

R E P O R T

**LM158AJ – Low Dose Rate Testing @ 36 rad h⁻¹
ESTEC - Contract No. 22051/08/NL/PA**

Project Coordinator: Peter Beck

Project Team: Michael Wind
Marcin Latocha

ESA Technical Project Officer: Marc Poizat

1 Document Approval Sheet

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| Prepared by: | |
| | Name: Michael Wind |
| | |
| Released by: | |
| | Name: Peter Beck |
| | |
| Approved by: | |
| | Name: Marc Poizat |

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5 List of Abbreviations

| | |
|--------|---|
| AIT | Austrian Institute of Technology |
| CMRR | Common Mode Rejection Ratio |
| CNS | Centre National d'Études Spatiales |
| CTB | Component Technological Board |
| CTR | Current Transfer Ratio |
| DIL | Dual In Line |
| DEL | Dosimetry Eichlabor (Dosimetry Laboratory) |
| DUT | Device Under Test |
| EEE | Electrical Electronic Electromechanical |
| ELDRS | Enhanced Low Dose Rate Sensitivity |
| ESA | European Space Agency |
| ESCC | European Space Component Coordination |
| ESTEC | European Space Research and Technology Centre |
| HDR | High Dose Rate |
| HDR-S | High Dose Rate – exposure of the switching experiment |
| HZL | Hot Cell Laboratory |
| IC | Integrated Circuit |
| LDR | Low Dose Rate |
| LDR-C | Low Dose Rate – Continuous exposure |
| LDR-S | Low Dose Rate – exposure of the switching experiment |
| LET | Linear Energy Transfer |
| NES | Nuclear Engineering Seibersdorf GmbH |
| OTA | Operational Transconductance Amplifier |
| PCB | Printed Circuit Board |
| PSRR | Power Supply Rejection Ratio |
| RD | Reference Document |
| RWG | Radiation Working Group |
| SCADUS | Smart Control and Development Universal Software |
| SOW | Statement Of Work |
| SR | Slew Rate |
| TID | Total Ionizing Dose |
| TRR | Test Readiness Review |
| TN | Technical Note |
| VEE | Visual Engineering Environment |
| WO | Work Order |
| WP | Work Package |

6 Scope and Objectives

This report journalizes low dose rate measurements conducted with the LM158AJ microcircuit at a dose rate of $36 \text{ rad}_{(Si)} \text{ h}^{-1}$. Results obtained from these measurements serve as a reference for an experiment that is investigating the accelerated switching test method (see [BOC04], [BOC05], [DUS08], and [BOC09]). The low dose rate degradation is measured for an extensive set of parameters.

This report serves as measurement protocol and a detailed reference data collection. In detail this report includes:

- General overview of the measurements
- Information on DUT properties (e.g. manufacturer, date code, lot ID)
- Enumeration of the DUTs (naming conventions) during the experiments
- Exposure plan
- Dose levels received by each DUT during the exposure
- Measured low dose rate data for each unit and each characterized parameter

7 General Overview of the Measurements

The low dose rate exposure is using a constant dose rate Co-60 photon field with a dose rate of approximately $10 \text{ mrad}_{(Si)} \text{ s}^{-1}$. The exposure is only interrupted for characterisation of the DUTs, which are performed on average every three to four weeks. In terms of total dose this means that a characterisation is done approximately every $20 \text{ krad}_{(Si)}$. 115 days of continuous exposure are needed to reach the specified total dose level of $100 \text{ krad}_{(Si)}$.

All units are mounted on one PCB that is presented in Figure 1. It is noted that this PCB is used also for other experiments that are carried out in parallel. Biased units are positioned in the centre of the board. They are arranged in columns of five units, in each column the biased units of one device type is mounted. To the left and to the right the unbiased units are mounted on antistatic foam that is enwrapped in aluminium. This ensures that all pins are grounded. The pin to ground resistance is typical less than 4Ω . A RadFET dosimeter is used to monitor the dose received by the DUTs.

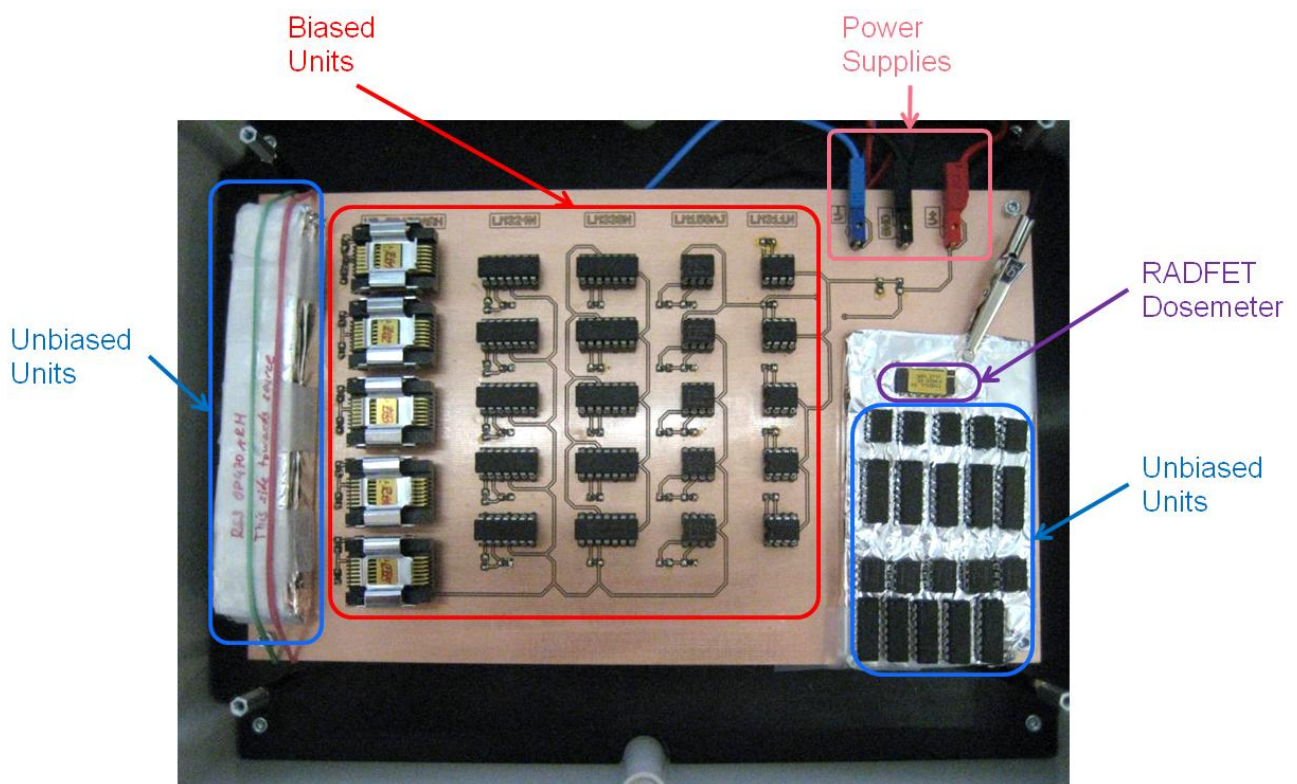


Figure 1: Printed circuit board housing all the biased and unbiased units used for the reference measurements during exposure.

The Co-60 source used for the exposure has an activity of 16.41 Ci (607 GBq); the source is mounted in a portable housing that is a gamma ray radiography camera, i.e. in a Gammamat TK-30. The required dose rate of $10 \text{ mrad}_{(Si)} \text{ s}^{-1}$ is available at a distance of approximately 70 cm from the point source.

The source is kept in a shielding made from depleted Uranium encircled by a stainless steel housing. The source can be moved in and out from the shielding via a locating channel. The source is turned off when it is completely retracted and the Uranium shutter is closed. For exposure the shutter is opened and the source is moved within the locating channel into a defined position. The result is a defined radiation field with the shape of a cone. The field will be adjusted in such a way, that it is sufficiently large to irradiate three irradiation boards in parallel. A picture of the setting is shown in Figure 2.

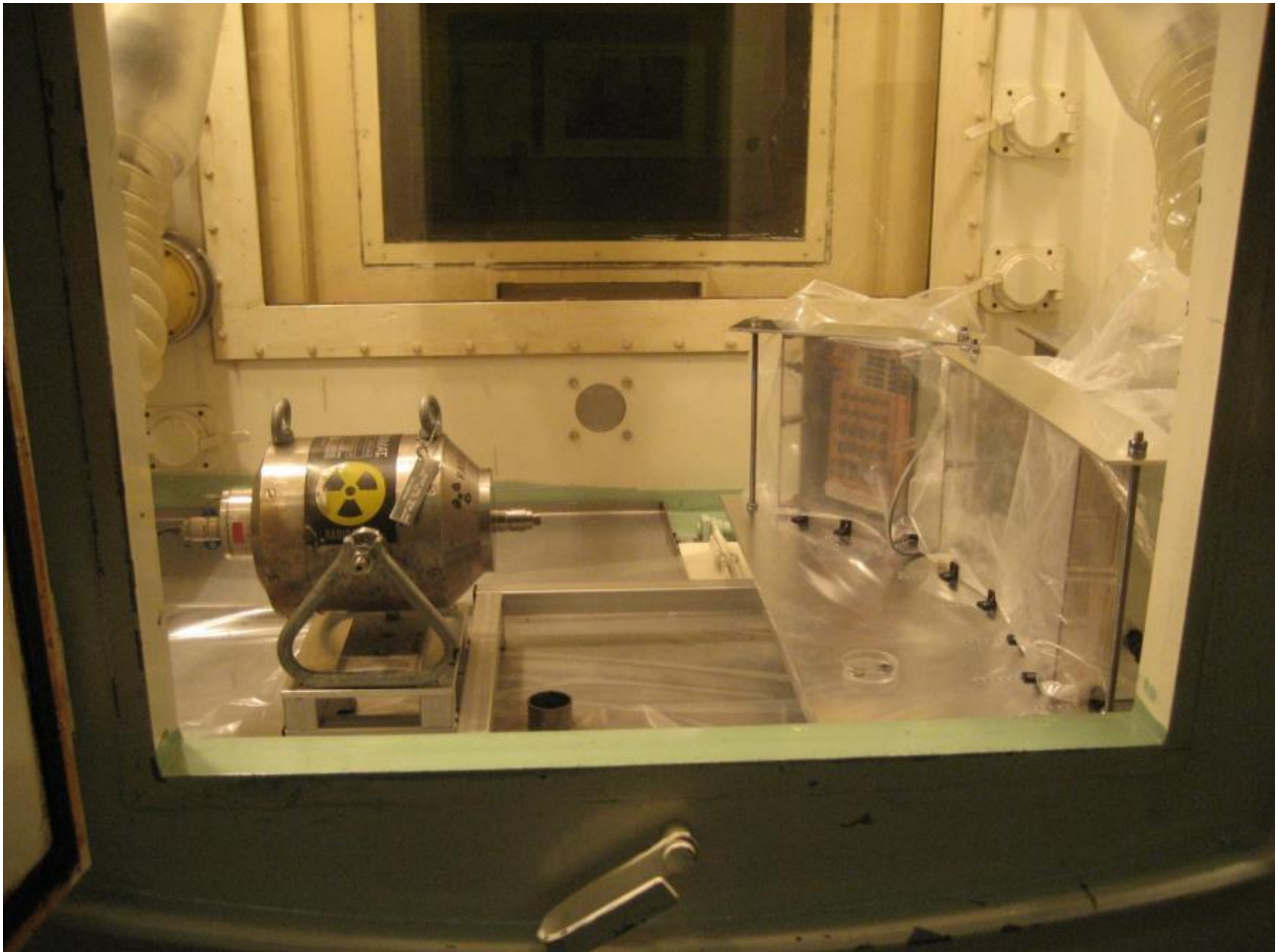


Figure 2: Low dose rate facility; on the left side the radiography camera is positioned, on the right side up to three boxes can be mounted that house one PCB each. The PCB used for the experiments reported here is mounted in the leftmost box.

