Sideband-Separating SIS Mixer at 110GHz for the measurement of atmospheric ozone

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ABSTRACT

We present performance and test observation result of a sideband-separating SIS mixer at 100GHz band. All mixer components are integrated on a split-block waveguide unit. The measured single-sideband (SSB) receiver noise temperatures with L-band IF (f_c = 1.5 GHz) are less than 60 K in the LO frequency range of 90-115 GHz, and minimum value of around 35 K is achieved at 100 GHz. The image rejection ratios are more than 11 dB in the frequency range of 90-110 GHz. We have installed the sideband-separating SIS mixer into an atmospheric ozone measuring system and successfully observed an ozone spectrum at 110 GHz in SSB mode.

1. INTRODUCTION

There is a strong interest in the millimeter astronomical and atmospheric community to operate low noise quasi-particle mixers in SSB mode in order to eliminate atmospheric noise in the image band during spectral line observations. SSB observations are more efficient not only for spectroscopic observations in one sideband, but even if spectral lines of interest are present in both sidebands. Therefore, wideband and tuner-less SSB receiver is requested for observations in radio astronomy and atmospheric radiometer. To meet these demands we have been developing a sideband-separating mixer. In this report we have demonstrated performance and test observation result of a sideband-separating SIS mixer at 100GHz band.

2. MIXER DESCRIPTION

Detailed structure of a split-block waveguide unit for our sideband-separating mixer is shown in Fig. 1. We adopted W-Band waveguide (2.54 x 1.27 mm) for our waveguide unit. The basic design of the sideband-separating SIS mixer is similar to that described by Claude *et al.*[1]. The split-block waveguide unit contains an RF quadrature hybrid, two LO directional couplers, a LO power divider, and 4 K cold image terminations. We also integrated two DSB mixers on the split-block waveguide unit through the waveguide taper transformer. Note that no LO power is reflected back into another mixer in the case of ideal quadrature hybrid, since most of LO power reflected at a mixer is transmitted to the 4 K load and the feed horn through the RF quadrature hybrid. The IF signals from the two DSB mixers are combined in a commercial quadrature hybrid (Anaren Microwave, Inc.). For the initial experiment, we have chosen an IF of 1.0-2.0 GHz suitable for the existing atmospheric ozone measuring system at Osaka Prefecture University.

More detailed information is written in ALMA MEMO 453 [2].

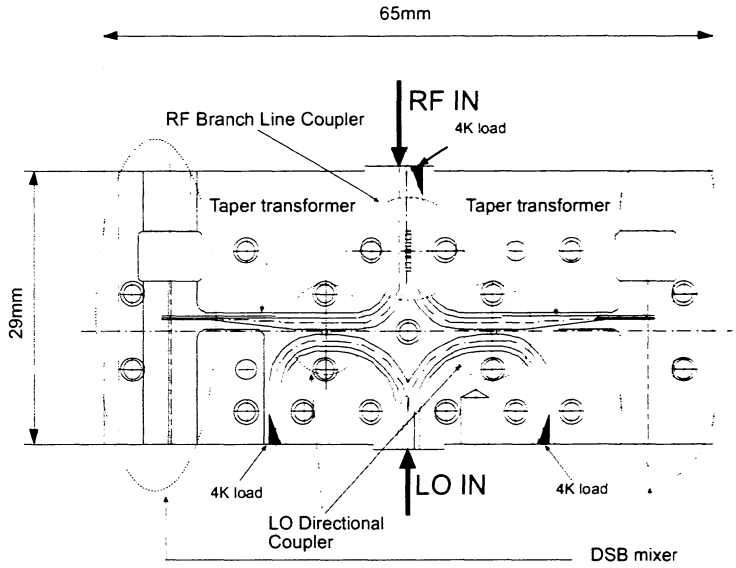

Fig. 1. Configuration of the split-block waveguide unit. The split-block waveguide contains two DSB mixers, an RF quadrature hybrid, two LO directional couplers, a LO power divider, and 4 K cold image terminations.

3. RESULT

3.1. Receiver Performance

The overall receiver noise temperature (SSB) of the receiver (including noise contribution of the vacuum window, feed horn, and IF amplifier chain) is plotted in Fig. 2 (a). The measured SSB receiver noise temperatures are less than 60 K in the LO frequency range of 90-115 GHz, and minimum value of around 35 K is achieved at 100 GHz. The measured sideband rejection ratio is plotted in Fig. 2 (b). The image rejection ratios are more than 11 dB in the frequency range of 90-110 GHz.

