K1DM3 Technical Note 872-LTN1032

Vibration Testing

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1 Introduction

Previous testing and FEA vibration analysis revealed modes of vibration of the mirror in the retracted position that were low frequency, in the range of high reponse predicted in Keck's earthquake analysis of the entire telescope. Those results showed accelerations as high as 15 g's the top of the tower where M3 resides. For this reason a docking system was designed that provides a structure fixed to the tower and clamps the swing-arm to make it more stiff and drive normal mode frequencies beyond this critical range.

The instrument is now assembled with the true mirror and equipped with the docking system. Vibration testing was again performed to determine if the docking structure achieved the desired goal of increasing the frequency of the fundamental modes when in this configuration.

2 Test description

Two accelerometers were attached by a fixture to the rear of the swing-arm at the on axis weld node which is the farthest point of the structure from the hinge. Figure 1 shows the accelerometers attached. One unit is oriented normal to the mirror plane. It will monitor motion relative to rotation about the hinge. Response traces of this unit are red in the screen shots of the response plots. The other accelerometer is normal to the mirror plane and parallel to the mirror's minor axis. Traces of this unit are white in the response plots.

For every configuration two runs were conducted. One was for a push (or impulse) at a bipod node in a direction normal to the mirror. The other was based on a push at the same location directed laterally, parallel to the mirror plane, roughly in a line from one bipod towards the other. Figures below show where and how these impulese were made.

Tests were conducted in both the deployed & retracted configurations. When retracted the docking system was engaged with the pin inserted.

3 Results and discussion

For the retracted position results show two dominant modes around 5.5 and 8.5 Hz (Figures 2 and 3). In the deployed configuration there were modes at 5.5, 10.5, 14, and 17.5 (Figures 6 and 7).

During these vibrations we noticed considerable motion of the hex ring. We also measured a response when applying a force directly to the hex ring. This response is shown in Figure 8 (similar to Figures 6 and 7).

While deployed, the instrument was rotated 90 degrees and re-tested. The orientation was to the right Nasmyth, Figures 9 and 10. Responses for the two pushes are shown in Figures 11 and 12.

It is difficult to distinguish instrument response from the hex ring stand. As stiff as the instrument is in the deployed state is reasonable to argue that the low mode frequencies we see between 5 and 10 Hz are the hex ring.

At this point the results so far are inconclusive. It would be worthwhile to either attempt to stiffen the hex ring in some way or to dampen it out so that it disappears from the response.

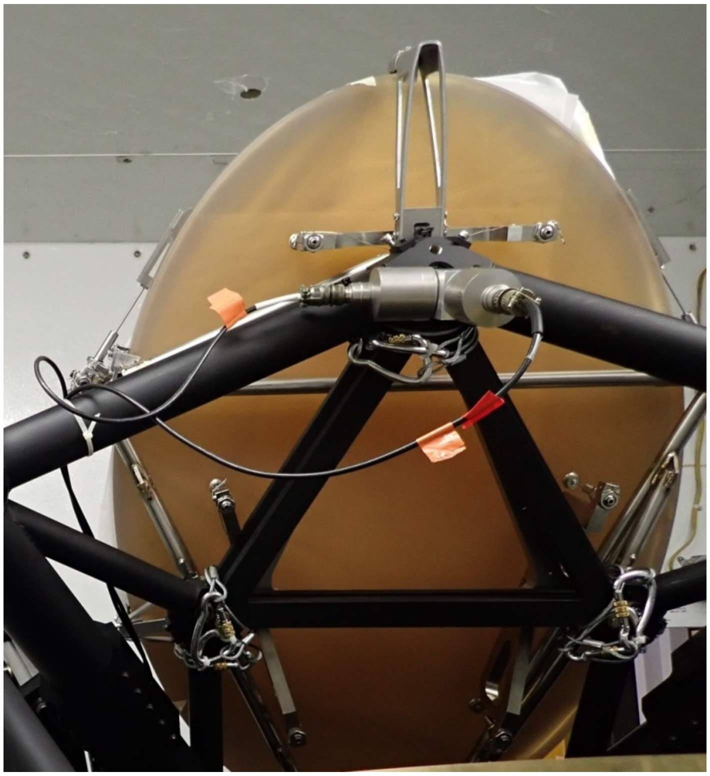

Figure 1 - Location and orientation of the accelerometers for the test. White traces on all the plots represent the lateral accelerometer in the plane of the mirror. The red traces are from the unit pointing away (normal) from the mirror

