A radiation evaluation was performed on MIC4429AJB High-Speed, High-Current, Single MOSFET Driver (Micrel) to determine the total dose tolerance of these parts. A brief summary of the test results is provided below. For detailed information, refer to Tables I through IV and Figure 1.

The total dose testing was performed using a Co$^{60}$ gamma ray source. During the radiation testing, five parts were irradiated under bias (see Figure 1 for bias configuration) and two parts were used as control samples. The total dose radiation levels were 5.0, 10.0, 15.0, 20.0, 30.0, 50.0, and 100.0 kRads. The dose rate was between 0.125 and 0.625 kRads/hour (0.035 to 0.174 Rads/s). After the 100.0 kRad exposure, the parts were annealed for 216 hours at 25°C. See Table II for the radiation schedule and effective dose rate calculation. The effective dose rate over all testing was 0.068 Rads/sec. After each radiation exposure and annealing treatment, parts were electrically tested according to the test conditions and the specification limits listed in Table III.

Initial electrical measurements were made on 6 samples. Five samples (SN’s 181, 182, 183, 184, and 185) were used as radiation samples while SN 180 was used as a control sample. All parts passed all tests during initial electrical measurements.

**VOL/VOH Tests**
For $V_s = 10V$, all parts passed all functional tests up to 15 kRads. All parts passed all VOH tests for hard 0V and $V_{il} = 0.2V$ and 0.4V up to 50kRads. At 100 kRads, some parts did fail VOH tests, even for $V_{il} = 0V$. For $V_s = 15V$, all parts passed all VOH tests up to 10 kRads. At 15 and 20 kRads, the parts failed VOH tests at $V_{il} = 0.8V$ but passed for $V_{il} = 0, 0.2, 0.4, and 0.6V$. All parts passed all VOH tests at $V_{il} = 0V$ and 0.2V through 100 kRads with most parts failing at $V_{il} = 0.4V$.

For the VOH = 4.5V functional tests, one part failed the $V_{il} = 0.8V$ test at 5 kRads, most parts failed all VOH tests including $V_{il} = 0V$ at 10 kRads, and all parts failed all tests for VOH at 15 kRads.

All parts passed all VOL tests at all voltages through 100 kRads. See Table V for further details.

**Parametric Tests**
After the 20.0 kRad irradiation, three parts exceeded the specification limit of 2.80Ω for ROUT_1 with readings greater than 51.2Ω. All parts passed all other tests.

After the 30.0 kRad irradiation, one part passed, four parts failed ROUT_1, all failing parts read $>51.2Ω$. All parts passed all other tests.

* The term Rads, as used in this document, means Rads (silicon). All radiation levels cited are cumulative.
** These are manufacturer’s pre-irradiation data specification limits. The manufacturer provided no post-irradiation limits at the time these tests were performed.
After the 50.0 kRad irradiation, all parts exceeded the specification limit for ROUT_1 with readings of >51.2Ω. **All parts passed all other tests.**

After the 100.0 kRad irradiation, three parts exceeded the specification limit of 0.150mA for Icc_0V_10V with readings of 1.376, 0.915, and 1.316mA. All parts exceeded the specification limit for ROUT_1 with readings of >51.2Ω. **All parts passed all other tests.**

After annealing the parts for 216 hours at 25°C, parts showed significant recovery. **All parts passed all other tests.**

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 me at (301) 731-8954.

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Figure 1. Radiation Bias Circuit for MIC4429

Notes:
1. Resistor is 10kΩ ±5% ¼W.
2. $V_S = 10.0 ±0.5V$, $V_{IN} = 0V$. 
<table>
<thead>
<tr>
<th>Generic Part Number</th>
<th>MIC4429</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAP SUBSYS. Part Number</td>
<td>MIC4429AJB</td>
</tr>
<tr>
<td>Charge Number</td>
<td>C80594</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>Micrel</td>
</tr>
<tr>
<td>Lot Date Code (LDC)</td>
<td>9309</td>
</tr>
<tr>
<td>Quantity Tested</td>
<td>6</td>
</tr>
<tr>
<td>Serial Number of Control Samples</td>
<td>180</td>
</tr>
<tr>
<td>Serial Numbers of Radiation Samples</td>
<td>181, 182, 183, 184, and 185</td>
</tr>
<tr>
<td>Part Function</td>
<td>High-Speed, High-Current, Dingle MOSFET Driver</td>
</tr>
<tr>
<td>Part Technology</td>
<td>Bipolar</td>
</tr>
<tr>
<td>Package Style</td>
<td>8 Pin DIP</td>
</tr>
<tr>
<td>Test Equipment</td>
<td>A540</td>
</tr>
<tr>
<td>Test Engineer</td>
<td>D. Davis</td>
</tr>
</tbody>
</table>

