Memorandum

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cc: J. Webber

From: J. Effland, R. Groves

Date: 29 June 2001

Subject: Comparison of Receiver Noise Temperatures Measured with Conical and Chopper-based Loads

Summary

Recent measurements show discrepancies between receiver noise temperatures obtained with the chopper wheel compared to the noise temperatures measured with standard conical loads so new data were collected to investigate these discrepancies. The results show average receiver noise temperatures agree within 1% when measured with the conical load *vs*. the chopper wheel assuming the chopper load's effective noise temperature is 93.5 K across the entire 200 - 300 GHz band.

Discrepancies in the average receiver noise temperatures appear well behaved and decrease monotonically from 200 to 300 GHz when using the two different load systems. This suggests that noise temperature measurement accuracy can be improved by creating an equation or table to look up the chopper's effective cold load temperature at each frequency of interest. However, scatter in the data remains large so additional measurements are recommended before implementing such a table.

Setup

Receiver noise temperatures were measured with a single-ended mixer (UVAV-L568A-2-F6-2-B3-371C-01 integrated with preamp IF4-12P.02) using the setup shown in Figure 1. This mixer/preamp combination provides low receiver noise temperatures and hence minimizes random errors when comparing receiver noise temperatures measured with the different types of hot/cold loads.

Results

Figure 2 shows receiver noise temperatures *vs*. IF frequency using both the chopper and conical loads at one particular LO frequency of 230 GHz. Most of the chopper measurements obtained over the rest of the 200-300 GHz band had the cold load mirror tilted at the same angle, which was determined by minimizing the receiver noise temperature at a specific, but unknown, LO and IF frequency. It was noticed that noise temperatures measured with the chopper at 230 GHz on 2001-06-27 differ across the IF band from those measured earlier.

Consequently, the angle of the cold load mirror was re-optimized in real-time to minimize receiver noise temperatures over the entire 4-12 GHz IF band. The new mirror angle essentially has the mirror touching the edge of the cold load bath. The re-optimized data show a lower receiver noise temperature which means that the new mirror angle yields a lower effective cold load temperature. Noise temperature measurements with the new mirror angle were not attempted at other LO frequencies.

Figure 3 graphs the discrepancies in the receiver noise temperature when measured with the conical load and with the chopper wheel, where:

$$Discrepancy = \frac{\left\langle T_{RX}^{Conical} \right\rangle - \left\langle T_{RX}^{Chopper} \right\rangle}{\left\langle T_{RX}^{Conical} \right\rangle}$$

and

$\left\langle T_{RX}^{Conical} \right\rangle$ = the average receiver noise temperature measured with the conical load, and

$\left\langle T_{RX}^{Chopper} \right\rangle$ = the average receiver noise temperature measured with the chopper wheel.

The average was taken by summing over all 9 measured IF frequencies and over the repeated measurements at each LO frequency. Data from an earlier cold load comparison[1] was recast to use the above discrepancy definition and also is included in Figure 3. For the present measurement, the monotonic decrease in receiver noise temperature differences with LO frequency suggests that an equation or table look-up could be used to improve the accuracy of chopper based measurements. But scatter in the data is large, as shown by the standard error of the mean in Figure 3 along with the data shown in Figure 2. Consequently, it is prudent to acquire additional data prior to using more sophisticated means to improve accuracy.

[1] "Recent Data Characterizing the SIS Noise Temperature Measurement System," J. Effland, NRAO CDL Internal Memo dated 2000-10-11.