8 DUT properties and Sample Enumeration

Ten units of the LM158AJ microcircuit are used for the low dose rate exposure; five units are exposed in biased condition and another five units are exposed in unbiased condition (see Section 9). Some basic device properties are presented in Table 1.

Table 1: Manufacturer, data code, and lot of the units used for reference exposure

| Device Type | Manufacturer | D/C | LOT |
|-------------|------------------------|----------|-----------|
| LM158AJ | National Semiconductor | H0D0437E | C6X405476 |

The units used for the low dose rate exposures are divided in two groups five units each. One group is exposed in biased condition, the other group in unbiased condition. All the five samples of either group are treated identically. Enumeration of the samples is shown in Table 2.

Table 2: Enumeration of the samples

| Exposure Series / Dose Rate | Biasing Condition | Enumeration |
|---|-------------------|-----------------------------------|
| Low Dose Rate / 36 rad _(Si) h ⁻¹ | biased | BRef1, BRef2, BRef3, BRef4, BRef5 |
| | unbiased | URef1, URef2, URef3, URef4, URef5 |

9 Biasing Conditions

Tests are conducted in biased and unbiased configuration. In the unbiased configuration all terminals of the microcircuits are held at ground potential. When using biased condition the microcircuits are driven under typical operational conditions. The test circuitry used for the experiments is described in the following.

9.1 Unbiased Configuration

The pins of the microcircuit are held at ground potential during the exposure to the ionizing radiation. Hereby they are mounted in antistatic foam that is enwrapped in aluminium foil. The foil itself is connected to ground potential. The pin to ground resistance is typical well below a few Ohms.

9.2 Biased Configuration

The LM158AJ microcircuit is an operational amplifier that is biased in a non inverting DC gain configuration. Dual voltage supply is used; the positive and negative supply voltages are kept large at $\pm 15V$. The loop gain of the devices is small enough not to drive the amplifier into saturation. V_{in} is set to to 0.5V, the loop gain is roughly 11 (for details see section 12).

10 Exposure Plan for Low Dose Rate Testing and Cumulative Dose Levels

The low dose rate applied to all units during the low dose rate exposure is 10 mrad_(Si) s⁻¹. The exposures are performed in steps of approximately 20 krad_(Si). In between two of such steps the DUTs are removed from the facility and transferred to the lab. An extensive parametric device characterisation is performed to investigate the low dose rate radiation response of the DUTs. After characterisation all the units are remounted in the irradiation facility and the exposure is continued.

Table 3 presents a time table of all exposure steps and the length of the breaks, during which parametric device characterization is done. The cumulative dose to which the DUTs were exposed (at the end of each exposure setup) is presented in the rightmost column.

Table 3: Time table of the low dose rate exposure steps and cumulative dose levels to which the DUTs have been exposed.

| Action # | Date | Exposure Stop | Exposure Resume | Duration of Interruption | Cumulative Dose Level |
|----------|--------------------------------|---------------|-----------------|--------------------------|----------------------------|
| 1 | 12 th December 2010 | ----- | 16:00 | ----- | 0.00 krad _(Si) |
| 2 | 22 nd December 2010 | 13:25 | 15:45 | 2:20 | 12.17 krad _(Si) |
| 3 | 12 th January 2011 | 13:00 | 16:00 | 3:00 | 28.19 krad _(Si) |
| 4 | 20 th January 2011 | 13:15 | 16:00 | 2:45 | 34.18 krad _(Si) |
| 5 | 17 th February 2011 | 13:00 | 16:05 | 3:05 | 55.61 krad _(Si) |
| 6 | 4 th April 2011 | 10:00 | ----- | ----- | 90.10 krad _(Si) |

11 Measured Low Dose Rate Data



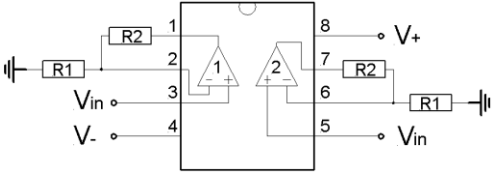
The parametric device degradation of all units is measured with a parameter analyzer. Measurement Data are presented as parameter value vs. dose (in units of $\text{krad}_{(Si)}$) for all parameters presented in Table 4. Data are presented as tabled values as well as in plots. For each device type and biasing condition five units are irradiated under identical conditions. The tabled data present the results of all five units as well as average values and the standard deviations. In the plots only the average values are presented. Uncertainty bars are calculated as the standard deviation.

The reference data obtained for LM158AJ microcircuit is presented in Annex A: Reference data obtained with the LM158AJ microcircuit.

Table 4: Parametes measured

| Electric Parameter used for the characterization of the low dose rate degradation | Symbol |
|--|---------------|
| Offset Voltage | V_{OS} |
| Positive Supply Current | I_{S+} |
| Negative Supply Current | I_{S-} |
| Input Bias Current at the Non Inverting Input | I_{b+} |
| Input Bias Current at the Inverting Input | I_{b-} |
| Input Bias Current | I_b |
| Input Offset Current | I_{OS} |
| Open Loop Gain | A_{VO} |
| Common Mode Rejection Ration | CMRR |
| Positive Power Supply Rejection Ratio | PSRR |
| Negative Power Supply Rejection Ratio | PSRR- |
| Positive Output Voltage Swing | V_{O+} |
| Negative Output Voltage Swing | V_{O-} |
| Positive Short Circuit Current | I_{SC+} |
| Negative Short Circuit Current | I_{SC-} |
| Slew Rate | SR |

12 Test Plan – Summary

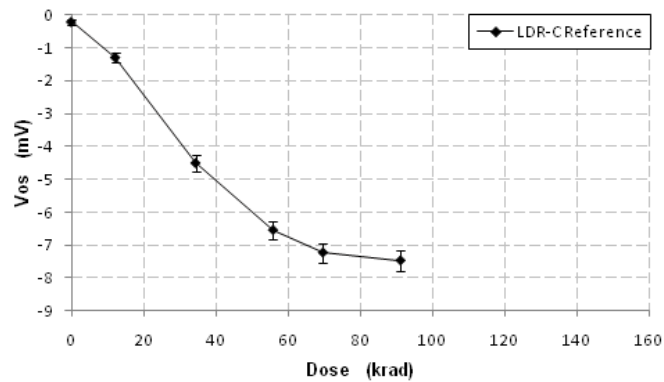
| | | | | | |
|--|--|--|--|--|--|
|  | |  | | Total Dose Test Report For: LM158AJ | |
| Family: Operational Amplifier Package: DIL | | Lot Code: C6X405476 Manufacturing Date Code: H0D0437E | | Manufacturer: National Semiconductor Contact Person: ALTER technology group Spain Address: Avd. Thomas Alba Edison, 4 41092 Seville, Spain | |
| Test Facility Name: Nuclear Engineering Seibersdorf GesmbH Address: Forschungszentrum Seibersdorf, Seibersdorf, A-2444 | | Irradiation Test Plan: No.: AIT-2 Iss.: 1 Rev.: 0 | | | |
| Irradiation Conditions: Biased (In-Situ) & Unbiased Electrical Measurement: Parameters Tested: V_{OS} , I_{S+} , I_{S-} , I_{b+} , I_{b-} , I_{b} , I_{OS} , A_{VO} , CMRR, PSRR, PSRR-, V_{O+} , V_{O-} , I_{sc+} , I_{sc-} , SR Temp: 26 °C | | Biased Configuration: Supply Voltages: V_{\pm} : $\pm 15V$ V_{in} : 0.5V Resistors: R_1 : 1k Ω , R_2 : 10k Ω | | Schematic of Test Circuitry:  | |
| Facilities: Hot Cell Laboratory of the Nuclear Engineering Seibersdorf GesmbH Source: gamma Absorber Material: PMMA | | Energy: Co-60 (1.17 MeV, 1.33MeV) Thickness: 3mm | | Dose Rate: 8.94 mrad _(Si) s ⁻¹ Duration: 129.5 d | |
| Anneal Test: No | | | | | |
| Irradiation Sequence | | | | | |
| Step No. | Description | Begin | End | Exposure Time | |
| 1 | Long term exposure Exposure is interrupted several times for ~2 hours for characterization of the electrical parameters. Electrical characterization is done at dose levels of: 12.2, 28.2, 34.2, 55.6, and 90.1 krad _(Si) | 7 th Dec 2010 | 4 th April 2011 | 118 d | |
| Irradiation Test Facility: Responsible Name: Michael Wind Telephone: +43 (0) 50550 - 4310 | | | Electrical Test: Responsible Name: Michael Wind Telephone: +43 (0) 50550 - 4310 | | |

