100 GHz Sideband Separating Mixerwith Wide IF Band: First Results

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***Abstract*— A sideband separating SIS mixer with a 4–12 GHz IF band and covering the RF frequency range of 80 to 116 GHz has been developed. Two prototype mixers have been fabricated and characterized for noise and image rejection showing very good performances. They will be integrated into the next generation receivers of IRAM's Pico Veleta observatory.**

I. Introduction

A 100 GHz sideband separating mixer based on single-ended DSB mixers and waveguide couplers has been designed [1]. The signal frequency range extends from 80 to 116 GHz and the mixer covers an IF band of 4 to 12 GHz. A detailed description of the design can be found in [2].

II. 2SB Mixer Assembly

RF quadrature coupler, two –23 dB LO couplers, LO splitter as well as two DSB mixers have been combined into one unit and realized as an E-plane splitblock. A picture of such a block with mounted mixer chips is shown in Figure 1. The two IF outputs are connected through two SMA right angles to a commercially available IF 90° hybrid coupler [3].

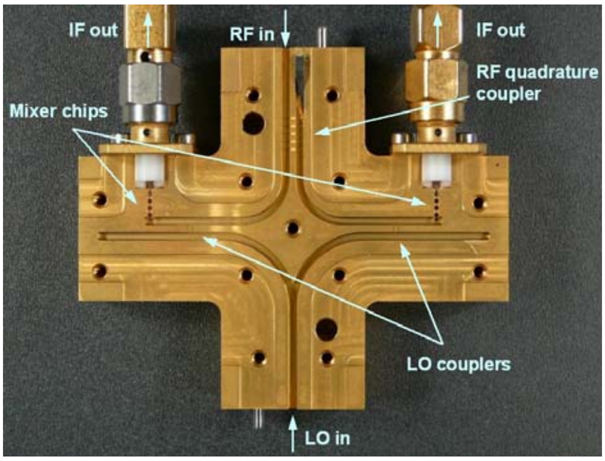

Figure 1: Photograph of the rf coupler/mixer block with mounted mixer chips.

A. Waveguide Couplers

The waveguide couplers have been realized as branchline couplers using 2 and 5 slots for LO and quadrature couplers, respectively (for details see [2]).

In order to decrease the LO noise contribution, the coupling of the LO couplers was designed to achieve –23 dB.

B. DSB Mixer

The design of the DSB mixers was described in detail in [2]. The baseline design employs a series of three junctions of which two are placed on an island structure (see Figure 2). Tuning is achieved with a parallel inductance. Since IRAM's standard fabrication process for SIS junctions includes anodization for better isolation [4], but the junctions on the isolated island cannot be anodized, a second design making use of the standard fabrication process was made.

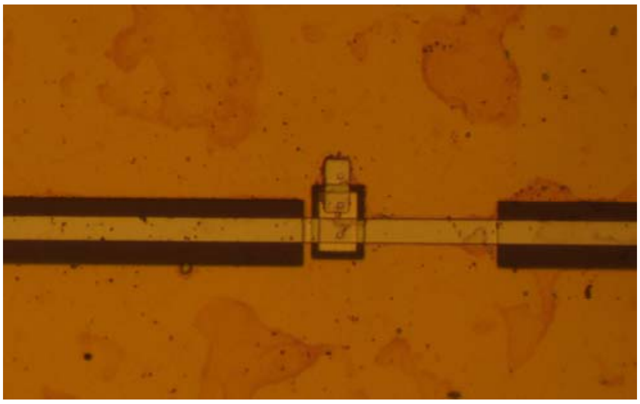

Figure 2: Photograph of the 3 junctions array.

Furthermore, in order to allow for uncertainties of the junction's capacitance and variations of processing parameters, three different variations of both designs have been included on the masks. The central design is called B, whereas A and C denote designs assuming lower and higher capacitances for the junctions, respectively.

Although in the final design the junctions are directly mounted into the integrated coupler/mixer block without prior testing, mixer blocks have been fabricated to be able to validate the mixer design by DSB mixer tests. Examples of such DSB noise measurements can be found in [2].

C. IF Coupler

IF couplers from different manufacturers have been tested both at room and liquid nitrogen temperature. Since these couplers are made for use at room temperature, their performances worsen at lower temperatures. The best results were obtained for the coupler from Pasternack [3]. They are shown in Figure 3. The worst case for the gain imbalance is 1.5 dB. Phase imbalance is always better than 3 degrees.

