Total Ionizing Dose Test Report for the AD9364 RF Transceiver

Dakai Chen, Tim Mondy

NASA Goddard Space Flight Center, Greenbelt, MD 20771

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I. Introduction

The purpose of this test is to determine the total-ionizing dose (TID) susceptibility of the AD9364 from Analog Devices.

II. Device Under Test

The AD9364 is a high performance, highly integrated radio frequency (RF) Agile Transceiver designed for use in 3G and 4G base station applications. The device combines an RF front end with a flexible mixed-signal baseband section and integrated frequency synthesizers, simplifying design-in by providing a configurable digital interface to a processor. The AD9364 operates in the 70 MHz to 6.0 GHz range, covering most licensed and unlicensed bands. Channel bandwidths from less than 200 kHz to 56 MHz are supported. The device is built on a commercial 65 nm complementary metal oxide semiconductor (CMOS) process. Figure 1 shows a functional block diagram of the device. Table I shows the basic part and test details. Detailed device parameters and functional descriptions can be found in the datasheet [1].

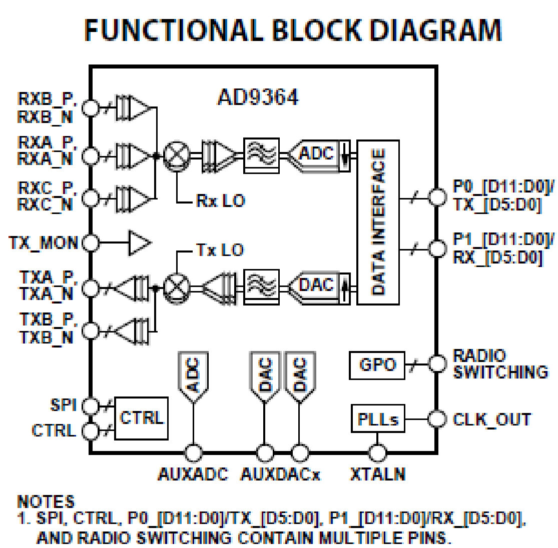

Figure 1. Schematic block diagram.

Table I
Part and test information.

Generic Part Number:	AD9364
Full Part Number	AD9364BBCZ
Manufacturer:	Analog Devices
Lot Date Code (LDC):	1401
Quantity Tested:	4
Serial Numbers of Control Sample:	CNTRL
Serial Numbers of Radiation Samples:	1, 2, 3, 4
Part Function:	RF transceiver
Part Technology:	65 nm CMOS
Case Markings:	AD9364BBCZ #1401 2785560.1 SINGAPORE
Package Style:	144-Ball chip scale package ball grid array (CSP_BGA)
Test Equipment:	AD-FMCOMMS4-EBZ evaluation platform, ZedBoard, PC
Cumulative Dose Levels:	2, 5, 10, 15, 20, 30, and 50 krad(Si)
Target Dose Rate:	100 rad(Si)/sec

III. Test Method

A. Irradiation Procedure

The irradiation procedures and dosimetry requirements conformed to MIL-STD-883-H Test Method 1019.8 [2]. The irradiation was carried out in a room air source gamma ray facility. Active dosimetry was performed using air ionization probes. The device under test (DUT) was placed inside a standard Pb/Al filter box. Four parts were irradiated while transmitting and receiving a random data pattern.

B. Test Setup

The DUTs were configured as a part of the AD-FMCOMMS4-EBZ evaluation platform, which constitutes the RF front end of a software defined radio (SDR). The AD-FMCOMMS4-EBZ is a high-speed 1 x 1 agile RF transceiver analog FPGA Mezzanine Card (FMC), software-tunable over the 56 MHz to 6 GHz band. The SDR system is a set of user tools running under a Linux operating system which allows the user to generate and receive RF waveforms. It is designed to operate with a FPGA evaluation board that supports the FMC interface and has the necessary fabric to support the Hardware Descriptive Language (HDL) requirement the SDR system and SD Card reader. The SDR system was provided by Analog Devices and loaded into the FPGA board using a specially configured SD-Card.

