A Horn-coupled 4-beam Dual-polarization Balanced SIS Mixer Based on Planar-integrated Circuits

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Coherent focal plane array receivers are employed in radio astronomical observations for imaging celestial objects with extended structures, whose size is much larger than the angular size of the telescope beam. However, in mm/sub-mm regime the complexity of coherent receiver frontends, which are conventionally constructed with metal waveguide circuits, imposes a limit on the number of pixels arrayed in the focal plane of a radio telescope and results in a narrow field of view. We have been developing a conceptual solution to enable compact focal plane heterodyne detector arrays with SIS mixers for wide field-of-view astronomical observation at mm and sub-mm wavelengths. The key ideas of this concept include (1) the exploitation of planar integrated circuits (ICs) to allow the use of compact planar orthomode transducers and hybrid bridge used in a balanced configuration (either a balanced mixer or sideband separation mixer); (2) the adoption of a semi-two-dimensional buried-in LO distribution network; and (3) the implementation of LO coupling between the LO distribution network and the mixer ICs by using membrane-borne waveguide probes. We have demonstrated the feasibility of THz superconducting integrated circuits with a single-pixel prototype receiver [1-2].

After that, we have been working on the development of a compact 4-beam horn-coupled dual-polarization balanced SIS mixer based on aforementioned ICs operating at 2 mm wavelengths. This experiment complements the conceptual study by demonstrating a fully functioning array with implementing all the key ideas in the concept. A photo of the receiver frontend is shown in Fig. 1. The lateral size of the frontend is limited by the horns and can be further smaller if the aperture size of the horn antenna reduces. This compactness is not achievable with the conventional integration method.

This presentation reports the uniformity of the LO distribution, followed by the RF performance of the array receiver. Moreover, a comparison is made between the performance of a mixer in the array context and that in a single-pixel mixer block. With this prototype receiver, the experimental methods and issues that are unique to a densely clustered SIS multibeam receiver are investigated.

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Fig. 1. Photo of the 4-beam mixer holder mounted inside the testing cryostat. Signals of 2 mm wavelengths are coupled through four corrugated horns attached at the upper side. The single LO injection port is seen at the near-side of the block. IF/DC are conducted by using 16 coaxial cables.

References

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