Laboratory measurements of horn-coupled and antenna-coupled microwave kinetic inductance detector (MKID) arrays

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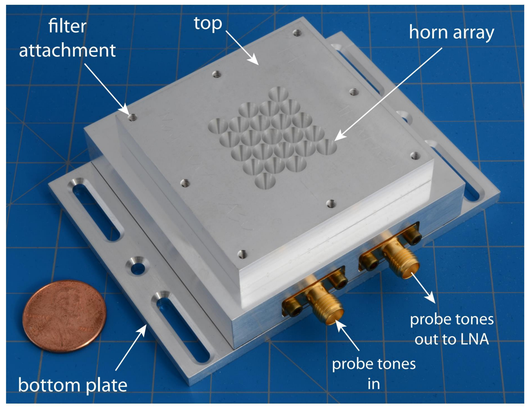
INTRODUCTION

- MKIDs are superconducting resonators that can be used as photon detectors. They are well-suited to use in large detector arrays.
- Our lab is developing polarization-sensitive multi-chroic MKIDs are sensitive to orthogonal polarizations in two spectral bands.
- We are testing horn-coupled and lens-coupled MKID modules.
- Our laboratory measurements will focus on sensitivity (NET) and low-frequency noise.

We are developing a low-noise homodyne readout system to be used in upcoming MKID characterization tests.



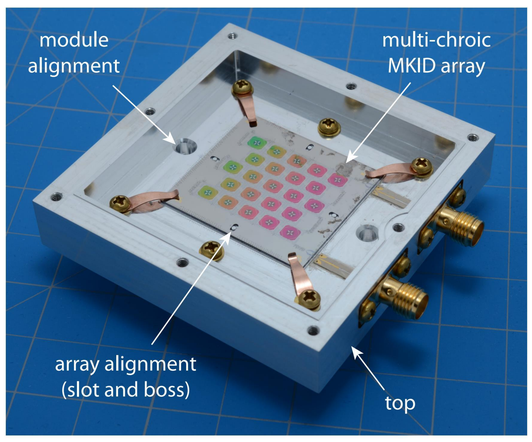


Fig. 1 Photograph of a horn-coupled multi-chroic MKID module with the cover containing the horn array on (top) and cover removed (bottom). With the cover off, the 23-element prototype array is visible. Each element contains four MKID resonators to achieve polarization sensitivity in two spectral bands. Reproduced from [1].

METHODS

Low-noise homodyne readout system

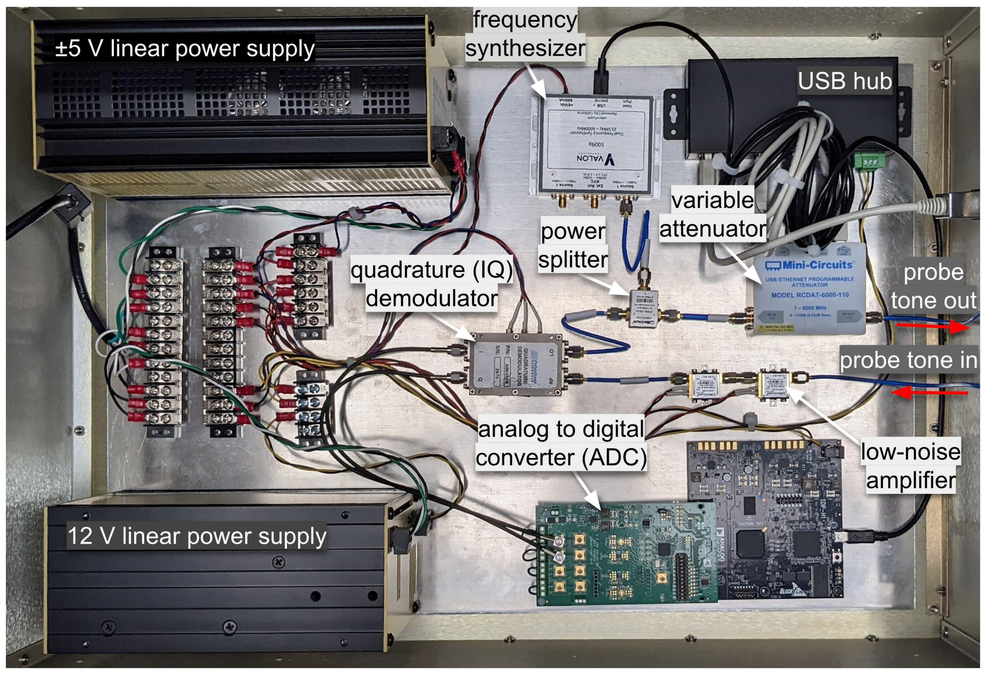


Fig. 3 Photograph of the readout system.

