Jet Propulsion Laboratory
California Institute of Technology

Characterization Testing of Lockheed Martin Standard Micro Pulse Tube Cryocooler

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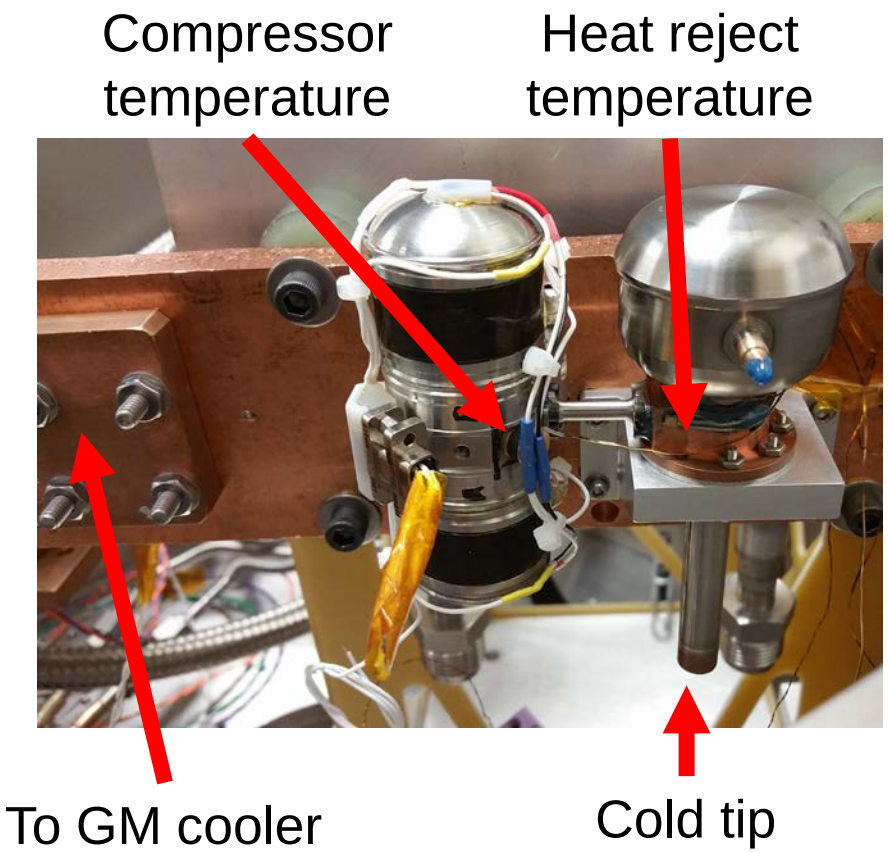
Lockheed Martin Standard Microcooler

- Pulse tube type
- Flexure bearings
- Maturity level: TRL 6
- Mass: 317 grams
- Optimized for 125 K to 150 K coldtip
- Compressor: 90 mm long
- Transfer line geometry: short and straight

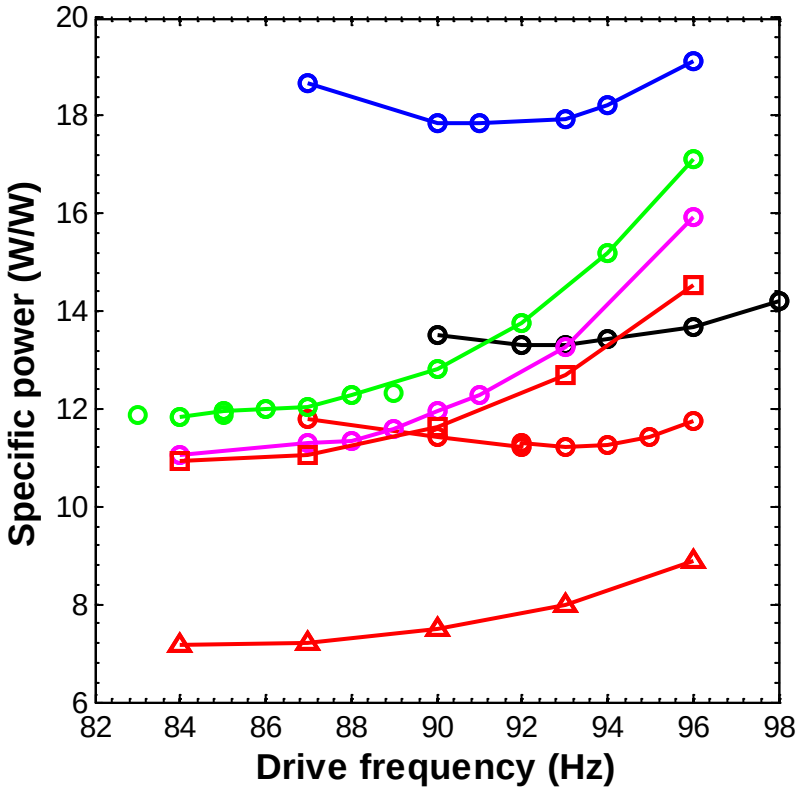
- The Jet Propulsion Laboratory has identified this cooler as a candidate for future space missions
- Characterization tests were performed to better understand the effect of this cooler on a spacecraft

