Memorandum

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Subject: Initial Low Frequency Power Spectrum Measurements

1. Summary

Initial measurements were take this week of the low frequency power spectrum for the Mixer/Preamp. The latest results include the response of the mixer, which shows an interesting feature at about 22 Hz, and a spike at 1.2 Hz that is related to pump power.

2. Setup

The setup, shown in Figure 1, includes the HP 35670 Dynamic Signal Analyzer fed by an HP 8473A detector. A DC amplifier was used between the detector and analyzer for earlier measurements, but that amplifer used a Burr Brown ANA101 instrumentation amplifier that had a 3-dB bandwidth of only about 20 kHz at a gain of 100. While this amp was being replaced by the higher-bandwidth ANA103, acceptable performance was achieved by including the third stage of amplification in the warm IF plate. Additional attenuators kept the IF plate linear over the large dynamic range. Linearity was confirmed by changing the warm IF variable attenuator by 3 dB and noting the same change on the power meter.

3. Results

Figure 2 shows the power spectrum as a function of frequency for curves shown from the bottom to top of the graph:

1. Warm IF switched to cal load
2. Warm IF input connected to hot load in Dewar
3. Warm IF input connected to mixer/preamp, but mixer bias was grounded and the LO was off.
4. Same as 3, but mixer was biased at 9 mV and 65 µA with LO at 245 GHz. No attempts were made to find the optimum bias point for this LO frequency.

To achieve the necessary frequency resolution, each curve consists of the superposition of transformed measurements for three different sampling times, corresponding to maximum frequencies of 25.6 kHz, 1.6 kHz, and 200 Hz. Retrieving data from the analzyer is cumbersome. Data files are written to a floppy, but the amplitude, frequency, and setup information are written to different text files. To simplify data acquisition, a program was written in four hours to store the data from the analyzer directly into Excel. The program also updates a graph in the spreadsheet, and later enhancements allow data corresponding to the three sampling times to be acquired automatically.

The ordinate scale is the spectral density as calculated by the analyzer. Data normalization will be made at a future date.

The bump around 22 Hz in the top curve of Figure 2, which corresponds to the mixer and preamp noise, is particularly interesting, because it is not present in the preamp-only data. If this bump results from Josephson noise, it was thought that changing the mixer junction's magnetic field would alter the bump, but it didn't. However, the current changes were made hastily so more careful measurements are needed.

The short trace spanning 0.1 to 12.5 Hz above the top mixer/preamp trace was recorded when the mixer bias had crept up from 65 μA to 75 μA. The data were repeated and indeed the spike at 1.2 Hz only occurs when the mixer current increases above 65 μA.

Figure 3 compares calculations of time data recorded by the analyzer to the predicted square root of integration time and bandwidth. The analyzer stored 1600 samples of the detector voltage at a sampling rate of 51.2 kHz, which corresponds to an upper frequency limit of 25.6 kHz. The mean (μ) and standard deviation (σ) were calculated for three cases:

1. Warm IF switched to cal load
2. Warm IF input connected to hot load in Dewar
3. Warm IF input connected to mixer/preamp, but mixer bias was grounded and the LO was off.

The mean for Case 1 was used as the DC offset and hence was subtracted from the other two to obtain their adjusted means. The results are summarized below, where the bandwidth (B) is assumed to be 12 GHz and the integration time is the inverse of the 51.2 kHz sampling rate, or 19.5 μS.

<table>
<tr><td>Case:</td><td>σ/μ</td><td>$1/\sqrt{B\tau}$</td></tr>
<tr><td>Warm IF input connected to hot load in Dewar</td><td>0.0035</td><td rowspan="2">0.0021</td></tr>
<tr><td>Warm IF input connected to mixer/preamp, but mixer bias was grounded and the LO was off.</td><td>0.0036</td></tr>
</table>