- No radiation tolerance/hardness was guaranteed by the manufacturer for this part.
### TABLE II. Radiation Schedule for MIC4429

<table>
<thead>
<tr>
<th>EVENT</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) INITIAL ELECTRICAL MEASUREMENT</td>
<td>12/06/97</td>
</tr>
<tr>
<td>2) 5.0 KRAD IRRADIATION (0.250 KRADS/HOUR)</td>
<td>12/08/97</td>
</tr>
<tr>
<td>POST-5.0 KRAD ELECTRICAL MEASUREMENT</td>
<td>12/09/97</td>
</tr>
<tr>
<td>3) 10.0 KRAD IRRADIATION (0.250 KRADS/HOUR)</td>
<td>12/09/97</td>
</tr>
<tr>
<td>POST-10.0 KRAD ELECTRICAL MEASUREMENT</td>
<td>12/10/97</td>
</tr>
<tr>
<td>4) 15.0 KRAD IRRADIATION (0.125 KRADS/HOUR)</td>
<td>12/10/97</td>
</tr>
<tr>
<td>POST-15.0 KRAD ELECTRICAL MEASUREMENT</td>
<td>12/12/97</td>
</tr>
<tr>
<td>5) 20.0 KRAD IRRADIATION (0.125 KRADS/HOUR)</td>
<td>12/15/97</td>
</tr>
<tr>
<td>POST-20.0 KRAD ELECTRICAL MEASUREMENT</td>
<td>12/17/97</td>
</tr>
<tr>
<td>6) 30.0 KRAD IRRADIATION (0.250 KRADS/HOUR)</td>
<td>12/17/97</td>
</tr>
<tr>
<td>POST-30.0 KRAD ELECTRICAL MEASUREMENT</td>
<td>12/19/97</td>
</tr>
<tr>
<td>7) 50.0 KRAD IRRADIATION (0.500 KRADS/HOUR)</td>
<td>12/19/97</td>
</tr>
<tr>
<td>POST-50.0 KRAD ELECTRICAL MEASUREMENT</td>
<td>12/22/97</td>
</tr>
<tr>
<td>8) 100.0 KRAD IRRADIATION (0.625 KRADS/HOUR)</td>
<td>12/22/97</td>
</tr>
<tr>
<td>POST-100.0 KRAD ELECTRICAL MEASUREMENT</td>
<td>12/24/97</td>
</tr>
<tr>
<td>9) 216 HOUR ANNEALING @25°C</td>
<td>12/24/97</td>
</tr>
<tr>
<td>POST-216 HOUR ANNEAL ELECTRICAL MEASUREMENT</td>
<td>01/02/98</td>
</tr>
</tbody>
</table>

Effective Dose Rate = 100,000 RADS/17 DAYS = 245.1 RADS/HOUR = 0.068 RADS/SEC

The effective dose rate is lower than that of the individual radiation steps as it takes into account the interim-annealing step.

PARTS WERE IRRADIATED AND ANNEALED UNDER BIAS, SEE FIGURE 1.
Table III. Electrical Characteristics of MIC4429 /1  

