Total Ionizing Dose Test Report for the AD2S80A Resolver-to-Digital Converter

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I. Introduction

The purpose of this study was to examine the total-ionizing dose (TID) susceptibility of the AD2S80A resolver-to-digital converter manufactured by Analog Devices, Inc.

II. Device Description

The AD2S80A is a monolithic 10-, 12-, 14-, or 16-bit tracking resolver-to-digital converter manufactured on a BiCMOS II process. The device converts the angular position or velocity of a rotating shaft by measuring the sine and/or cosine of the shaft angle. The detailed device specifications can be found in the manufacturer's datasheet [1]. Figure 1 shows the pin configuration of the 40-pin dual-inline-package (DIP). Figure 2 shows a schematic functional diagram.

Table I
Test and part information.

Generic Part Number	AD2S80A
DLA drawing	5962-9096201MQA
Manufacturer	Analog Devices, Inc.
Lot/Date Code	1452
Quantity tested	20
Part Function	Resolver-to-digital converter
Package Style	40-pin dual-inline-package
Test Equipment	TBD
Test Engineer	James Forney
Dose Levels	3, 6, 9, 12, 18, and 30 krad(Si)
Target Dose Rate	50 rad(Si)/sec and 10 mrad(Si)/sec

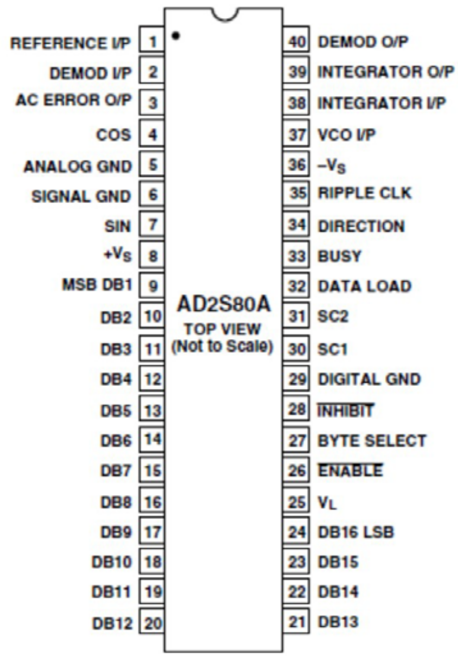

Figure 1. Pin configuration.

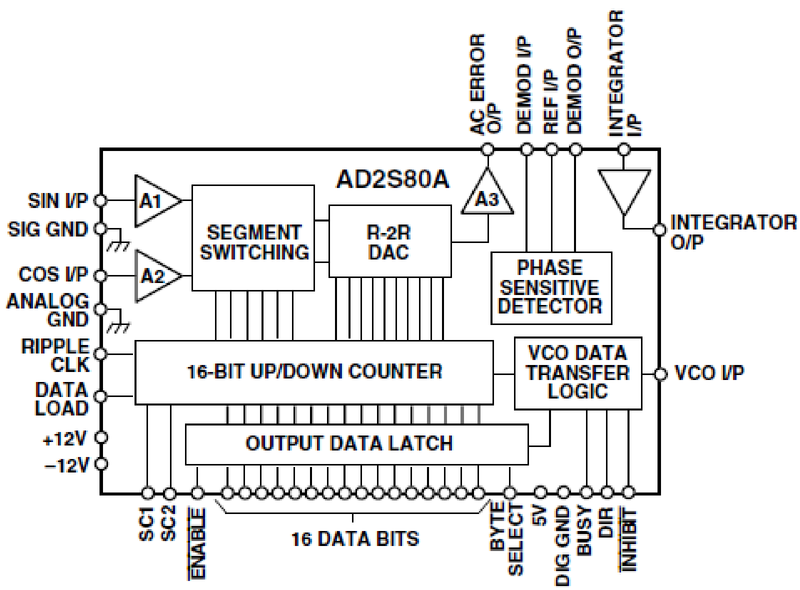

Figure 2. Functional diagram.

III. Test Method

A. Irradiation Procedure

The irradiation procedures and dosimetry requirements should conform 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.

B. Device Characterization

Ten samples were irradiated at low dose rate (10 mrad(Si)/sec), and ten samples were irradiated at high dose rate (50 rad(Si)/sec). Five samples at each dose rate were irradiated under the bias configuration shown in Figure 3. The bias conditions are: $+V_S$ = 12 V, $-V_S$ = -12 V, and $+V_I$ = 5 V. Five samples at each dose rate were irradiated with all pins grounded. The control devices were characterized before the irradiated devices for each measurement step. The DUTs were characterized in the same order throughout the test. The measurement sequence remained consistent throughout the test. The parts irradiated at high dose rate were annealed for 1 week, under the same bias condition as during irradiation.

