GOOGLE'S RANDOM VIBRATION TESTING METHODOLOGY, OPEN TEST DATA

Part 3.1: 3D DISPLACEMENT DATA OF A MACHINE DURING RACK LEVEL VIBRATION TESTING
REVISION A

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24Hz, 2.0G Sine Vibration, Rack Level, 4000 Frames Per Second
Video link: https://www.youtube.com/watch?v=wu03SmzM5ew

The 2G amplitude was chosen through trial and error to make 3D displacements easy to detect. Such amplitudes are well within the typical range of G level seen in field vibration data.

These 3D displacement plots really need to be seen in high definition videos, so I encourage everyone to download them from the link above. For now, I will describe the motion with critical frames. Green represents zero relative displacement (in mm). Up to -3mm (downward, in blue) and +3mm (upward, in red) relative displacement are seen as the video advances forward. Upward relative displacements are more distributed on the left side, while downward ones more on the right.

These distributions aren't evenly symmetric around the middle. PCBs and server racks don't behave perfectly in the real world, particularly when subjected to shock and vibration.

Lenovo SR650 V2 3D Displacement During Rack Level Test, 24Hz, Frame 0, +/- 3mm

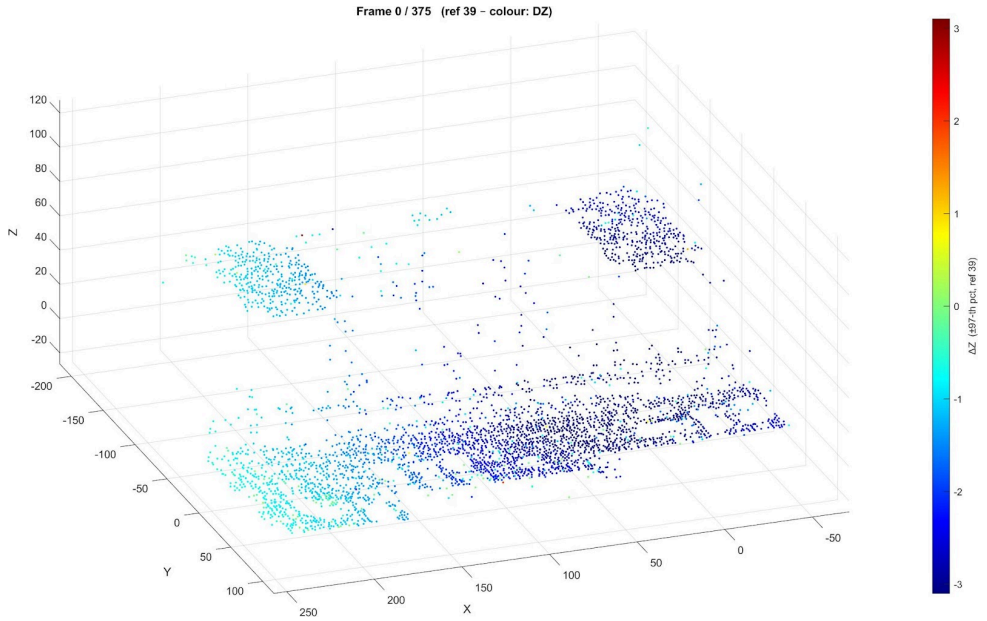


Figure 5.

