Unisys

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TO: T. O'Connor/Ball Aerospace
FROM: K. Sahu/S. Kniffin/300.1
SUBJECT: Radiation Report on **ATR2815TF (Lambda Advanced Analog) (LDC 9907)**
PROJECT: Ball Aerospace (GOES)

cc: M. D'Ordine/Ball Aerospace, R. Reed/562, A. Sharma/562, OFA Library/300.1

A radiation evaluation was performed on **ATR2815TF Hybrid-High Reliability, High Power, Triple Output DC/DC Converter (Lambda Advanced Analog)** to determine the total dose tolerance of these parts. The total dose testing was performed using a Co^{60} gamma ray source. During the radiation testing, six parts were irradiated under bias (see Figure 1 for bias configuration) and one part was used as a control sample. The total dose radiation levels were 5.0, 10.0, 15.0, 20.0, and 25.0kRads.[1] The dose rate was 0.080 kRads/hour (0.022 Rads/s). See Table II for the radiation schedule and effective dose rate calculation. After the 15.0kRad irradiation, the parts were annealed under bias at 25°C for 72 hours. After the 20.0kRad irradiation, the parts were annealed under bias at 25°C for 96 hours. After the 25.0kRad irradiation, the parts were annealed under bias at 25°C for 72 and 168 hours and at 100°C for 48, 72, and 168 hours.[2] After each radiation exposure and annealing treatment, parts were electrically tested according to the test conditions and the specification limits[3] 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 after each radiation level and annealing step.

All parts passed all tests up to 10kRads. After the 15kRad irradiation, all parts failed Efficiency measurements made at full P_{OUT} = 10W. (The Efficiency measurements were not stable; ranging from a <1% to >100% due to oscillations in the parts.) After annealing the parts for 72 hours at 25°C, the measurements were made with reduced power conditions and no instabilities were noted, however the Efficiency under these conditions was about 40% compared to 80% under full power conditions. After the 20kRad irradiation, some parts began failing Line Regulation at 5V and 15V. The parts were annealed for 96 hours at 25°C and all parts passed all tests under the reduced power conditions.

After the 25kRad irradiation, some parts again showed Line Regulation Failures. The V_{IN} conditions were reduced and all parts passed all tests after 25kRads at the lower power and V_{IN} conditions. After annealing the parts for a total of 168 hours at 25°C, all parts passed all tests at the lower power and V_{IN} conditions. After annealing the parts for 168 hours at 100°C, no rebound effects were observed, however two parts were physically warped as a result of internal pressure. Some modest failures were noted in these two parts but should not be construed as rebound effects.

Initial electrical measurements were made on 7 samples. Six samples (SN's 103, 106, 113, 115, 110, and 118) were used as radiation samples while SN 126 was used as a control sample. All parts passed all tests during initial electrical measurements.

All parts passed all tests up to 10.0kRads.

After the 15.0kRad irradiation, one part failed the Efficiency measurement at P_{OUT} = 10W for V_{CC} = ±15V. All parts failed the Efficiency test for V_{CC} = ±5V. The reason for these Efficiency failures was found to be oscillations within the parts as observed on the oscilloscope. These oscillations made the Efficiency measurements unstable and

[1] The term Rads, as used in this document, means Rads (silicon). All radiation levels cited are cumulative.
[2] The temperature 25°C as used in this document implies room temperature.
[3] These are manufacturer's pre-irradiation data specification limits. The manufacturer provided no post-irradiation limits at the time these tests were performed.

unreproduceable under these power conditions. The parts were kept under annealing at room temperature for 72 hours while resolving the Efficiency measurement issue. **All parts passed all other tests.**

After annealing the parts for 72 hours at 25°C, the Efficiency measurements were made under reduced power conditions similar to the intended application mode. The Efficiency for V_{CC} = 5V was made at 4W while the Efficiency for V_{CC} = 15V was measured at P_{OUT} = 1.25W for +15V and 1.75W for –15V. Under these reduced power output conditions, no instabilities or oscillations were seen in the part. However the Efficiency under these conditions was 40% compared to 80% under the original power conditions. It should be noted that the control sample was measuring about the same as the radiation samples under the reduced power conditions. **This indicates that the application of this part at higher power output can cause problems at 15kRads and above. However, the application at the reduced power conditions of 4W at V_{CC} = 5V, 1.25W at V_{CC} = +15V and 1.75W at V_{CC} = -15V should cause no problems as long as it is noted that the Efficiency is about 40% and not 80% as specified at P_{OUT} = 10W in the manufacturer's data sheet.**