For this test, we used the ZedBoard to interface with the AD-FMCOMMS4-EBZ evaluation platform. The ZedBoard contains the Zynq-7020 System-on-Chip (SoC), 512 MB DDR3, 256 Mb Quad-SPI flash, and 4 GB SD memory card.

Figure 2 shows the top and bottom view of the evaluation board. The AD9364 is circled. As shown, there are several other active components mounted on the bottom of the board. We used lead bricks as shielding for these components Figure 3 shows a photograph of the test setup on the bench, with the evaluation cards mated with the ZedBoard. During irradiation, the entire ZedBoard was behind the lead brick shielding. We performed dosimetry at various locations behind the shielding, and determined that at a spot one inch away from the edge of the shielding, the total dose is negligible. However, approximately ½ inch away from the edge, the total dose was 1/5 of the total dose received by the DUT at the unshielded target. Therefore, the components on the evaluation card near the edge of the shielding accumulated approximately 5 - 10 krad(Si) during the exposure.

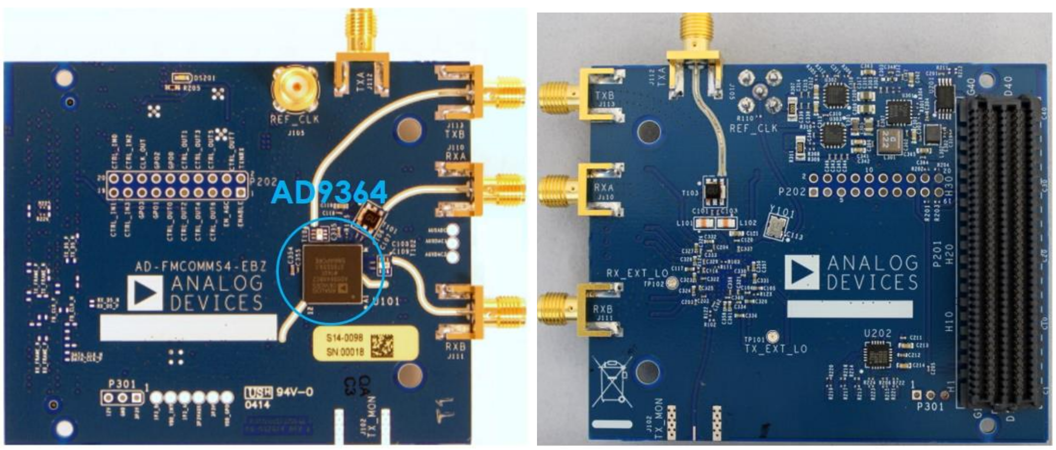

Figure 2. Top and bottom view of the AD-FMCOMMS4-EBZ evaluation board.

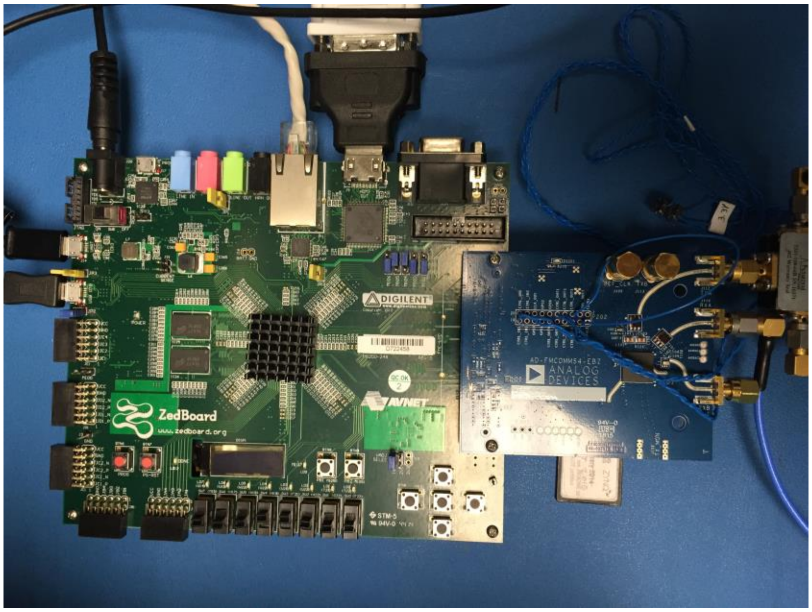

Figure 3. Photograph of the test setup.

