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Wide-Band Tunerless Mixer Mounts for 100 GHz and 150 GHz SIS receivers

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ABSTRACT The performance of the new SIS receiver systems at the Nobeyama Millimeter Array are described. These receivers operate at 100 GHz and 150 GHz bands and tunerless mixer mounts have been adopted. These receivers show very low noise temperature (< 50 K) over a very wide frequency range because of the large embedding impedance range.

1. Mixer mount design

Previously, we adopted the mixer mount design shown in Figure 1-(a). There are two movable tuners, a back short tuner and an E-plane tuner. These tuners are needed to cancel out the large SIS junctions' capacitance (D'Addario, 1984). Unfortunately, these mechanical tuners degrade receiver performance, because they generate loss due to mechanical wear during prolonged operation.

To improve receiver performances, we considered the very simple mixer mount design shown in Figure 1-(b). We adopted the back short cavity instead of the movable tuners to cancel the SIS junctions' capacitance. The cavity position (L) was obtained from the theoretical calculation using Tucker theory under 3-port assumption (Tucker, 1979) (Hicks *et al.*, 1985).

This simple mixer mount design has many advantages. First, it minimizes loss because this design is very simple and it is easy to fabricate. Second, tuning the receivers is very easy and takes little time because it is only necessary to change the LO frequency then optimize the DC bias and LO power. Third, we can develop a multi-frequency receiver because the space saved inside the Dewar allows the components to be rearranged.

To investigate the feasibility of this simple design, we fabricated and measured the receiver performances.

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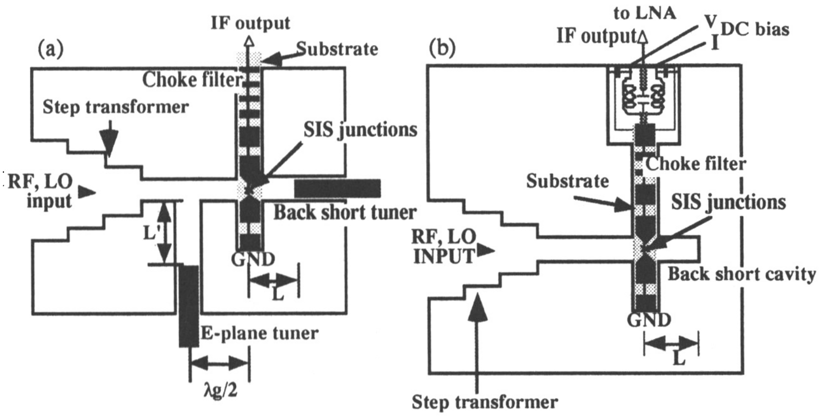

Fig.1 - Schematic display of the mixer mount. (a) is the mixer mount with two mechanical tuners. (b) is the tunerless mixer mount used in the NMA.

2. Receiver system

Figure 2 contains a block diagram of the measurement receiver system. All components, feed horn, cross guide coupler for LO injection, mixer mount, and 1st IF amplifier, were placed on the 4 K stage. The fundamental local frequencies are 40-60 GHz for the 100 GHz band receiver and 65-85 GHz for the 150 GHz band receiver. A frequency doubler was employed.

A 1-2 GHz FET amplifier was used for the measurements of the 100 GHz band receiver. The FET amplifier has a noise temperature of about 12 K. On the other hand, we used an HEMT amplifier for the measurements of the 150 GHz band receiver. This amplifier has a noise temperature of 5 K.

We measured the receiver performances by the Y-factor method. Responses were measured at Hot load and Cold load sites in front of the input-window at an IF frequency of 1.4 GHz.

3. Measurement results

The measurements obtained are shown in Fig. 3. The minimum receiver noise temperature was 15 K at around 95 GHz. Noise temperatures of 50 K were obtained for the 100 GHz receiver in the range 80-120 GHz and for the 150 GHz receiver in the range 125-165 GHz.

We must note that these broad band widths are limited by wave guide or frequency doubler, not by the mixer mount itself.

4. Discussion

We investigated why these mixer mounts show this broad band characteristic. One reason is the low Q-value, 0.3-0.5.