Lenovo SR650 V2 3D Displacement During Rack Level Test, 24Hz, Frame 18, +/- 3mm

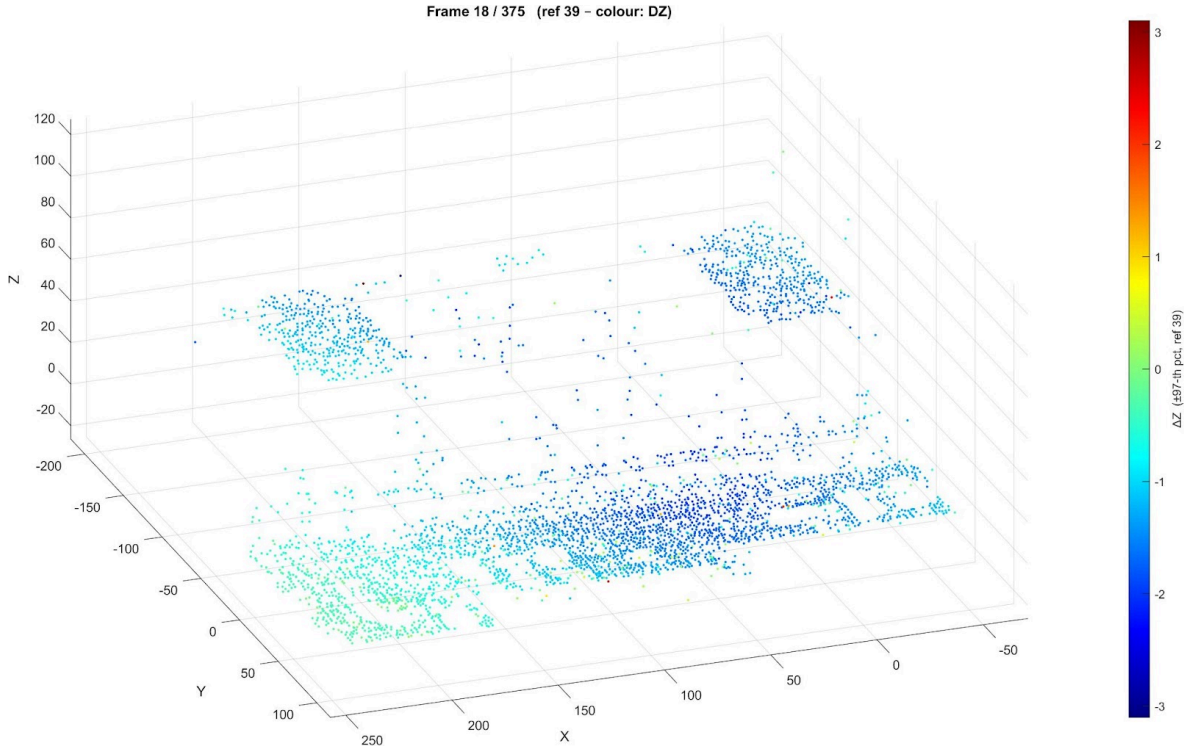


Figure 6.