C. Device characterization

Four parts were irradiated while transmitting and receiving data in the form of an image file. We used the evaluation kit software and a Matlab program to characterize the various electrical parameters. In addition, we evaluated the signal transfer performance using the image transmission test. The test conditions and the characterized parameters are shown below.

D. Test Conditions

Test Temperature:	Ambient temperature
Operating Frequency:	70 MHz to 6 GHz (internally driven)
Power Supply:	3.3 V
Parameters:	1) Main supply voltage 2) Main supply current 3) GPO supply voltage 4) GPO supply current 5) Interface supply voltage 6) Interface supply current 7) Output voltage 8) Frequency 9) Tx Output Power 10) Rx Output Power 11) Tx Gain 12) Rx Gain

IV. Results

The parts exhibited limited degradation in general. Most of the electrical parameters showed negligible change up to 50 krad(Si). The supply currents remained at their nominal levels throughout the test as shown by Tables II – V. The temperature remained stable at around 28°C to 32°C. The digital to analog converter outputs remained unchanged. However, the transmission power gain showed some degradation with increasing total dose. Figure 4 shows the gain generally decreasing with increasing total dose. The trend is visible even though there was some measurement variability.

The gain degradation manifested visually through the image transmission tests. Figures 5 and 6 show a pristine image and an image transmitted with a gain of 62 dB after 50 krad(Si), for DUT1 and DUT2, respectively. The transmitted image after 50 krad(Si) becomes pixelated due to the loss in power. Additionally, we examined the transmission capability at 50 dB, as illustrated in Figure 7. The image is less pixelated relative to that at 62 dB shown in Figure 6. The transmitted image is pristine again at 40 dB (not shown). This behavior is consistent with the idea that the pixilation and loss in image quality is the result of power gain degradation. Figures 8 and 9 show the pristine and transmitted images at 62 dB after 50 krad(Si) for DUT3 and DUT4, respectively.

DUT1 and DUT2 were annealed unpowered for approximately 1 week following irradiation. DUT3 and DUT4 were annealed under operating conditions for 1 week after irradiation. In general, the parts showed reduction in the number of errors from the image transmission test, given the variability in measurements.