13 References

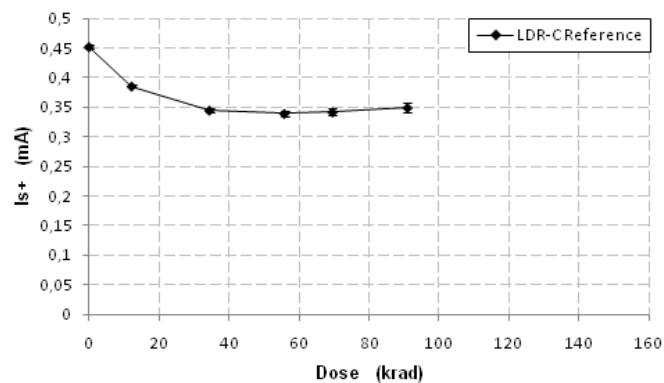
- BOC04 J. Boch, F. Saigné, R.D. Schrimpf, D.M. Fleetwood, S. Ducret, L. Dusseau, J.P., David, J. Fesquet, J. Gasiot, R. Ecoffet, Effect of Switching From High to Low Dose Rate on Linear Bipolar Technology Radiation response, IEEE-TNS, vol.51(5), p.2896, October 2004
- BOC05 J. Boch, F. Saigné, R.D. Schrimpf, J.-R. Vaillé, L. Dusseau, S. Ducret, M. Bernard, E. Lorfèvre, and C. Chatry, Estimation of Low-Dose-Rate Degradation on Bipolar Linear Integrated Circuits Using Switching Experiments, IEEE-TNS, vol. 52 (6), p. 2616, December 2005
- BOC09 J. Boch, Y. Gonzalez Velo, F. Saigné, N. J-H. Roche, R.D. Schrimpf, J.-R. Vaillé, L. Dusseau, C. Chatry, E. Lorfèvre, R. Ecoffet, A.D. Touboul, The use of a Dose- Rate Switching Technique to Characterize Bipolar Devices, submitted to IEEE-TNS, accepted for NSREC, 2009
- DUS08 L. Dusseau, M. Bernard, J. Boch, Y. Gonzalez velo, N. Roche, E. Lorfèvre, F. Bezerra, P. Calvel, R. Marec, F. Saigné, Review and Analysis of the Radiation - Induced Degradation Observed for the Input Bias Current of Linear Integrated Circuits, IEEE-TNS, vol. 55 (6), p.3174, December 2008
- NAT05 National Semiconductor Corporation, LM158/LM258/LM358/LM2904, Low Power Dual Operation Amplifiers, datasheet, October 2005

Annex A: Reference data obtained with the LM158AJ microcircuit

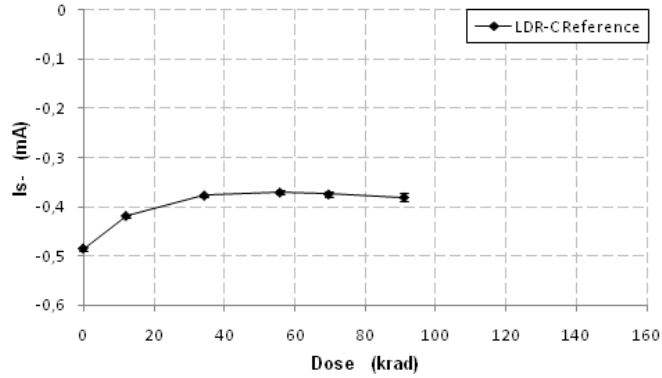
| Raw Data | — | Device Type: LM158AJ | Parameter: Vos (mV) | Biasing Condition: Biased | | | |
|-----------------|-------------|----------------------|---------------------|---------------------------|-------|-------|-------|
| LDR-C Reference | Dose (krad) | 0.00 | 12.16 | 34.37 | 55.80 | 69.59 | 91.03 |
| | BRef1 | -0.27 | -1.48 | -4.65 | -6.68 | -7.33 | -7.59 |
| | BRef2 | -0.11 | -1.16 | -4.12 | -6.08 | -6.79 | -7.02 |
| | BRef3 | -0.28 | -1.34 | -4.77 | -6.86 | -7.63 | -7.84 |
| | BRef4 | -0.23 | -1.37 | -4.59 | -6.6 | -7.19 | -7.38 |
| | BRef5 | -0.13 | -1.08 | -4.39 | -6.51 | -7.21 | -7.51 |
| | Mean | -0.20 | -1.29 | -4.50 | -6.54 | -7.23 | -7.47 |
| | StdDev | 0.08 | 0.16 | 0.25 | 0.28 | 0.30 | 0.30 |



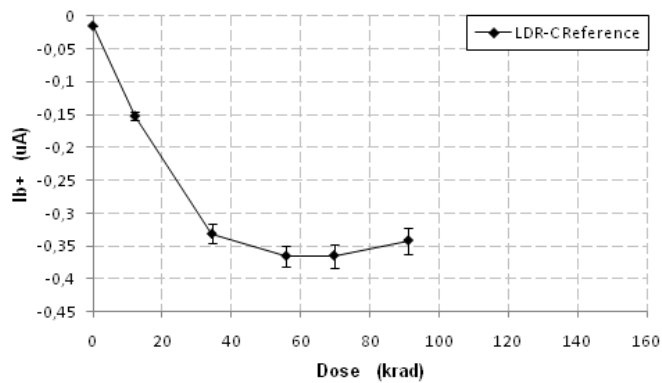
| Raw Data | — | Device Type: LM158AJ | Parameter: Is+ (mA) | Biasing Condition: Biased | | | |
|-----------------|-------------|----------------------|---------------------|---------------------------|----------|----------|----------|
| LDR-C Reference | Dose (krad) | 0.00 | 12.16 | 34.37 | 55.80 | 69.59 | 91.03 |
| | BRef1 | 0.45 | 0.38 | 0.34 | 0.34 | 0.34 | 0.35 |
| | BRef2 | 0.45 | 0.38 | 0.34 | 0.34 | 0.34 | 0.35 |
| | BRef3 | 0.44 | 0.38 | 0.34 | 0.33 | 0.33 | 0.33 |
| | BRef4 | 0.45 | 0.38 | 0.34 | 0.34 | 0.34 | 0.35 |
| | BRef5 | 0.45 | 0.38 | 0.34 | 0.33 | 0.33 | 0.34 |
| | Mean | 0.45 | 0.38 | 0.34 | 0.33 | 0.34 | 0.34 |
| | StdDev | 3.82E-03 | 3.01E-03 | 2.57E-03 | 4.79E-03 | 6.19E-03 | 7.33E-03 |



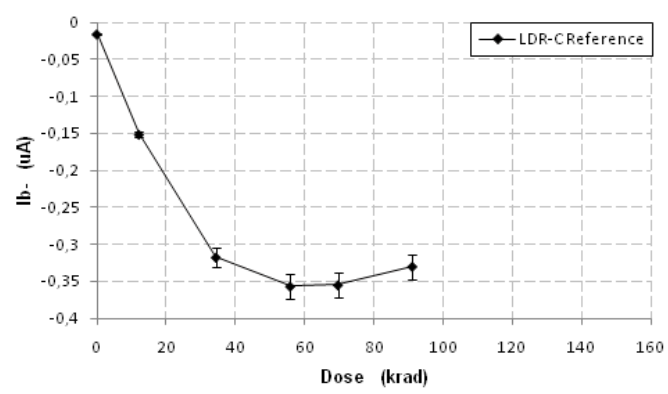
| Raw Data | Device Type: LM158AJ | Parameter: Is- (mA) | Biasing Condition: Biased | | | | |
|-----------------|----------------------|---------------------|---------------------------|----------|----------|----------|----------|
| LDR-C Reference | Dose (krad) | 0.00 | 12.16 | 34.37 | 55.80 | 69.59 | 91.03 |
| | BRef1 | -0.48 | -0.41 | -0.37 | -0.37 | -0.37 | -0.38 |
| | BRef2 | -0.49 | -0.42 | -0.37 | -0.37 | -0.38 | -0.38 |
| | BRef3 | -0.47 | -0.42 | -0.37 | -0.36 | -0.36 | -0.36 |
| | BRef4 | -0.48 | -0.41 | -0.37 | -0.37 | -0.37 | -0.38 |
| | BRef5 | -0.48 | -0.41 | -0.37 | -0.36 | -0.37 | -0.37 |
| | Mean | -0.48 | -0.41 | -0.37 | -0.37 | -0.37 | -0.38 |
| | StdDev | 4.01E-03 | 3.09E-03 | 2.62E-03 | 4.99E-03 | 6.40E-03 | 7.48E-03 |



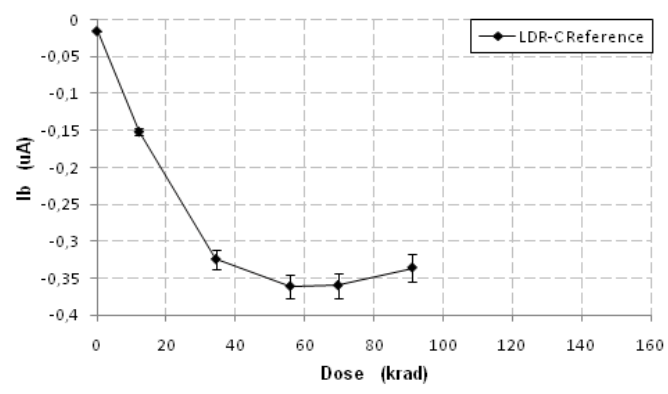
| Raw Data | Device Type: LM158AJ | Parameter: Ib+ (uA) | Biasing Condition: Biased | | | | |
|-----------------|----------------------|---------------------|---------------------------|----------|----------|----------|----------|
| LDR-C Reference | Dose (krad) | 0.00 | 12.16 | 34.37 | 55.80 | 69.59 | 91.03 |
| | BRef1 | -0.01 | -0.15 | -0.32 | -0.35 | -0.35 | -0.33 |
| | BRef2 | -0.01 | -0.14 | -0.31 | -0.34 | -0.34 | -0.32 |
| | BRef3 | -0.01 | -0.15 | -0.35 | -0.39 | -0.38 | -0.36 |
| | BRef4 | -0.01 | -0.15 | -0.32 | -0.35 | -0.35 | -0.32 |
| | BRef5 | -0.01 | -0.14 | -0.32 | -0.37 | -0.37 | -0.36 |
| | Mean | -0.01 | -0.15 | -0.33 | -0.36 | -0.36 | -0.34 |
| | StdDev | 3.41E-04 | 6.30E-03 | 1.49E-02 | 1.64E-02 | 1.78E-02 | 2.01E-02 |