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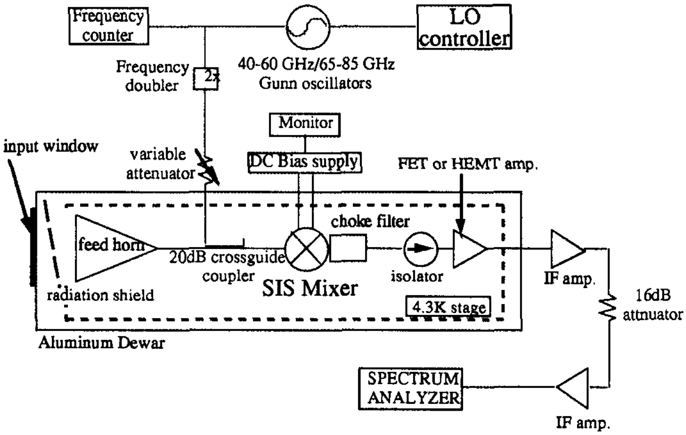


Fig. 2 - Block diagram of receiver system.

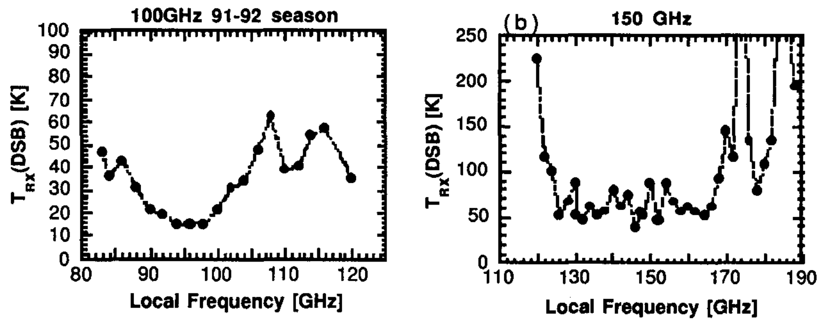


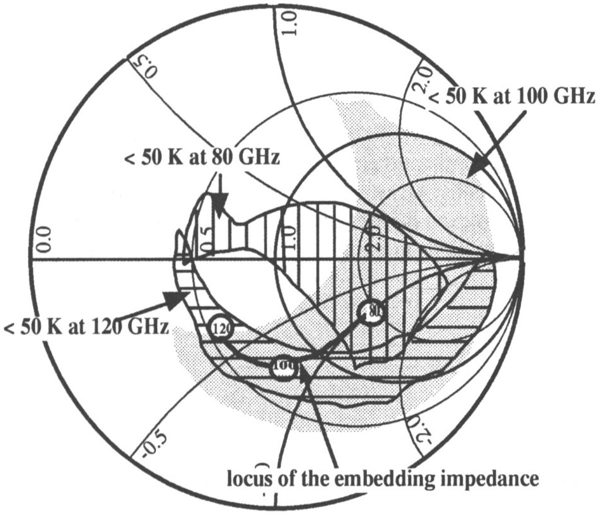
Fig. 3 - (a) is the results for 100 GHz receiver. (b) is the results for 150 GHz.

We think the main reason is that the large area of the embedding impedance causes low receiver noise temperature.

We analyzed the 100 GHz mixer mount design, and the results are shown in Fig. 4. From 80 to 120 GHz, the embedding impedance traces the locus which is shown by solid line. Hatched areas show the source impedance which cause receiver noise temperatures below 50 K at the frequencies of 80, 100, and 120 GHz. 50 K was used as the upper limit for the plot, as this is the same T_{RX} measured with the tuner type mixers. This value was also the upper limit of performance which we would consider acceptable if the new mixers were to be used on a telescope.

Thus, the wide band characteristics can be explained by the fact that a large impedance area can give below 50 K, and because all the embedding impedances of the mixer mount are included in these regions.

Fig. 4 - Smith Chart normalized to 50 Ω. These results were obtained from the theoretical calculations. Hatched areas show the source impedance giving the receiver noise temperature below 50 K at 80, 100, and 120 GHz. The embedding impedances of tunerless mixer mount over the frequency range of 80-120 GHz (solid line) are also shown.



5. Summary

We developed 100 GHz and 150 GHz SIS receiver systems for use in a tunerless mixer mount. These show very low noise performances over a wide frequency range.

This system offers many advantages for astronomical applications, such as easy operation and simple retuning. These systems have already been used in NMA and multi-beam receiver in 45 m telescope.

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