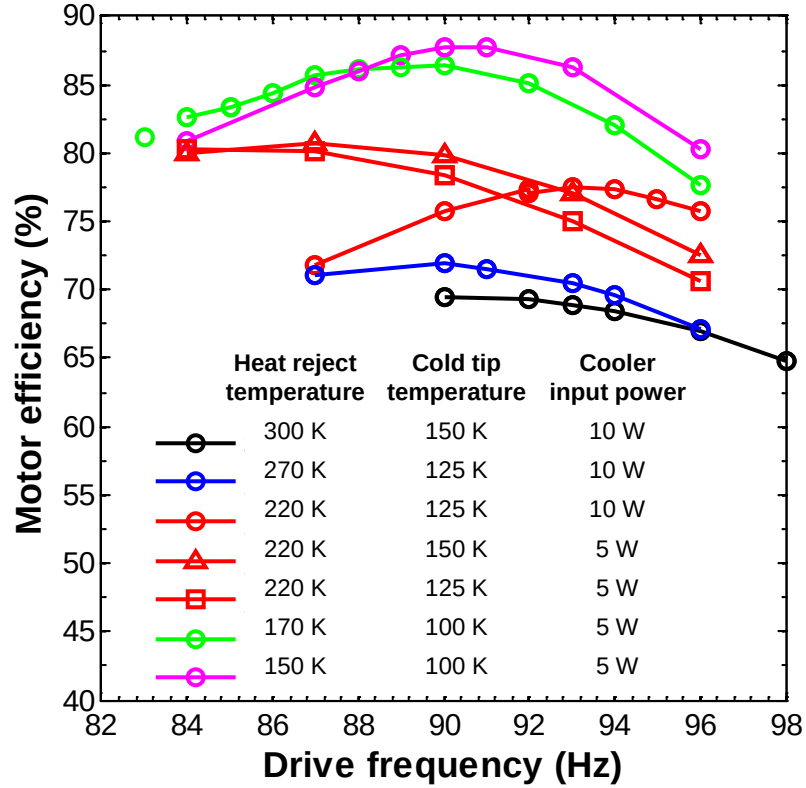
Thermal Vacuum Performance Testing



- Parametric study:
  - Frequency: 84 Hz to 98 Hz
  - Heat rejection temperature: 150 K to 300 K
  - Input power: 4 to 20 W
  - Heat lift: 0 W to 2.5 W
- Not shown:
  - Cold tip heater
  - MLI
- Compressor temperature was ~5 K larger than expander temperature
- Cooler driven with Thales XPCDE4865 drive electronics

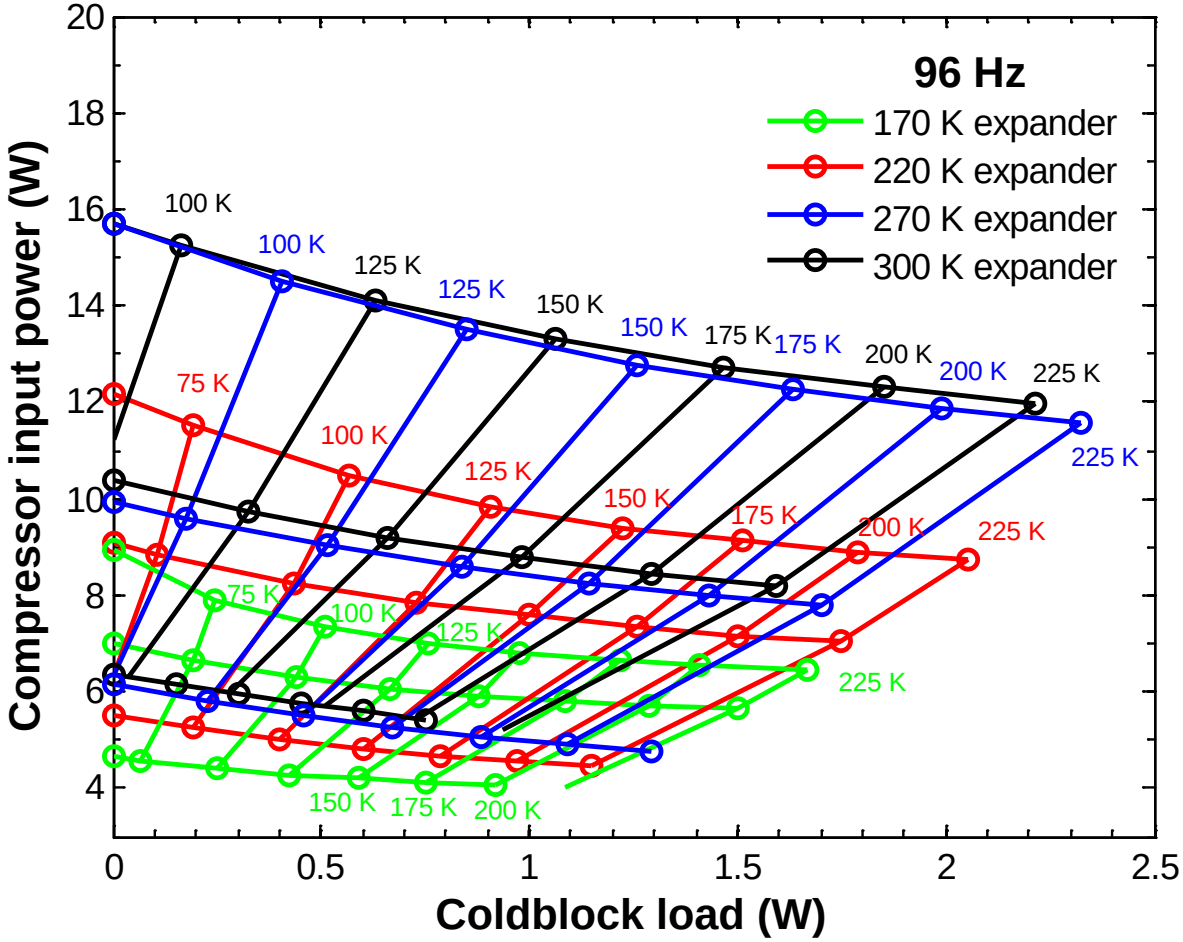
Effect of Drive Frequency on Performance