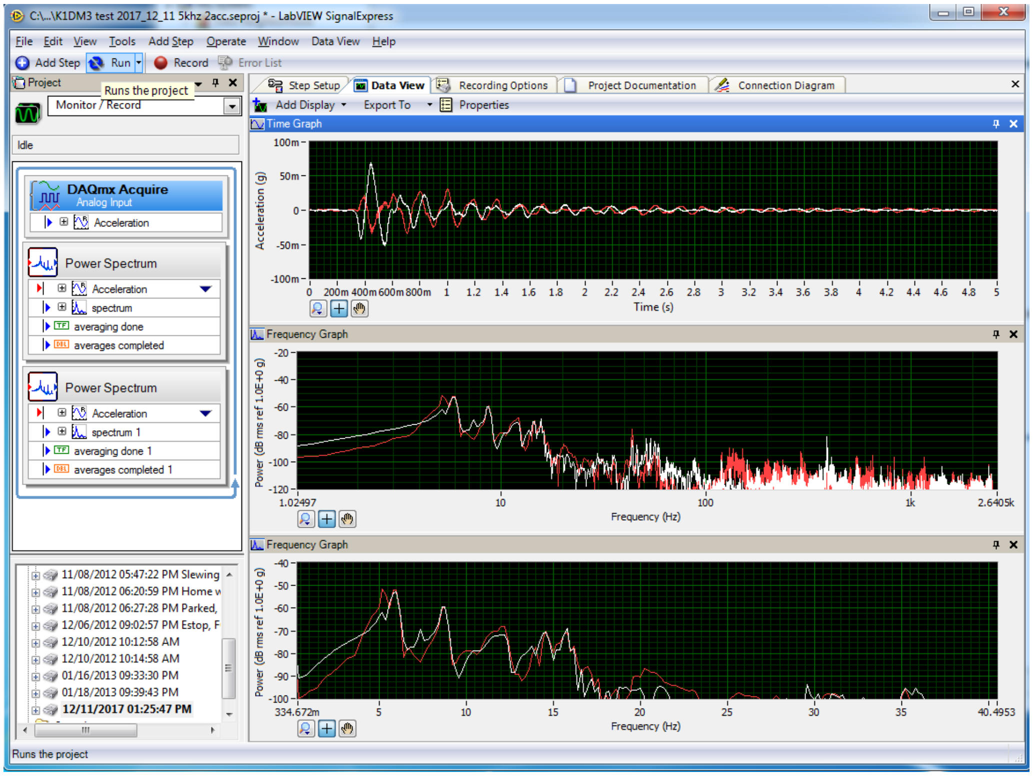

Figure 2 - Retracted and docked position. Lateral push response.