Table II shows the parameters that were extracted for each set of test condition. AD2S80A is operated in 10-bit mode (SC1 = 0, SC2 = 0) for the specific application of this investigation. Also, only the upper 8 bits (DB1-8) are utilized to form the encoder's lower 8 bits (D14-21) in high-resolution mode for the application. However, we characterized all 10 bits. Figure 4 shows a block diagram of the test setup.

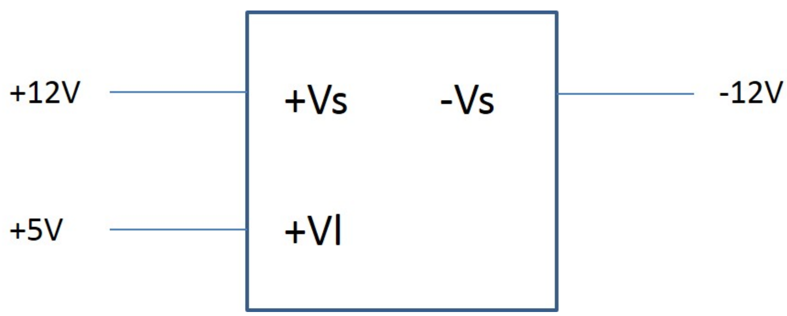

Figure 3. Schematic diagram of the irradiation bias configuration.

Test Conditions

Test temperature:	Room temperature
Frequency:	DC bias
Supply voltage:	5 V
Device parameters:	*Refer to datasheet for measurement conditions*

Table II
Device parameters to be characterized.

Parameter	Value
SIGNAL INPUTS Input bias current	 Typ: 60 nA Max: 150 nA
REFERENCE INPUT Reference voltage Input bias current	 Min: 1 V Max: 8 V Typ: 60 nA Max: 150 nA
ANGULAR ACCURACY Accuracy Missing codes (16-bit resolution)	 8 ± 1 LSB arc min 4 missing codes
VELOCITY SIGNAL	
RIPPLE CLOCK	

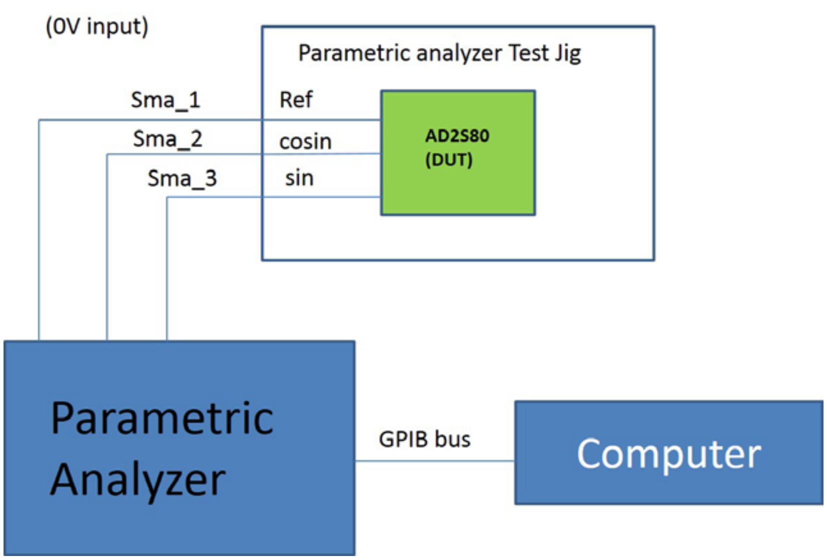

Figure 4. Block diagram of the measurement test setup.

IV. Results

The parts irradiated under bias at high dose rate failed functionally between 18 and 30 krad(Si). The unbiased parts irradiated at high dose rate survived up to 30 krad(Si) which is the highest tested total dose. All except for one part irradiated at low dose rate survived up to 30 krad(Si). One part irradiated under bias at low dose rate failed between 12 and 18 krad(Si). There was minimal parametric degradation prior to failure in all cases. Figure 5 and 6 show the positive supply current as a function of total dose for devices irradiated at 50 and 0.01 rad(Si)/sec, respectively. At high dose rate, all of the biased devices showed increasing current with dose. The biased devices showed functional failure after 30 krad(Si). At low dose rate, one biased device showed degradation in I_{CC}. That device failed after 18 krad(Si).

