Memorandum

To: File

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Date: 2003-09-04

Revisions:	2003-08-22	jee	Initial
	2003-09-04	jee	Updated to include Allan Variance format for PSD data

Subject: Notes on Gain Stability Measurements of 13 Jun 2003

Summary

Gain stability of the 2SB mixer-preamp was measured around 13 Jun 2003 and is about 8 x 10^{-4} for 1 second integration time. The ALMA specification for gain stability is 1 x 10^{-4} and although the measured data includes a significant contribution from the ancillary equipment, it appears that meeting this specification will be difficult. Both power spectral density (PSD) and Allan Variance (AVAR) data are presented here.

Setup

The equipment setup is shown in Figure 1 and uses the sideband separating mixer-preamp UVA10-03-0403-L1362A-2-HI-C12-L56-3-4-373-01-P.01.02 that is electrically identical to the ALMA Band 6 production version. An HP 35670 Dynamic Signal Analyzer Fourier-transforms the video signal in real time and the results are then dumped to spreadsheets for further analysis and graphing. The output to the spreadsheet is power spectral density in volts per root Hz and the bin frequency. Gain stability using 8 GHz bandwidth was acquired using the 4 GHz high-pass filter, which means the effective noise bandwidth is essentially limited only by the preamplifiers. As a consistency check, the 4-GHz high-pass filter was replaced by a 500-MHz wide bandpass filter centered at 4.75 GHz.

Results

1.1 IF System: Spectal Density

The PSD response of the IF system, exclusive of the mixer-preamp, is shown in Figure 2 and includes an InP amplifier operating in the Dewar at 4.2K. The data were acquired for all the amplifiers that follow the mixer-preamp by connecting the Radiall IF switch to the IF load in the Dewar as shown in Figure 1. All data are reconstructed from a number of sweeps on the FFT analyzer using different maximum frequencies. This is required to obtain adequate resolution at the lower frequencies. The PSD data in Figure 2 falls close to the theoretical 8 GHz bandwidth mark, which provides a check of the calibration.

1.2 IF System: Allan Variance

The corresponding Allan variance for the IF system is shown in Figure 3. Allan Variance data were produced from the power spectral density data using the following technique. Recall that the power spectral density plots are graphed in normalized form by dividing each PSD point output from the FFT analyzer, which is in units of volts/root-Hz, by the mean detector voltage. The Allan Variance was obtained from the PSD data by multiplying each normalized PSD value by the square root of the corresponding FFT bin frequency. That Allan Variance value is plotted at an averaging time corresponding to the inverse of the bin frequency.

Note that for integration times longer than 0.01s, the slope of the Allan Variance plot is -1/2, which is the expected value for white noise. The pink AVAR curve is just the response of the detector, video amplifier, and HP 35670 FFT analyzer with no IF amplifiers.

1.3 Mixer-Preamp: PSD and AVAR

Gain stability of the actual mixer-preamp (which also includes the contribution from the measurement setup) for the entire 8 GHz IFG is shown as power spectral density in Figure 4 and as Allan Variance in Figure 5. A check of the calibration is given by the purple X, which is the theoretical $\Delta V/V$ assuming an 8 GHz bandwidth. It's not surprising that the measured $\Delta V/V$ is higher that the theoretical value because the shape of the noise passband from the mixer-preamp has a drop in the middle of the IF band. That most likely yields an effective noise bandwidth that's smaller than 8 GHz and hence the measured $\Delta V/V$ should be greater than the theoretical value.

Higher frequency data should have been obtained to allow a clearer display of the Allan Variance for white-noise limited regime, but such data is presently unavailable. The 60 Hz peaks and the mysterious 37 Hz peaks in the PSD data map to the appropriate integration times in the AVAR graph. Gain variation from the JT refrigerator is clearly seen in the AVAR plot at 0.5 s.

