Electronic Parts Engineering

NASA Reliability/Quality Data Analysis

High Speed 16-bit Operational Amplifier Part Type

Preliminary Release for NASA Distribution Only

Commercial Off-The-Shelf Plastic Encapsulated Microcircuits Evaluation for NASA Space Requirements

NASA NEPP Task Number 100774 1.J.49.1
Contents:

• Burn-In Data Analysis; slides

• FIT Data Analysis; slides

• Initial Electrical Data Analysis; slides

• Operating Life Data Analysis; slides

• Incoming Quality Analysis; slides

• Summary; slides
Vendor B Burn-In Data
Reliability Analysis

“High Speed 16-bit Operational Amplifier”

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The purpose of this test is to electrically and thermally stress the parts to identify/accelerate potential failure modes due to weak devices which can then be eliminated
Introduction

This reliability analysis highlights Vos (Input Offset Voltage) rated at Vsupply of ±15V and ± 5V. This report does not include failure analysis as to the root cause such as design, process, or assembly faults.

Various plots and graphs are shown that demonstrate reliability and data sheet electrical performance.

Reliability of a component is finding out the probability that the component will perform under it’s intended operating conditions for a set period of time. A degradation failure has occurred if a parameter value drifts or degrades outside a pre-determined limit or an imposed performance application requirement(s).
DEFINING AN EFFECTIVE BURN-IN

If \( F_b(t) \) = failure distribution (all failures) \textit{before} burn-in

And \( F_a(t) \) = failure distribution (all failures) \textit{after} burn-in

And \( \tau \) is the burn-in time

Then \( F_a(t) = \frac{[F_b(t + \tau) - F_b(\tau)]}{[1 - F_b(\tau)]} \)

For burn-in to be \textit{effective}, \( F_a \) must be superior to \( F_b \)

\[
\lambda = \left( \frac{\gamma}{n \times t \times Kt \times Kv} \right) \times 1E9 \ [\text{fit}]
\]

\[
Kt = \exp \left[ \frac{Ea}{k} \left( \frac{1}{T1} - \frac{1}{T2} \right) \right]
\]

\[
Kv = 10^{B(E2-E1)}
\]

Failure Rate Calculation

<table>
<thead>
<tr>
<th>Number of Failures</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient ( \gamma )</td>
<td>0.92</td>
<td>2.02</td>
<td>3.11</td>
<td>4.18</td>
<td>5.24</td>
<td>6.29</td>
</tr>
</tbody>
</table>
SN224 failed post burn-in data sheet electricals at 25°C.
SN224 failed post burn-in data sheet electricals at 25C.
All parts passed pre-burn-in electricals at 105C to the limit of 0.175 mV. Note the 85C data sheet limit is relaxed to 0.330 mV.
POST BURN-IN

Temp: 105C
VOSVS=±5V
MIN:-0.175 MAX:0.175
LO:-0.247 HI:0.316 MED:0.015 UNIT:mV

Note: This trend indicates that the parts are more sensitive to VOS degradation at high temperature.

The following 29 parts failed post-burn-in to the 25C limits at 105C: Serial numbers 31,51,62,81,119,131,134,138,143,155,158,180,183,190,194,196,197,199,208,221,222,224,225,251,258,261,265,268,270. However all parts do pass the 85C relaxed limit of 0.330 mV.
Medium parametric delta shift after burn-in is 12%.
Vendor B FIT Burn-In Data
Reliability Analysis

“High Speed 16-bit Operational Amplifier”

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The purpose of this test is to determine the failure rate as a point estimate on a portion (sample) of the population using established confidence intervals.
One part failed post FIT Burn-in at 25C and at 70C (SN11).
Parametric change varied from <10% to >90% after 1500 hrs of FIT static burn-in.
Vendor B Initial Electrical Data (incoming inspection)
Reliability Analysis

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The purpose of this test is to determine if the vendor’s outgoing testing and or sampling plans guarantee the published data sheet specifications and performance over temperature.
All parts passed initial electricals at 25C, 0C, and 70C.
Vendor B Operating Life Test Data
Reliability Analysis

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The purpose of this test is to evaluate the bulk stability of the die and to generate defects resulting from manufacturing aberrations that are manifested as time and stress-dependent failures.
Vendor B Operating Life Test Data

One part failed after 1500 hrs of dynamic operating life test (SN 188). This same part also failed the VOS VS ± 5V test at 25C and VOS VS ± 5V/±15V at 70C.
Vendor B Incoming Inspection Data
Assembly/Process Quality Analysis