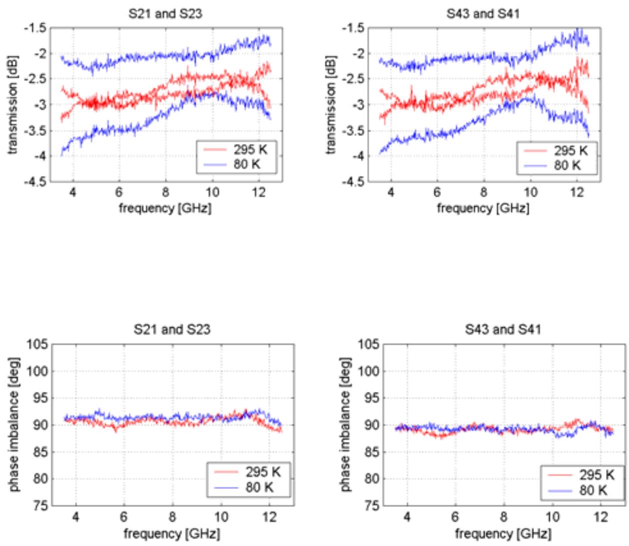

Figure 3: Characterization of the IF coupler for gain and phase imbalance both at room (blue) and liquid nitrogen (red) temperature.

III. 2SB Mixer Tests

So far junction fabrication is still an issue. The produced wafers showed inhomogeneous results and low yield. Nevertheless two pairs of similar mixer chips of the baseline design could be found for integration into a sideband noise

amplifiers used for these measurements were HEMT amplifiers from CAY with typically 6 K noise temperature [5].

A. Integrated noise measurements

Although mixer chips of different designs were chosen for the two 2SB mixers, their performances are quite comparable. The RF frequency range of the mixers is

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clearly recognisable and coincides well with the intended range of 80o 116 GHz. The obtained noise temperatures in this range lie between 28 and 41 K. For same signal frequencies lsb measurements resulted in better performance.

B. IF noise measurements

In order to evaluate the IF bandwidth of the mixers, noise temperatures have been measured in the 4 to 12 GHz IF band for LO frequencies between 88 and 108 GHz. These measurements are shown in Figure 5.

Again the results obtained for the two mixers do not differ very much. The IF response of both mixers is quite flat and lies except for a few points below 40 K.

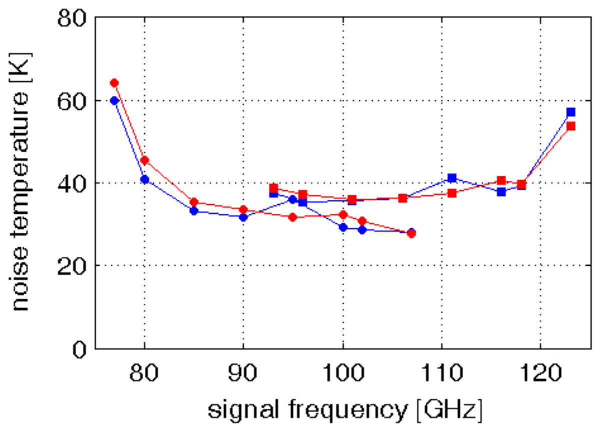

Figure 4: Integrated noise measurements obtained for an IF of 4 to 12 GHz. The results of mixer No. 1 are shown in blue. Those of mixer No. 2 are plotted in red. Upper sideband measurements are represented as squares; lower sideband results are plotted as circles.separating mixer. The first 2SB mixer was made with mixer chips of the central design, i.e. design B. Mixer No. 2 used mixer chips of design C, which was made assuming a higher capacitance of the junctions. Both mixers were completely characterized as sideband separating mixers

C. Image rejection measurements

The image rejection of the 2SB mixers has been measured using a Martin-Puplett interferometer. Again measurements were made in the 4 to 12 GHz IF band for different LO frequencies. The results are shown in Figure 6. Except for a few points the obtained values are better than –10 dB

