Electronics development for the readout of microwave SQUID multiplexers

Main author:

GARD Johnathon D.

Co-authors:

Becker Daniel , NIST

Bennett Douglas A. , NIST

Fowler Joseph W. , NIST

Gard Johnathon D., University of Colorado and NIST

Mates John A. B., University of Colorado and NIST

Reintsema Carl D. , NIST

Ullom Joel N. , NIST

Microcalorimeters based on transition-edge sensors (TESs) are being deployed in numerous spectroscopic instruments that require high bandwidth readout. These instruments are intended for several applications including x-ray beamline science and direct neutrino mass measurement. The size and sampling speed of existing arrays of TES microcalorimeters is limited by existing readout technologies, primarily time-division, code-division, and frequency-division multiplexing. A readout technology is needed that is capable of delivering the desired count rate, maintain the high signal to noise of TESs, and is scalable to larger arrays. The most promising candidate for multi-kilopixel arrays of TES microcalorimeters is the microwave SQUID multiplexer. The microwave SQUID multiplexer offers several gigahertz of total output bandwidth per pair of coaxial cables.

To this end, we are pursuing a scalable FPGA-based architecture for the room temperature microwave electronics. The room temperature readout electronics are an extension of the second generation Reconfigurable Open Architecture Computing Hardware (ROACH2), developed by the Berkeley CASPER consortium and adapted to probe superconducting resonators by groups developing microwave kinetic inductance detectors (MKIDs).

There are a number of challenges associated with the readout of TESs because of the nonlinear amplification of the microwave SQUID. We present our adaptation of the ROACH2 architecture for microwave SQUID multiplexer readout. For example, we will describe the requirements and recent progress towards implementing flux ramp demodulation, which linearizes the response of the RF SQUIDs. We will also describe preliminary efforts at implementing firmware for a multichannel system to readout small groups of resonators. We have demonstrated the synthesis and channelization of multiple microwave tones and further progress is anticipated. This work will provide a baseline metric for acceptable noise and signal distortion while preserving the exceptional energy resolution possible with TES microcalorimeters. With this information, we will be able to assess the hardware and firmware resources required for a much larger and scalable readout solution.