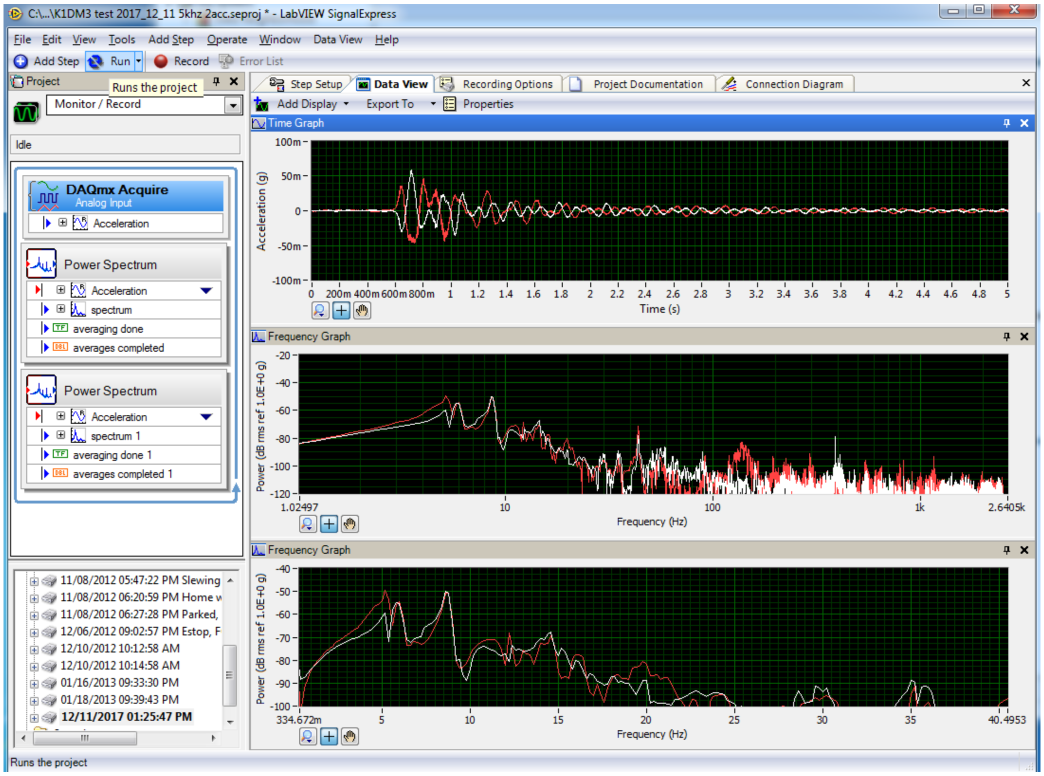

Figure 3 - Retracted and docked position. Normal push response

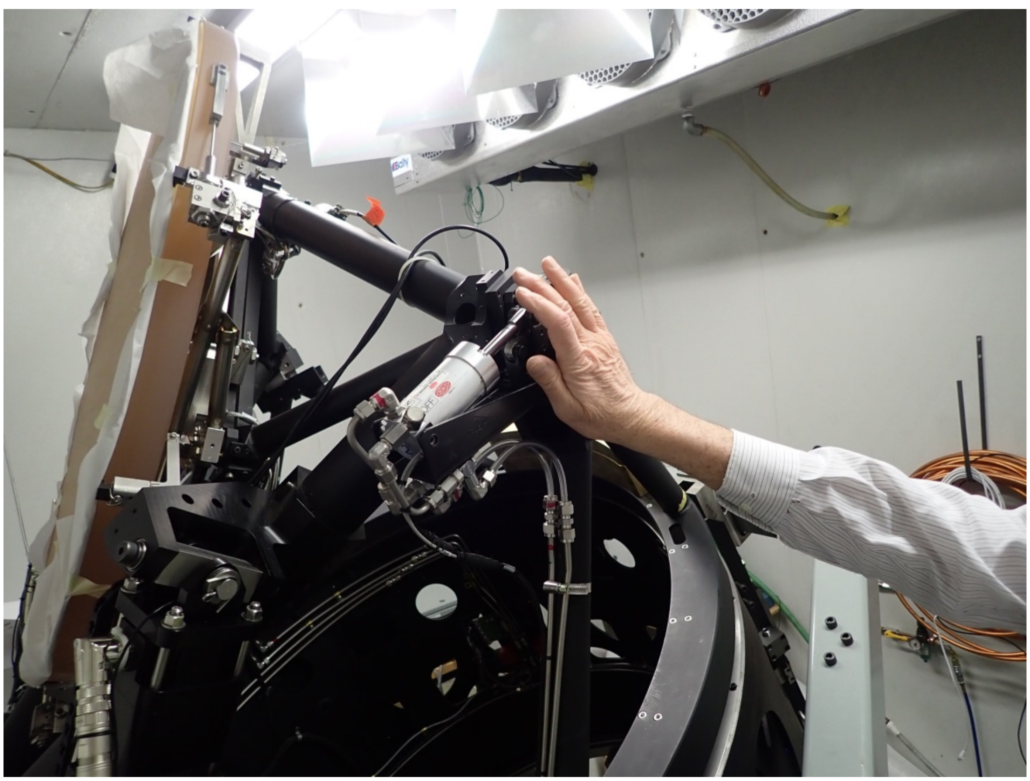