<table>
<thead>
<tr>
<th>Test #</th>
<th>Parameter</th>
<th>Units</th>
<th>Test Conditions /2</th>
<th>Spec. min</th>
<th>Lim. max</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,3,5</td>
<td>Icc_0V</td>
<td>mA</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 4.5, 10, &amp; 15V, V&lt;sub&gt;IN&lt;/sub&gt; = 0V</td>
<td>0</td>
<td>0.15</td>
</tr>
<tr>
<td>2,4,6</td>
<td>Icc_3V</td>
<td>mA</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 4.5, 10, &amp; 15V, V&lt;sub&gt;IN&lt;/sub&gt; = 3V</td>
<td>0</td>
<td>1.5</td>
</tr>
<tr>
<td>13,19,25,31,37</td>
<td><a href="mailto:4.5V_VOL@vih_4.5V">4.5V_VOL@vih_4.5V</a></td>
<td>V</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 4.5V, V&lt;sub&gt;III&lt;/sub&gt; = 4.5V</td>
<td>0</td>
<td>1.5</td>
</tr>
<tr>
<td>14,20,26,32,38</td>
<td>4.5V_VOH@vil_*.V</td>
<td>V</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 4.5V, V&lt;sub&gt;III&lt;/sub&gt; = 0.0 to 0.8V in 0.2V steps</td>
<td>4.475</td>
<td>0.025</td>
</tr>
<tr>
<td>15,21,27,33,39</td>
<td>10V_VOL@vih_10V</td>
<td>V</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 10V, V&lt;sub&gt;III&lt;/sub&gt; = 10V</td>
<td>0</td>
<td>0.025</td>
</tr>
<tr>
<td>16,22,28,34,40</td>
<td>10V_VOH@vil_*.V</td>
<td>V</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 10V, V&lt;sub&gt;III&lt;/sub&gt; = 0.0 to 0.8V in 0.2V steps</td>
<td>9.975</td>
<td>0.025</td>
</tr>
<tr>
<td>17,23,29,35,41</td>
<td>15V_VOL@vih_15V</td>
<td>V</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 15V, V&lt;sub&gt;III&lt;/sub&gt; = 15V</td>
<td>0</td>
<td>0.025</td>
</tr>
<tr>
<td>18,24,30,36,42</td>
<td>15V_VOH@vil_*.V</td>
<td>V</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 15V, V&lt;sub&gt;III&lt;/sub&gt; = 0.0 to 0.8V in 0.2V steps</td>
<td>14.975</td>
<td>0.025</td>
</tr>
<tr>
<td>43</td>
<td>ROUT_1</td>
<td>Ω</td>
<td>I&lt;sub&gt;OUT&lt;/sub&gt; = 10mA, V&lt;sub&gt;DD&lt;/sub&gt; = 18V</td>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>HARD_ROUT_1</td>
<td>Ω</td>
<td>I&lt;sub&gt;OUT&lt;/sub&gt; = 10mA, V&lt;sub&gt;DD&lt;/sub&gt; = 18V</td>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>ROUT_0</td>
<td>Ω</td>
<td>I&lt;sub&gt;OUT&lt;/sub&gt; = 10mA, V&lt;sub&gt;DD&lt;/sub&gt; = 18V</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>HARD_ROUT_0</td>
<td>Ω</td>
<td>I&lt;sub&gt;OUT&lt;/sub&gt; = 10mA, V&lt;sub&gt;DD&lt;/sub&gt; = 18V</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>III_4.5V</td>
<td>μA</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 4.5V</td>
<td>-10.0</td>
<td>10.0</td>
</tr>
<tr>
<td>48</td>
<td>IIIH_4.5V</td>
<td>μA</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 4.5V</td>
<td>-10.0</td>
<td>10.0</td>
</tr>
<tr>
<td>49</td>
<td>III_10V</td>
<td>μA</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 10V</td>
<td>-10.0</td>
<td>10.0</td>
</tr>
<tr>
<td>50</td>
<td>IIIH_10V</td>
<td>μA</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 10V</td>
<td>-10.0</td>
<td>10.0</td>
</tr>
<tr>
<td>51</td>
<td>III_15V</td>
<td>μA</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 15V</td>
<td>-10.0</td>
<td>10.0</td>
</tr>
<tr>
<td>52</td>
<td>IIIH_15V</td>
<td>μA</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 15V</td>
<td>-10.0</td>
<td>10.0</td>
</tr>
</tbody>
</table>

Notes:

1/ These are the manufacturer’s non-irradiated data sheet specification limits. No post-irradiation limits were provided by the manufacturer at the time the tests were performed.

2/ For all tests, ±V<sub>S</sub> = ±15V, T<sub>A</sub> = 25°C unless otherwise specified.
**TABLE IV: Summary of Electrical Measurements after Total Dose Exposures and Annealing for MIC4429**