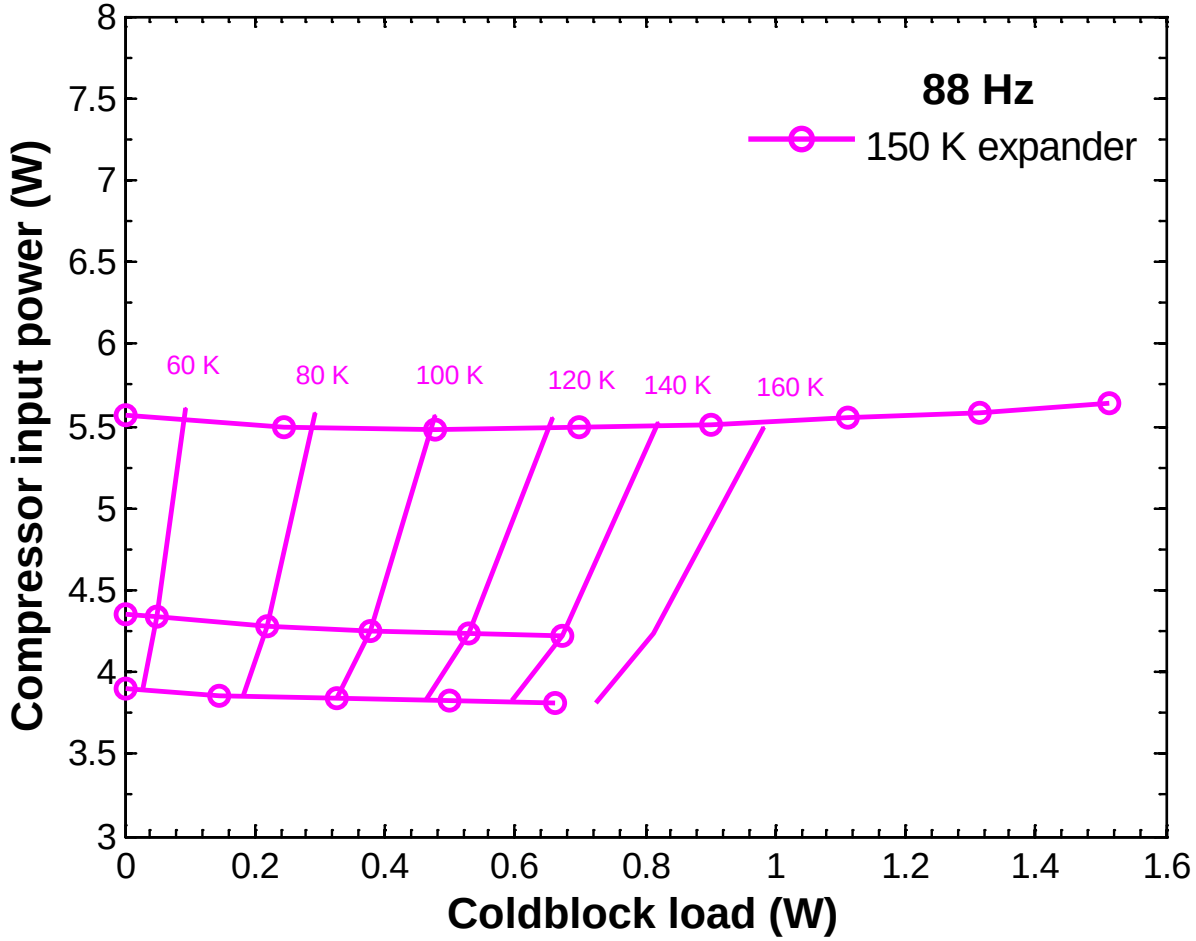
- Optimal frequency dependent on heat reject temperature and compressor input power
- For a given set of conditions, minimum specific power and maximum efficiency occur at nearly the same frequency

Ross Plot at 96 Hz



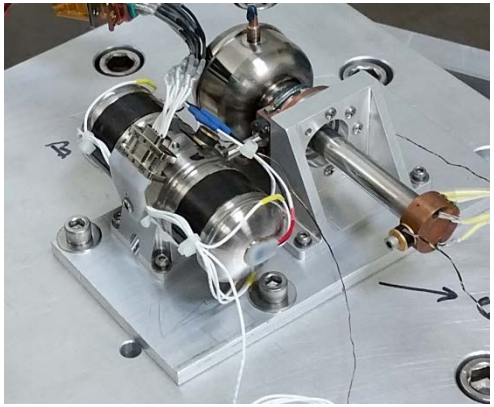
- Cooling power increased with decreasing heat reject temperature
- The maximum input power was not necessarily reached