“High Speed 16-bit Operational Amplifier”

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The purpose of this inspection is to evaluate the package assembly and wafer fabrication processes.
**Vendor B CSAM Incoming Inspection Data**

**Assembly Quality Analysis**

“High Speed 16-bit Operational Amplifier”

Examples:

- **Die top coating (non delamination)**
  ![Image](image1)

- **Non uniformity of die top coating**
  ![Image](image2)

- **Backside delamination**
  ![Image](image3)

- **Poor Die attach**
  ![Image](image4)

### Quality Analysis Table

<table>
<thead>
<tr>
<th></th>
<th>TOPSIDE (top of die)</th>
<th>BACKSIDE (die paddle area)</th>
<th>THRUSCAN (die attach area)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LR</td>
<td>MR</td>
<td>HR</td>
</tr>
<tr>
<td><strong>206</strong></td>
<td>226</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>201</strong></td>
<td>220</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td><strong>218</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Vendor A X-Ray Incoming Inspection Data
Assembly Quality Analysis

“High Speed 16-bit Operational Amplifier”

**X-Ray Inspection (Wire Sweep)**

<table>
<thead>
<tr>
<th>SN</th>
<th>LR</th>
<th>MR</th>
<th>HR</th>
</tr>
</thead>
<tbody>
<tr>
<td>29-217</td>
<td>289</td>
<td></td>
<td></td>
</tr>
<tr>
<td>218</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>219-278</td>
<td>60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>349</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Ref. Mil-Std-883, meth. 2012.6 for non-plastic, reject for slack wire within 0.002 in (0.05mm) of another wire.
Vendor A Outgassing Incoming Inspection Data
Assembly Quality Analysis

“High Speed 16-bit Operational Amplifier”

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>2N001 D/C 0112</th>
<th>2N002 D/C 0148</th>
<th>2N003 D/C 0149</th>
<th>2N004 D/C 0202</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAMPLE NO.</td>
<td>13</td>
<td>14</td>
<td>AVG</td>
<td>16</td>
</tr>
<tr>
<td>WT. LOSS %</td>
<td>0.42</td>
<td>0.42</td>
<td>0.42</td>
<td>0.29</td>
</tr>
<tr>
<td>WATER VAPOR RECOVERED, WVR, %</td>
<td>0.20</td>
<td>0.15</td>
<td>0.17</td>
<td>0.13</td>
</tr>
<tr>
<td>(WT. LOSS - WVR) %</td>
<td>0.22</td>
<td>0.27</td>
<td>0.25</td>
<td>0.16</td>
</tr>
<tr>
<td>VOC %</td>
<td>0.04</td>
<td>0.04</td>
<td>0.04</td>
<td>0.02</td>
</tr>
<tr>
<td>DEPOSIT</td>
<td>OPAQUE</td>
<td>LIGHT OPAQUE</td>
<td>LIGHT OPAQUE</td>
<td>OPAQUE</td>
</tr>
</tbody>
</table>

All samples tested passed.
Vendor A Lead Coating Incoming Inspection Data
Assembly Quality Analysis

“High Speed 16-bit Operational Amplifier”

X-Ray energy dispersive spectrum of the lead-tin solder on the leads
Vendor A SEM Incoming Inspection Data
Process Quality Analysis

“High Speed 16-bit Operational Amplifier”

Step coverage passes
Methodology Summary:

- A COTS PEMs precision 16-bit operational amplifier part, and encapsulated in an 8 ld SOIC package was tested and evaluated for its reliability and quality for use in NASA hardware.

- The part under this evaluation was one of five parts selected and chosen to be evaluated by NASA.

- A total of 278 parts were evaluated utilizing one date code.

- Testing was conducted by an outside approved test house while all analyses/engineer reviews were conducted by JPL/NASA parts engineers, parts managers, including test and reliability specialists.

- The analysis, findings, conclusions were solely based on the data and evidence collected and did not include any follow-up device failure analysis but did include initial destructive physical analysis.

- Careful attention was given to methods, procedures, and accuracy to insure the integrity and quality of the data taken.
Burn-In Summary:

- A +105°C 168 hr dynamic burn-in was completed to determine the infant mortality failure rate and identify any reliability issues that are intrinsic to the die and those that are extrinsically related to the package.

- There were no devices that failed catastrophically that is none were found to be non-functional. One device failed the data sheet limits at 25C and 0C.

- A significant number of devices drifted >10% but stayed within the maximum limits allowed. Sensitive parameters are VOSVS, IBVS, IOSVS.