD ELECTRICAL MEASUREMENT .....	03/24/98
3) 40.0 KRAD IRRADIATION (1.200 KRADS/HOUR) .....	03/24/98
POST-40.0 KRAD ELECTRICAL MEASUREMENT .....	03/25/98
4) 60.0 KRAD IRRADIATION (1.200 KRADS/HOUR) .....	03/25/98
POST-60.0 KRAD ELECTRICAL MEASUREMENT .....	03/26/98
5) 80.0 KRAD IRRADIATION (1.200 KRADS/HOUR) .....	03/26/98
POST-80.0 KRAD ELECTRICAL MEASUREMENT .....	03/27/98
6) 72 HOUR ANNEALING @25°C * .....	03/27/98
POST-72 HOUR ANNEAL ELECTRICAL MEASUREMENT .....	03/30/98
7) 100.0 KRAD IRRADIATION (1.200 KRADS/HOUR) .....	03/30/98
POST-100.0 KRAD ELECTRICAL MEASUREMENT .....	03/31/98
8) 150.0 KRAD IRRADIATION (1.200 KRADS/HOUR) .....	04/31/98
POST-150.0 KRAD ELECTRICAL MEASUREMENT .....	04/02/98
9) 200.0 KRAD IRRADIATION (0.450 KRADS/HOUR) ** .....	04/02/98
POST-200.0 KRAD ELECTRICAL MEASUREMENT .....	04/06/98
10) 4 HOUR ANNEALING @25°C .....	04/06/98
POST-4 HOUR ANNEAL ELECTRICAL MEASUREMENT .....	04/06/98
11) 24 HOUR ANNEALING @25°C .....	04/06/98
POST-24 HOUR ANNEAL ELECTRICAL MEASUREMENT .....	04/07/98
12) 168 HOUR ANNEALING @25°C .....	04/07/98
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT .....	04/14/98

Effective Dose Rate = 200,000 RADS/14 DAYS=595.2 RADS/HOUR=0.165 RADS/SEC  
 The effective dose rate is lower than that of the individual radiation steps as it takes into account the interim-annealing step.

\* This 72 hour annealing step was added to maintain the prescribed dose rate due to the weekend.  
 \*\* The dose rate was adjusted to allow the parts to receive radiation dose over the weekend.

PARTS WERE IRRADIATED AND ANNEALED UNDER BIAS, SEE FIGURE 1.

Table III. Electrical Characteristics of OP27 /1

Test #	Parameter	Units	Test Conditions	Spec. min	Lim. max
1	+Icc	mA	+V <sub>S</sub> = 15V, V <sub>O</sub> = 0V	0.0	4.67
2	-Icc	mA	-V <sub>S</sub> = -15V, V <sub>O</sub> = 0V	-4.67	0.0
3	Power_Diss	mW	V <sub>CC</sub> = ±15V, V <sub>O</sub> = 0V		120
4	VOS	μV	+V <sub>S</sub> = 15V, -V <sub>S</sub> = -15V, warmed up	-25	25
5	P_IIB	nA	+V <sub>S</sub> = 15V, -V <sub>S</sub> = -15V	-40	40
6	N_IIB	nA	+V <sub>S</sub> = 15V, -V <sub>S</sub> = -15V	-40	40
7	IIOS	nA	+V <sub>S</sub> = 15V, -V <sub>S</sub> = -15V	-35	35
8	CMRR	dB	V <sub>CM</sub> = ±11V	114	
9	PSRR	dB	+V <sub>S</sub> = ±4V to ±18V	100	
10	P_VOUT_2k	V	R <sub>L</sub> = 2kΩ	10.0	
11	N_VOUT_2k	V	R <sub>L</sub> = 2kΩ		-10.0
12	P_VOUT_600	V	R <sub>L</sub> = 600Ω	10.0	
13	N_VOUT_600	V	R <sub>L</sub> = 600Ω		-10.0
14	P_AOL_2k	V/mV	R <sub>L</sub> = 2kΩ, V <sub>O</sub> = +10V	1000	
15	N_AOL_2k	V/mV	R <sub>L</sub> = 2kΩ, V <sub>O</sub> = -10V	1000	
16	P_AOL_600	V/mV	R <sub>L</sub> = 600Ω, V <sub>O</sub> = +10V	800	
17	N_AOL_600	V/mV	R <sub>L</sub> = 600Ω, V <sub>O</sub> = -10V	800	
18	Slew Rate	V/μs	C <sub>L</sub> = 100pF, R <sub>L</sub> = 2kΩ, V <sub>O</sub> = ±5V	1.70	

Notes:

1/ These are the manufacturer's non-irradiated data sheet specification limits. The manufacturer provided no post-irradiation limits at the time the tests were performed.