Ross Plot at 88 Hz

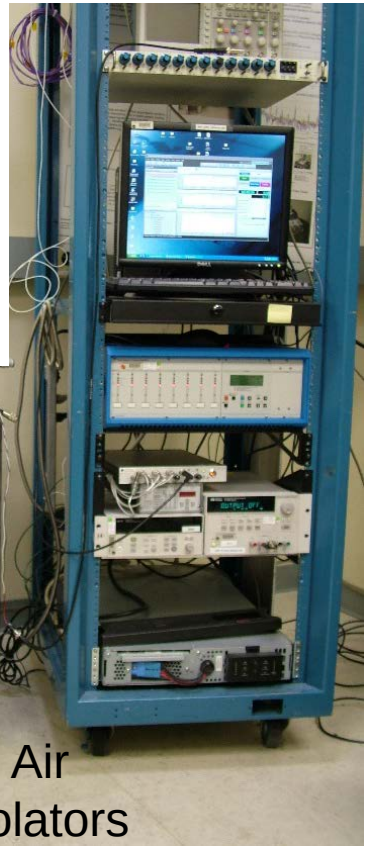


- Cooler successfully operated with 150 K heat rejection
- Achieved 650 mW of cooling at 120 K

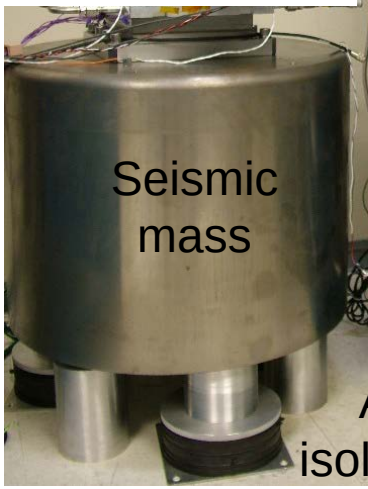
Measurement of Exported Forces



Rack electronics



Dynamometer

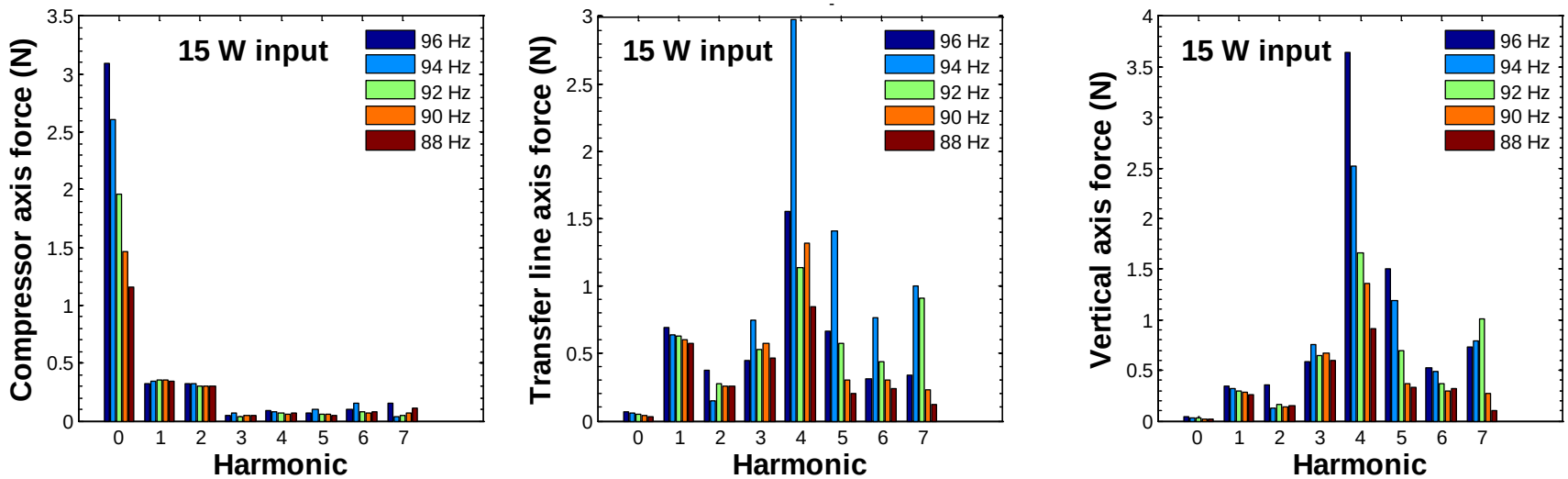


Seismic mass

Air isolators

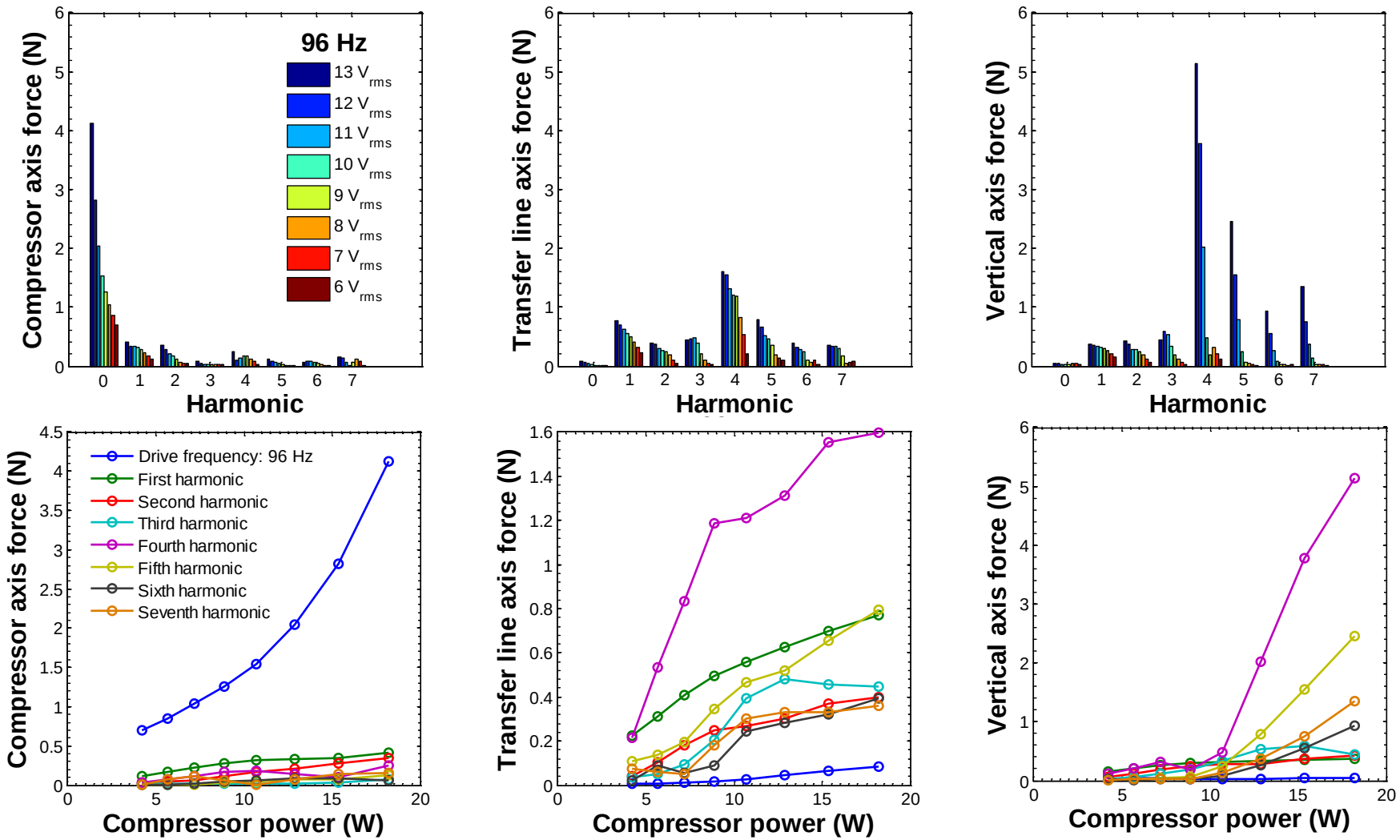
- Parametric study:
  - Drive frequency
  - Input power
  - Drive electronics
- Cold tip exposed to ambient air during tests
- Cooler driven with Thales CDE7232 drive electronics
  - Equipped with automatic vibration reduction function
- Force signal in compressor axis used as feedback