Figure 6 and Figure 7 are additional calibration data using the mixer-preamp that shows $\Delta V/V$ when the measurement bandwidth is reduced from 8 GHz to 500 MHz using the K&L 4B380-4750/500-0 filter (shown by the dashed lines in the block diagram of the setup). Note that the theoretical PSD level using this filter, shown by the square, is just slightly higher than the measured trace. This is explained by recalling that the filter's noise bandwidth is certainly greater than 500 MHz, which is just the 3-dB bandwidth.

The Allan variance graph shows the expected increase in the integration time for the knee corresponding to this narrower-band case

Acknowledgements

The authors would like to thank J. Webber, A.R. Kerr, and G. Ediss for their useful comments. We wish to especially thank R. Groves for assisting us in taking the data.

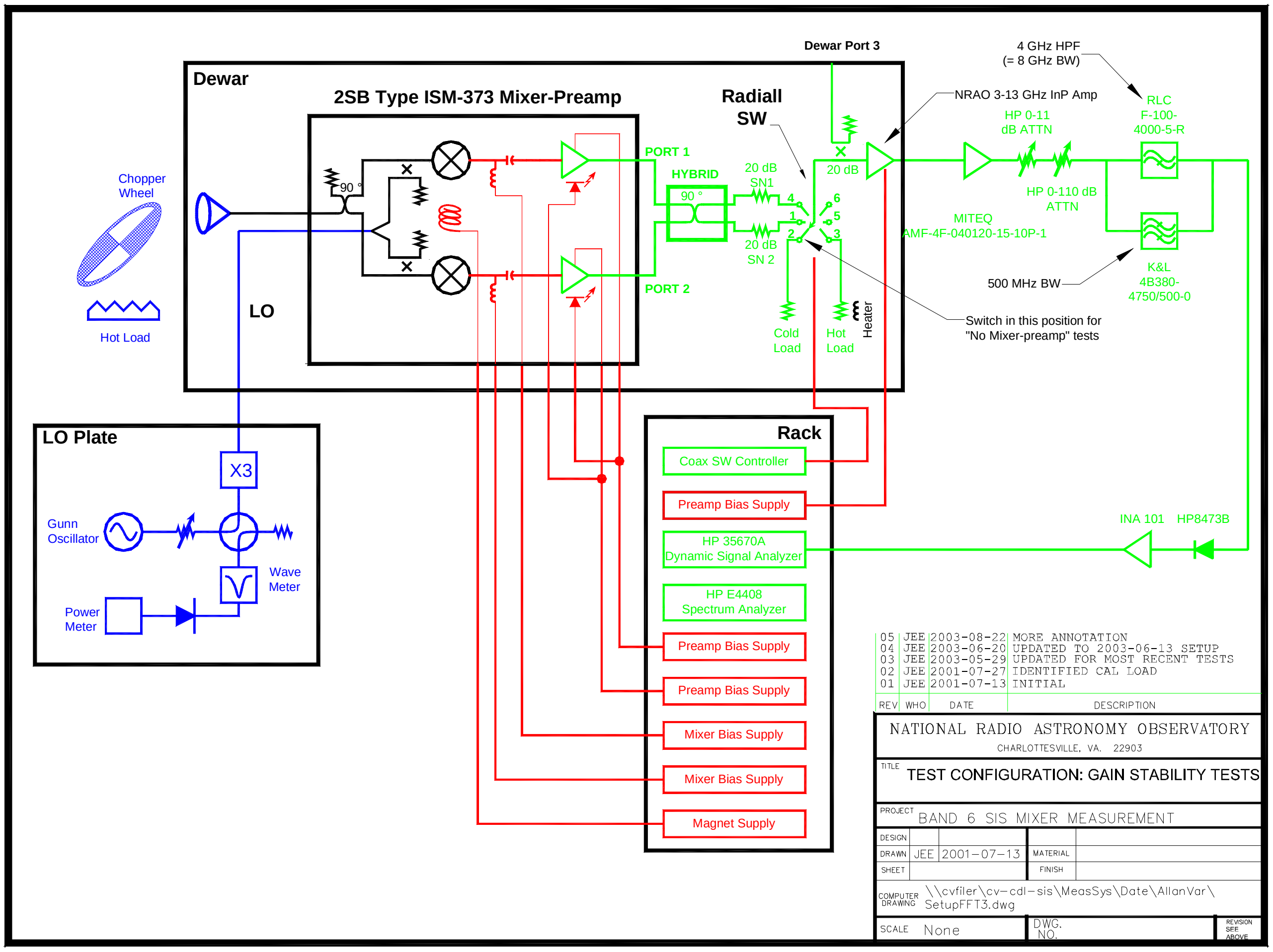

Figure 1: Equipment Setup

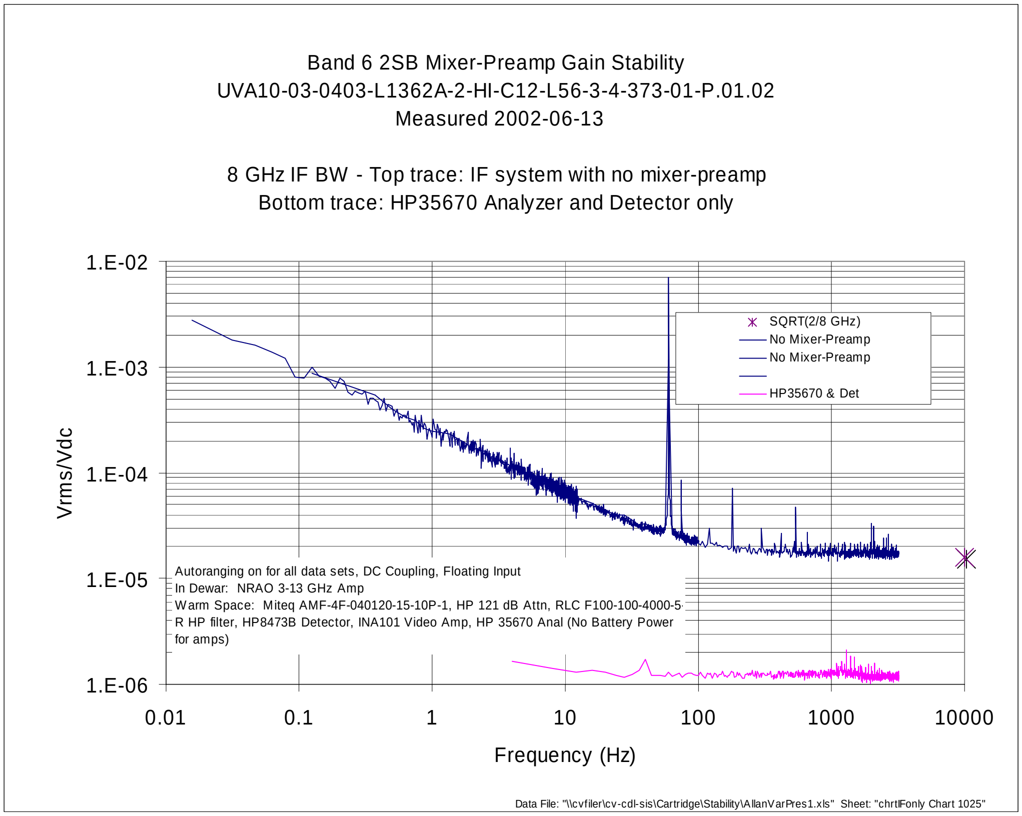

Figure 2: Spectral Density for IF System

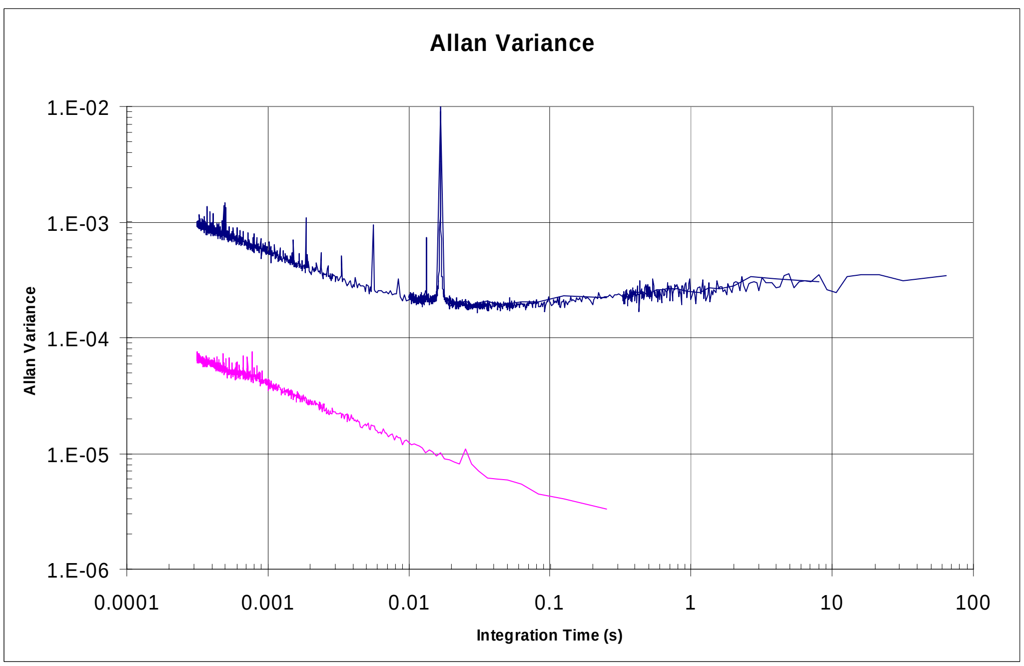

Figure 3: Allan Variance from PSD data shown in Figure 2

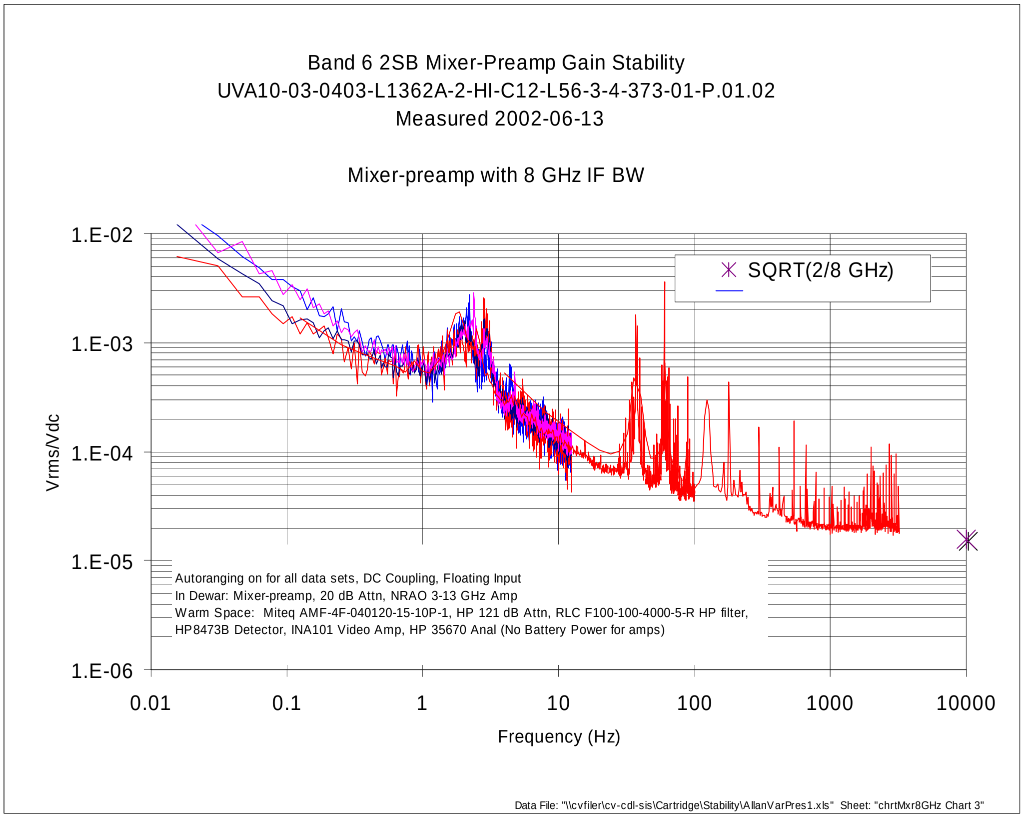

Figure 4: Spectral Density data for Mixer-Preamp (The data also includes the IF response shown in Figure 2).