The parts irradiated at high dose rate were annealed under bias. After 940 hours of biased annealing at room temperature, the failed devices recovered functionality. The supply currents annealed to the pre-irradiation levels.

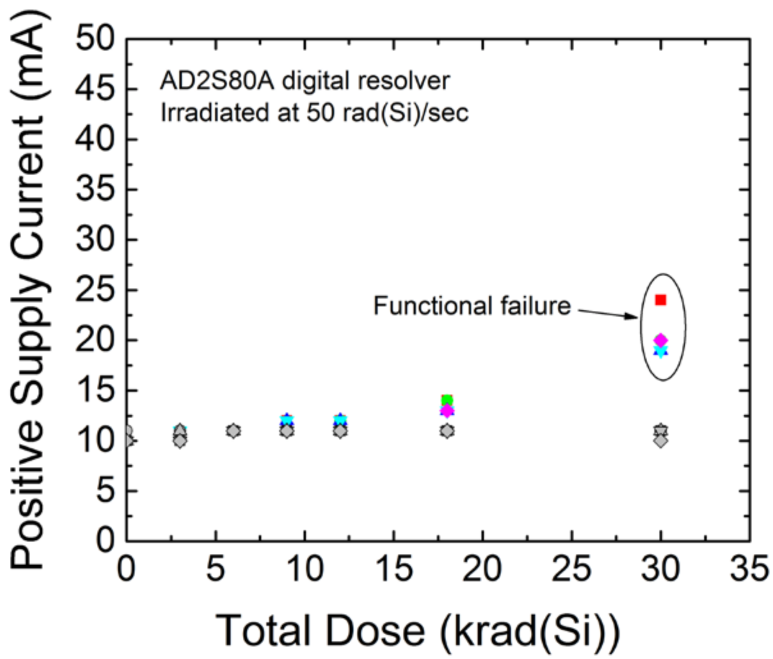

Figure 5. Positive supply current vs. total dose for devices irradiated at 50 rad(Si)/sec. Color symbols and gray symbols represent parts irradiated with bias and without bias, respectively. Functional failures occurred for all parts irradiated under bias after 30 krad(Si).

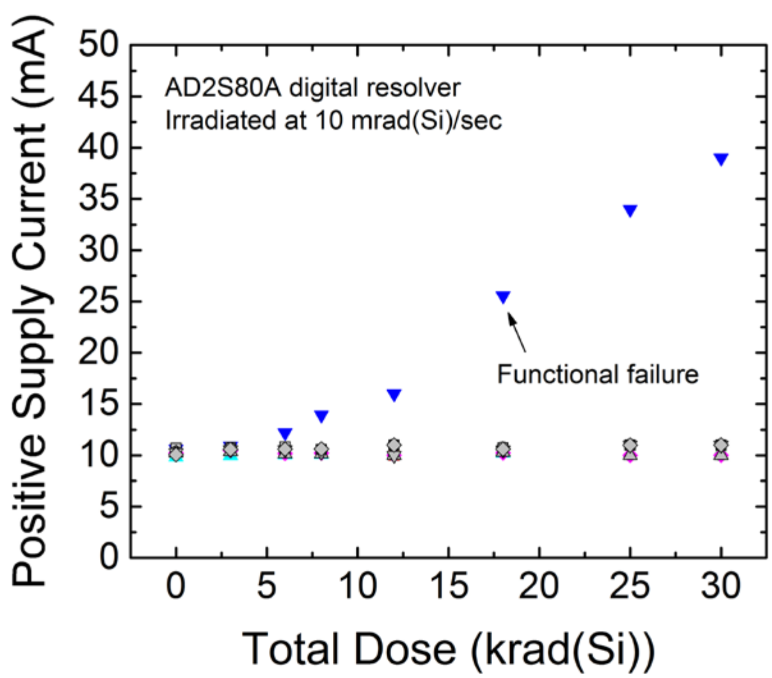

Figure 6. Positive supply current vs. total dose for devices irradiated at 0.01 rad(Si)/sec. Color symbols and gray symbols represent parts irradiated with bias and without bias, respectively. Functional failure occurred for one part irradiated under bias after 18 krad(Si). All other devices remained functional up to 30 krad(Si).

V. Reference

[1] Analog Devices, Inc., “Variable Resolution, Monolithic Resolver-to-Digital Converter,” AD2S80A datasheet, January 2016 [Rev. D]

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