NPOI Vacuum Manifold

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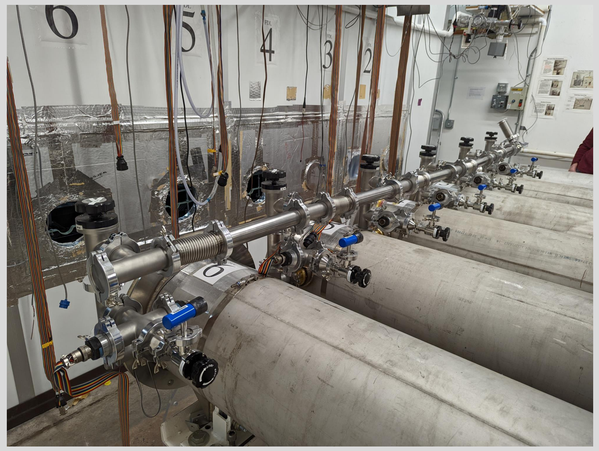
Abstract

As part of an upgrade to the Navy Precision Optical Interferometer, a final year Mechanical Engineering Capstone Team discusses the redesign and integration of a vacuum manifold for the precision optical delay line system. The new manifold utilizes modular construction allowing for rapid development, manufacturing, deployment, maintenance, and expands the functionality of the optical delay system over the former manifold.

While the new manifold improves the functionality and safety over the former design, the primary objective of the new manifold is to decrease maintenance time while maintaining a low-pressure environment to improve stellar observations.



Requirements

- Maintain less than 30 mTorr of vacuum for five days without vacuum pump
- Improve high-voltage electrical control vacuum passthrough
- Allow for future expansion of the manifold for other NPOI projects
- Improve ease of operation
- Reduce maintenance time for basic FDL procedures
- Stay within allocated budget of $14,000

Methods

By combining the vacuum manifold and electrical passthrough into one system the team eliminates shortcomings in both previous designs while improving the reliability of both functions and ensures the project stays on budget. The new design aims to maximize the implementation of industry standard handwear. In order to mate “Quick Flange” components to the custom delay lines an interface was machined by the students from solid brass stock. Brass can thread into the existing electrical port without lubricant that could contaminate optics. Previously, vacuum rated grease was used to prevent galling of the matting threads.

Additional vacuum ports with isolation valves allow engineers to test/expand future vacuum systems. The new electrical passthrough allows for an additional 10 conductors in/out of each delay line allowing for future electro-mechanical expansion.

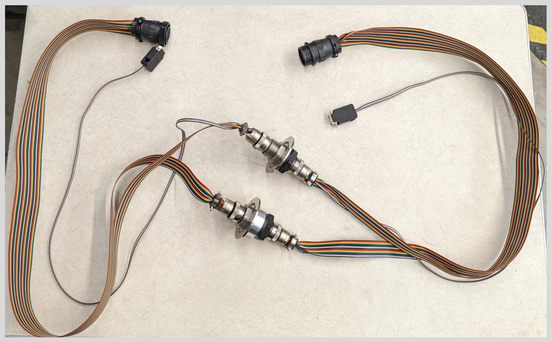
Results

To integrate the new manifold the interferometer must be taken completely offline. To minimize interference with regular operations the team was provided a one-week downtime window. The installation went smoothly, and normal operation continued the following week.

The manifold must connect to a turbomolecular pump suspended from the ceiling. The pump sits on a floating shelf to isolate the optical train from vibration. Over time the shelf has begun to degrade. To connect the new manifold to the turbomolecular pump the team implemented a steal support structure with rubber isolation clamps. This support secures the manifold but also works to improve the structural integrity of the floating vacuum shelf.

The new vacuum feedthrough cables utilize military shell style connectors making electrical connection more reliable over previous plastic connectors. Additionally, the PVAVE vacuum feedthrough is a standard component with proven reliability and can be sourced commercially. An improvement over the previous custom epoxy-potted ribbon cable.

Bellowed vacuum tubes are used to accommodate for variations in the as-built delay line system. The bellows proved necessary as the existing structure exhibits large variation from ideal engineering drawings.



Conclusion

The new vacuum manifold has achieved all requirements requested by the customer. The team provided a safe and reliable design that has already been integrated with daily operations. The manifold fulfills a fundamental role at the Navy Precision Optical Interferometer and functions better than the predecessor.

The greatest engineering challenge was to interface with an existing real-world system. The location of each optical delay line, the location of the turbomolecular pump, the weldments of the existing electrical feedthrough, and the large thread pitch all deviated from ideal engineering drawings. The Capstone Team worked to ensure the new manifold inherently accommodated for variation in the as-build structure.

The new vacuum manifold’s success highlights other areas in need of improvement. More work can be done to the vacuum and optical systems of the delay lines. Most notably the new manifold allows engineers greater access to the front of the delay line tanks, but the optical snoots are still cumbersome to disconnect.

References

- “Kurt J. Lesker Company | KF (QF) HV Flange Technical Notes | Vacuum Science Is Our Business.” https://www.lesker.com/newweb/flanges/flanges_technicalnotes_kf_1.cfm (accessed Oct. 13, 2021).
- EDWARDS, “VACUUM EQUIPMENT FOR RESEARCH AND DEVELOPMENT,” *EDWARDS*, 2021. Accessed: Sep. 11, 2021. [Online]. Available: https://www.edwardsvacuum.com/content/dam/brands/edwards-vacuum/edwards-website-assets/scientific-vacuum/documents/brochures/edwards-rnd-brochure-3601001801-en.pdf
- “Kurt J. Lesker Company | Flange Systems Overview | Vacuum Science Is Our Business.” https://www.lesker.com/newweb/flanges/flanges_technicalnotes_overview_1.cfm (accessed Sep. 11, 2021).

Acknowledgements

Client: Jim Clark (Naval Research Laboratory)
Advisor: Dr. David Willy (Northern Arizona University)