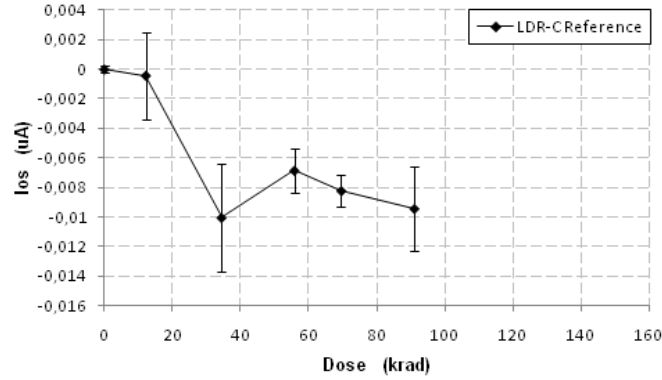
| Raw Data | Device Type: LM158AJ | Parameter: Ib- (uA) | Biasing Condition: Biased | | | | |
|-----------------|----------------------|---------------------|---------------------------|----------|----------|----------|----------|
| LDR-C Reference | Dose (krad) | 0.00 | 12.16 | 34.37 | 55.80 | 69.59 | 91.03 |
| | BRef1 | -0.01 | -0.15 | -0.31 | -0.35 | -0.34 | -0.32 |
| | BRef2 | -0.01 | -0.14 | -0.30 | -0.33 | -0.33 | -0.31 |
| | BRef3 | -0.01 | -0.15 | -0.33 | -0.38 | -0.37 | -0.35 |
| | BRef4 | -0.01 | -0.15 | -0.31 | -0.35 | -0.34 | -0.31 |
| | BRef5 | -0.01 | -0.14 | -0.31 | -0.36 | -0.36 | -0.34 |
| | Mean | -0.01 | -0.15 | -0.31 | -0.35 | -0.35 | -0.32 |
| | StdDev | 4.23E-04 | 4.01E-03 | 1.26E-02 | 1.64E-02 | 1.67E-02 | 1.67E-02 |



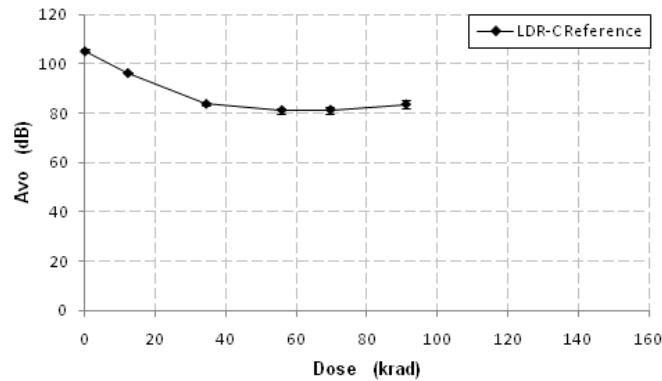
| Raw Data | Device Type: LM158AJ | Parameter: Ib (uA) | Biasing Condition: Biased | | | | |
|-----------------|----------------------|--------------------|---------------------------|----------|----------|----------|----------|
| LDR-C Reference | Dose (krad) | 0.00 | 12.16 | 34.37 | 55.80 | 69.59 | 91.03 |
| | BRef1 | -0.01 | -0.15 | -0.32 | -0.35 | -0.35 | -0.32 |
| | BRef2 | -0.01 | -0.14 | -0.31 | -0.34 | -0.34 | -0.31 |
| | BRef3 | -0.01 | -0.15 | -0.34 | -0.38 | -0.38 | -0.35 |
| | BRef4 | -0.01 | -0.15 | -0.32 | -0.35 | -0.34 | -0.32 |
| | BRef5 | -0.01 | -0.14 | -0.32 | -0.36 | -0.37 | -0.35 |
| | Mean | -0.01 | -0.15 | -0.32 | -0.36 | -0.35 | -0.33 |
| | StdDev | 3.47E-04 | 5.12E-03 | 1.36E-02 | 1.63E-02 | 1.73E-02 | 1.84E-02 |



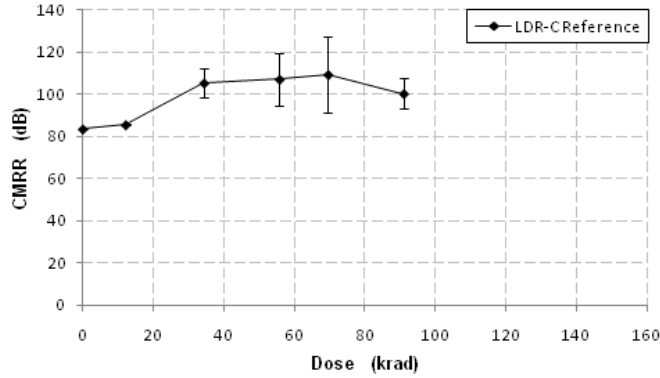
| Raw Data | Device Type: LM158AJ | Parameter: Ios (uA) | Biasing Condition: Biased | | | | |
|-----------------|----------------------|---------------------|---------------------------|----------|----------|----------|----------|
| LDR-C Reference | Dose (krad) | 0.00 | 12.16 | 34.37 | 55.80 | 69.59 | 91.03 |
| | BRef1 | -0.00 | -0.00 | -0.01 | -0.00 | -0.00 | -0.00 |
| | BRef2 | -0.00 | -0.00 | -0.01 | -0.00 | -0.00 | -0.00 |
| | BRef3 | -0.00 | -0.00 | -0.01 | -0.00 | -0.00 | -0.01 |
| | BRef4 | -0.00 | -0.00 | -0.00 | -0.00 | -0.00 | -0.00 |
| | BRef5 | 0.00 | 0.00 | -0.00 | -0.00 | -0.00 | -0.01 |
| | Mean | -0.00 | -0.00 | -0.01 | -0.00 | -0.00 | -0.00 |
| | StdDev | 2.46E-04 | 2.96E-03 | 3.66E-03 | 1.46E-03 | 1.06E-03 | 2.81E-03 |



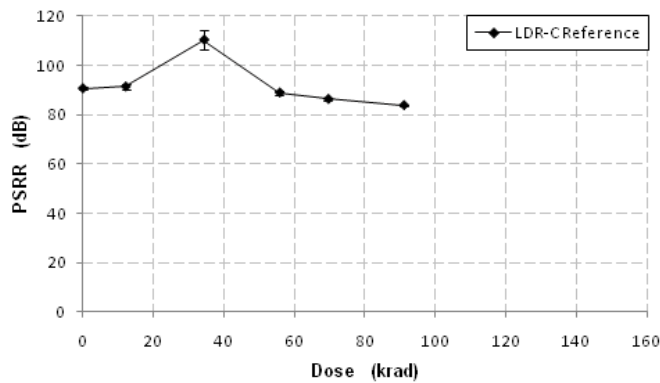
| Raw Data | Device Type: LM158AJ | Parameter: Avo (dB) | Biasing Condition: Biased | | | | |
|-----------------|----------------------|---------------------|---------------------------|-------|-------|-------|-------|
| LDR-C Reference | Dose (krad) | 0.00 | 12.16 | 34.37 | 55.80 | 69.59 | 91.03 |
| | BRef1 | 105.4 | 96.12 | 83.7 | 81.43 | 81.73 | 84.17 |
| | BRef2 | 105.1 | 96.59 | 84.51 | 82.31 | 82.55 | 85.13 |
| | BRef3 | 105.7 | 96.5 | 82.9 | 79.46 | 79.16 | 81.07 |
| | BRef4 | 104.4 | 95.9 | 83.79 | 81.67 | 82.06 | 84.48 |
| | BRef5 | 105.9 | 96.43 | 83.19 | 80.33 | 80.41 | 82.51 |
| | Mean | 105.3 | 96.30 | 83.61 | 81.04 | 81.18 | 83.47 |
| | StdDev | 0.58 | 0.28 | 0.61 | 1.13 | 1.38 | 1.65 |



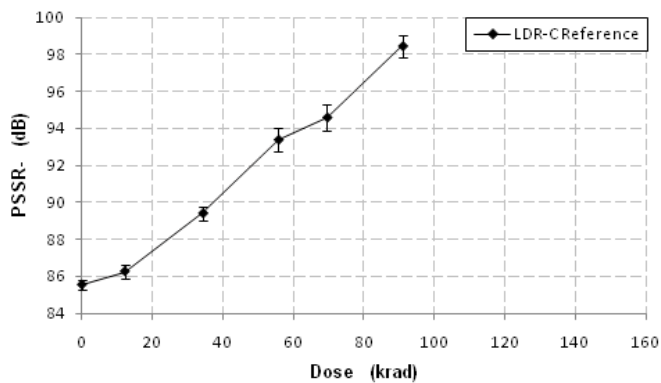
| Raw Data | Device Type: LM158AJ | Parameter: CMRR (dB) | Biasing Condition: Biased | | | | |
|-----------------|----------------------|----------------------|---------------------------|--------|--------|--------|--------|
| LDR-C Reference | Dose (krad) | 0.00 | 12.16 | 34.37 | 55.80 | 69.59 | 91.03 |
| | BRef1 | 83.45 | 85.54 | 101.9 | 109.4 | 138.5 | 96.49 |
| | BRef2 | 83.66 | 85.68 | 99.22 | 120.8 | 105.5 | 94.48 |
| | BRef3 | 83.22 | 85.14 | 115.7 | 92.53 | 92.33 | 103.2 |
| | BRef4 | 83.51 | 85.58 | 101.5 | 116.1 | 111.2 | 95.43 |
| | BRef5 | 83.26 | 85.33 | 107.8 | 96.06 | 98.5 | 111.3 |
| | Mean | 83.42 | 85.45 | 105.22 | 106.97 | 109.20 | 100.18 |
| | StdDev | 0.18 | 0.21 | 6.65 | 12.32 | 17.85 | 7.09 |



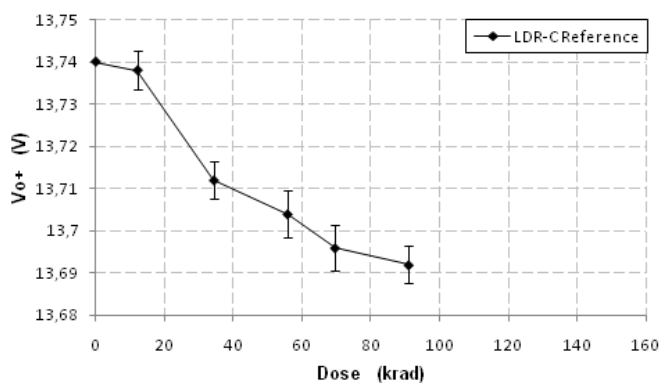
| Raw Data | Device Type: LM158AJ | Parameter: PSRR (dB) | Biasing Condition: Biased | | | | |
|-----------------|----------------------|----------------------|---------------------------|--------|-------|-------|-------|
| LDR-C Reference | Dose (krad) | 0.00 | 12.16 | 34.37 | 55.80 | 69.59 | 91.03 |
| | BRef1 | 90.74 | 91.75 | 112.8 | 88.49 | 86.2 | 83.9 |
| | BRef2 | 91.35 | 92.56 | 105.9 | 88.65 | 86.06 | 84.23 |
| | BRef3 | 89.89 | 89.97 | 113.7 | 90.3 | 87 | 83.47 |
| | BRef4 | 90.88 | 91.83 | 106.1 | 88.57 | 86.18 | 84.21 |
| | BRef5 | 90.37 | 90.63 | 112.9 | 88.7 | 86.15 | 83.32 |
| | Mean | 90.64 | 91.34 | 110.28 | 88.94 | 86.31 | 83.82 |
| | StdDev | 0.54 | 1.03 | 3.92 | 0.76 | 0.38 | 0.41 |