An MKID is driven by a probe tone at the resonance frequency (f_r) of the detector. When the MKID is illuminated, f_r shifts, changing the amplitude and phase of the probe tone. Outside the cryostat, the readout system generates and attenuates a probe tone. The attenuated probe tone is sent to the detector module inside the cryostat. The detector module output is amplified inside and outside of the cryostat. The amplified signal is sent to an IQ demodulator. An ADC records the output and writes it to a computer for analysis.

Cryogenic system

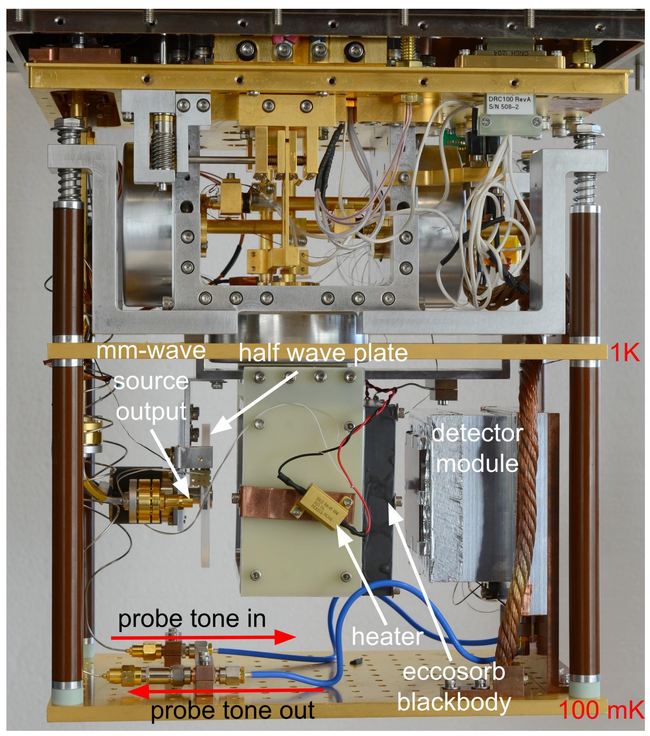


Fig. 2 Photograph of the cryogenic system.

MKID modules are tested inside the Star Cryo ADR PTC cryogenic system at UVA.

The test system components [1-3]:

- MKIDs calibration uses a variable blackbody load.
- Response time and spectral sensitivity are measured with a mm-wave source producing broadband or continuous radiation centered on 150 and 285 GHz.
- Polarization response is measured with a rotating stepped half wave plate.

CURRENT STATUS

We have measured the noise level of the readout system alone and found that it is consistent with the nominal phase noise of the frequency synthesizer.

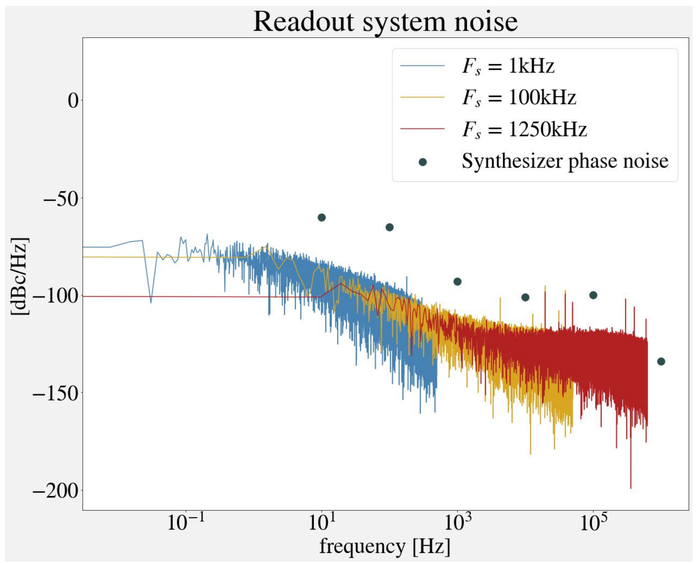


Fig. 4 PSD of the readout system alone.

- The LO input of the IQ demodulator was powered by a second, independent output of the signal generator.
- The attenuator output bypassed the cryostat and was instead routed directly back to the LNAs which connect to the RF input of the IQ demodulator.
- The ADC has a limited memory buffer. Multiple sample frequencies were used to cover the required bandwidth.

FUTURE WORK

In the next six months, we will use the readout system presented here to characterize MKIDs.

If the phase noise of the readout system is too high, then we plan to add an external reference to the signal generator. The ADC will also be upgraded to one that continuously streams data to the readout computer.

REFERENCES

1. Johnson *et al.* 2018, *Development of Multi-chroic MKIDs for Next-Generation CMB Polarization Studies*
2. Flanigan 2018, *Kinetic inductance detectors for measuring the polarization of the cosmic microwave background*
3. McCarrick *et al.* 2014, *Horn-coupled, commercially-fabricated aluminum lumped-element kinetic inductance detectors for millimeter wavelengths*