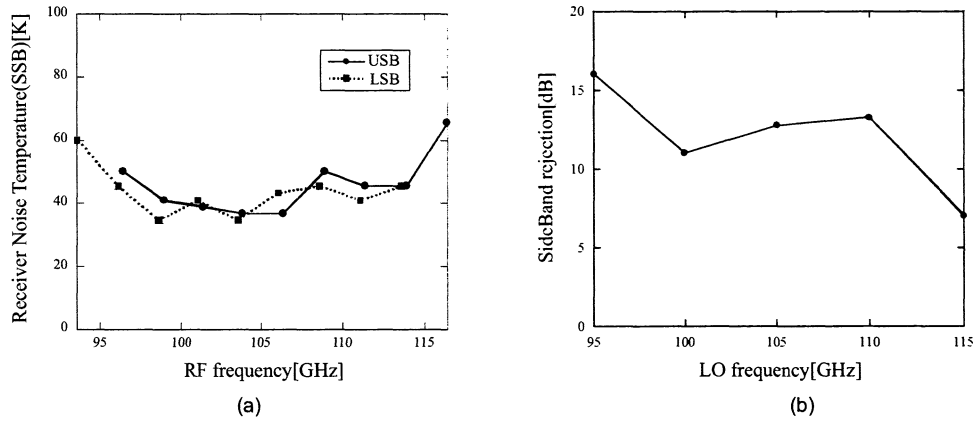

Fig. 2. (a) SSB receiver noise temperatures and (b) sideband-rejections as functions of frequency.

3.2. Observation

We have installed the sideband-separating SIS mixer into the atmospheric ozone measuring system at Osaka Prefecture University. The atmospheric ozone spectra obtained with DSB and SSB (USB) receiver system are shown in Fig. 3. It is noted here that the brightness temperature of the ozone spectrum observed in SSB mode is just twice of that observed in DSB mode as expected.

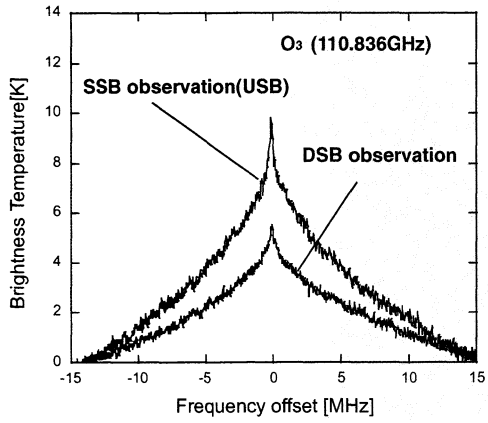

Fig. 3. Atmospheric ozone spectra obtained with DSB and SSB receiver system.

4. CONCLUSION

We have demonstrated performance and test observation result of a sideband-separating SIS mixer at W-band. We integrated all mixer components on the split-block waveguide unit, which contains two DSB SIS mixers, an RF quadrature hybrid, two LO directional couplers, a LO power divider, and 4 K cold image terminations. The measured single-sideband (SSB) receiver noise temperatures with L-band IF (f_c = 1.5 GHz) are less than 60 K in the LO frequency range of 90-115 GHz, and minimum value of around 35 K is achieved at 100 GHz. The image rejection ratios are more than 11 dB in the frequency range of 90-110 GHz. We have installed the sideband-separating SIS mixer into an atmospheric ozone measuring system and successfully observed an ozone spectrum at 110 GHz in SSB mode. This experimental result indicates that the sideband separating SIS mixer is very useful for astronomical observation as well as atmospheric observation.

References

[1] S.M.X. Claude, C.T. Cunningham, A.R. Kerr, S.-K. Pan, "Design of a Sideband-Separating Balanced SIS Mixer Based on Waveguide Hybrids", ALMA Memo 316, http://www.alma.nrao.edu/memos

[2] S. Asayama, H. Ogawa, T. Noguchi, K. Suzuki, H. Andoh, A. Mizuno, "An Integrated Sideband-Separating SIS mixer Based on Waveguide Split Block for 100 GHz Band," ALMA Memo 453, http://www.alma.nrao.edu/memos