Lenovo SR650 V2 3D Displacement During Rack Level Test, 24Hz, Frame 39, +/- 3mm

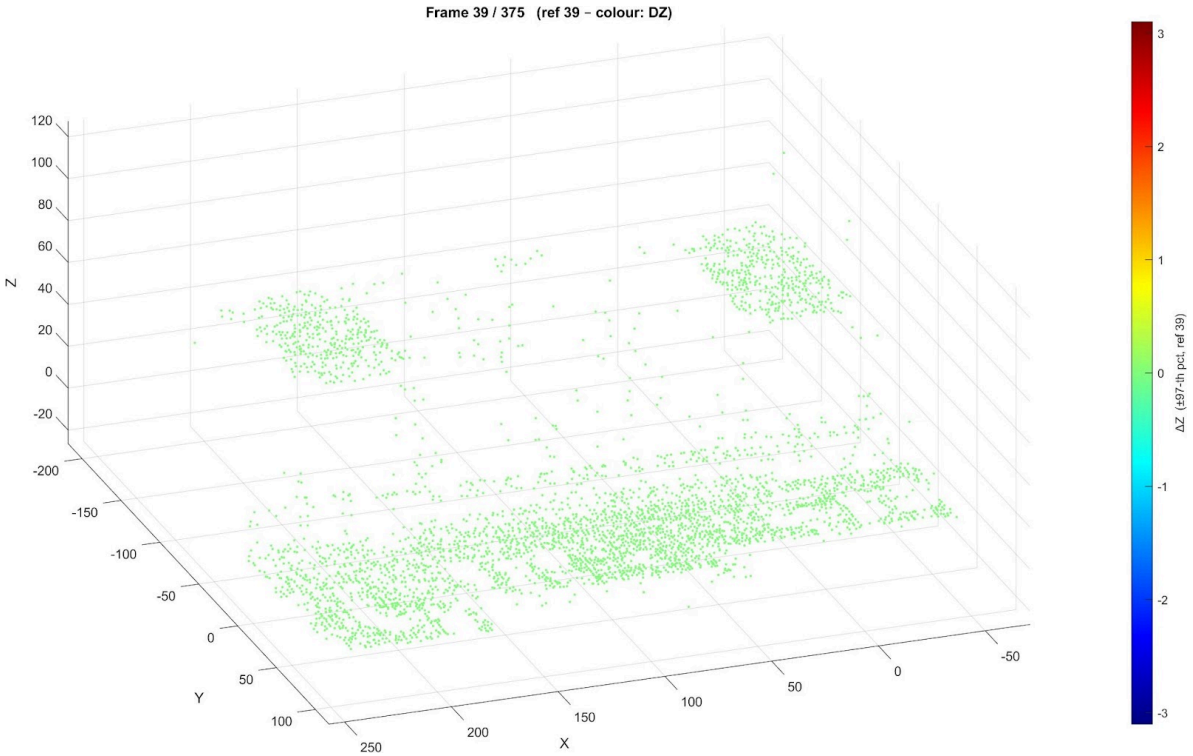


Figure 7.

Lenovo SR650 V2 3D Displacement During Rack Level Test, 24Hz, Frame 57, +/- 3mm

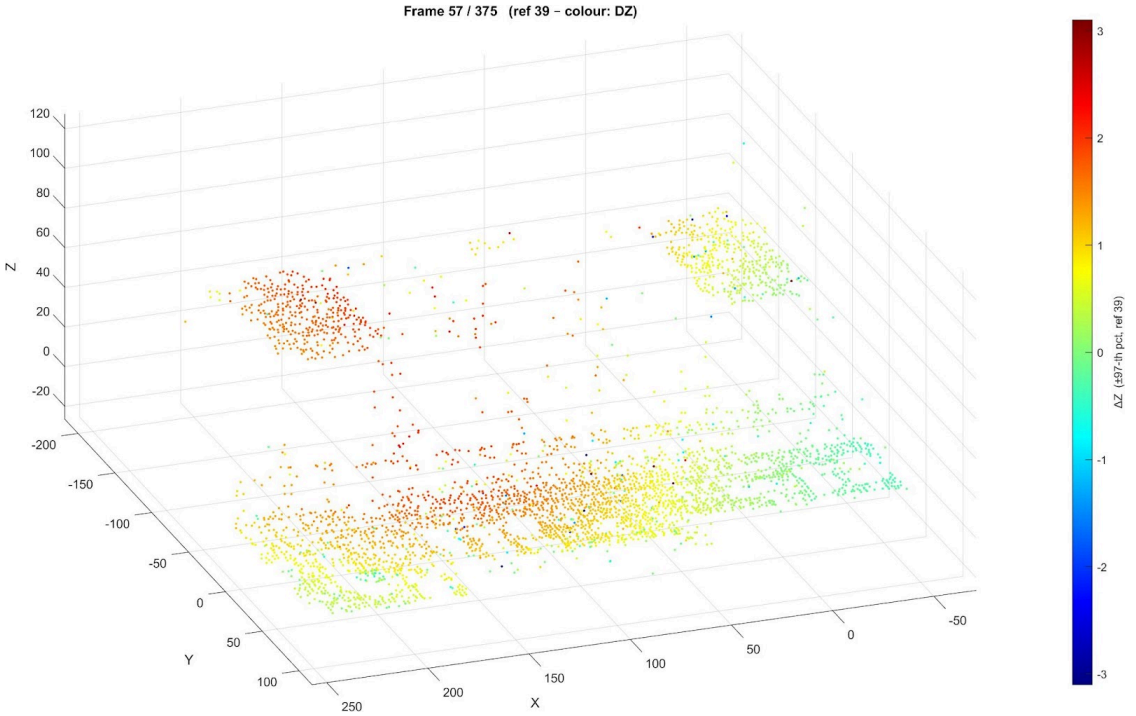


Figure 8.