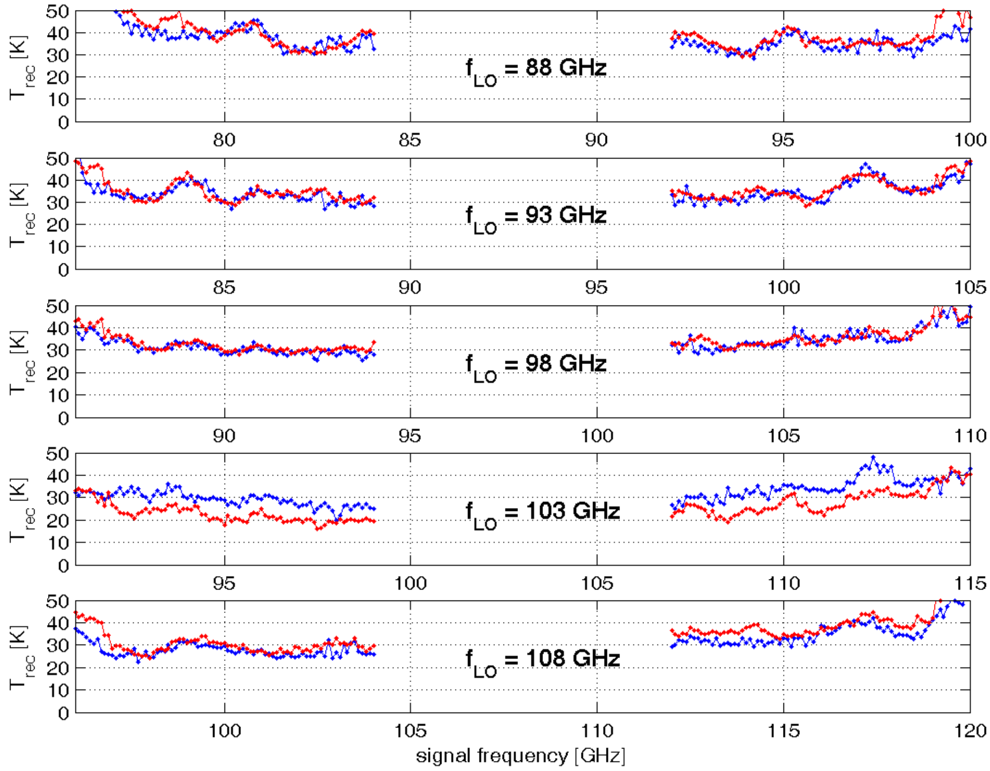

Figure 5: Noise measured in the IF band for different LO frequencies (Mixer No. 1: blue, Mixer No. 2: red).

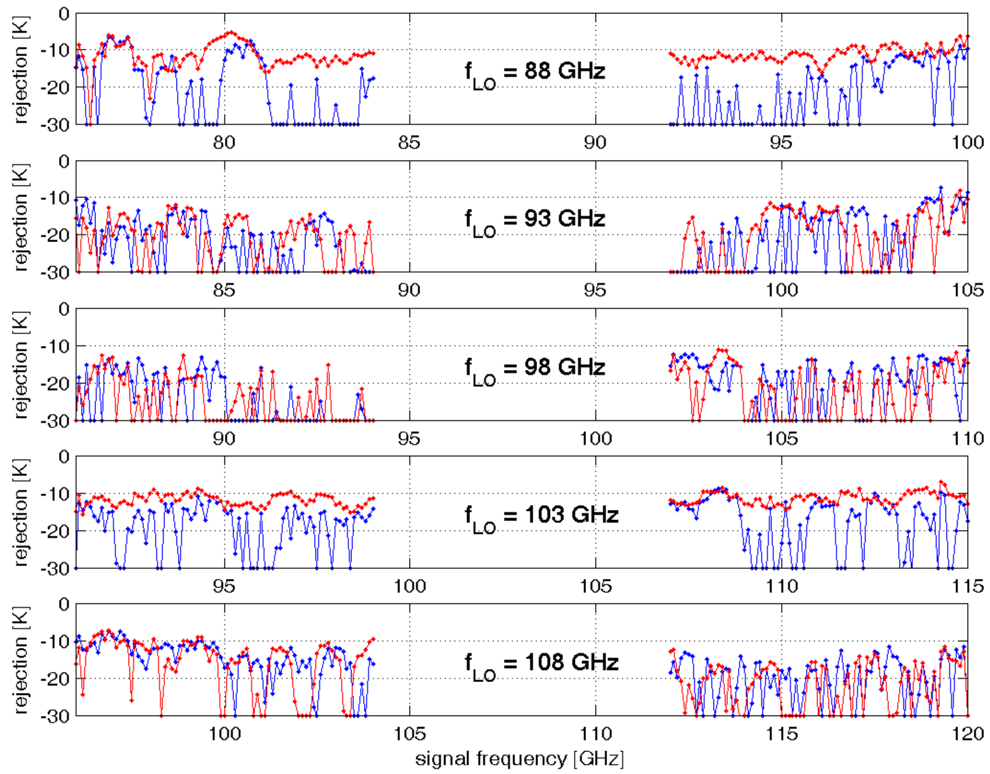

Figure 6: Image rejection measured for different LO frequencies (Mixer No. 1: blue, Mixer No. 2: red).

CONCLUSIONS

A sideband separating mixer for the RF frequency range of 80 to 116 GHz has been designed, fabricated, and tested obtaining good results. The requirements both for RF and IF frequency range could be met. The integrated noise temperatures measured for 4 to 12 GHz lie between 28 and 41 K and image rejection results are in general better than –10 dB.

Because of their good performances these two mixers will be integrated into the next generation receivers of IRAM's observatory at Pico Veleta in Spain.

ACKNOWLEDGMENT

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