Figure 4 - A lateral push when deployed

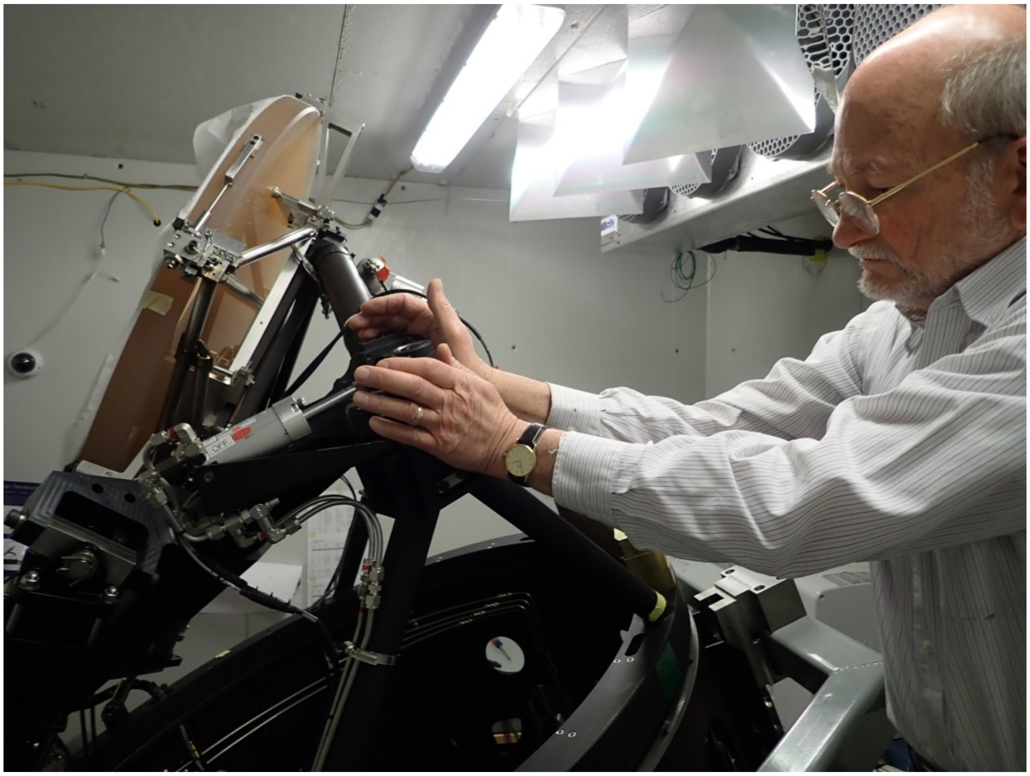

Figure 5 - A normal push when deployed

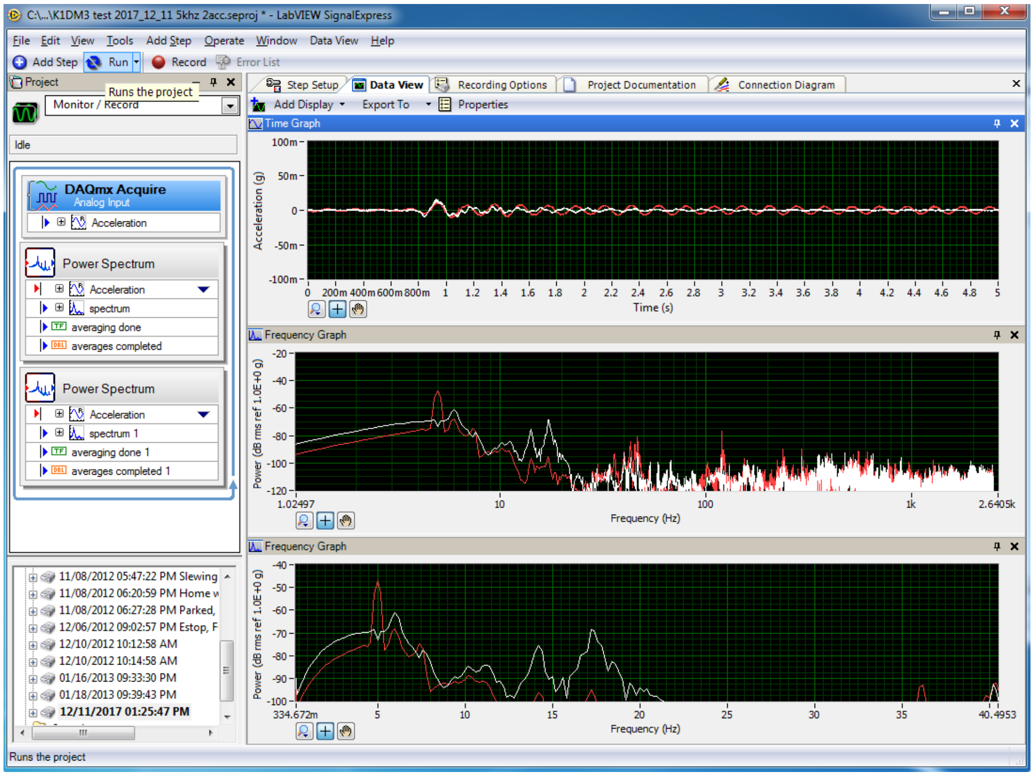