Lenovo SR650 V2 3D Displacement During Rack Level Test, 24Hz, Frame 76, +/- 3mm

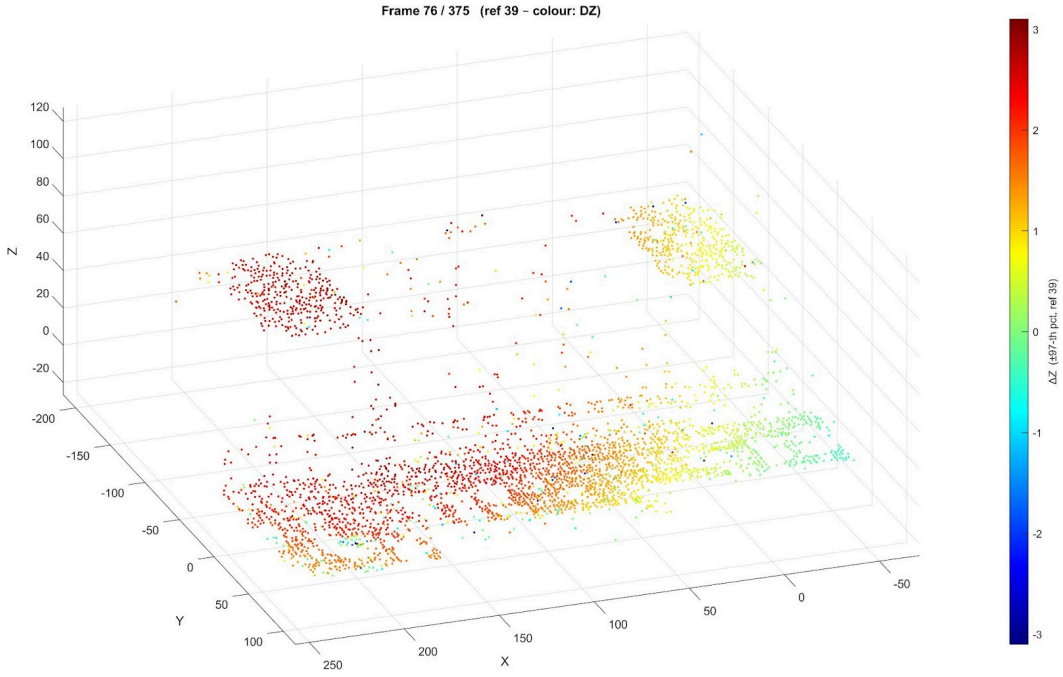


Figure 9.

33Hz, 2.0G Sine Vibration, Rack Level, 4000 Frames Per Second
Video link: https://www.youtube.com/watch?v=-T_IkCDuNpw

During machine level vibration, we saw a single resonance at 28.5Hz (Part 1.1). At rack level, we saw them at 22.6Hz and 28.3Hz (Part 1.2). At the time, we didn't know where the extra resonance came from, but guessed that the lower mode came from flexing of the shelf. With 3D displacement, it's easy to see the 2nd mode is more inline with machine level resonance, in terms of shape (more centered) and amplitude (+/- 1.25mm).

Lenovo SR650 V2 3D Displacement During Rack Level Test, 33Hz, Frame 0 Thru 60, +/- 1.5mm
(Last Figure - Same Tray Under Machine Level Sine Vibration in Part 1.1, +/- 1.3mm)