After the 20.0kRad irradiation, three parts failed Line Regulation at V_{CC} = 5V and one part failed Line Regulation at V_{CC} = 15V. The failing parts were reading about 4V with a specification limit of 25mV for V_{CC} = 5V and a reading of 14V with a specification limit of 75mV for V_{CC} = 15V. These readings indicate that the converter is not able to regulate under the V_{IN} conditions of 16V to 40V. See Table 3 for more details. **All parts passed all other tests at the same reduced power levels as at 15kRads.**

After annealing the parts for 96 hours at 25°C, all failing parts showed recovery in the Line Regulation tests and all parts passed all tests at the same reduced power levels as at 15kRads.

After the 25.0kRad irradiation, one part failed Line Regulation at V_{CC} = 5V and three parts failed Line Regulation at V_{CC} = 15V. **The Line Regulation measurement conditions were changed at this point to match with the application conditions of this part for the project.** The V_{IN} conditions were changed from 16V-40V to the new condition of 22V-37V. Under the new test condition, all parts passed Line Regulation tests at V_{CC} = 5V and ±15V. **This indicates that the application of this part at the V_{IN} conditions of 16V to 40V can cause problems at 20kRads and above. However, if the input conditions are limited to 22V to 37V, the parts should be able to operate satisfactorily up to 25kRads exposure. All parts passed all other tests at the same reduced power levels as at 15kRads.**

After annealing the parts for 72 and 168 hours at 25°C, all parts passed all tests at the reduced power levels and reduced V_{IN} conditions.

After annealing the parts for 96 hours at 100°C, no rebound effects were observed.

After annealing the parts for 168 hours at 100°C, two parts (SN113 and 118) showed physical deformation from internal pressures resulting in modest failures in input ripple and output ripple. No rebound effects were observed.

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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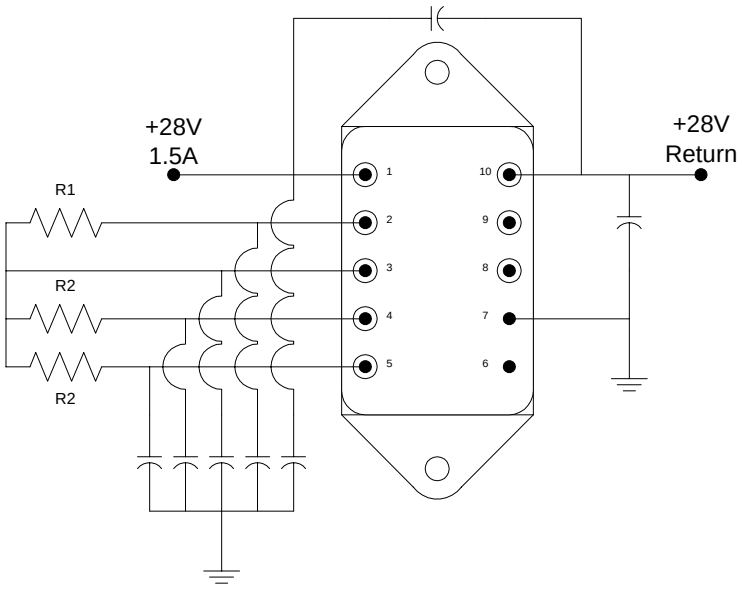
Figure 1. Radiation Bias Circuit for ATR2815TF



Pinout:
1. V_{IN}
2. +5V
3. Out COM
4. -15V
5. +15V
6. NC
7. Case
8. INH
9. SYNC IN
10. In COM

Notes:
1. $R_1 = 4.8\Omega \pm 5\%$, 10W.
2. $R_2 = 200\Omega \pm 5\%$, 2W.
3. C = 0.033µF, 10%, 100V.