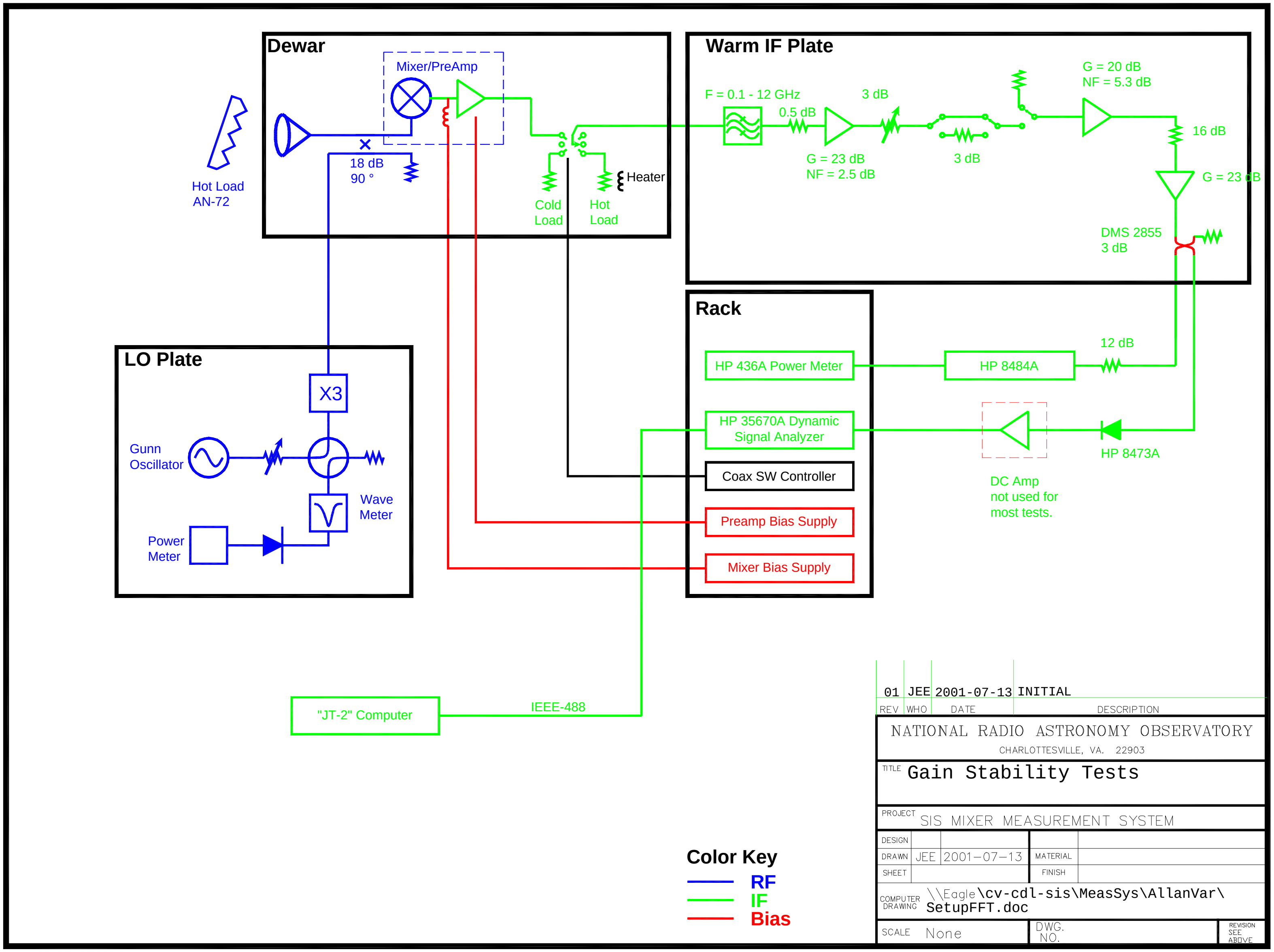

Figure 1: Test Configuration

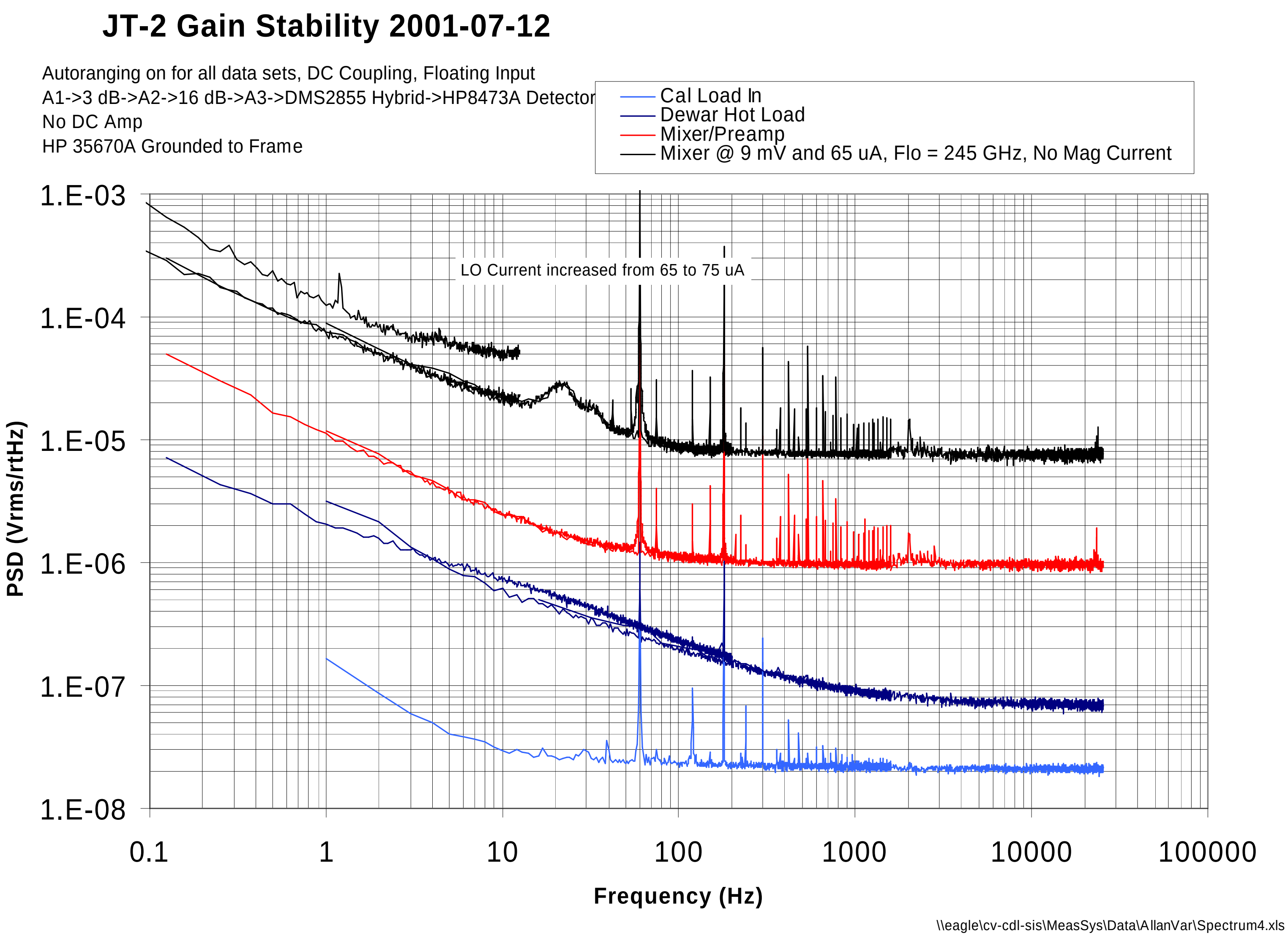

Figure 2: Measured Data

Integration time = 19.5 us (Sampling @ 51.2 kHz)

Statistics	Cal Load In	Autorange Dewar Hot Load	Mixer Preamp
Std Dev	3.565E-06	1.335E-05	1.961E-04
Mean	1.260E-04	3.955E-03	5.531E-02
SDEV/Mean	0.0283	0.0034	0.0035
SDEV/Mean less offset		0.0035	0.0036
Bandwidth (Hz)		1.200E+10	
Sampling Freq (Hz)		51200	
Integration Time (s)		1.953E-05	
Predicted 1/Root(BT)		0.0021	

Figure 3: Comparison of Measured Data to 1/Root(BT)