Total Ionizing Dose (TID) Testing of the PA10 Power Operational Amplifier

Ray Ladbury, Michael Campola, and Alvin Boutte
Goddard Space Flight Center
Greenbelt, Maryland

June 2021
Since its founding, NASA has been dedicated to the advancement of aeronautics and space science. The NASA scientific and technical information (STI) program plays a key part in helping NASA maintain this important role.

The NASA STI program operates under the auspices of the Agency Chief Information Officer. It collects, organizes, provides for archiving, and disseminates NASA’s STI. The NASA STI program provides access to the NTRS Registered and its public interface, the NASA Technical Reports Server, thus providing one of the largest collections of aeronautical and space science STI in the world. Results are published in both non-NASA channels and by NASA in the NASA STI Report Series, which includes the following report types:

- **TECHNICAL PUBLICATION.** Reports of completed research or a major significant phase of research that present the results of NASA Programs and include extensive data or theoretical analysis. Includes compilations of significant scientific and technical data and information deemed to be of continuing reference value. NASA counterpart of peer-reviewed formal professional papers but has less stringent limitations on manuscript length and extent of graphic presentations.

- **TECHNICAL MEMORANDUM.** Scientific and technical findings that are preliminary or of specialized interest, e.g., quick release reports, working papers, and bibliographies that contain minimal annotation. Does not contain extensive analysis.

- **CONTRACTOR REPORT.** Scientific and technical findings by NASA-sponsored contractors and grantees.

- **CONFERENCE PUBLICATION.** Collected papers from scientific and technical conferences, symposia, seminars, or other meetings sponsored or co-sponsored by NASA.

- **SPECIAL PUBLICATION.** Scientific, technical, or historical information from NASA programs, projects, and missions, often concerned with subjects having substantial public interest.

- **TECHNICAL TRANSLATION.** English-language translations of foreign scientific and technical material pertinent to NASA’s mission.

Specialized services also include organizing and publishing research results, distributing specialized research announcements and feeds, providing information desk and personal search support, and enabling data exchange services.

For more information about the NASA STI program, see the following:

- Access the NASA STI program home page at [http://www.sti.nasa.gov](http://www.sti.nasa.gov)

- E-mail your question to help@sti.nasa.gov

- Phone the NASA STI Information Desk at 757-864-9658

- Write to:
  NASA STI Information Desk
  Mail Stop 148
  NASA Langley Research Center
  Hampton, VA 23681-2199
Total Ionizing Dose (TID) Testing of the PA10 Power Operational Amplifier

Raymond L. Ladbury
Goddard Space Flight Center, Greenbelt, MD

Michael J. Campola
Goddard Space Flight Center, Greenbelt, MD

Alvin J. Boutte
Goddard Space Flight Center, Greenbelt, MD

Test Date: July-August 2010
Test Report First Draft: September 18, 2012
Test Report Final: April 1, 2021

June 2021
I. Introduction

This study was undertaken to determine the total ionizing dose (TID) sensitivity of the PA10 Power Op Amp Manufactured by APEX (figure 1), which is a candidate for use on the LDCM TIRS instrument. The test was conducted with interest in both parametric degradation and functional failure in the configuration like that of the TIRS application. (See figure 2). The DUT was irradiated in a stepwise fashion, with parametric and functional degradation measured between steps. The parts were irradiated with gamma rays at a low dose rate (~0.01 rads(Si)/sec.).

II. Devices Tested

The PA10 devices were designed and fabricated by Apex. They are fabricated in a hybrid bipolar process. All 6 devices were characterized prior to exposure. The 5 devices tested are from the 0936 Lot Date Code (LDC). Complete package markings for the devices are:

<table>
<thead>
<tr>
<th>Product</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA10M/883</td>
<td>APEX</td>
</tr>
<tr>
<td>5962-9082801HXA</td>
<td>5C023800936</td>
</tr>
<tr>
<td>USA B80</td>
<td>60024</td>
</tr>
</tbody>
</table>

These are all 8 pin devices in a TO-5 package. The actual devices are shown in the Figure 1.

Product Datasheet: [PA10.pdf](PA10.pdf)
Figure 1 Picture of PA10 Power Operational Amplifier

**EQUIVALENT SCHEMATIC**

Figure 2 Pinout for the PA10
The sample size consisted of 5 op amps manufactured by Apex/Cirrus.

### IV. Test Facility

**Facility:** GSFC Radiation Effects Facility  
**Dose Rate:** 5-10 mrad(Si)/s.  
**Dose Levels:** 2 krad(Si), 5 krad(Si), 10 krad(Si), 15 krad(Si), 20 krad(Si), 30 krad(Si), 50 krad(Si)

### V. Test Conditions and Error Modes

The following test conditions were observed:

**Test Temperature:** Room Temperature.  
**Operating Frequency:** DC  
**Power Supply Voltage:** $+24 \, V/-24 \, V$.  
**Output Voltage:** $+2.5 \, V$ and $+3.3 \, V$.  
**Parameters of Interest:** Voltage Swing, Input Bias Current, Open Loop Gain, $dV_{\text{out}}$, Voltage Offset

### VI. Test Method

Parts were verified functional prior to testing. Parametric values were measured and recorded at each dose step. The parts were placed in a Pb/Al box to minimize dose enhancement. The dose rate for the parts was measured and recorded. Following completion of the first dose step, each part was verified and the parameters were measured and recorded. These functional and parametric measurements were repeated for each subsequent dose step.
VII. Test Results

The results show no significant parametric degradation up to 50 krad for the tested lot of devices at low dose rate.