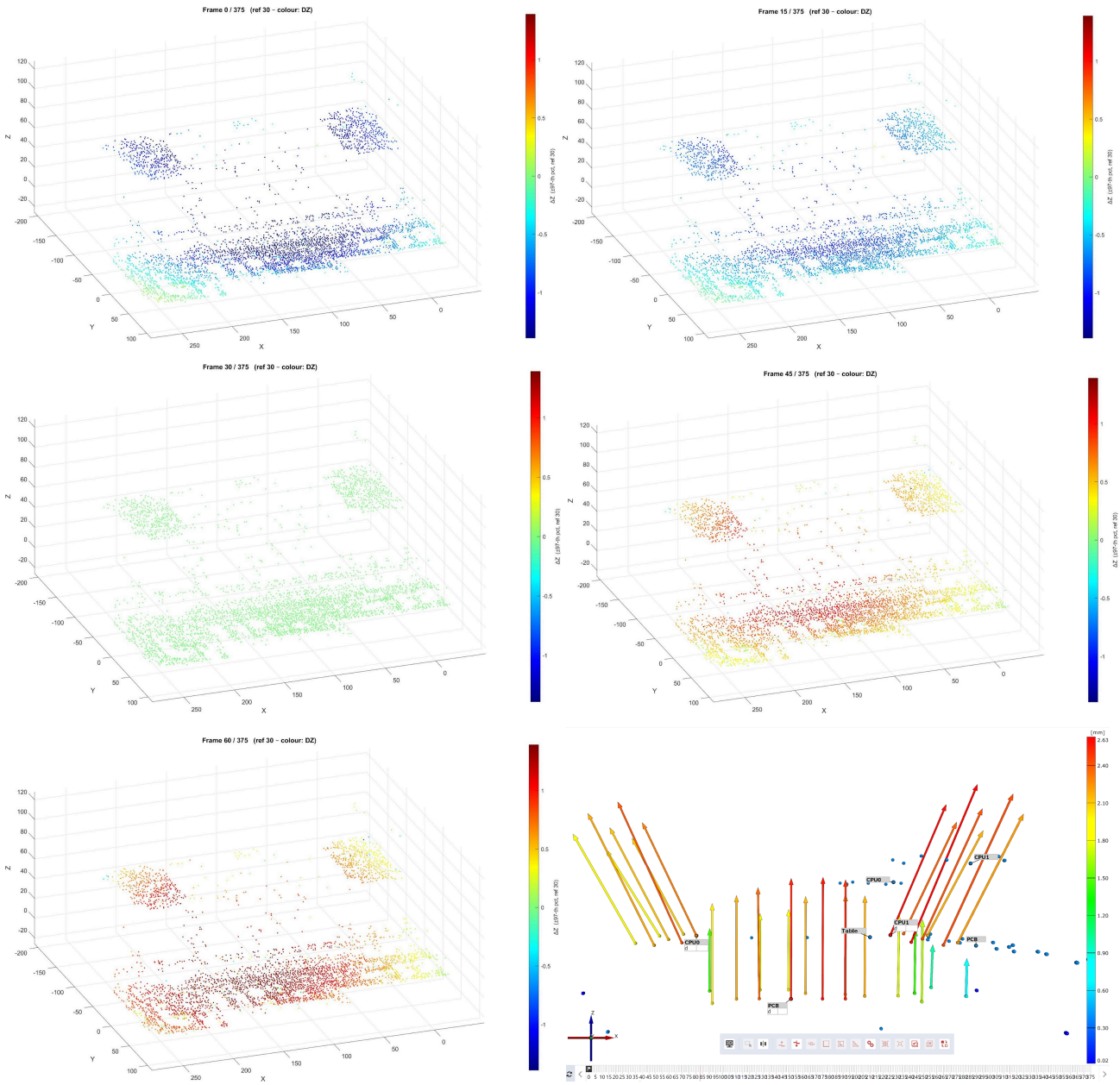


Figure 10.

49Hz, 2.0G Sine Vibration, Rack Level, 4000 Frames Per Second

Video link: https://www.youtube.com/watch?v=GqtJm9s86Js

Lenovo SR650 V2 3D Displacement During Rack Level Test, 49Hz, Frame 0 Thru 154, +/- 1mm

