A 1.3 mm Superconductor Insulator Superconductor Mixer Receiver with 40 GHz Wide Instantaneous Bandwidth

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The majority of SIS mixers at millimeter and submillimeter wavelengths have been designed for radioastronomy applications where low-noise and high sensitivity are of paramount importance. These include double sideband, single sideband, and 2 SB mixer receivers. Historically, the development of low noise IF amplifiers has enabled the instantaneous frequency coverage of these receivers to be extended from about 500 MHz or so available bandwidth using L Band amplifiers, centered typically at 1.5 GHz, to 8 GHz and beyond. For example, many of the receivers incorporated into the Atacama Large Millimeter Array provide IF output from 4 – 12 GHz, which is similar to that of receivers operating at the IRAM 30 m radio telescope and those at the SMA, which now provide IF output across the 4 – 16 GHz frequency range. However, in all of these recent designs, IF output below 4 GHz is not generally processed.

In this paper, we present an SIS mixer receiver with an IF bandwidth of 20 GHz, which also makes use of the frequency range below 4 GHz with low noise. To achieve this, we use an IF diplexer with two outputs, the first is used to couple IF from ~ 100 MHz to 4 GHz to a commercially available low-noise SiGe amplifier, and the second couples IF above 4 GHz to a separate commercially available low noise amplifier via a wideband circulator produced in-house[1]. In this way, the instantaneous frequency response of the receiver extends over an almost continuous 40 GHz band, with only a small gap, about 100 MHz wide, centered at the local oscillator frequency.

Referring to figure 1, the receiver noise performance at low IF is similar to that at intermediate IF. However, at high IF, the receiver noise increases as a result of increased IF noise contribution, which is partly due to non-optimal mixer tuning and partly due to higher IF noise. In addition, a standing wave with period of about 1 GHz occurs at high IF. A more optimized mixer tuning coupled with improved circulator performance is expected to reduce this.

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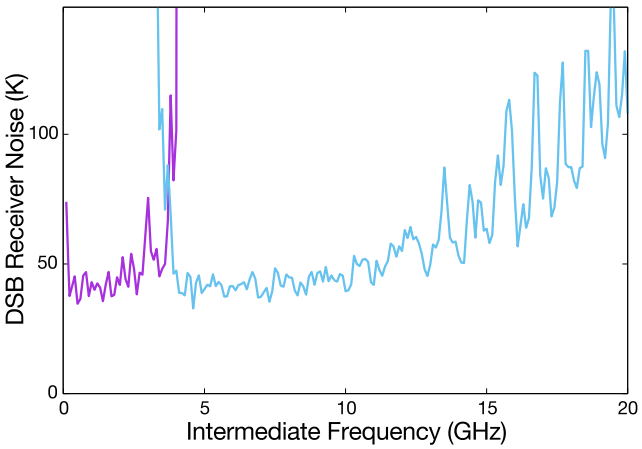

Fig. 1. Double Side Band receiver noise as a function of IF measured at an LO frequency of 225.5 GHz: the low frequency IF chain shows good receiver performance to ~ 4 GHz, whereas the high frequency IF extends operation to ~ 20 GHz.

This is the first demonstration of a truly wide-band SIS mixer, which when coupled to an ortho-mode transducer could be used to perform wide band dual polarization observations. Alternatively, incorporating separate local oscillators (40 GHz apart) to feed the mixers, one could observe an 80 GHz instantaneous bandwidth, to facilitate spectral line surveys or to enable accurate determination of the redshift of high-z targets without the need for multiple frequency tunings.

References

[1] L. Zeng, C. E. Tong, R. Blundell, P. K. Grimes and S. N. Paine, "A Low-Loss Edge-Mode Isolator with Improved Bandwidth for Cryogenic Operation," *IEEE Trans. Microwave Theory and Techniques* vol. 66, no. 5, pp. 2154-2160, May 2018. 10.1109/TMTT.2018.2799574.

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