Effect of Drive Frequency on Exported Forces

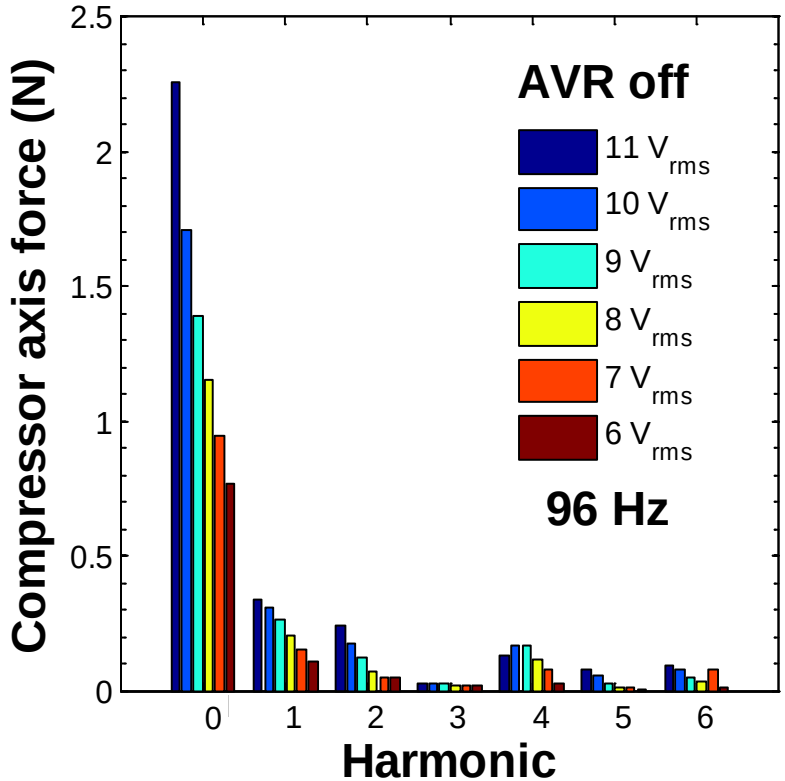


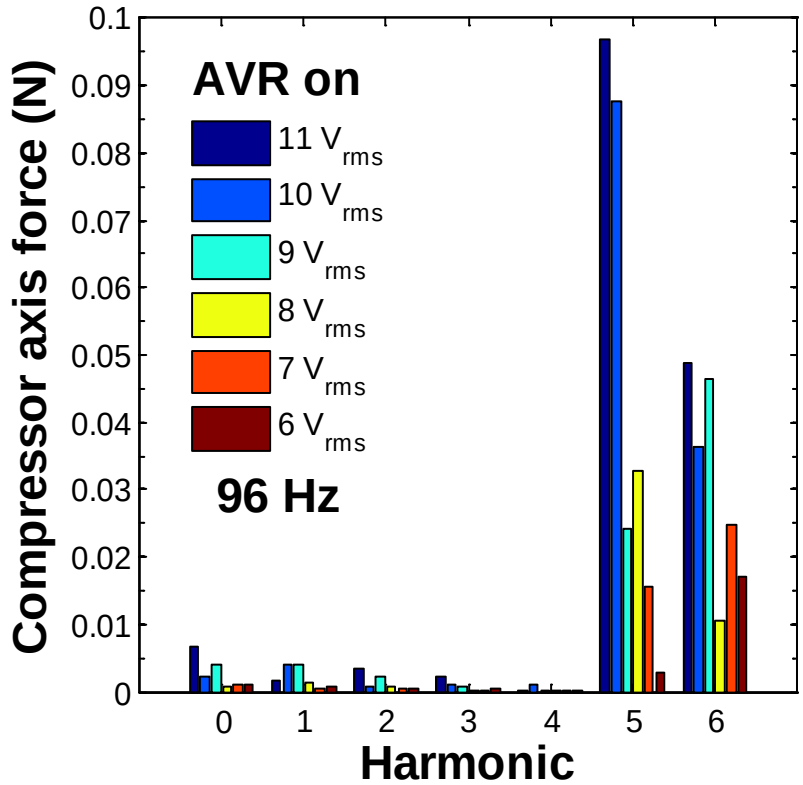
- Force decreased with decreasing drive frequency
- Large forces observed at higher harmonics radial direction from the compressor
  - Possibly due to non-uniform magnetic materials in the compressor or small motor misalignment
- Jitter due to forces at higher harmonics negligible compared to that due to forces in the compressor axis at the drive frequency

