Increased multiplexing of kinetic-inductance detector arrays by post-characterization adaptation of the individual detectors

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Kinetic Inductance Detectors (KIDs) have been proven to be an interesting technology for continuum detection from the mm-wave to infrared frequencies. Their intrinsic multiplexibility makes the fabrication of large arrays relatively simple, and a number of instruments have shown high quality performance on telescope, while many more instruments employing this technology are being developed.

A major challenge in fabricating large KID arrays is the frequency scatter of individual detectors, due to fabrication imperfections. This frequency scatter inevitably causes cross talk when two pixels get too close in resonance frequency. This problem can be mitigated at the expense of increasing the available frequency bandwidth per pixel, but this approach significantly limits the possible number of pixels, and is therefore not preferred especially when readout bandwidth is a scarce resource.

In this work, we follow a different approach, inspired by the work of Liu et al. [1]. We demonstrate that it is possible to improve the frequency scatter and readout bandwidth of an existing KID array, by individually adapting the on-chip capacitors of the individual pixels. We show the viability of this approach on a small (112 pixel) prototype array, optimized for detection in the 230 GHz atmospheric window.

After fabrication of the array, we characterize the optical response of all pixels using an optical cryostat and a sky simulator. This allows us to identify each individual pixel with its position on the array and its resonance frequency. As shown in Fig. 1 (top), the resonance frequencies show an irregular frequency comb, with a scatter of a few percent around the design frequency. [2]

We use these characterization results to define a unique adaptation mask. This mask allows to trim the capacitor fingers of each individual pixel, such that after this trimming, the resonance frequencies form a regular frequency comb. The resulting feedline transmission of this array, after adaptation, is shown in Fig. 1 (bottom). It can be clearly seen that not only the necessary readout bandwidth is reduced by ~ 15%, but more importantly, the frequency scatter is reduced by approximately 2 orders of magnitude.

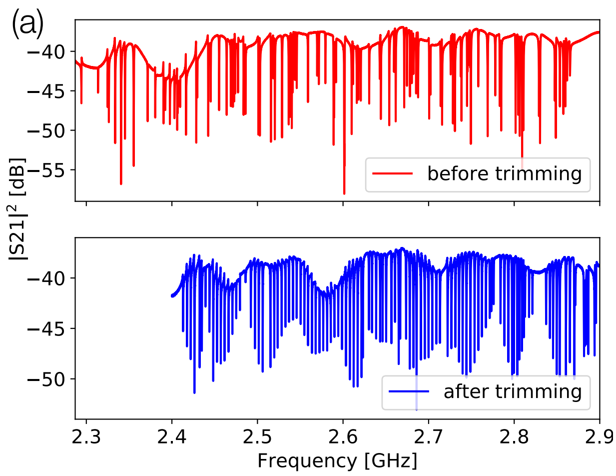

Fig. 1. Feedline transmission of the KID array before (up) and after adaptation of the individual pixels. The necessary readout bandwidth is reduced from 562 MHz to 490 MHz, whereas the frequency scatter with respect to the design value is reduced from ~ 2% to ~ 0.02 % .

In this contribution, we will discuss in detail the causes of the observed frequency scatter, the methodology to improve, and the limitations of our current procedures. Besides that we will focus on the feasibility of this trimming method for larger arrays, such as the NIKA2 1.3 mm arrays, that currently host 1140 pixels, and can be estimated to go up to 2500 pixels per array, using the same readout electronics. We will also discuss possible improvements on the characterization method and the trimming procedure.

References

[1] X. Liu et al., "Superconducting micro-resonator arrays with ideal frequency spacing and extremely low frequency collision rate", *Appl. Phys. Lett.* **111**, 252601 (2017).

[2] S. Shu et al., "Increased multiplexing of superconducting microresonator arrays by post-characterization adaptation of the on-chip capacitors", *Appl. Phys. Lett.* **113**, 082603 (2018).

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