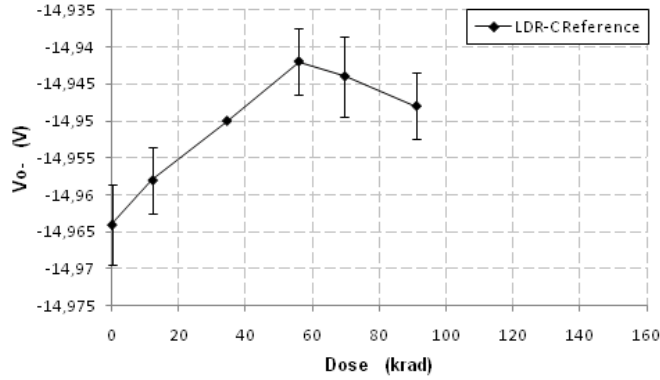
| Raw Data | Device Type: LM158AJ | Parameter: PSSR- (dB) | Biasing Condition: Biased | | | | |
|-----------------|----------------------|-----------------------|---------------------------|-------|-------|-------|-------|
| LDR-C Reference | Dose (krad) | 0.00 | 12.16 | 34.37 | 55.80 | 69.59 | 91.03 |
| | BRef1 | 85.56 | 86.28 | 88.93 | 93.06 | 94.4 | 98.22 |
| | BRef2 | 85.89 | 86.77 | 89.95 | 94.2 | 95.62 | 99.02 |
| | BRef3 | 85.22 | 85.89 | 89.16 | 92.5 | 93.85 | 98.95 |
| | BRef4 | 85.53 | 86.34 | 89.46 | 93.4 | 94.01 | 97.61 |
| | BRef5 | 85.42 | 85.94 | 89.46 | 93.73 | 95.04 | 98.47 |
| | Mean | 85.52 | 86.24 | 89.39 | 93.37 | 94.58 | 98.45 |
| | StdDev | 0.24 | 0.35 | 0.38 | 0.64 | 0.73 | 0.57 |



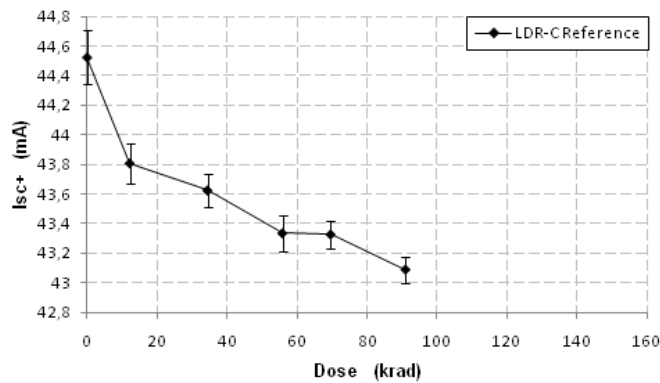
| Raw Data | Device Type: LM158AJ | Parameter: Vo+ (V) | Biasing Condition: Biased | | | | |
|-----------------|----------------------|--------------------|---------------------------|----------|----------|----------|----------|
| LDR-C Reference | Dose (krad) | 0.00 | 12.16 | 34.37 | 55.80 | 69.59 | 91.03 |
| | BRef1 | 13.74 | 13.74 | 13.71 | 13.71 | 13.69 | 13.69 |
| | BRef2 | 13.74 | 13.73 | 13.71 | 13.7 | 13.69 | 13.69 |
| | BRef3 | 13.74 | 13.74 | 13.72 | 13.7 | 13.7 | 13.7 |
| | BRef4 | 13.74 | 13.74 | 13.71 | 13.7 | 13.7 | 13.69 |
| | BRef5 | 13.74 | 13.74 | 13.71 | 13.71 | 13.7 | 13.69 |
| | Mean | 13.74 | 13.73 | 13.71 | 13.70 | 13.69 | 13.69 |
| | StdDev | 0.00 | 4.47E-03 | 4.47E-03 | 5.47E-03 | 5.47E-03 | 4.47E-03 |



| Raw Data | Device Type: LM158AJ | Parameter: Vo- (V) | Biasing Condition: Biased | | | | |
|-----------------|----------------------|--------------------|---------------------------|--------|----------|----------|----------|
| LDR-C Reference | Dose (krad) | 0.00 | 12.16 | 34.37 | 55.80 | 69.59 | 91.03 |
| | BRef1 | -14.97 | -14.96 | -14.95 | -14.94 | -14.95 | -14.95 |
| | BRef2 | -14.97 | -14.96 | -14.95 | -14.95 | -14.95 | -14.95 |
| | BRef3 | -14.96 | -14.96 | -14.95 | -14.94 | -14.94 | -14.94 |
| | BRef4 | -14.96 | -14.96 | -14.95 | -14.94 | -14.94 | -14.95 |
| | BRef5 | -14.96 | -14.95 | -14.95 | -14.94 | -14.94 | -14.95 |
| | Mean | -14.96 | -14.95 | -14.95 | -14.94 | -14.94 | -14.94 |
| | StdDev | 5.47E-03 | 4.47E-03 | 0.00 | 4.47E-03 | 5.47E-03 | 4.47E-03 |

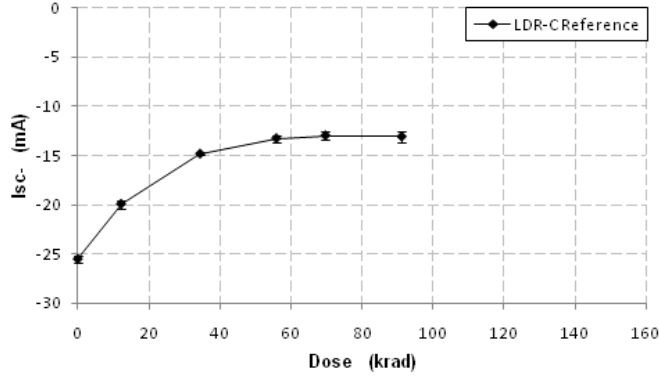


| Raw Data | Device Type: LM158AJ | Parameter: Isc+ (mA) | Biasing Condition: Biased | | | | |
|-----------------|----------------------|----------------------|---------------------------|-------|-------|----------|----------|
| LDR-C Reference | Dose (krad) | 0.00 | 12.16 | 34.37 | 55.80 | 69.59 | 91.03 |
| | BRef1 | 44.24 | 43.63 | 43.45 | 43.14 | 43.18 | 42.97 |
| | BRef2 | 44.53 | 43.87 | 43.67 | 43.41 | 43.43 | 43.11 |
| | BRef3 | 44.62 | 43.91 | 43.7 | 43.36 | 43.31 | 43.07 |
| | BRef4 | 44.51 | 43.7 | 43.57 | 43.31 | 43.33 | 43.07 |
| | BRef5 | 44.72 | 43.93 | 43.73 | 43.45 | 43.38 | 43.22 |
| | Mean | 44.52 | 43.80 | 43.62 | 43.33 | 43.32 | 43.08 |
| | StdDev | 0.17 | 0.13 | 0.11 | 0.12 | 9.39E-02 | 9.01E-02 |



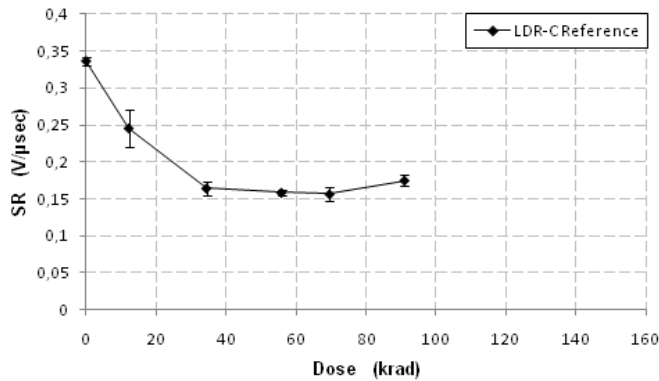
Raw Data — Device Type: LM158AJ Parameter: Isc- (mA) Biasing Condition: Biased

| LDR-C Reference | Dose (krad) | 0.00 | 12.16 | 34.37 | 55.80 | 69.59 | 91.03 |
|-----------------|-------------|--------|--------|--------|--------|--------|--------|
| | BRef1 | -25.33 | -19.63 | -14.78 | -13.4 | -13.16 | -13.34 |
| | BRef2 | -25.27 | -19.79 | -15.06 | -13.73 | -13.51 | -13.7 |
| | BRef3 | -26.01 | -20.61 | -14.86 | -12.82 | -12.32 | -12.23 |
| | BRef4 | -25.26 | -19.57 | -14.81 | -13.47 | -13.25 | -13.48 |
| | BRef5 | -25.83 | -20.13 | -14.72 | -13.03 | -12.73 | -12.77 |
| | Mean | -25.54 | -19.94 | -14.84 | -13.29 | -12.99 | -13.10 |
| | StdDev | 0.35 | 0.43 | 0.12 | 0.36 | 0.46 | 0.59 |