Effect of Input Power on Exported Forces



Effect of Automatic Vibration Reduction (AVR)

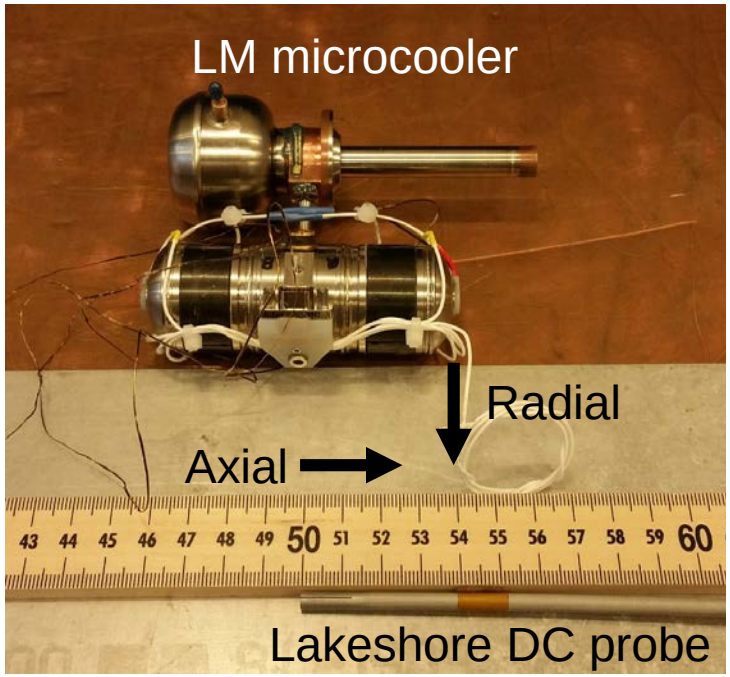




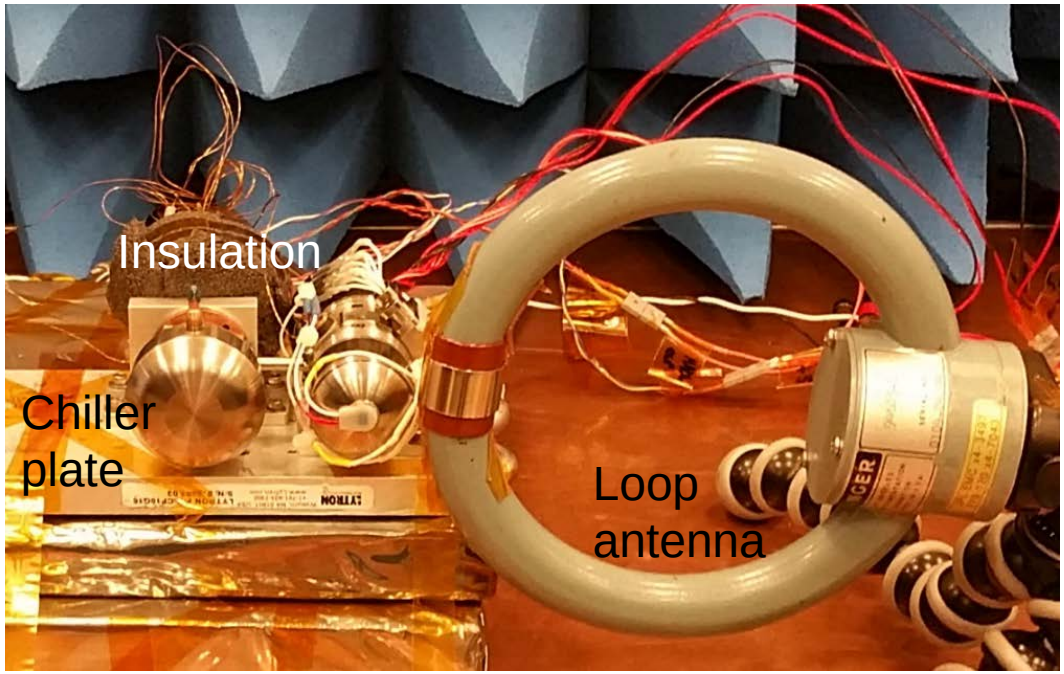
- AVR reduced the forces of harmonics 0 to 4 to below 10 mN 0-pk
- AVR did not function correctly for input voltage above 11 V_{rms}
- AVR did not affect the forces in the compressor radial direction

