

GOOGLE'S OPEN SOURCE RANDOM VIBRATION TESTING OF FULLY POPULATED RACKS WITH OFF-THE-SHELF DATA CENTER HARDWARE

TABLE OF CONTENT AND SCHEDULE OF FUTURE RELEASE

REVISION A

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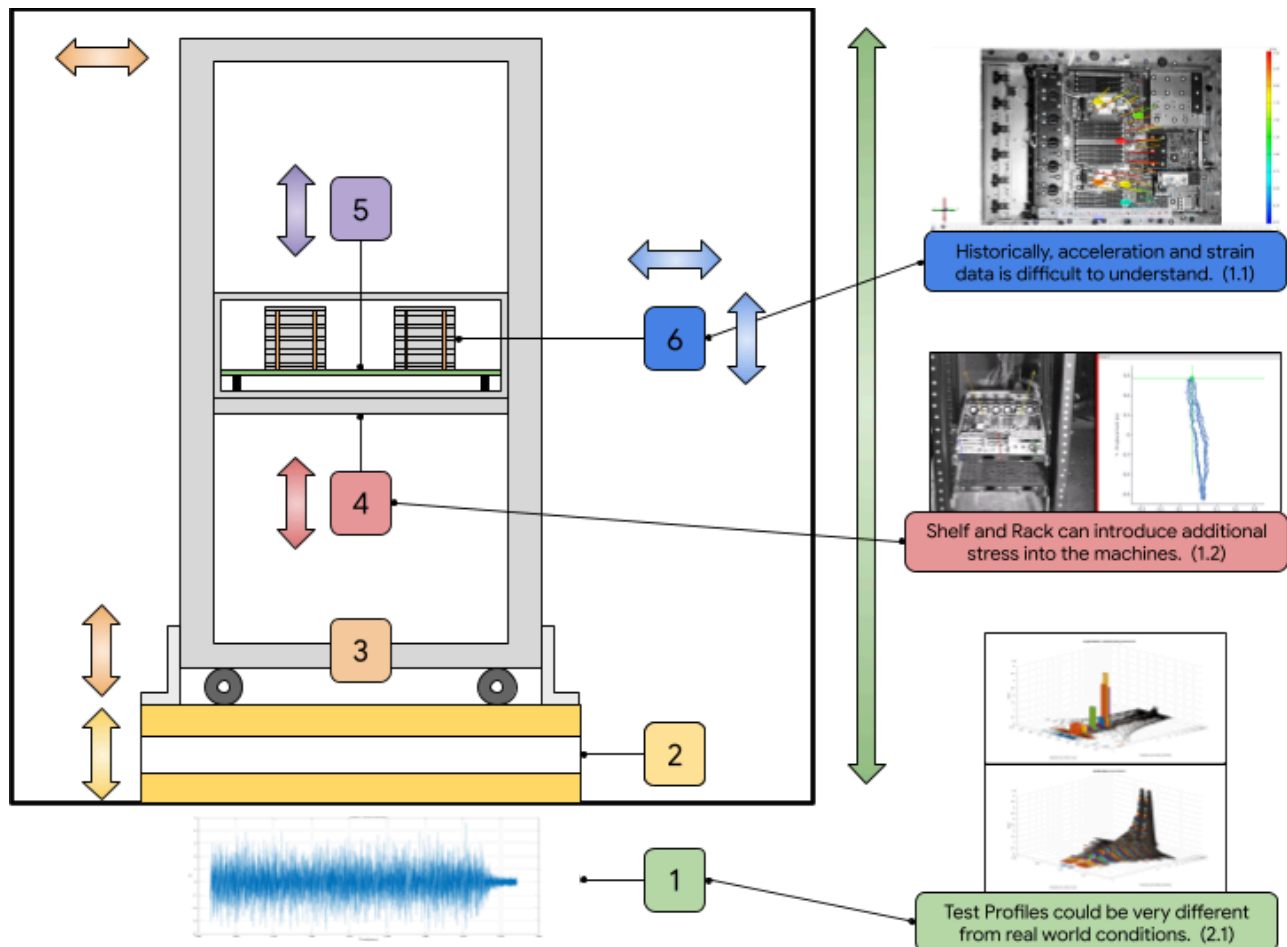
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Papers and sample data/diagrams/photos/videos have been uploaded under specific tracks in the "[White Papers](#)" folder. The material is organized in the following ways:

Content Descriptions

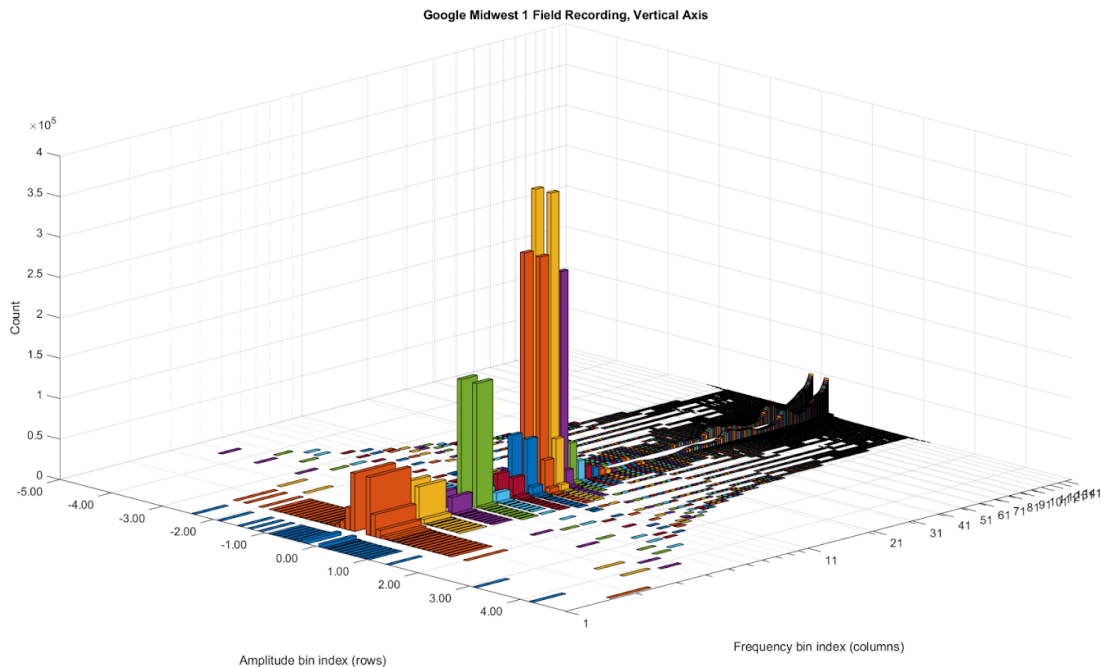
Challenges of Traditional Random Vibration Test Methods



Track 1. [A High Level Overview of Google's Random Vibration Testing Methodology](#) (In Progress)

A high level overview of Google's Random Vibration Testing Methodology, and a quick walk through of major analysis techniques and measurement capabilities.

Example of a 3D Bar Diagram of amplitude vs. frequency (1 Hz to 301 Hz) vs. cycle
Google US Field Measurement, 2019



Track 2. [Environmental Conditions](#) (In Progress)

In depth discussions on how environmental conditions are measured, collected, and analyzed. The focus is primarily on random vibration and shock conditions, but will also include environmental data collected during the field trials when applicable.

Track 3. Rack Level Analysis (Planned)

In depth discussions on how rack structures are tested and analyzed.

Track 4. Machine Level Analysis (Planned)

In depth discussions on how machines are tested and analyzed. We will look at common data center machine weights, sizes, and form factors and evaluate how dynamic behaviors of board and critical components are impacted.

Track 5. Component Level Analysis (Planned)

Track 6. Packaging Analysis (Planned)

In depth discussions on how critical components are tested and analyzed. We will look at common data center critical components, and how dynamic behaviors lead to local stress and strain and component specific failure modes.

Table of Content

Track 1. [A High Level Overview of Google's Random Vibration Testing Methodology](#) (In Progress)

- 1.0 [A High Level Overview of Populated Rack Transportation Vibration](#)
- 1.1 [Sine Vibration of A Machine](#)
- 1.2 [Sine Vibration of A Machine Inside A Rack](#)
- 1.3 [Random Vibration's Impact on Machine and PCB](#)
- 1.4 [Component Level Measurement and Analysis](#)
- 1.5 Highlight of Additional Measurement Methods for Shock and Vibration (Planned)
- 1.6 Comparing Sine/Random Vibration/Shock Conditions (Planned)
- 1.7 Fatigue and Factor of Safety Calculation

Track 2. [Environmental Conditions](#) (In Progress)

- 2.1 [An Examination of Random Vibration from Google's Supply Chain](#)
- 2.2 Extracting More Information From Field Data (Planned)

Track 3. Rack Level Analysis (Planned)

Track 4. Machine Level Analysis (Planned)

- 4.1 Comparing Natural Frequencies and Mode Shapes of Different Machine Form Factors (Planned)

Track 5. Component Level Analysis (Planned)

- 5.1 Pressure Measurement of ASIC/Heatsink During Shock and Vibration (Planned)
- 5.2 Strain Measurement during Shock and Vibration (Planned)
- 5.3 Microscopic Displacement Measurement of Microelectronics (Planned)
- 5.4 High Speed Resistance Measurement of Solder Joints and Interconnects (Planned)

Schedule of Future Release

Moving forward, we will release new materials on a biweekly basis following a regular release schedule. If you have questions or requests for specific topics, please e-mail openrandomvibe@ocproject.net directly and I

will be happy to add them to the schedule. Feedback is always welcomed on how to make this project better and more useful to you, the readers.

Bi-Weekly Schedule of Future Release:

Date	Topic
April 7th	1.4 Component Level Measurement and Analysis (Completed)
April 28th	1.5 Highlight of Additional Measurement Methods for Shock and Vibration
May 5th	2.2 Extracting More Information From Field Data
May 19th	5.1 Pressure Measurement of ASIC/Heatsink During Shock and Vibration
May 26th	5.2 Strain Measurement during Shock and Vibration
June 2nd	5.3 Microscopic Displacement Measurement of Microelectronics
June 9th	4.1 Comparing Natural Frequencies and Mode Shapes of Different Machine Form Factors
June 16th	1.6 Comparing Sine/Random Vibration/Shock Conditions
June 23rd	1.7 Fatigue and Factor of Safety Calculation
June 30th	5.4 High Speed Resistance Measurement of Solder Joints and Interconnects