| Test # | Parameters /3 | Spec. Lim. /2 | Units | min | max | Initial | 5.0 | 10.0 | 15.0 | 20.0 | 30.0 | 50.0 | 100.0 | 216 hours @25°C |
|--------|---------------|---------------|-------|-----|-----|---------|-----|-----|-----|-----|-----|-----|-------|------------|----------------|
| 1      | Icc_0V_4.5V   | mA            | 0     | 0.15|     | 0.049  | 0.009| 0.025| 0.015| 0.005| 0.005| 0.005| 0.004| 0.005| 0.130  | 0.075| 0.011 | 0.006| 0.007 | 0.009|        |
| 2      | Icc_3V_4.5V   | mA            | 0     | 1.5 |     | 0.247  | 0.036| 0.117| 0.084| 0.012| 0.002| 0.010| 0.001| 0.024| 0.012| 0.048  | 0.028| 0.111 | 0.053| 0.016 | 0.027| 0.007 | 0.012 |
| 3      | Icc_0V_10V    | mA            | 0     | 0.15|     | 0.057  | 0.014| 0.041| 0.012| 0.029| 0.013| 0.025| 0.013| 0.019| 0.005| 0.021  | 0.013| 0.019 | 0.014| 0.733 | 0.597| 0.359 | 0.448 |
| 4      | Icc_3V_10V    | mA            | 0     | 1.5 |     | 0.343  | 0.041| 0.186| 0.055| 0.111| 0.026| 0.085| 0.009| 0.091| 0.012| 0.108  | 0.024| 0.171 | 0.058| 0.061 | 0.027| 0.051 | 0.012 |
| 5      | Icc_0V_15V    | mA            | 0     | 0.15|     | 0.094  | 0.027| 0.065| 0.020| 0.059| 0.022| 0.057| 0.021| 0.053| 0.020| 0.051  | 0.020| 0.048 | 0.022| 0.054 | 0.022| 0.044 | 0.021 |
| 6      | Icc_3V_15V    | mA            | 0     | 1.5 |     | 0.435  | 0.046| 0.277| 0.022| 0.233| 0.024| 0.210| 0.016| 0.212| 0.023| 0.225  | 0.022| 0.283 | 0.059| 0.168 | 0.032| 0.154 | 0.017 |
| 43     | ROUT_1 /4     | Ω             | 2.8   |    |     | 1.3  | 0  | 0  | 0  | 0  | 1.4  | 0  | 1.4  | 0  | 1.4  | 0  | 2P/3F | >51.2 | >51.2 | >51.2 |
| 44     | HARD_ROUT_1   | Ω             | 2.8   |    |     | 1.3  | 0  | 0  | 0  | 0  | 1.4  | 0  | 1.4  | 0  | 1.5  | 0  | 1.5  | 0  | 1.5  | 0  | 1.6  | 0.08 | 1.6  | 0.08 |
| 45     | ROUT_0        | Ω             | 2.5   |    |     | 1.7  | 0.04| 1.7  | 0.04| 1.7  | 0.05| 1.7  | 0.05| 1.7  | 0.05| 1.7  | 0.05| 1.7  | 0.05| 1.7  | 0.05 |
| 46     | HARD_ROUT_0   | Ω             | 2.5   |    |     | 1.7  | 0.04| 1.7  | 0.04| 1.7  | 0.05| 1.7  | 0.05| 1.7  | 0.05| 1.7  | 0.05| 1.7  | 0.05| 1.7  | 0.05 |
| 47     | IIL_4.5V      | μA            | -10.0 | 10.0|     | -0.02 | 0.001| -0.02 | 0.001| -0.02 | 0.001| -0.02 | 0.001| -0.02 | 0.001| -0.02 | 0.001| -0.02 | 0.001| -0.02 | 0.001|        |
| 48     | IIH_4.5V      | μA            | -10.0 | 10.0|     | 0.03  | 0  | 0.03 | 0.001| 0.03 | 0.002| 0.02 | 0.001| 0.02 | 0.001| 0.02 | 0.001| 0.02 | 0.001| 0.02 | 0.001| 0.02 | 0.003 |
| 49     | IIL_10V       | μA            | -10.0 | 10.0|     | -0.02 | 0.001| -0.02 | 0.001| -0.02 | 0.001| -0.02 | 0.001| -0.02 | 0.001| -0.02 | 0.001| -0.02 | 0.001| -0.02 | 0.001| -0.02 | 0.003 |
| 50     | IIIH_10V      | μA            | -10.0 | 10.0|     | 0.07  | 0.001| 0.07  | 0.001| 0.06  | 0.001| 0.06  | 0.001| 0.06  | 0.001| 0.06  | 0.001| 0.06  | 0.001| 0.06  | 0.001| 0.06  | 0.001 |
| 51     | IIL_15V       | μA            | -10.0 | 10.0|     | -0.06 | 0.011| -0.04 | 0.004| -0.05 | 0.003| -0.06 | 0.001| -0.06 | 0.001| -0.06 | 0.001| -0.06 | 0.001| -0.06 | 0.001| -0.08 | 0.015 |
| 52     | IIIH_15V      | μA            | -10.0 | 10.0|     | 0.06  | 0.001| 0.07  | 0.001| 0.06  | 0.001| 0.06  | 0.001| 0.06  | 0.001| 0.06  | 0.001| 0.06  | 0.001| 0.06  | 0.001| 0.06  | 0.001 |

Notes:
1/ The mean and standard deviation values were calculated over the five parts irradiated in this testing. The control samples remained constant throughout testing and are not included in this table.
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/ See Table V for tests 13 to 42.
4/ "P" ("F") implies all parts passed (failed) this test at this level. nPmF implies that "n" parts passed and "m" parts failed this test at this level.