Electromagnetic Interference Testing

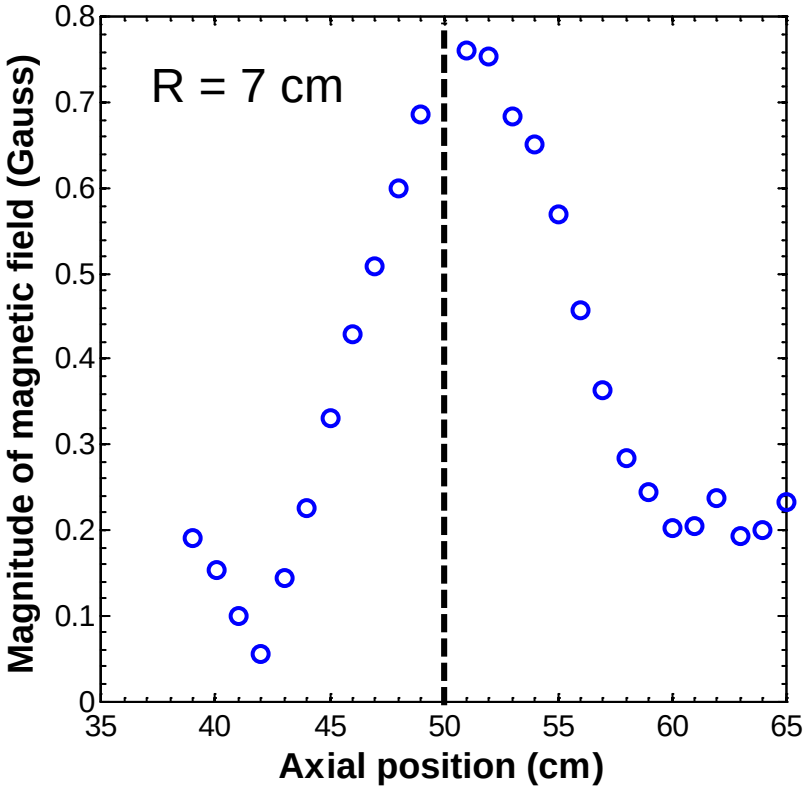
DC test setup

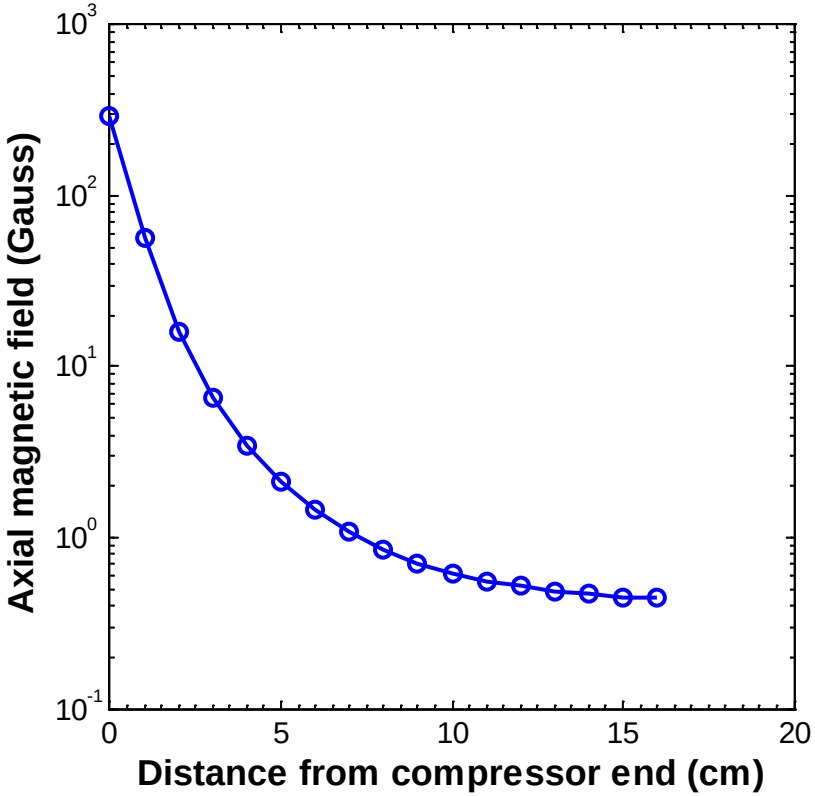


AC test setup



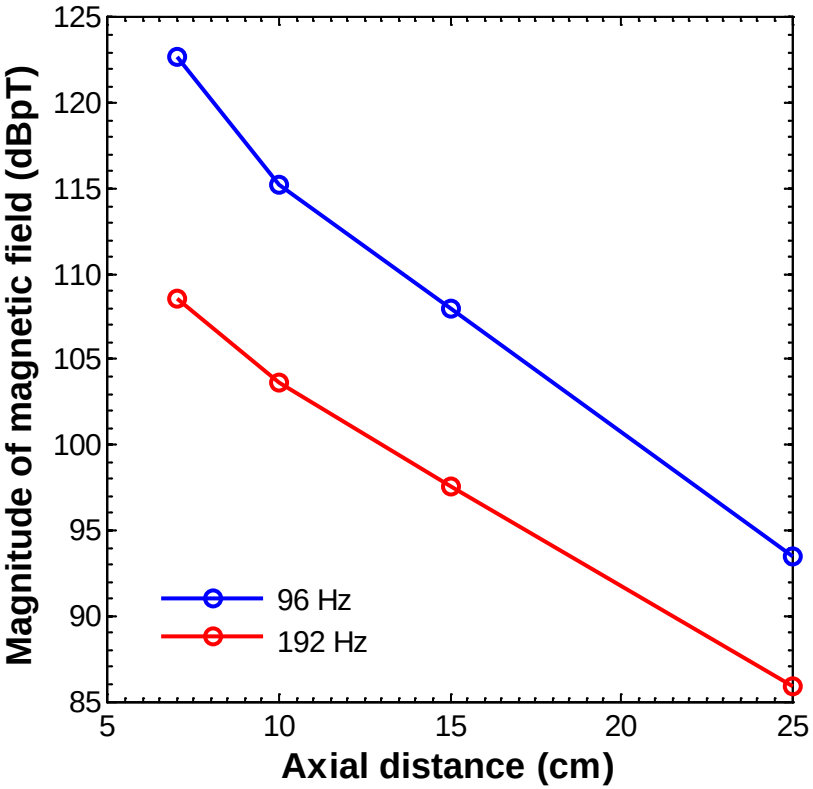
DC Electromagnetic Interference

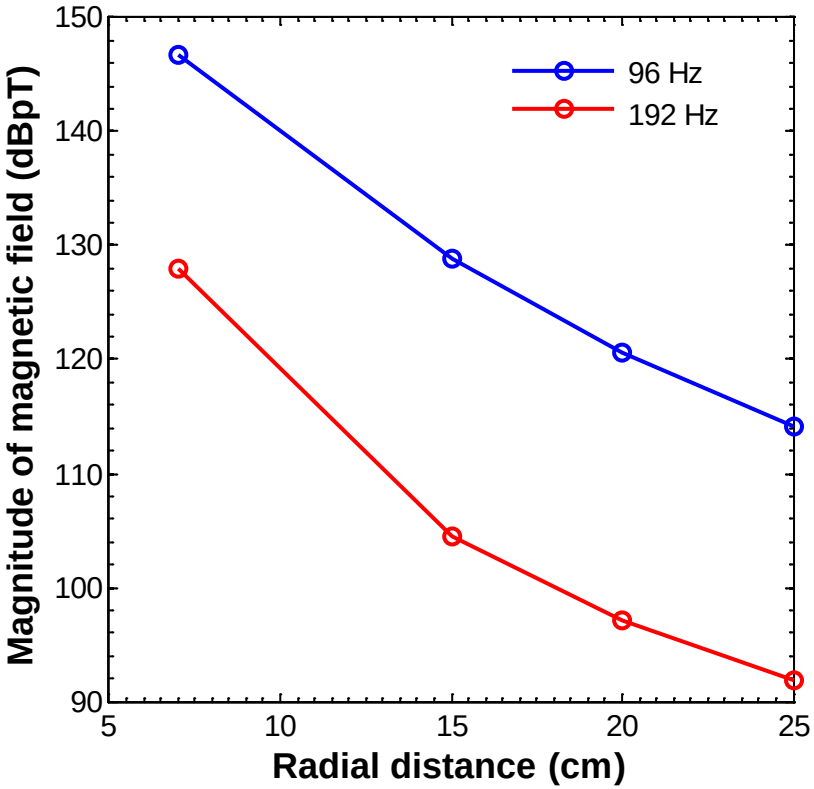




- Earth's magnetic field (0.5 Gauss) was subtracted from data
- Magnetic mapping: quadrupole magnetic field of 14.41 nT pk-pk at R = 1 m
- Overall magnetic dipole moment: 9.18 mA-m^2
- Magnetic dipole field: 3.67 nT pk-pk at R = 1 m

AC Electromagnetic Interference





- Peaks of field vs. frequency spectrums are shown
- Field varied by less than 5% for input power range 10 W to 20.5 W
- Cooler does not meet the RE101 requirement without shielding

Conclusions

- The optimal drive frequency of the cooler depends on input power and heat rejection temperature
- The thermal performance increased with decreasing heat rejection temperature
- The exported forces in the compressor axis were successfully suppressed to below 10 mN for input voltage up to 11 V_{rms} with the AVR function of the Thales CDE7232 drive electronics
- The AC and DC magnetic interference was thoroughly measured
- The cooler remains an excellent candidate for future space missions

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