Design and Fabrication of an on-Chip Sideband Separating (2SB) Balanced SIS Mixer for 400 – 500 GHz on a 9µm Silicon Membrane

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Abstract: Superconductor-Insulator-Superconductor (SIS) tunnel junctions are currently used as heterodyne mixers with quantum limited sensitivity in millimeter and sub-millimeter wavelength receiver in radio astronomy. Well-engineered technology offers the opportunity to replace the traditionally used single-ended double-sideband (DSB) mixer by a balanced or sideband separating (2SB) mixer. 2SB mixers, which detect each sideband at a different output, giving the opportunity to suppress the atmospheric noise and/or the lines of the unwanted sideband, are today mostly made in waveguide technology [1][2]. Due to the large volume of the mixers in this technology, it is difficult to build many-pixel (> 32 pixels) array receivers where the footprint of each pixel must be small (e.g. (10x10) mm² for the planned CCAT-prime Heterodyne Array Instrument (CHAI) receiver [3]).

We show the development of the RF part of the first on-chip sideband separating balanced Nb-Al2O3-Nb SIS mixer for the frequency range between 400 and 500 GHz. The mixer is designed in the same technology as the existing integrated balanced mixer (IBAMI) [4]. The total size of the mixer including three 90° hybrid couplers, an RF load, four SIS junctions and an LO In-Phase power divider is (2.3 x 1.7) mm². For the first planned measurements, we designed a prototype mixer block - which includes the RF chip, the IF boards to the four G2PO connectors and the permanent magnets for suppressing the Josephson current. The prototype block allows us to amplify the IF signals of the four SIS mixer devices first and then combine them at room temperature to test predominantly the performance of the RF part of the circuit. In addition the same block will be used in an absorption cell measurement to show the sideband suppression of the mixer with the detection of molecular lines.

[1] Kamikura, M. et. al., International Journal of Infrared and Millimeter Waves (2007), **"A 385-500 GHz Sideband-Separating (2SB) SIS mixer based on a waveguide split-block coupler"**
[2] Serizawa, Y. et. al., Journal of Infrared, Millimeter and Terahz Waves (2012), **"Development of a 385–500 GHz Sideband-Separating Balanced SIS Mixer"**
[3] CCAT-prime Webpage**: http://www.ccatobservatory.org/index.cfm/page/index.htm**
[4] Westig, M. P. et. al., Journal of Applied Physics 112, 093919 (2012) , **"A 490 GHz planar circuit balanced Nb-Al2O3-Nb quasiparticle mixer for radio astronomy: Application to quantitative local oscillator noise determination"**