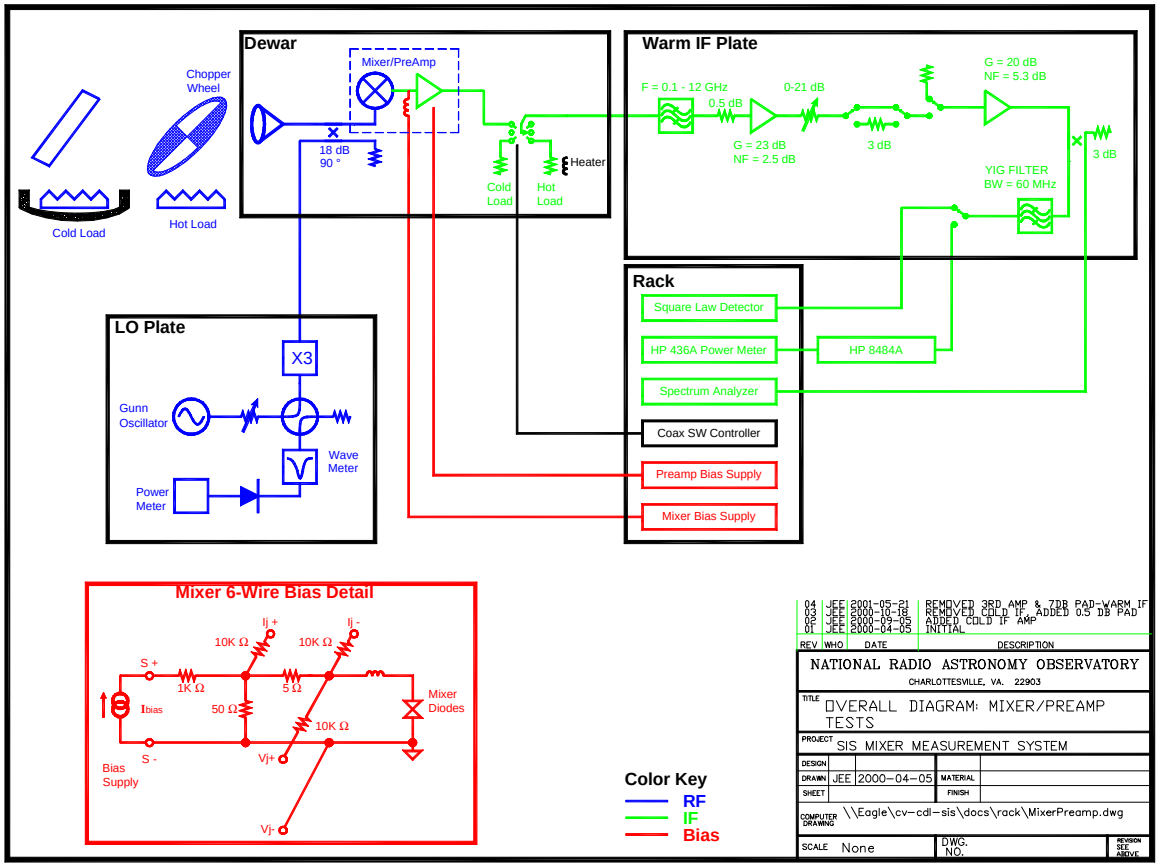

Figure 1: Measurement Setup

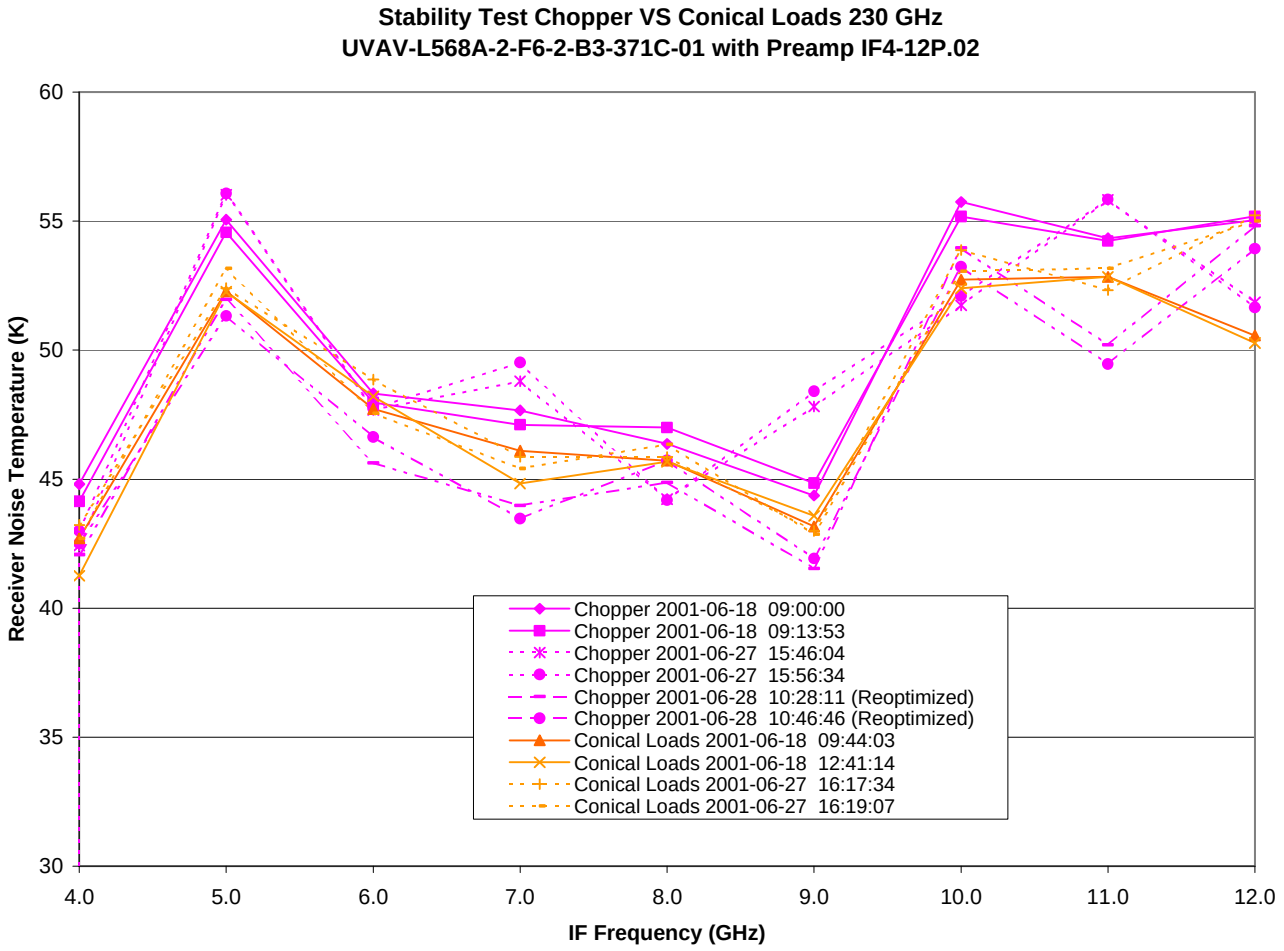