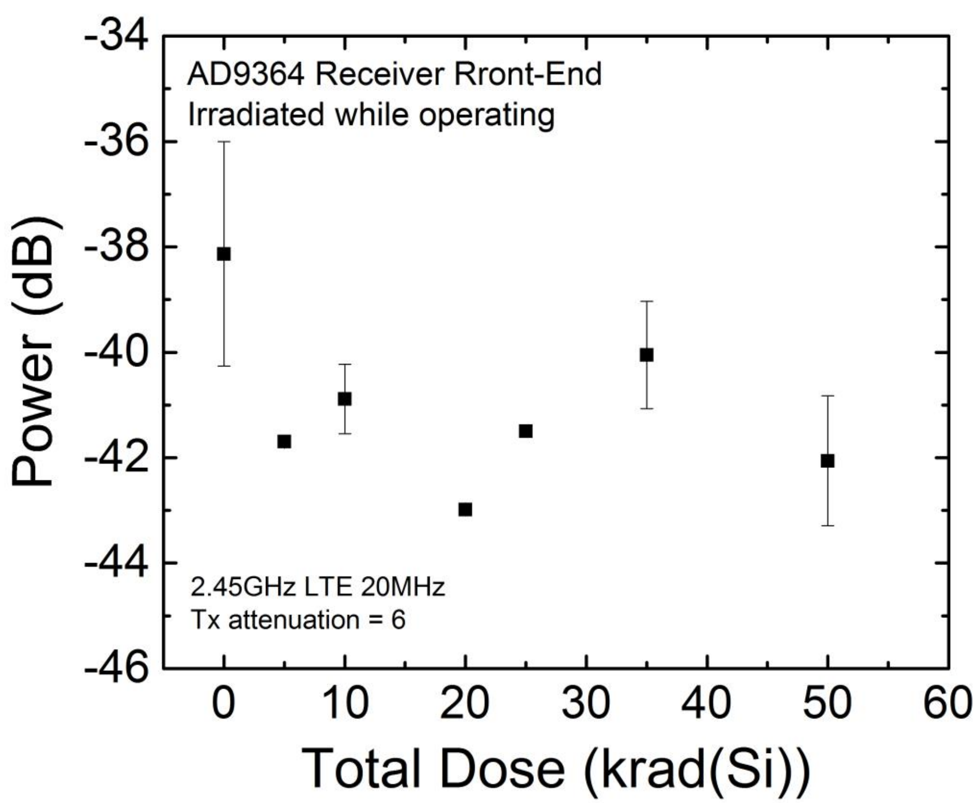

Figure 4. Power vs. total dose for the AD9364 irradiated at an average dose rate of approximately 100 rad(Si)/sec.

Figure 5. Image transmitted after 50 krad(Si) for DUT1.

Figure 6. Image transmitted after 50 krad(Si) for DUT2. The second read produced relatively less errors.

Figure 7. Image transmitted with gain of 50 dB after 50 krad(Si) for DUT2.

Figure 8. Image transmitted at 62 dB after 50 krad(Si) for DUT3.

Figure 9. Image transmitted at 62 dB after 50 krad(Si) for DUT4.

Table II
Supply currents vs. total dose for DUT1.

TID	ICC_1.8V	ICC_3.3V	ICC_GPO
krad(Si)	Amperes		
0	0.019545	0.000126	0.624
5	0.019636	0.000126	0.624
10	0.019545	0.000126	0.622
15	0.019545	0.000126	0.6183
25	0.019573	0.000126	0.6231
35	0.019564	0.000126	0.6221
50	0.019609	0.000126	0.6198
Annealed	0.019462	0.000126	0.62134

Table III
Supply currents vs. total dose for DUT2.

TID	1.8V	3.3V	GPO
krad(Si)	Amperes		
0	0.019636	0.000127	0.482
5	0.019636	0.000127	0.6217
10	0.019636	0.000127	0.62
15	0.019682	0.000127	0.617
25	0.019691	0.000127	0.62
35	0.019691	0.000127	0.6173
50	0.019664	0.000127	0.6163
Annealed	0.019697	0.000127	0.61795

Table IV
Supply currents vs. total dose for DUT3.

TID	1.8V	3.3V	GPO
Krad(Si)	Amperes		
0	0.019491	0.000127	0.542
5	0.019536	0.000126	0.8184
10	0.019409	0.000127	0.531
20	0.019455	0.000126	0.606
35	0.0195	0.000127	0.616
50	0.019545	0.000125	0.6159
Annealed	0.019545	0.000127	0.6159

Table V
Supply currents vs. total dose for DUT4.

TID	1.8V	3.3V	GPO
Krad(Si)	Amperes		
0	0.019955	0.000127	0.548
5	0.019923	0.000127	0.619
10	0.019864	0.000128	0.607
20	0.019818	0.000124	0.607
35	0.019936	0.000128	0.62
50	0.019936	0.000128	0.618
Annealed	0.02	0.000125	0.62

V. Reference

[1] Analog Devices, Inc. (2015, Nov.), "*AD9364 RF Agile Transceiver*" [Online]. Available: http://www.analog.com/media/en/technical-documentation/data-sheets/AD9364.pdf, Accessed on: Nov. 23, 2015.

[2] MIL-STD-883-H, Test Method 1019.8, Ionizing Radiation (Total Dose) Test Procedure Feb. 26, 2010.