TABLE I. Part Information

Generic Part Number:	ATR2815TF
GOES Part Number	ATR2815TF
Charge Number:	D-0326-0011-0000-002-0
Manufacturer:	Lambda Advanced Analog
Lot Date Code (LDC):	9907, 9745
Quantity Tested:	7
Serial Number of Control Samples:	126 (LDC9745)
Serial Numbers of Radiation Samples:	110, 118, 103, 106, 113, and 115 (LDC9907)
Part Function:	High Power Triple Output DC/DC Converter
Part Technology:	Hybrid
Package Style:	10-Pin Metal Hermetic
Test Equipment:	Bench Test
Test Engineer:	S. Norris

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

TABLE II. Radiation Schedule for ATR2815TF

EVENT	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	03/15/98
2) 5.0 KRAD IRRADIATION (0.294 KRADS/HOUR)	03/17/98
POST-5.0 KRAD ELECTRICAL MEASUREMENT	03/18/99
3) 10.0 KRAD IRRADIATION (0.294 KRADS/HOUR)	03/18/98
POST-10.0 KRAD ELECTRICAL MEASUREMENT	03/19/99
4) 15.0 KRAD IRRADIATION (0.121 KRADS/HOUR)	03/19/98
POST-15.0 KRAD ELECTRICAL MEASUREMENT	03/22/99
5) 72 HOUR ANNEALING @25°C	03/22/99
POST-72 HOUR ANNEAL ELECTRICAL MEASUREMENT	03/25/99
6) 20.0 KRAD IRRADIATION (0.294 KRADS/HOUR)	03/25/98
POST-20.0 KRAD ELECTRICAL MEASUREMENT	03/26/99
7) 96 HOUR ANNEALING @25°C	03/26/99
POST-96 HOUR ANNEAL ELECTRICAL MEASUREMENT	03/29/99
8) 25.0 KRAD IRRADIATION (0.294 KRADS/HOUR)	03/29/98
POST-25.0 KRAD ELECTRICAL MEASUREMENT	03/30/99
9) 96 HOUR ANNEALING @25°C	03/30/99
POST-96 HOUR ANNEAL ELECTRICAL MEASUREMENT	04/02/99
10) 168 HOUR ANNEALING @25°C	03/30/99
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	04/06/99
11) 48 HOUR ANNEALING @100°C	04/06/99
POST-48 HOUR ANNEAL ELECTRICAL MEASUREMENT	04/08/99
12) 72 HOUR ANNEALING @100°C	04/06/99
POST-72 HOUR ANNEAL ELECTRICAL MEASUREMENT	04/09/99
13) 168 HOUR ANNEALING @100°C	04/06/99
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	04/13/99

Effective Dose Rate = 25,000 RADS/13 DAYS=80.1 RADS/HOUR=0.022 RADS/SEC

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

Table III. Electrical Characteristics of ATR2815TF /1

Test #	Parameter	Units	Spec. min	Lim. max	Test Conditions
1	Vout, No Load	V	4.95	5.05	I_{OUT} = 0A
2	Vout, 10W	V	4.95	5.05	P_{OUT} = 10W *Replaced by 2A after 15kRads* See Note 2
2A	Vout, 4W	V	4.95	5.05	P_{OUT} = 4W
3	Efficiency_5V_10W	%	75		P_{OUT} = 10W *Replaced by 3A after 15kRads* See Note 2
3A	Efficiency_5V_4W	%			P_{OUT} = 4W
4	Input Rip.	mA p-p		50	P_{OUT} = 5W
5	Load Reg.	mV		25	P_{OUT} = 5W
6	Line Reg.	mV		25	V_{IN} = 16V to 40V, P_{OUT} = 5W *Replaced by 6A at 25kRads* See Note 3
6A	Line Reg. 22V-37V	mV		25	V_{IN} = 22V to 37V, P_{OUT} = 5W
7	Output Rip.	mA p-p		60	V_{IN} = 28V
1	+Vout, No Load	V	14.85	15.15	I_{OUT} = 0A
2	-Vout, No Load	V	-15.15	-14.85	I_{OUT} = 0A
3	+Vout, 10W	V	14.85	15.15	P_{OUT} = 10W *Replaced by 3A after 15kRads* See Note 2
4	-Vout, 10W	V	-15.15	-14.85	P_{OUT} = 10W *Replaced by 4A after 15kRads* See Note 2
3A	+Vout, 1.25W	V	14.85	15.15	P_{OUT} = 1.25W
4A	-Vout, 1.75W	V	-15.15	-14.85	P_{OUT} = 1.75W
5	+Input Rip.	mA p-p		50	P_{OUT} = 5W
6	-Input Rip.	mA p-p		50	P_{OUT} = 5W
7	Efficiency_15V	%	72		±15V, P_{OUT} = 10W *Replaced by 7A after 15kRads* See Note 2
7A	Efficiency_15V	%			+15V P_{OUT} = 1.25W, -15V P_{OUT} = 1.75W
8	Iin, No Load	mA		75	I_{OUT} = 0A, Pin 8 (inhibit) = open
9	+Load Reg.	mV		75	P_{OUT} = 5W
10	-Load Reg.	mV		75	P_{OUT} = 5W
11	+Line Reg.	mV		75	V_{IN} = 16V to 40V, P_{OUT} = 5W *Replaced by 11A at 25kRads* See Note 3
12	-Line Reg.	mV		75	V_{IN} = 16V to 40V, P_{OUT} = 5W *Replaced by 12A at 25kRads* See Note 3
11A	+Line Reg. 22V-37V	mV		75	V_{IN} = 22V to 37V, P_{OUT} = 5W
12A	-Line Reg. 22V-37V	mV		75	V_{IN} = 22V to 37V, P_{OUT} = 5W
13	+Output Rip.	mV p-p		40	V_{IN} = 28V
14	-Output Rip.	mV p-p		40	V_{IN} = 28V
15	Isolation	MΩ	100		Input to output or any pin to case