Figure 6 - Deployed configuration. Lateral push response.

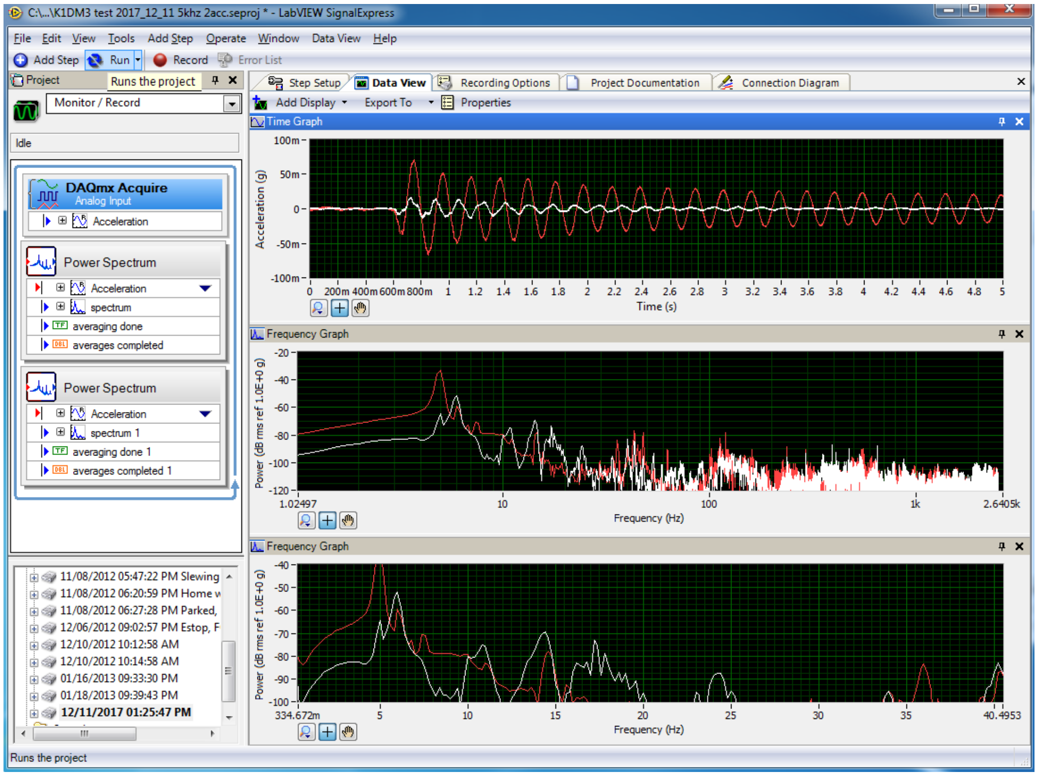

Figure 7 - Deployed configuration. Normal push reponse showing wobbling of the hex ring.