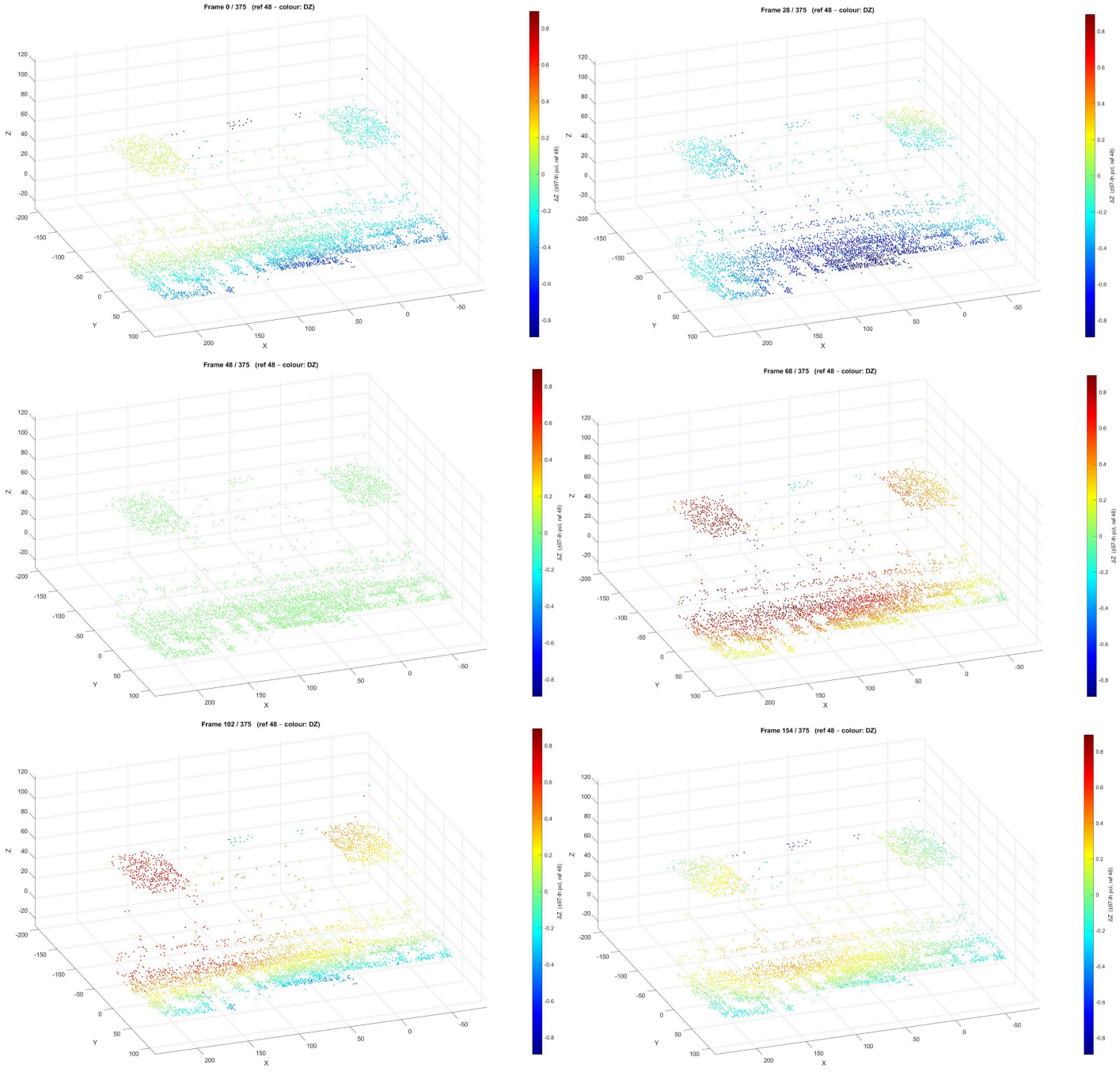


Figure 11.

By 49Hz, the motion becomes more complex. The distribution isn't always even across the whole PCB, and in this case increases in the front right to back left direction. It is much easier and more intuitive to visualize what's happening when watching the motion through multiple loops of HD video.

Lenovo SR650 V2 3D Displacement During Rack Level Test, 49Hz, Frame 170 Thru 230, +/- 1mm