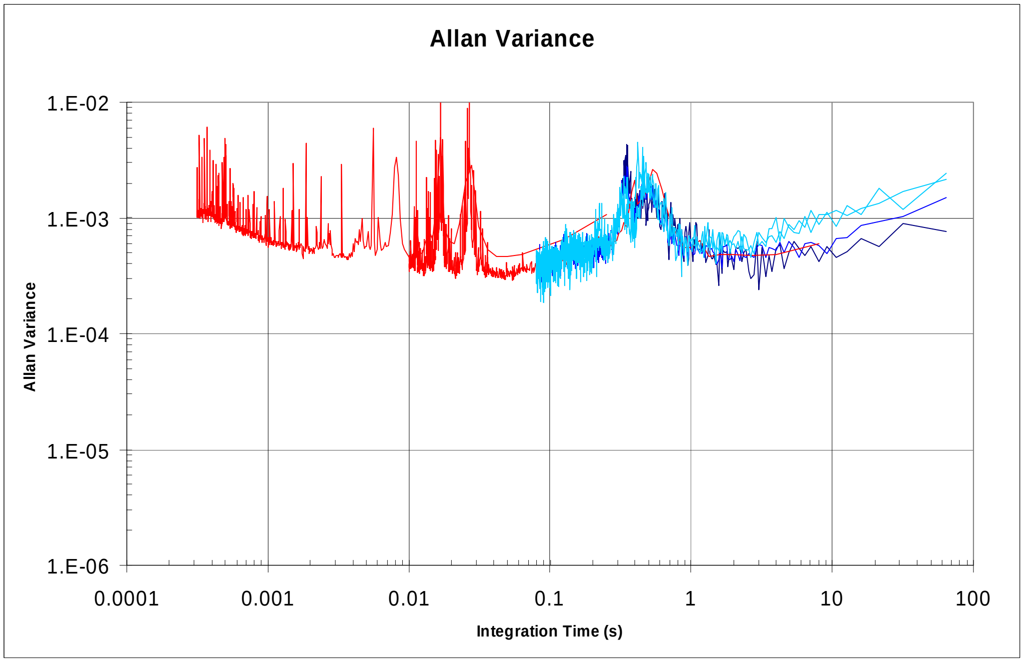

Figure 5: Allan Variance from PSD data shown in Figure 4

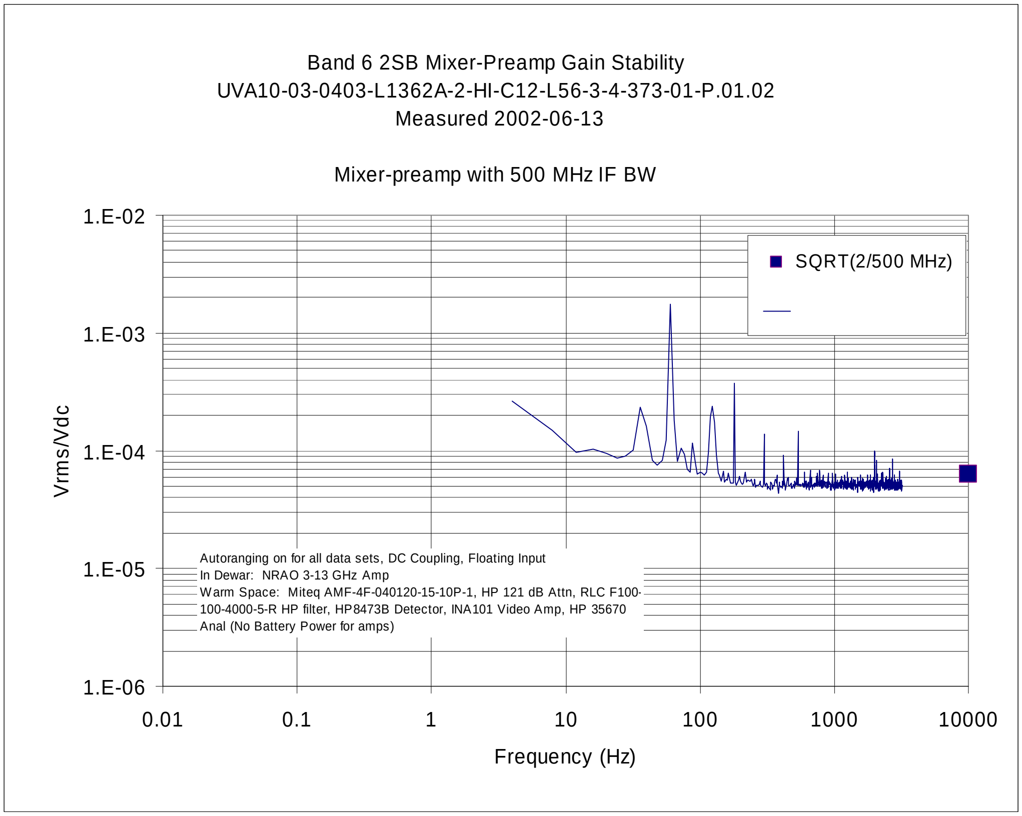