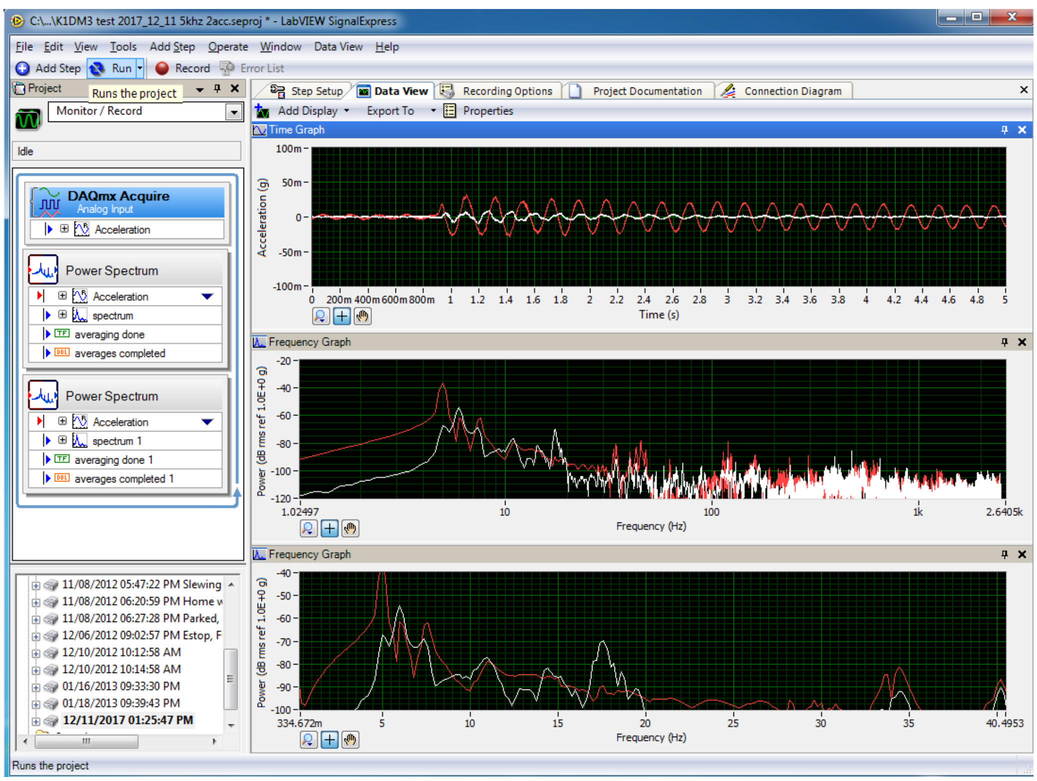

Figure 8 - Deployed configuration. Response due to push on hex ring.

Figure 9 - Deployed configuration at right Nasymth. Normal push.

Figure 10 - Deployed at right Nasmyth. Lateral push.