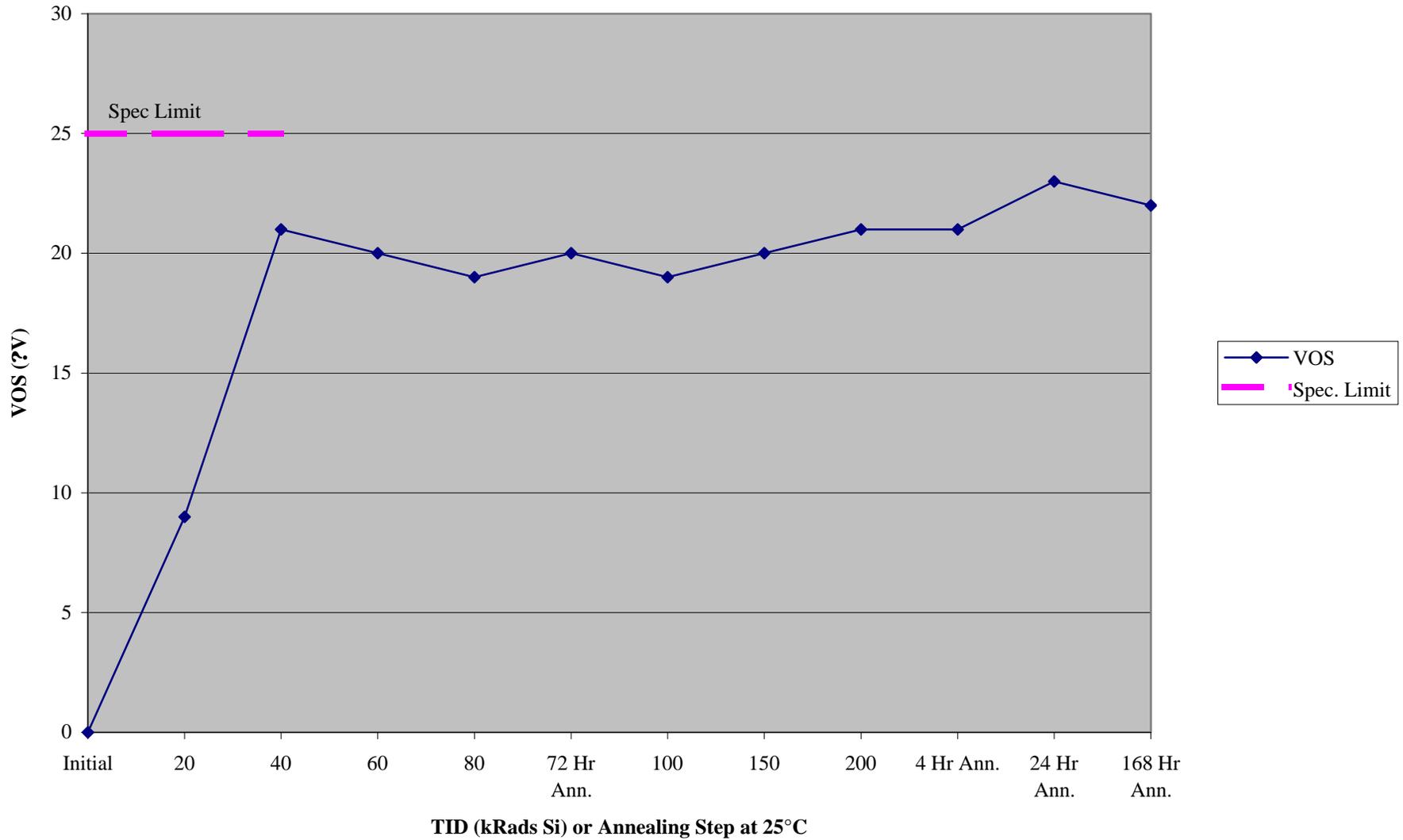
**TABLE IV: Summary of Electrical Measurements after Total Dose Exposures and Annealing for OP27 /1**

