PCBA Random Vibration Analysis using FEA

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PCBA Random Vibration Analysis

Introduction
• Modal Analysis with PCBA Assembly-4 constraint locations
• PSD Analysis for 1Grms Input
• PSD Analysis for MIL Standard input profile
• Modal Analysis for modified PCBA Assembly -8 Constraint locations
• PSD Analysis for new PCBA Assembly structure & MIL standard profile

Note: Power Spectral Density (PSD) Analysis in FEA is a linear, elastic and frequency domain based stress analysis
Test Objective
• To characterize the PCBA Assembly boundary conditions for different random vibration loads using FEA

Methodology
• Step 1: Geometry and Material Properties
• Step 2: Loads and Boundary Conditions
• Step 3: FEA Model Details
• Step 4: Sample Results
• Case Study Benefits
Step 1: Geometric Model & Material Properties

CAD MODEL: PCBA-Fixture setup with standoffs

<table>
<thead>
<tr>
<th>Material</th>
<th>Young’s Modulus (psi)</th>
<th>Poisson’s Ratio</th>
<th>Density (lb/in^3)</th>
<th>Tensile Strength (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FR4</td>
<td>2.81E+06</td>
<td>0.35</td>
<td>6.50E-02</td>
<td>38000</td>
</tr>
<tr>
<td>Stainless Steel</td>
<td>2.80E+07</td>
<td>0.31</td>
<td>2.80E-01</td>
<td>30023</td>
</tr>
<tr>
<td>ABS</td>
<td>3.39E+05</td>
<td>0.3</td>
<td>3.78E-02</td>
<td>5800</td>
</tr>
</tbody>
</table>

Material Properties
Step 2: Loads & Boundary Conditions

<table>
<thead>
<tr>
<th>Constraints / BC</th>
<th>Fixed Support / Contacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixture Constraint Location</td>
<td>8 Mounting holes on fixture-shaker table</td>
</tr>
<tr>
<td>PCBA Assembly Constraints</td>
<td>4 Mounting holes PCBA-standoffs- fixture</td>
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<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>PSD (G^2/Hz)</th>
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</thead>
<tbody>
<tr>
<td>5</td>
<td>0.0001</td>
</tr>
<tr>
<td>10</td>
<td>0.001</td>
</tr>
<tr>
<td>800</td>
<td>0.001</td>
</tr>
<tr>
<td>2000</td>
<td>0.0001</td>
</tr>
<tr>
<td><strong>Total:</strong> 1Grms**</td>
<td></td>
</tr>
</tbody>
</table>
Step 3: FEA Model

Element Type Used

**SOLID187**
- 3-D 10-Node Tetrahedral Structural Solid
- 10 nodes 3-D space
- DOF: UX, UY, UZ

**SOLID186**
- 3-D 20-Node Structural Solid or Layered Solid
- 20 nodes 3-D space
- DOF: UX, UY, UZ
Step 4: Sample Modal Analysis Results

1st Mode Shape - Frequency: 305 Hz

2nd Mode Shape - Frequency: 585 Hz

3rd Mode Shape - Frequency: 850 Hz

Note:

- Modal Analysis: Prerequisite for PSD Analysis
- Extracting the Fundamental mode shapes is useful for calculating the dynamic response of the structure
Step 4: Sample Response PSD Results

Locations of Interest

- Plots show Z Direction PSD acceleration response at the chosen locations.
- Peak values reveal important information about the critical resonating frequencies and the transmissibility of the assembly structure which is almost 9X input at PCBA Centre.
Step 4: Sample Z-Direction Displacement Results

Range of displacements seen by the product at a certain instant of time help determine the critical locations for the components on the PCBA Assembly.
PCBA Stress Analysis with MIL Standard Input Profile
Step 2: Boundary Conditions & Input Profiles

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**Input: Mil STD PSD Profile**

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>PSD (G^2/Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>0.0064</td>
</tr>
<tr>
<td>400</td>
<td>0.0064</td>
</tr>
<tr>
<td>2000</td>
<td>0.000096</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>2.47 Grms</strong></td>
</tr>
</tbody>
</table>
Step 3: FEA Model

Element Type Used

**SOLID187**
3-D 10-Node Tetrahedral Structural Solid
10 nodes 3-D space
DOF: UX, UY, UZ

**SOLID186**
3-D 20-Node Structural Solid or Layered Solid
20 nodes 3-D space
DOF: UX, UY, UZ
Step 4: Sample Response PSD Results

For the same boundary conditions as before & MIL standard input profile the G-level amplification on the PCBA centre measured up to 20x the input which may be considered a potential risk for the product.
Case Study Benefits

• Analysis “virtually” qualified the product behavior for chosen test loads.
• Identified critical locations for the components on the PCBA in random vibration environment.
• Quantified the transmissibility factors through the structure to various input vibration loads.
• Provided design inputs for material and geometry changes.
• Useful for designing accelerated product life tests.