Figure 2: Receiver Noise Temperature Measured at 230 GHz

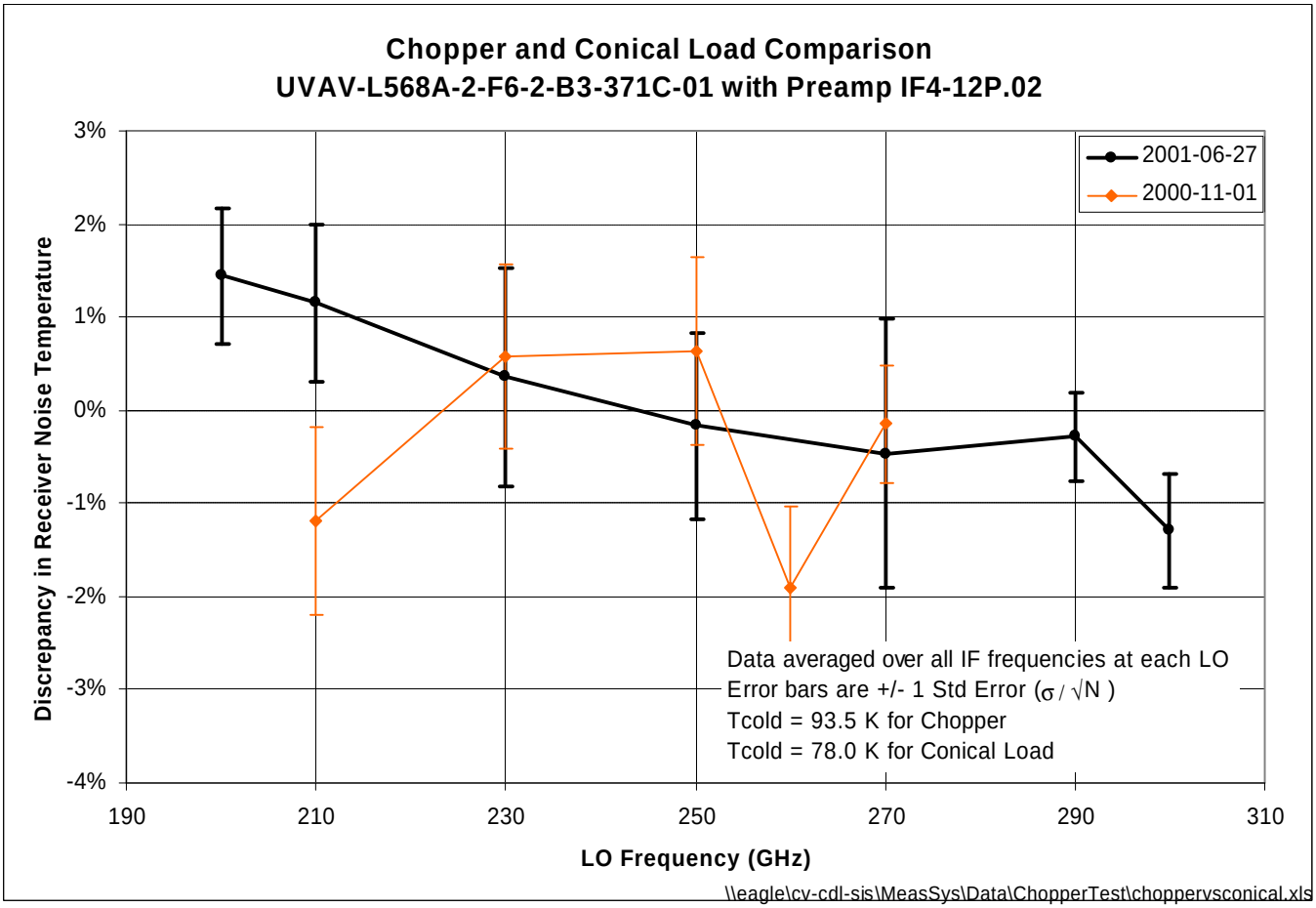

Figure 3: Chopper and Conical Load Comparison