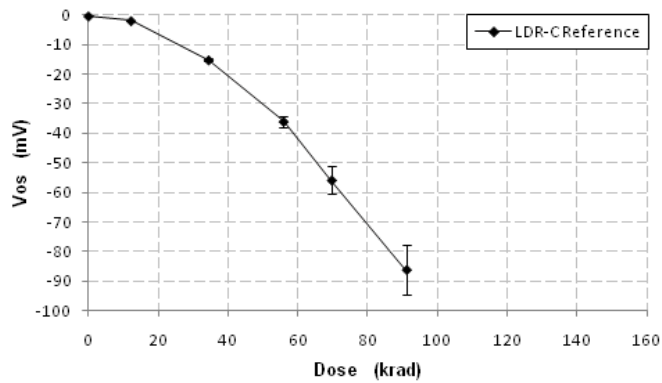


Raw Data — Device Type: LM158AJ Parameter: SR (V/μsec) Biasing Condition: Biased

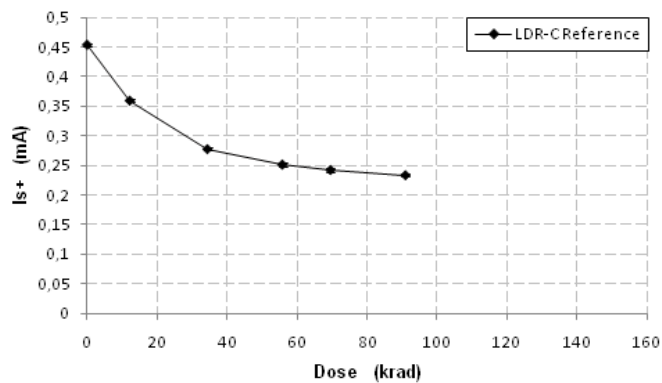
| LDR-C Reference | Dose (krad) | 0.00 | 12.16 | 34.37 | 55.80 | 69.59 | 91.03 |
|-----------------|-------------|----------|----------|----------|----------|----------|----------|
| | BRef1 | 0.33 | 0.22 | 0.15 | 0.15 | 0.17 | 0.18 |
| | BRef2 | 0.33 | 0.28 | 0.17 | 0.15 | 0.14 | 0.17 |
| | BRef3 | 0.34 | 0.25 | 0.17 | 0.16 | 0.16 | 0.16 |
| | BRef4 | 0.32 | 0.22 | 0.16 | 0.15 | 0.15 | 0.17 |
| | BRef5 | 0.34 | 0.24 | 0.15 | 0.16 | 0.15 | 0.17 |
| | Mean | 0.33 | 0.24 | 0.16 | 0.15 | 0.15 | 0.17 |
| | StdDev | 6.01E-03 | 2.53E-02 | 9.34E-03 | 4.15E-03 | 8.70E-03 | 7.28E-03 |



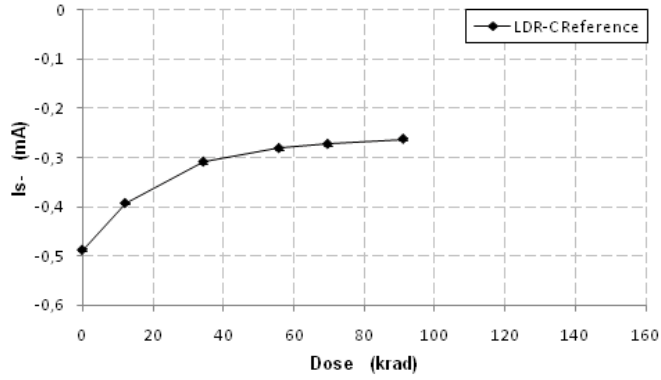
| Reference Data | Device Type: LM158AJ | Parameter: Vos (mV) | Biasing Condition: Unbiased | | | | |
|-----------------|----------------------|---------------------|-----------------------------|--------|--------|--------|--------|
| LDR-C Reference | Dose (krad) | 0.00 | 12.16 | 34.37 | 55.80 | 69.59 | 91.03 |
| | URef1 | -0.30 | -2.04 | -15.31 | -35.91 | -53.38 | -83.34 |
| | URef2 | -0.28 | -1.69 | -15.34 | -39.23 | -63.19 | -100.2 |
| | URef3 | -0.25 | -1.82 | -14.95 | -35.38 | -55.29 | -84.98 |
| | URef4 | -0.25 | -1.80 | -15.52 | -35.36 | -56.61 | -85.44 |
| | URef5 | -0.33 | -2.00 | -14.58 | -33.92 | -50.63 | -76.76 |
| | Mean | -0.28 | -1.87 | -15.14 | -35.96 | -55.82 | -86.14 |
| | StdDev | 3.54E-02 | 0.14 | 0.37 | 1.97 | 4.69 | 8.59 |



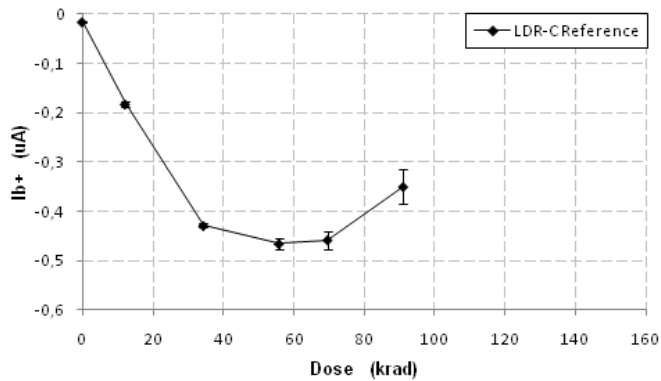
| Reference Data | Device Type: LM158AJ | Parameter: Is+ (mA) | Biasing Condition: Unbiased | | | | |
|-----------------|----------------------|---------------------|-----------------------------|----------|----------|----------|----------|
| LDR-C Reference | Dose (krad) | 0.00 | 12.16 | 34.37 | 55.80 | 69.59 | 91.03 |
| | URef1 | 0.45 | 0.36 | 0.27 | 0.25 | 0.24 | 0.23 |
| | URef2 | 0.45 | 0.35 | 0.27 | 0.24 | 0.23 | 0.22 |
| | URef3 | 0.45 | 0.35 | 0.27 | 0.25 | 0.24 | 0.23 |
| | URef4 | 0.45 | 0.36 | 0.27 | 0.25 | 0.24 | 0.23 |
| | URef5 | 0.45 | 0.36 | 0.28 | 0.25 | 0.24 | 0.23 |
| | Mean | 0.45 | 0.35 | 0.27 | 0.25 | 0.24 | 0.23 |
| | StdDev | 1.89E-03 | 2.36E-03 | 2.49E-03 | 2.98E-03 | 2.80E-03 | 2.71E-03 |



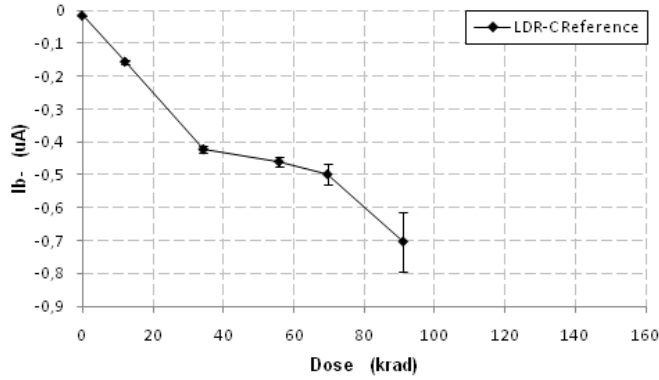
| Reference Data | Device Type: LM158AJ | Parameter: Is- (mA) | | | | | Biasing Condition: Unbiased |
|-----------------|----------------------|---------------------|----------|----------|----------|----------|-----------------------------|
| LDR-C Reference | Dose (krad) | 0.00 | 12.16 | 34.37 | 55.80 | 69.59 | 91.03 |
| | URef1 | -0.48 | -0.39 | -0.30 | -0.28 | -0.27 | -0.26 |
| | URef2 | -0.48 | -0.38 | -0.30 | -0.27 | -0.26 | -0.25 |
| | URef3 | -0.48 | -0.39 | -0.30 | -0.28 | -0.27 | -0.26 |
| | URef4 | -0.48 | -0.39 | -0.30 | -0.28 | -0.27 | -0.26 |
| | URef5 | -0.48 | -0.39 | -0.31 | -0.28 | -0.27 | -0.26 |
| | Mean | -0.48 | -0.39 | -0.30 | -0.28 | -0.27 | -0.26 |
| | StdDev | 1.94E-03 | 2.22E-03 | 2.49E-03 | 2.99E-03 | 2.82E-03 | 2.71E-03 |



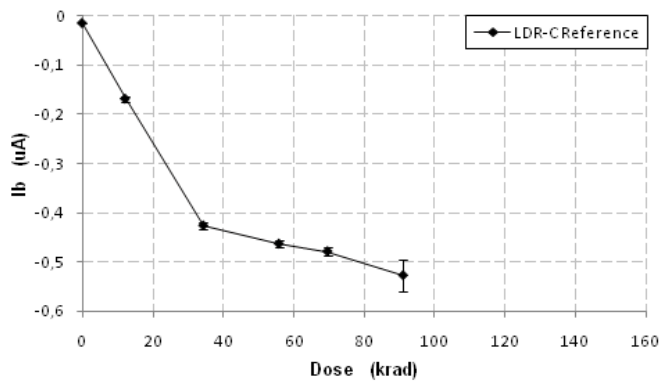
| Reference Data | Device Type: LM158AJ | Parameter: Ib+ (uA) | | | | | Biasing Condition: Unbiased |
|-----------------|----------------------|---------------------|----------|----------|----------|----------|-----------------------------|
| LDR-C Reference | Dose (krad) | 0.00 | 12.16 | 34.37 | 55.80 | 69.59 | 91.03 |
| | URef1 | -0.01 | -0.18 | -0.43 | -0.47 | -0.46 | -0.36 |
| | URef2 | -0.01 | -0.18 | -0.43 | -0.46 | -0.42 | -0.30 |
| | URef3 | -0.01 | -0.17 | -0.42 | -0.47 | -0.47 | -0.32 |
| | URef4 | -0.01 | -0.18 | -0.42 | -0.46 | -0.46 | -0.39 |
| | URef5 | -0.01 | -0.17 | -0.42 | -0.44 | -0.45 | -0.35 |
| | Mean | -0.01 | -0.18 | -0.42 | -0.46 | -0.45 | -0.34 |
| | StdDev | 3.86E-04 | 5.40E-03 | 4.01E-03 | 1.08E-02 | 1.84E-02 | 3.47E-02 |



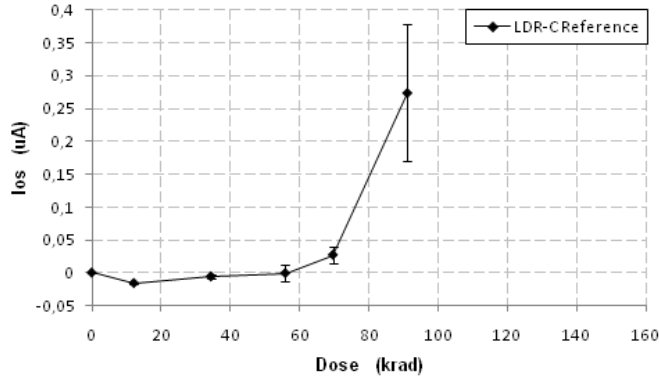
| Reference Data | | Device Type: LM158AJ | | Parameter: Ib- (uA) | | Biasing Condition: Unbiased | |
|-----------------|-------------|----------------------|----------|---------------------|----------|-----------------------------|-------|
| LDR-C Reference | Dose (krad) | 0.00 | 12.16 | 34.37 | 55.80 | 69.59 | 91.03 |
| | URef1 | -0.01 | -0.16 | -0.43 | -0.45 | -0.48 | -0.65 |
| | URef2 | -0.01 | -0.16 | -0.42 | -0.47 | -0.55 | -0.76 |
| | URef3 | -0.01 | -0.15 | -0.42 | -0.46 | -0.48 | -0.83 |
| | URef4 | -0.01 | -0.15 | -0.42 | -0.44 | -0.50 | -0.64 |
| | URef5 | -0.01 | -0.14 | -0.40 | -0.47 | -0.47 | -0.62 |
| | Mean | -0.01 | -0.15 | -0.42 | -0.46 | -0.49 | -0.70 |
| | StdDev | 6.09E-04 | 6.85E-03 | 1.01E-02 | 1.44E-02 | 3.18E-02 | 0.09 |