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.
2/ Due to oscillations in the parts at full P_{OUT} = 10W, the Ball Aerospace Radiation Engineer requested that we reduce the power requirements for Vout and Efficiency to 4W which is similar to the intended application mode.
3/ Due to failures in Line Regulation, the Ball Aerospace Radiation Engineer requested that we reduce the V_{IN} conditions from 16V - 40V to 22V - 37V for Line Regulation, which is similar to the intended application mode.

TABLE IVa: Summary of Electrical Measurements after Total Dose Exposures and Annealing for ATR2815TF /1
Vcc = 5V

					Total Dose Exposure (kRads Si)								Annealing		TID (kRads Si)		Annealing		TID (kRads Si)		Annealing				Annealing			
					Initial		5.0		10.0		15.0		72 hours		20.0		96 hours		25.0		72 hours		168 hours		96 hours		168 hours	
Test			Spec. Lim. /2										@25°C		3/		@25°C				@25°C		@25°C		@100°C		@100°C	
#	Parameters	Units	min	max	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	Vout, No Load	V	4.95	5.05	5.02	0.01	5.02	0.01	5.03	0.01	5.03	0.01	5.04	0.01	5.04	0.01	5.04	0.01	5.04	0.01	5.04	0.01	5.04	0.01	5.04	0.02	5.03	0.02
2	Vout, 10W	V	4.95	5.05	5.01	0.01	5.02	0.01	5.02	0.01	5.02	0.01	5.02	0.01	5.03	0.01	4/											
2A	Vout, 4W	V	4.95	5.05									5.03	0.01	5.03	0.02	5.03	0.01	5.03	0.01	5.03	0.01	5.04	0.02	5.03	0.01	5.03	0.02
3	Efficiency_5V_10W	%	75		82	0.9	82	0.5	82	0.5	4/																	
3A	Efficiency_5V_4W	%											40	0.1	40	0.2	40	0.3	40	0.2	40	0.2	40	0.3	40	0.3	40	0.2
4	Input Rip.	mA p-p		50	3	0	3	0	3	0	3	0	3	0	3	0	13	5.7	13	5.7	13	5.8	13	5.8	12	5.9	5	4.3
5	Load Reg.	mV		25	11	0.1	12	0.1	12	0.4	12	0.5	12	0.5	12	0.5	6	0.7	6	0.5	6	0.5	6	0.8	6	0.5	8	3.9
6	Line Reg.	mV		25	2	0	2	0	2	0	2	0	2	0	3P/3F		2	0	5P/1F		5/							
6A	Line Reg. 22V-34V	mV		25															1	0	1	0	1	0	1	0	4	5.8
7	Output Rip.	mV p-p		60	0.4	0	0.4	0	0.4	0	0.4	0	0.4	0	0.4	0	0.4	0	0.4	0	0.4	0	0.4	0	0.4	0	146	209

Notes:

1/

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/ nPmF implies that n parts passed this test and m parts failed this test at this level.

4/ Due to oscillations in the parts at full Pout = 10W following the 15kRad irradiation, the Ball Aerospace Radiation Engineer requested that we reduce the power requirements for Vout and Efficiency to 4W which is similar to the intendec

5/ Due to failures in Line Regulation following the 20 and 25kRad irradiaitons, the Ball Aerospace Radiation Engineer requested that we reduce the Vin conditions from 16V-40V to 22V-37V for Line Regulation, which is similar to the int

Radiation sensitive parameters: Vout, Efficiency, Line Reg.