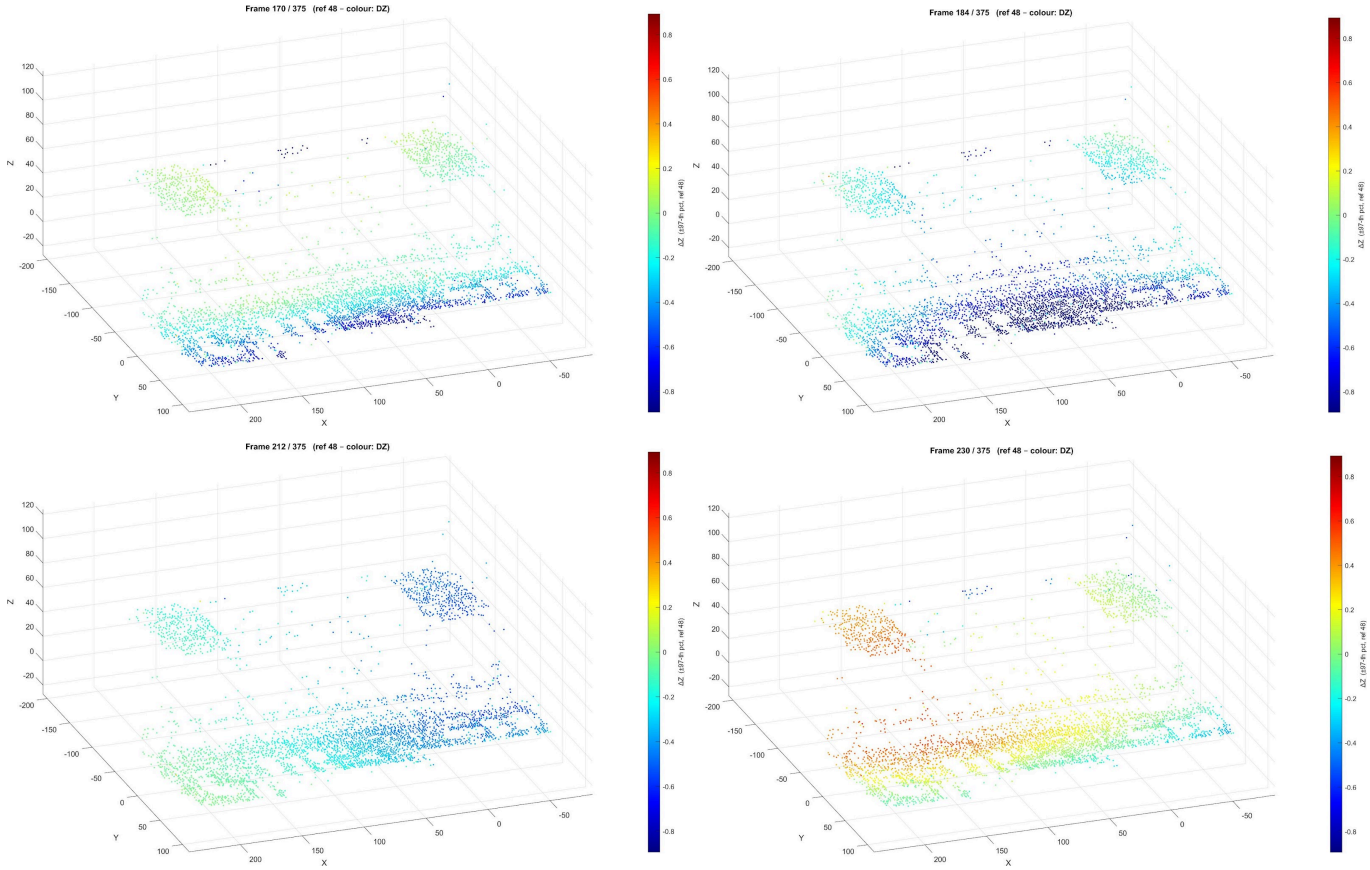
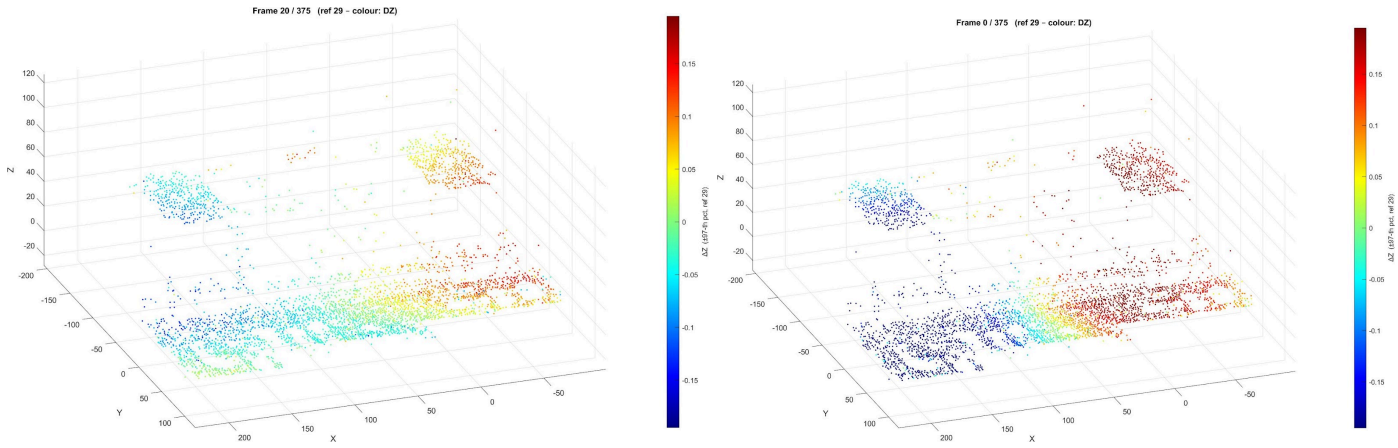


Figure 12.