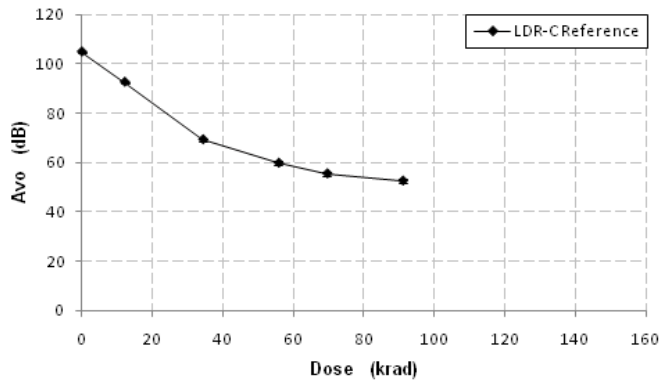
| Reference Data | | Device Type: LM158AJ | | Parameter: Ib (uA) | | Biasing Condition: Unbiased | |
|-----------------|-------------|----------------------|----------|--------------------|----------|-----------------------------|----------|
| LDR-C Reference | Dose (krad) | 0.00 | 12.16 | 34.37 | 55.80 | 69.59 | 91.03 |
| | URef1 | -0.01 | -0.17 | -0.43 | -0.46 | -0.47 | -0.50 |
| | URef2 | -0.01 | -0.17 | -0.43 | -0.47 | -0.49 | -0.53 |
| | URef3 | -0.01 | -0.16 | -0.42 | -0.46 | -0.47 | -0.57 |
| | URef4 | -0.01 | -0.16 | -0.42 | -0.45 | -0.48 | -0.51 |
| | URef5 | -0.01 | -0.16 | -0.41 | -0.46 | -0.46 | -0.49 |
| | Mean | -0.01 | -0.16 | -0.42 | -0.46 | -0.47 | -0.52 |
| | StdDev | 4.00E-04 | 5.87E-03 | 6.74E-03 | 6.67E-03 | 9.38E-03 | 3.24E-02 |



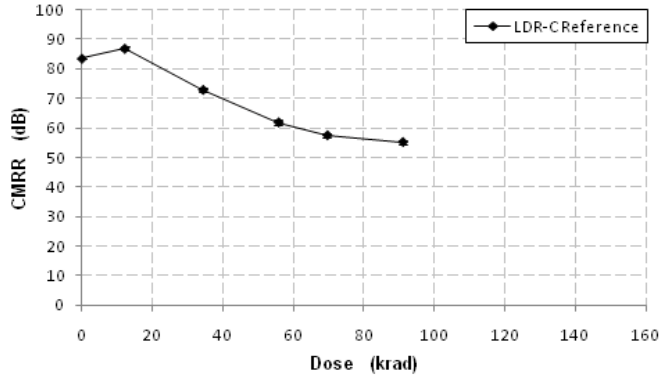
| Reference Data | | Device Type: LM158AJ | | Parameter: Ios (uA) | | Biasing Condition: Unbiased | |
|-----------------|-------------|----------------------|----------|---------------------|----------|-----------------------------|-------|
| LDR-C Reference | Dose (krad) | 0.00 | 12.16 | 34.37 | 55.80 | 69.59 | 91.03 |
| | URef1 | -0.00 | -0.01 | -0.00 | -0.00 | 0.02 | 0.22 |
| | URef2 | -0.00 | -0.01 | -0.00 | 0.00 | 0.04 | 0.38 |
| | URef3 | 0.00 | -0.01 | -0.00 | -0.00 | 0.02 | 0.39 |
| | URef4 | -0.00 | -0.01 | -0.00 | -0.01 | 0.02 | 0.19 |
| | URef5 | 0.00 | -0.01 | -0.01 | 0.01 | 0.01 | 0.17 |
| | Mean | -0.00 | -0.01 | -0.00 | -0.00 | 0.02 | 0.27 |
| | StdDev | 3.88E-04 | 1.45E-03 | 3.19E-03 | 1.26E-02 | 1.17E-02 | 0.10 |



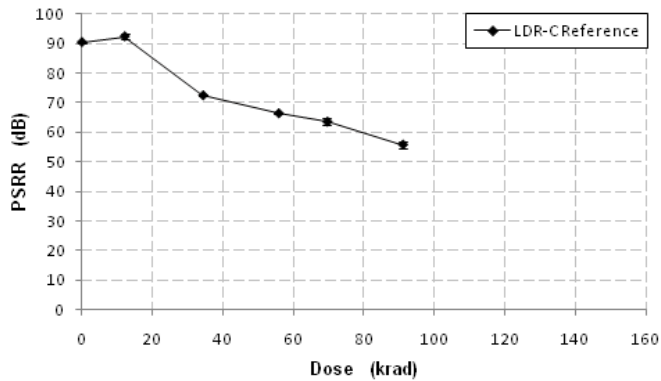
| Reference Data | | Device Type: LM158AJ | | Parameter: Avo (dB) | | Biasing Condition: Unbiased | |
|-----------------|-------------|----------------------|-------|---------------------|-------|-----------------------------|-------|
| LDR-C Reference | Dose (krad) | 0.00 | 12.16 | 34.37 | 55.80 | 69.59 | 91.03 |
| | URef1 | 104.3 | 92.4 | 69.05 | 59.66 | 55.6 | 52.45 |
| | URef2 | 104.5 | 92.41 | 68.51 | 58.65 | 54.18 | 51.25 |
| | URef3 | 105 | 92.44 | 69.11 | 59.56 | 55.25 | 52.62 |
| | URef4 | 105.1 | 92.19 | 68.93 | 59.78 | 55.26 | 52.42 |
| | URef5 | 104.9 | 93 | 70.28 | 60.67 | 56.44 | 53.39 |
| | Mean | 104.76 | 92.48 | 69.17 | 59.66 | 55.34 | 52.42 |
| | StdDev | 0.34 | 0.30 | 0.66 | 0.71 | 0.81 | 0.76 |



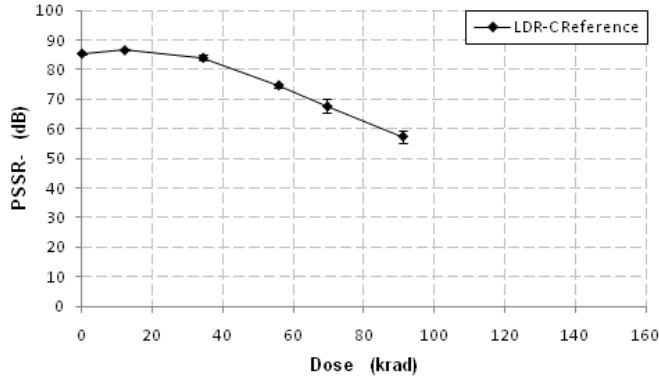
| Reference Data | | Device Type: LM158AJ | | Parameter: CMRR (dB) | | Biasing Condition: Unbiased | |
|-----------------|-------------|----------------------|-------|----------------------|-------|-----------------------------|-------|
| LDR-C Reference | Dose (krad) | 0.00 | 12.16 | 34.37 | 55.80 | 69.59 | 91.03 |
| | URef1 | 83.37 | 86.39 | 72.66 | 61.64 | 57.49 | 54.99 |
| | URef2 | 83.36 | 86.94 | 71.78 | 60.61 | 56.19 | 54.25 |
| | URef3 | 83.58 | 87.33 | 72.74 | 61.63 | 57.24 | 55.11 |
| | URef4 | 83.63 | 87.48 | 72.82 | 61.95 | 57.35 | 55.02 |
| | URef5 | 83.44 | 86.22 | 74.27 | 63.07 | 58.55 | 55.91 |
| | Mean | 83.47 | 86.87 | 72.85 | 61.78 | 57.36 | 55.05 |
| | StdDev | 0.12 | 0.55 | 0.89 | 0.88 | 0.83 | 0.58 |



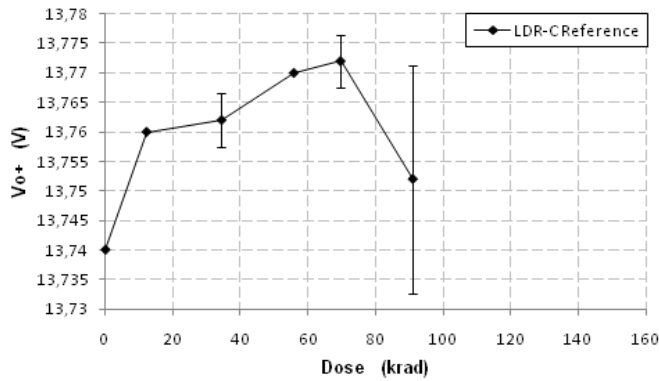
| Reference Data | | Device Type: LM158AJ | | Parameter: PSRR (dB) | | Biasing Condition: Unbiased | |
|-----------------|-------------|----------------------|-------|----------------------|-------|-----------------------------|-------|
| LDR-C Reference | Dose (krad) | 0.00 | 12.16 | 34.37 | 55.80 | 69.59 | 91.03 |
| | URef1 | 90.17 | 91.93 | 71.98 | 66.54 | 65.16 | 56.4 |
| | URef2 | 90.55 | 91.79 | 72.7 | 65.87 | 61.9 | 54.03 |
| | URef3 | 90.47 | 92.81 | 72.57 | 66.64 | 63.47 | 55.87 |
| | URef4 | 90.58 | 91.84 | 72.28 | 66.35 | 62.92 | 55.72 |
| | URef5 | 90.51 | 93.59 | 72.64 | 66.35 | 64.03 | 56.84 |
| | Mean | 90.45 | 92.39 | 72.43 | 66.35 | 63.49 | 55.77 |
| | StdDev | 0.16 | 0.78 | 0.30 | 0.29 | 1.21 | 1.07 |



