SASA Mobile Attitude Control Testbed Research Notes

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Abstract

The widespread use of reaction wheel assemblies for attitude control of spacecrafts has proven to be unreliable, causing many missions to end early. In an effort to address the issue, Professor James Allison of the University of Illinois has been researching the use of Strain Actuated Solar Arrays (SASA) for attitude control. Piezoelectric wafers in the solar arrays use electric energy to change the attitude. A mobile lab-scale testbed using air bearings was developed to test the effectiveness of these Solar Arrays in a simulated frictionless environment.

Vibration Isolation

While CUBEsat spacecrafts are commonly tested on spherical testbeds, evaluating SASA effectiveness requires the ability to sense linear rotations. The first step in developing a specialized testbed was addressing how to dampen all possible vibrations. Vibrations are typically separated into three categories; seismic, acoustic, and whatever forces are applied on the surface. Seismic vibrations stem from the ground, caused by sources such as foot traffic or air conditioning. Acoustic vibrations are a measure of how the air pressure variations effect the experiment. The last category covers all vibrations stemming from forces directly on the equipment or attached to the equipment. All categories of vibrations can be random or periodic. Random vibrations result from unpredictable sources such as outside construction, while constant vibrations may result from periodic noise. The vibrations in the testbed system come from the ambient environment, air bearings, and various connections. To combat the vibrations from the ground and the environment the testbed was mounted on an optical breadboard, which in turn was connected to an optical table. The next step was to cancel out from the experiment. The testbed started

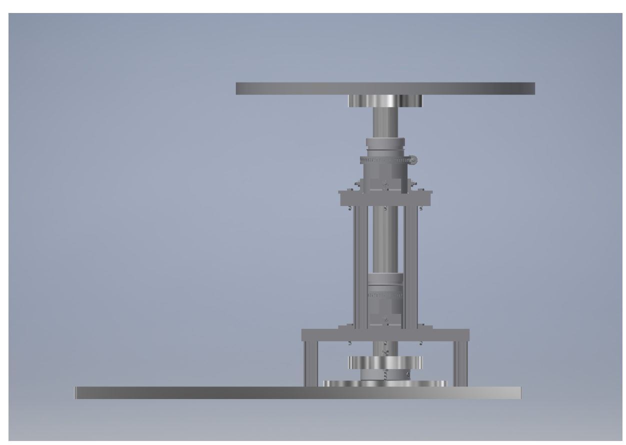

Figure 1.1

out as a shaft floating over a puck air bearing stabilized by two air bushings. When the air is turned on these air bushings would travel up the shaft slightly and create vertical vibrations. Collars were created to hold down the air bushings and minimize these linear vibrations, while a compliant hose was used to further reduce vibrations from pneumatic components. To further reduce vibrations from the pneumatic components we decided to use a compliant hose. The final design is above and to the right (Figure 1.1 and 1.2).

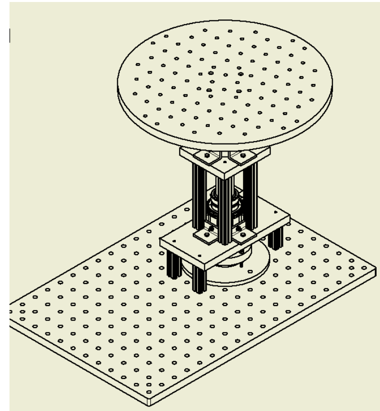

Figure 1.2

Mobility

The Vicon system in Talbot Laboratory is necessary to measure the very small degree changes of the equipment. This required the testbed to be mobile, presenting the next challenge. Initially a cart was designed out of 80/20 but a switch was made to look into optical carts to isolate vibrations as much as possible. Optical carts come designed as either active or passive. Active tables are used when the environment has a large amount of vibrations, as they dampen both horizontal and vertical vibrations. Passive tables work well in environments without many vibrations, as they dampen only horizontal vibrations. The relatively small amount of vibrations in the test environment and affordability made a passive table an acceptable choice. In addition, passive tables are more straightforward to mobilize and fashion into carts as opposed to active tables. Active tables are considerably heavier, and require the machining of the legs in order to lift the cart. A passive table is a lot easier to make mobile. It will be rolled onto a cart with large pneumatic casters in order to keep the various bumps and cracks in the road from affecting the setup of the testbed. Once in the Vicon system room the table would be rolled off the cart and onto dampening pads for further vibration isolation. A perk of the passive cart model is the additional storage it offers, making the trip from lab to lab easier to accomplish in one go.

Conclusion

While the project is still under work and likely will be for a few more years, progress has been made in manufacturing the testbed and designing the cart. We have started manufacturing the testbed and will soon start on the cart and the rest of the components needed. The first iteration of the testbed will allow for testing the effectiveness of the design, and pave the way for future improvements.

Acknowledgements

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References

[1] Christian M Chilan, Daniel R Herber, Yashwanth Kumar Nakka, Soon-Jo Chung, James T Allison, Jack B Aldrich, Oscar S Alvarez-Salazar. *'Co-Design of Strain-Actuated Solar Arrays for Spacecraft Precision Pointing and Jitter Reduction.'* AIAA Journal, 55(9), pp. 3180-3195, Sep 2017.

[3] Optical Tables Tutorial. (n.d.). Retrieved from https://www.thorlabs.com/newgroup page9.cfm?objectgroup_id=8275

[2] Oscar S Alvarez-Salazar, Jack B Aldrich, James T Allison, Soon-Jo Chung. *'Strain Actuated Solar Arrays for Precision Pointing of Spacecraft.'* In 2016 AAS Guidance, Navigation, and Control Conference, Breckenridge, CO, USA, Feb 2016.