Test #	Parameters	Units	Spec. Lim. /2		Total Dose Exposure (kRads Si)										Annealing		Total Dose Exposure (kRads Si)						Annealing							
					Initial		20.0		40.0		60.0		80.0		72 hours @25°C		100.0		150.0		200.0		4 hours @25°C		24 hours @25°C		168 hours @25°C			
					mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
1	+Icc	mA	0.0	4.67	3.6	0.1	3.3	0.2	3.1	0.2	2.9	0.2	2.9	0.2	3.01	0.2	2.9	0.1	3.0	0.1	3.1	0.1	3.1	0.1	3.1	0.1	3.1	0.1	3.2	0.1
2	-Icc	mA	-4.67	0.0	-3.6	0.1	-3.3	0.2	-3.1	0.2	-2.9	0.2	-2.9	0.2	-3.1	0.2	-2.9	0.1	-3.0	0.1	-3.1	0.1	-3.1	0.1	-3.1	0.1	-3.1	0.1	-3.2	0.1
3	Power_Diss	mW		120	54	1.0	49	1.8	47	2.5	44	1.6	43	1.2	46	1.4	43	1.0	45	0.7	46	0.7	46	0.7	46	0.7	46	1.1	48	1.0
4	VOS	?V	-25	25	-1	17	9	15	21	18	20	17	19	16	20	17	19	16	20	17	21	17	21	17	21	17	23	17	22	17
5	P_IIB	nA	-40	40	4	2.4	10	2.8	63	23	139	42	193	13	111	23	203	18	190	24	136	21	146	18	137	18	73	13		
6	N_IIB	nA	-40	40	3	2.5	8	2.9	61	23	132	39			108	22	199	18	185	28	136	21	139	19	133	18	71	14		
7	IIOS	nA	-35	35	1	0.4	1	0.5	2	0.8	3	1.1			3	0.7	4	0.7	5	3.9	8	3.1	6	2.2	4	2.6	3	2.0		
8	CMRR	dB	114		135	15	135	14	133	8	132	8			132	9	134	9	133	8	132	9	132	9	133	9	133	9	133	11
9	PSRR	dB	100		138	7	138	10	139	10	137	10			138	11	136	8	138	12	137	7	137	7	143	15	137	6.4		
10	P_VOUT_2k	V	10.0		14.0	0	14.0	0	14.0	0	14.0	0			14.0	0	14.0	0	14.0	0	14.0	0	14.0	0	14.0	0	14.0	0	14.0	0
11	N_VOUT_2k	V		-10.0	-13.9	0	-13.9	0	-14.0	0	-14.0	0			-14.0	0	-14.0	0	-14.0	0	-14.0	0	-14.0	0	-14.0	0	-14.0	0	-14	0
12	P_VOUT_600	V	10.0		13.2	0	13.2	0	13.2	0	13.1	0.1			13.0	0.1	12.9	0.1	13.0	0.1	13.1	0.1	13.1	0.1	13.1	0.1	13.1	0.1	13.2	0.1
13	N_VOUT_600	V		-10.0	-13.3	0.1	-12.6	0.1	-12.4	0.1	-12.4	0.1			-12.4	0.1	-12.4	0.1	-12.3	0.1	-12.3	0.1	-12.3	0.1	-12.3	0.1	-12.3	0.1	-12.3	0.1
14	P_AOL_2k	V/mV	1000		3700	110	3120	130	2930	430	2540	160			2680	170	2500	110	2910	78	3190	150	3110	110	3180	100	3490	190		
15	N_AOL_2k	V/mV	1000		2600	230	2200	160	2640	1430	2010	180			2130	160	2040	100	2200	150	2390	230	2360	200	2280	170	2370	250		
16	P_AOL_600	V/mV	800		6250	280	4810	250	4240	710	3580	350			3790	300	3490	200	4260	234	4940	170	4770	230	4910	270	5900	510		
17	N_AOL_600	V/mV	800		1630	330	1400	240	1650	940	1280	240			1350	240	1197	202	1301	285	1397	333	1413	331	1334	311	1513	317		
18	Slew Rate	V/?s	1.70		4.89	0.24	4.24	0.26	4.10	0.06	4.05	0.09			4.01	0.04	3.98	0.04	4.00	0.03	3.90	0.07	3.90	0.05	4.05	0.04	4.07	0.8		

- Notes:
- 1/ The mean and standard deviation values were calculated over the eight parts irradiated in this testing. The control samples remained constant throughout testing and are not included in this table.
  - 2/ These are manufacturer's pre-irradiation data sheet specification limits. No post-irradiation limits were provided by the manufacturer at the time the tests were performed.
  - 3/ Due to an error in the automatic test equipment, no measurements were made past P\_IIB at 80kRads. The post annealing data shows no significant changes that might affect performance.

Radiation sensitive parameters:VOS, P\_IIB, N\_IIB .

**Figure 2: VOS vs TID for OP27**



**Figure 3: Ibias vs TID for OP27**