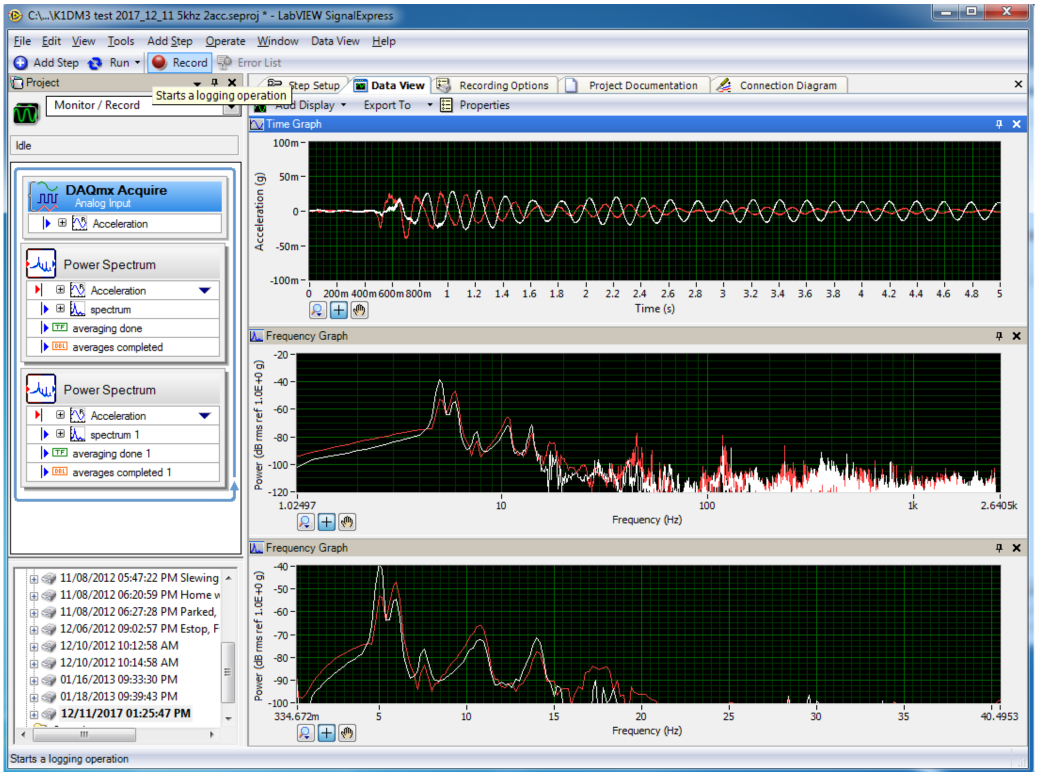

Figure 11 - Deployed at right Nasmyth. Normal push response.

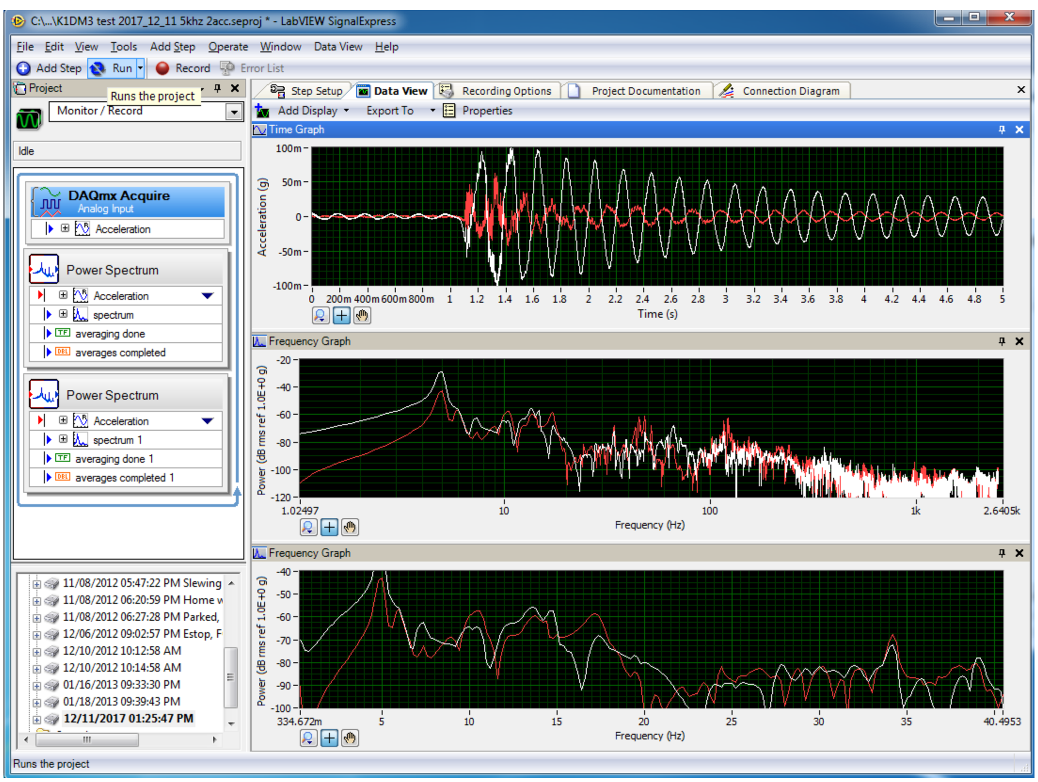

Figure 12 - Deployed at right Nasmyth. Lateral push reponse.