Radiation sensitive parameters: ROUT_1, Icc_0V_10V.
TABLE V: Summary of Electrical Measurements after Total Dose Exposures and Annealing for MIC4429 /1 VOL/VOH Tests

<table>
<thead>
<tr>
<th>Test #</th>
<th>Parameters /3</th>
<th>Spec. Lim. /2</th>
<th>Units</th>
<th>min</th>
<th>max</th>
<th>Initial</th>
<th>5.0</th>
<th>10.0</th>
<th>15.0</th>
<th>20.0</th>
<th>30.0</th>
<th>50.0</th>
<th>100.0</th>
<th>216 hours @25°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td><a href="mailto:4.5V_VOL@vih_4.5V">4.5V_VOL@vih_4.5V</a> V</td>
<td>0.025</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>14</td>
<td><a href="mailto:4.5V_VOH@vil_0.0V">4.5V_VOH@vil_0.0V</a> V</td>
<td>4.475</td>
<td>P</td>
<td>P</td>
<td>2P/3F</td>
<td>F</td>
<td>1P/4F</td>
<td>F</td>
<td>F</td>
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<td>F</td>
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<tr>
<td>20</td>
<td><a href="mailto:4.5V_VOH@vil_0.2V">4.5V_VOH@vil_0.2V</a> V</td>
<td>4.475</td>
<td>P</td>
<td>P</td>
<td>2P/3F</td>
<td>F</td>
<td>1P/4F</td>
<td>F</td>
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<td>26</td>
<td><a href="mailto:4.5V_VOH@vil_0.4V">4.5V_VOH@vil_0.4V</a> V</td>
<td>4.475</td>
<td>P</td>
<td>P</td>
<td>1P/4F</td>
<td>F</td>
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<td>32</td>
<td><a href="mailto:4.5V_VOH@vil_0.6V">4.5V_VOH@vil_0.6V</a> V</td>
<td>4.475</td>
<td>P</td>
<td>P</td>
<td>1P/4F</td>
<td>F</td>
<td>1P/4F</td>
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<tr>
<td>38</td>
<td><a href="mailto:4.5V_VOH@vil_0.8V">4.5V_VOH@vil_0.8V</a> V</td>
<td>4.475</td>
<td>P</td>
<td>4P/1F</td>
<td>1P/4F</td>
<td>F</td>
<td>F</td>
<td>F</td>
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</tr>
<tr>
<td>15</td>
<td>10V_VOL@vih_10V V</td>
<td>0.025</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
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<td>16</td>
<td><a href="mailto:10V_VOH@vil_0.0V">10V_VOH@vil_0.0V</a> V</td>
<td>9.975</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>2P/3F</td>
<td>3P/2F</td>
<td>3P/2F</td>
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<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>2P/3F</td>
<td>3P/2F</td>
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<td>9.975</td>
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<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>2P/3F</td>
<td>3P/2F</td>
<td>3P/2F</td>
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<td><a href="mailto:10V_VOH@vil_0.6V">10V_VOH@vil_0.6V</a> V</td>
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<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>2P/3F</td>
<td>F</td>
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<td>14.975</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
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<td>36</td>
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<td>14.975</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>1P/4F</td>
<td>F</td>
<td>F</td>
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<td>42</td>
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<td>14.975</td>
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<td>P</td>
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<td>F</td>
<td>F</td>
<td>F</td>
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</table>

Notes:
1/ The mean and standard deviation values were calculated over the five parts irradiated in this testing. The control samples remained constant throughout testing and are not included in this table.
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/ "P" ("F") implies all parts passed (failed) this test at this level. nPmF implies that "n" parts passed and "m" parts failed this test at this level.

Radiation sensitive parameters: 4.5V_VOH@vil_*.0V, 10V_VOH@vil_*.0V, 15V_VOH@vil_0.4/0.6/0.8V.