Performance analysis of superconductor insulator superconductor mixer for 260 GHz atmospheric window.

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Abstract—**Heterodyne receivers in 260 GHz atmospheric transmission window (ALMA band 6) play key role in several scientific facilities and initiatives such as Atacama Large Millimeter Array (ALMA), Event Horizon Telescope (EHT), Latin American Millimetre Array (LLAMA) and Millimetron project. It is crucial to develop an superconductor insulator superconductor (SIS) mixer with large RF and extremely large IF bandwidth up to 20 GHz with noise performance close to quantum noise limit. We have designed and manufactured a waveguide SIS mixer for 200-280 GHz atmospheric window. We report detailed laboratory measurement of such a mixer which operates close to a quantum limit and provide analysis based on mixer theory of all gain/noise contributions. We will discuss feasibility of actually reaching quantum limit with such a system.**

Keywords—Supercnductor Insulator Superconductor mixer, cryogenic heterodyne receiver, quantum limit,

I. Extended Rationale

Heterodyne receivers in 260 GHz atmospheric transmission window (ALMA band 6) play key role in several scientific facilities and initiatives such as Atacama Large Millimeter Array (ALMA), Event Horizon Telescope (EHT), Latin American Millimetre Array (LLAMA) and Millimetron project. Due to presence of quantum limit, performance of heterodyne receiver can be improved in two major ways: increase of instantaneous bandwidth and reduction of the receiver noise up to the quantum limit. It is crucial to develop an superconductor insulator superconductor (SIS) mixer with large RF and extremely large IF bandwidth up to 20 GHz with noise performance close to quantum noise limit. While many existing designs demonstrate performance which is several times the quantum limit of h f/(2 k) non has actually touched this limit. It must be recognized that in any low heterodyne noise system the receiver noise is made out of contribution of several receiver elements, not only SIS mixer. To further approach to a quantum limit a careful analysis of these contribution needs to be performed based on the mixer theory and precise measurements.

We have designed and manufactured a waveguide SIS mixer for 200-280 GHz atmospheric window. The mechanical layout and mixer chip layout is shown in fig. 1. The mixer consist of a backport cavity, a substrate channel with quartz substrate mixer chip. The mixer contains a Nb superconducting low pass filter, waveguide probe, SIS junction and integrated tuning circuit. It has been designed to cover 4-12 GHz IF band.

We report detailed laboratory measurement of such a mixer which operates close to a quantum limit and provide analysis based on mixer theory of all gain/noise contributions. As result of this analysis we will discuss feasibility of actually reaching quantum limit with such a system and possible ways to further improve the performance.

The developed mixer will be a basic building block of a sideband separating (2SB) mixer which is described in the contribution of S. Realini et al at this conference. Two of such 2SB mixers will be used in a LLAMA telescope receiving system.

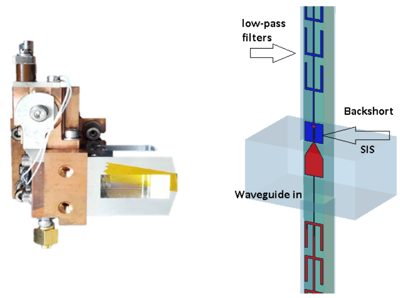

Fig. 1. SIS mixer mechanical construction (left) and mixer chip layout as calculated in 3D

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