Figure 6: Spectral Density data for Mixer-Preamp with 500 MHz IF

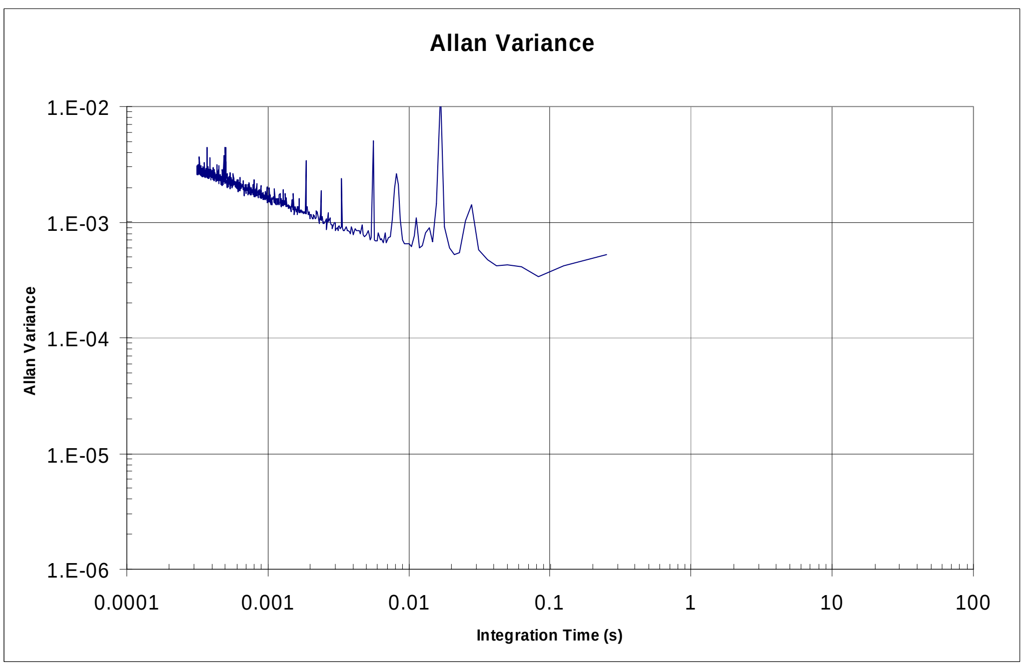

Figure 7: Allan Variance from PSD data shown in Figure 6