Comparative Analysis of Reed Switches and Hall Sensors at Cryogenic Temperatures: An Argument for a Cost-Effective Alternative for Cryogenic Applications

Charles Stanford-Jones[1], Jake Roberts[1]

[1] IRLabs (Infrared Laboratories), 85719, Tucson, AZ, USA

CONCLUSION

COTS **reed switches** are a cost-effective alternative to **Hall sensors** in cryogenic motion control applications

BACKGROUND

Switches are often used in motion control applications to indicate home positions, limits of travel, or positions-of-interest within the range of motion. Cryogenic systems also feature motion control, but many switches stop functioning properly at cryogenic temperatures. Magnetic switches are of interest since they are non-contact, minimizing component wear and contamination inside the vacuum chamber.

Fig 1. Example filter wheel assembly controlled by motor with position feedback from mechanical switches

Cryogenic Hall Sensor are often selected for cryogenic motion control applications, but have **disadvantages:**

- High Cost for cryogenically-rated precision Hall Sensors
- Additional costs in designing and debugging Hall output conversion electronics

METHODS

Two different experiments done in this study:

1. Position Comparison Test

The goal was to measure the position repeatability of the reed switches compared to the Hall sensor at cryogenic temperatures:

- A reed switch and Hall sensor were both cooled down to 77K using liquid cryogen.
- The dewar contained a wheel controlled via stepper motor. A magnet embedded into wheel acts as trigger for the magnetic switches
- Position repeatability measured using an optical measurement tool and target mounted onto the wheel. Resolution of optical measurement tool: 0.1um.
- Motor commanded to home the wheel using the magnetic switch as feedback.

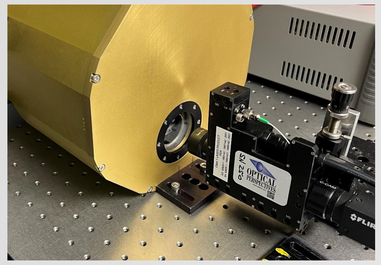


Fig 2. Position Repeatability Test Experiment Setup showing the Optical Measurement Tool measuring target inside dewar

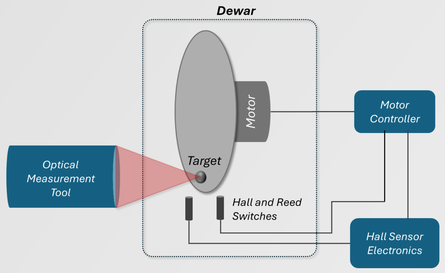


Fig 3. Position Repeatability Test Experiment Schematic

2. Bulk Test

The goal of the bulk test was to test multiple reed switches to get an estimate of failure rate after cooling to cryogenic temperatures.

- The Bulk Test dewar cooled down to LN2 temperature (77K) and LHe temperature (4.2K). Dewar cooled down with liquid cryogen.
- Ten reed switches tested to see how many fail when cooled down to cryogenic temperatures
- Magnets inside the Dewar were rotated to actuate the reed switches during test
- Output from switches measured with Digital Multimeter to check reed switches actuated when cold

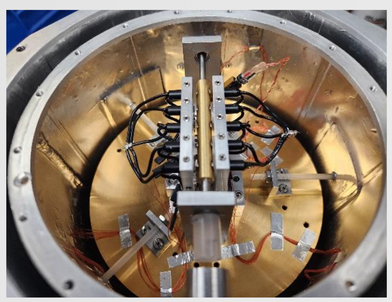


Fig 4. Inside of Bulk Test dewar

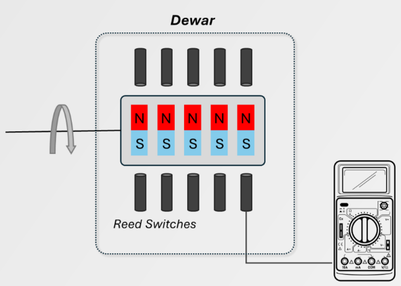
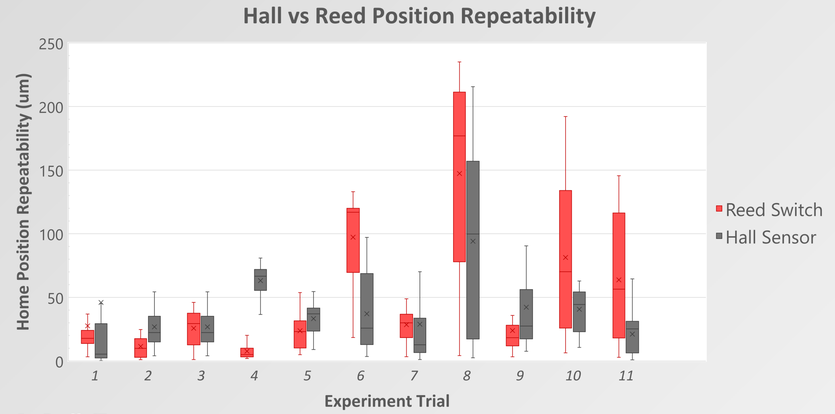


Fig 5. Experiment schematic of Bulk Test dewar

RESULTS

1. Position Comparison Test

The Position Comparison Test showed comparable positioning performance between the reed switch and Hall sensor. After multiple cycles there wasn't any apparent degradation in performance of either the Hall Sensor or the reed switch. Experiments 4 and 8 also indicate that temperature changes result in a large change in positioning accuracy.



2. Bulk Test

The Bulk test showed a failure rate of 20% when cooling down the reed switches. However, after doing the initial LN2 cooldown, the switches continue working at LHe temperatures. This suggests some "freeze-in" testing may be necessary to find switches that fail early.

DISCUSSION

- Magnetic reed switches are a low-cost, easy-to-implement alternative for motion application (at or above 4.2K) that requires position accuracy to within +/- 150um. They appear well-suited for motion control applications such as home switches or limit switches at these temperatures.
- Performance of reed switches comparable to cryogenic Hall sensors
- Study also showed that temperature of the switch and magnet has a significant impact on its position repeatability.
- It is recommended to perform initial "freeze-in" testing with the reed switches to stress switches that cannot handle cryogenic temperatures.
- Further study needed to verify the long-term repeatability of the reed switches. Additional testing with high vibration cryocooler systems, would show how resilient switches are to vibrations from these cryocoolers.

ACKNOWLEDGEMENTS

Special thanks to Mr. Robert Parks at Optical Perspectives Group in Tucson, AZ for providing the Point Source Microscope. The Point Source Microscope was used for measuring the position repeatability of the reed and Hall switches in the Position Comparison Test.

Email Addresses

Charles Stanford-Jones: cjones@irlabs.com

Jake Roberts: jroberts@irlabs.com

IRLabs INNOVATING THE INFRARED

OPTICAL PERSPECTIVES