<u>107Hz, 2.0G Sine Vibration, Rack Level, 4000 Frames Per Second</u>
Video link: https://www.youtube.com/watch?v=VgOVQxYrHs8

Lenovo SR650 V2 3D Displacement During Rack Level Test, 107Hz, Frame 0 Thru 102, +/- 0.2mm



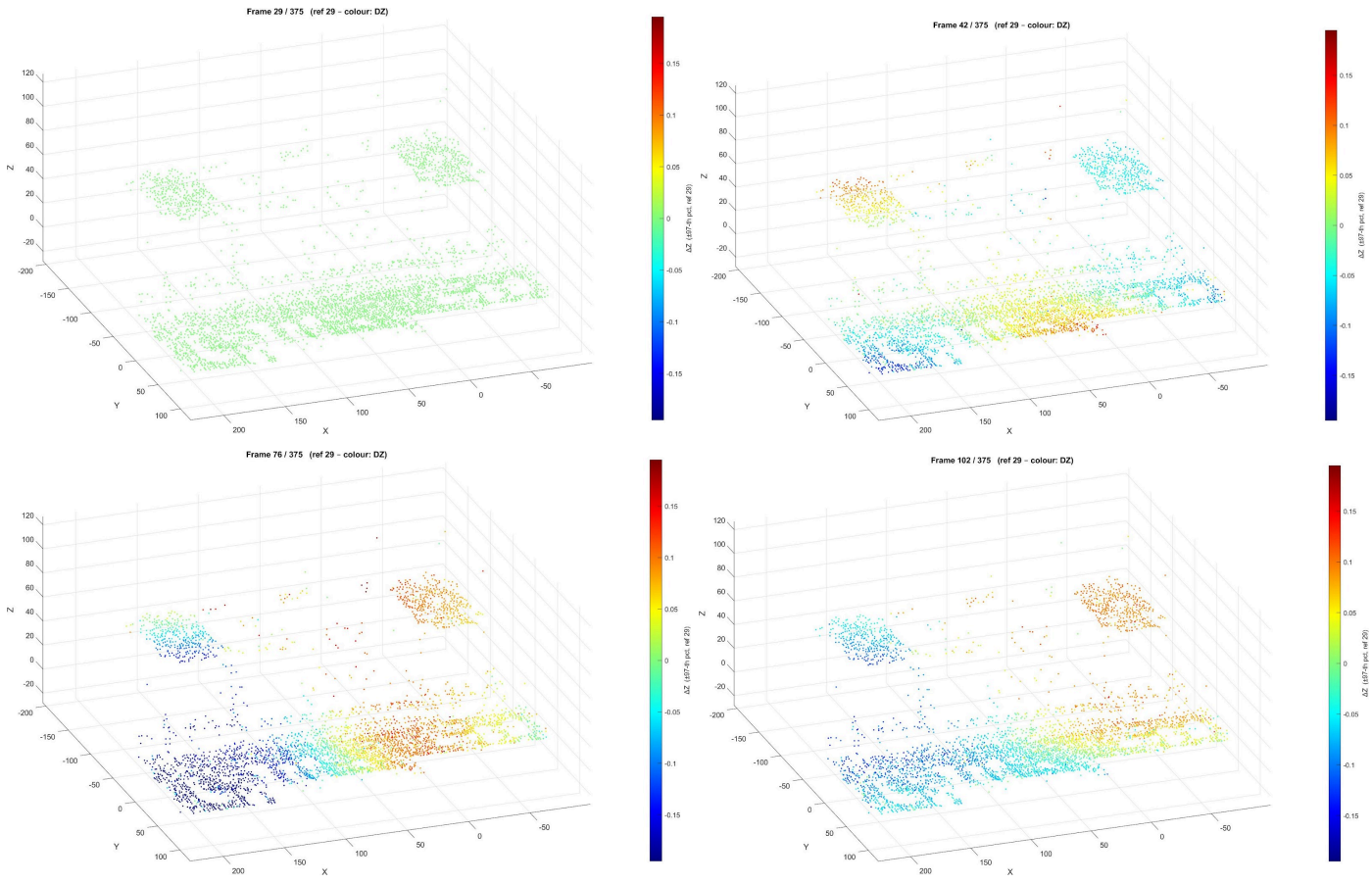


Figure 13.

107Hz is interesting because it is mostly focused on the right side. It also only shows +/- 0.2mm of relative displacement, which is significantly smaller than lower frequency resonance. The higher the frequency, the lower the amplitude. This mode is potentially less stressful to the components on board due to the lowered amplitude. The other consideration is how concentrated the stress is. If the stress is really concentrated, there might be a lot more localized stress underneath the component above it.