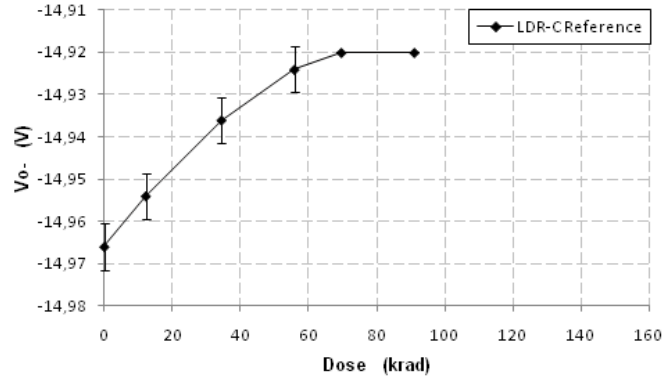
| Reference Data | | Device Type: LM158AJ | | Parameter: PSSR- (dB) | | Biasing Condition: Unbiased | |
|-----------------|-------------|----------------------|-------|-----------------------|-------|-----------------------------|-------|
| LDR-C Reference | Dose (krad) | 0.00 | 12.16 | 34.37 | 55.80 | 69.59 | 91.03 |
| | URef1 | 85.27 | 86.39 | 82.89 | 74.96 | 70.82 | 57.84 |
| | URef2 | 85.49 | 86.67 | 84.04 | 73.61 | 64.62 | 53.99 |
| | URef3 | 85.61 | 86.72 | 84.24 | 75.1 | 67.17 | 58.06 |
| | URef4 | 85.67 | 86.74 | 83.6 | 74.91 | 66.54 | 57.89 |
| | URef5 | 85.42 | 86.57 | 85.41 | 75.28 | 69.06 | 59.6 |
| | Mean | 85.49 | 86.61 | 84.03 | 74.77 | 67.64 | 57.47 |
| | StdDev | 0.15 | 0.14 | 0.92 | 0.66 | 2.38 | 2.08 |



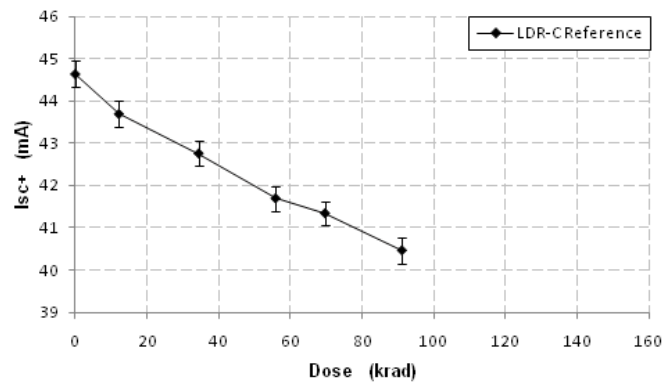
| Reference Data | | Device Type: LM158AJ | | Parameter: Vo+ (V) | | Biasing Condition: Unbiased | |
|-----------------|-------------|----------------------|-------|--------------------|-------|-----------------------------|----------|
| LDR-C Reference | Dose (krad) | 0.00 | 12.16 | 34.37 | 55.80 | 69.59 | 91.03 |
| | URef1 | 13.74 | 13.76 | 13.76 | 13.77 | 13.78 | 13.76 |
| | URef2 | 13.74 | 13.76 | 13.77 | 13.77 | 13.77 | 13.72 |
| | URef3 | 13.74 | 13.76 | 13.76 | 13.77 | 13.77 | 13.76 |
| | URef4 | 13.74 | 13.76 | 13.76 | 13.77 | 13.77 | 13.75 |
| | URef5 | 13.74 | 13.76 | 13.76 | 13.77 | 13.77 | 13.77 |
| | Mean | 13.74 | 13.76 | 13.76 | 13.77 | 13.77 | 13.75 |
| | StdDev | 0.00 | 0.00 | 4.47E-03 | 0.00 | 4.47E-03 | 1.92E-02 |



| Reference Data | | Device Type: LM158AJ | | Parameter: Vo- (V) | | Biasing Condition: Unbiased | |
|-----------------|-------------|----------------------|----------|--------------------|----------|-----------------------------|----------|
| LDR-C Reference | Dose (krad) | 0.00 | 12.16 | 34.37 | 55.80 | 69.59 | 91.03 |
| | URef1 | -14.97 | -14.96 | -14.93 | -14.93 | -14.92 | -14.92 |
| | URef2 | -14.96 | -14.95 | -14.94 | -14.92 | -14.92 | -14.92 |
| | URef3 | -14.96 | -14.95 | -14.93 | -14.92 | -14.92 | -14.92 |
| | URef4 | -14.97 | -14.95 | -14.94 | -14.92 | -14.92 | -14.92 |
| | URef5 | -14.97 | -14.96 | -14.94 | -14.93 | -14.92 | -14.92 |
| | Mean | -14.96 | -14.95 | -14.93 | -14.92 | -14.92 | -14.92 |
| | StdDev | 5.47E-03 | 5.47E-03 | 5.47E-03 | 5.47E-03 | 1.98E-15 | 1.98E-15 |

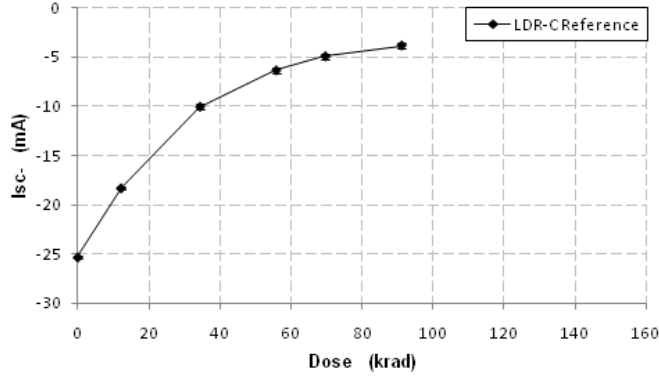


| Reference Data | | Device Type: LM158AJ | | Parameter: Isc+ (mA) | | Biasing Condition: Unbiased | |
|-----------------|-------------|----------------------|-------|----------------------|-------|-----------------------------|-------|
| LDR-C Reference | Dose (krad) | 0.00 | 12.16 | 34.37 | 55.80 | 69.59 | 91.03 |
| | URef1 | 44.43 | 43.47 | 42.54 | 41.52 | 41.13 | 40.29 |
| | URef2 | 44.94 | 43.94 | 42.98 | 41.82 | 41.41 | 40.38 |
| | URef3 | 44.67 | 43.72 | 42.78 | 41.69 | 41.37 | 40.47 |
| | URef4 | 44.23 | 43.33 | 42.4 | 41.35 | 41.04 | 40.21 |
| | URef5 | 44.93 | 44.03 | 43.12 | 42.12 | 41.78 | 40.99 |
| | Mean | 44.64 | 43.69 | 42.76 | 41.7 | 41.34 | 40.46 |
| | StdDev | 0.31 | 0.29 | 0.29 | 0.29 | 0.28 | 0.30 |



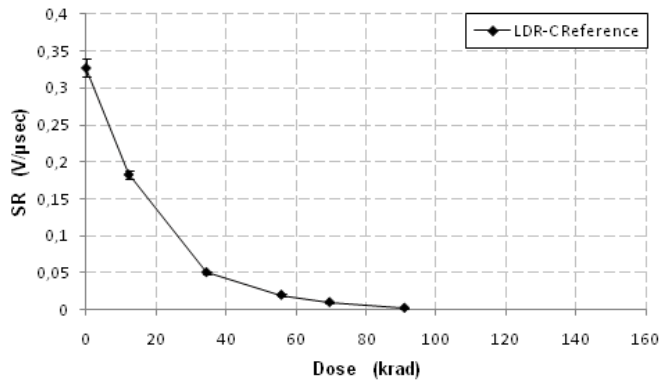
Reference Data — Device Type: LM158AJ Parameter: I_{sc} (mA) Biasing Condition: Unbiased

| LDR-C Reference | Dose (krad) | 0.00 | 12.16 | 34.37 | 55.80 | 69.59 | 91.03 |
|-----------------|-------------|--------|--------|--------|-------|-------|-------|
| | URef1 | -25.28 | -18.27 | -10.02 | -6.34 | -4.97 | -3.89 |
| | URef2 | -25.56 | -18.31 | -9.73 | -5.96 | -4.57 | -3.53 |
| | URef3 | -25.24 | -18.25 | -10.01 | -6.33 | -4.90 | -3.80 |
| | URef4 | -25.07 | -18.15 | -10.02 | -6.41 | -4.97 | -3.87 |
| | URef5 | -25.34 | -18.56 | -10.51 | -6.83 | -5.38 | -4.22 |
| | Mean | -25.29 | -18.30 | -10.05 | -6.37 | -4.96 | -3.86 |
| | StdDev | 0.17 | 0.15 | 0.27 | 0.30 | 0.28 | 0.24 |



Reference Data — Device Type: LM158AJ Parameter: SR (V/μsec) Biasing Condition: Unbiased

| LDR-C Reference | Dose (krad) | 0.00 | 12.16 | 34.37 | 55.80 | 69.59 | 91.03 |
|-----------------|-------------|----------|----------|----------|----------|-------|----------|
| | URef1 | 0.34 | 0.17 | 0.05 | 0.01 | 0.01 | 0.00 |
| | URef2 | 0.32 | 0.18 | 0.04 | 0.01 | 0.01 | 0.00 |
| | URef3 | 0.33 | 0.18 | 0.04 | 0.01 | 0.00 | 0.00 |
| | URef4 | 0.30 | 0.18 | 0.05 | 0.02 | 0.00 | 0.00 |
| | URef5 | 0.32 | 0.18 | 0.05 | 0.02 | 0.01 | 0.00 |
| | Mean | 0.32 | 0.18 | 0.05 | 0.01 | 0.01 | 0.00 |
| | StdDev | 1.15E-02 | 6.00E-03 | 1.67E-03 | 1.64E-03 | 0.00 | 4.47E-04 |



Contact

AIT Austrian Institute of Technology GmbH
Donau-City-Straße 1, 1220 Wien, Austria

www.ait.ac.at
Fax +43 (0) 50550-2201

Dr. Peter Beck
Nanodosimetry
+43 (0) 50550-4305
hubert.brueckl@ait.ac.at

Mag. Dr. Susanne Kiefer
Marketing
+43 (0) 50550-3579
susanne.kiefer@ait.ac.at

Mag. Shweta Kumar
Sekretary
+43 (0) 50550-4300
Kerstin.formanek@ait.ac.at