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Readout of a 160 pixel FDM system for SAFARI TES arrays

Main author:

HIJMERING Richard

Co-authors:

Bruijn Marcel, SRON Netherlands institute for Space Research, Utrecht, The Netherlands

den Hartog Roland, SRON Netherlands institute for Space Research, Utrecht, The Netherlands

Hijmering Richard, SRON Netherlands institute for Space Research

Jackson Brian, SRON Netherlands institute for Space Research, Groningen, The Netherlands

Jian-Rong Gao, SRON Netherlands institute for Space Research, Utrecht, The Netherlands

Ridder Marcel, SRON Netherlands institute for Space Research, Utrecht, The Netherlands

van der Kuur Jan, SRON Netherlands institute for Space Research, Utrecht, The Netherlands

van der linden Anthony, SRON Netherlands institute for Space Research, Utrecht, The Netherlands

At SRON we are developing Frequency Domain Multiplexing for read out of large AC biased TES arrays for both the SAFARI instrument, for the far-IR SPICA mission, and XIFU instrument, for the X-ray Athena mission. In this paper we focus on the development of a FDM demonstration model for the SAFARI instrument. The SAFARI instrument will contain focal plane kilo pixel arrays of TES-based bolometers with noise-equivalent powers (NEP) of 2x10-19 W/ÖHz operating in the wavelength range of 35 to 210 µm, and have background-limited sensitivity.

The TES bolometer arrays will be divided into channels with each 160 pixels. The resonance frequencies of each pixel are defined by in house developed cryogenic lithographic LC filters. FDM is based on the amplitude modulation of a carrier signal, which also provides the AC voltage bias, with the signal detected by the TES. Baseband feedback (BBFB), which cancels the error signal in the summing point at the input coil of the SQUID, is used to overcome the dynamic range limitation of the SQUID pre-amplifier.

Previously we have reported on the simultaneous read-out of 38 TES pixels, with NEP levels of 1 - 2x10-18 W/ÖHz, using FDM and on a detailed study of crosstalk among different pixels using a 160 TES array, with a NEP levels of ~7x10-19 W/ÖHz. This 160 pixel experiment suffers from the problems of carrier leakage, mutual inductance and common impedance, which prevent the simultaneous readout of all pixels. With carrier leakage the bias signal for one pixel is not sufficiently blocked by the LC of the other pixels, with mutual inductance the signal is transferred into neighboring pixels via magnetic coupling and with common impedance a significant impedance creates a voltage divider with the LC bias circuit and therefore changes in the LC circuit, like changing setpoint or power on one of the TES bolometers, affects the bias on the pixels. Next to the crosstalk between the pixels, another problem is that the circuit becomes so complicated that is impossible to calibrate.

In this paper we report on the results of a new 176 pixel FDM experiment with optimized cryogenic bias and read-out circuit to reduce the common impedance, carrier leakage and mutual inductance to an acceptable minimum. The cold part of the experiment consists of a detector chip with 176 TES bolometers with a designed NEP of 8x10-19 W/ÖHz and two matching LC filter chips, each of which contains 88 carefully placed high-Q resonators, with in total 176 different resonance frequencies, and a single-stage SQUID. The lines on the chips have been optimized in geometry and routing. Furthermore, the number of needed wire bounds is reduced.