Photoreceiver Measurements for the LISA Mission & Development of a LISA Sciencecraft 3D Model

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Introduction:
Imagine two black holes pulled together by their immense gravitational forces, accelerating around one another until they finally collide. Such a massive interstellar event propagates gravitational waves in the curvature of spacetime, which will give insight on galactic formation and evolution that can unlock secrets about our own Milky Way galaxy. The objective of my project is to characterize different low-noise operational amplifiers (op-amps) in photoreceivers for precise laser interferometry in the LISA mission. I have modeled these electronics with LTspice, and then experimentally tested their noise levels and frequency responses, processing the data with MATLAB. I also soldered a 14-pin power feed-through for a vacuum chamber to facilitate testing of these photoreceivers in a simulated space environment. In addition, I test-printed, rearranged, and improved a LISA 3D model for online publishing.

Frequency Response & Noise:
Noise is all around us. Electrical noise accounts for the underlying variations in the basic attributes of a certain circuit, and these disturbances can make it extremely difficult to measure faint signals such as gravitational waves. Some different types of noise are voltage noise, current noise, and thermal noise.

- The frequency response shows its gain, or the ratio of its output divided by its input over a range of frequencies. This helps determine at which frequencies it will work efficiently. For LISA, it is important to transmit photoreceiver signals clearly at high frequencies.
- Used a network analyzer to measure the gain of the LMH6629 configured as an inverting amplifier.
- Measured output noise using a spectrum analyzer.
- Divided the output noise by the gain to estimate the input noise, which is consistent with the expected low noise specifications for the op-amp.

- The 3D models are extremely useful for reference and visualization during the technology development phase of projects like LISA. We optimized an existing computer-aided design (CAD) project by scaling to eliminate interference between parts and grouping them into six separate build plates that can be printed in different colors and assembled with little additional work. Once the printing process is finalized, the model will be distributed on the NASA 3D model website for education and public outreach.

The Next Steps:
- Develop photoreceivers using the low-noise op-amps and test them in simulated space conditions.
- Develop noise models for these circuits to check against measurements.
- Simulate and test Texas Instruments op-amps OPA847 and LMH6624.
- Configure op-amp as a transimpedance amplifier and measure the electrical output of an optical input.
- Improve the 3D model by reinforcing the bases of the telescopes and connections between the solar array parts.
- 3D-print a full-color model of the LISA scale model in a different type of plastic and adjust tolerances for reassembly.

Bibliography / Acknowledgements:
- For more information on the LISA mission, visit: www.lisa.nasa.gov

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