Stability Tests on the Warm CTT IF Amplifier: Memo No. 2

Date: 21-Sept-2005, Riley Ceria

1 Introduction and Summary of Results

From previous tests (See Stability Tests on the Warm CTT IF Amplifier: Memo No. 1), there was an observed instability from the amplifier due to a periodicity in the temperature of about 38 minutes.

The new circuit created was just a normal Proportional Integral (PI) Controller using and large low leakage capacitor. This new controller is a unipolar controller that can only cool the amplifier since the amplifier is constantly dissipating a large amount of heat. The previous controller was a bipolar controller that could heat and cool the circuit.

This memo presents the results from the new controller compared to the old controller. It will compare the two sets of data qualitatively by looking at the data, and somewhat quantitatively by analyzing the fourier spectrum and allan variances of both data sets. With the controller on, we obtained extremely stable readings with an Allan Variance time of about 6000 seconds for the RF power. In one set-of data there seemed to be a periodicity which could be seen by looking at the raw data in the RF power of about 21 minutes, but it only varied by 0.002 mW, and therefore could be attributed to the test instruments.

2 Measurement Setup

The setup consisted of a RF signal generator connected to the amplifier input, and the output connected to a RF power meter. The signal generator used is a HP83620B synthesizer that put out a CW tome centered at 6.0000 Ghz with an output power of -10.0 dBm. At the signal generator output a 30 dB attenuator was used before the amplifier. The RF power meter, HP 438A, controlled through GPIB protocol, read the total RF power from the IF amplifier. Connected to the CTT amplifier pin3 of the 9-pin D connector, was a potentiometer that was manually adjusted until the RF power meter read near 1 mW so that the data could easily be compared the the tests done in the previous memo.

The amplifier itself had a temperature sensor attached to the top, an aluminum plate attached to the bottom of the amplifier and both parts had thermal grease applied for a good thermal contact. The sensor on top was held in place by an aluminum strip and two screws that went down through the amplifier and screwed into the bottom plate to ensure a strong connection with the amplifier. The aluminum plate was then followed by a bar of invar, then the Thermal Electric Cooler (TEC).The aluminum plate was screwed to the TEC sandwiching the invar so that everything had a strong contact. Every layer had thermal grease applied in between for a strong thermal contact. Everything was then covered in foam except for the TEC so that the heat of the amplifier would only be dissipated through the TEC.

The room did not have any air conditioning on during the whole testing process. In these tests, the data was read in through the same computer and build that was used in the last memo's tests. The only change was modifications in the program used. One modification in the program was done so that the data read in from the RF power meter kept the settings that were manually put in the beginning for calibration purposes. The other change to the program was the way the temperature sensor, DS18b20, was read in.

3 Results and Discussion

3.1 Best Results

The best results were obtained with the PI controller having the T-junction disconnected from the integrator and instead place 4 metal film resistors in series having a total of about 1MΩ. This probably made the controller more stable by eliminating some of the ground noise while at the same time providing more DC feedback for stable biasing. This modification will roll off integrator action at low frequencies of $f < 1/RC$.

The graphs that are analyzed are ones that use the best data over a 20 hr period (see figure 1). This will make it easy to compare to the data from the previous experiment.

Analyzing the RF power we can see that the allan variance is extremely stable at around 6000 seconds (see figure 2). The graphs resembles a 1/x graphs continually getting smaller, so there is no minimum that can be seen by the eye, but the slope goes towards 1 at about 6000 seconds. The plot of the spectral power shows no peaks that there are very distinctive (see figure 3).

3.2 Comparing The Best Data with the Old Data

There is a large improvement from the previous tests. Plots of the allan variances were done on the same scale for both the old data and new data. There are two separate figures for the allan variances, one for the temperature, and the other for the RF power. Previously the allan variance for the RF power was only 33 seconds. The allan variance for the best 20 hrs set of data in the new tests was at least 6000 seconds, an extremely large improvement. This shows that the new data was stable for a very long period of time, and that there wasn't any oscillations. The old data's allan variance quickly reached its minimum and then shot back up showing that there was some type of periodic structure in the data and that it was not too stable.

Looking at the Fourier spectrum, there is a notable spike in the RF power from the old data. Analyzing the fourier spectrum on the same scale for the new data set, there are no spikes that are extremely prominent over the whole spectrum. This means that there was no periodic structure in the new data, while the old data's spike at $1.6Hr^{-1}$ shows an oscillation of period 38 minutes.

The allan variance of the temperature for the old data was around 66 seconds. However the allan variance for the new data set was around 3500 seconds (see figure 4). This was also a considerable improvement. The allan variance plot for the new data also did not increase much showing that although there might be some periodic structure, it was extremely small.

The fourier analysis of the temperature also showed nice results (see figure 5). There were not any prominent peaks unlike the previous data's spectrum. The previous spectrum from the old data had to significant peaks in the fourier spectrum at about 1.6Hr^{-1} and at about 2.8 Hr^{-1}.

4 Conclusions

In conclusion, the new temperature controller is extremely stable and can serve its purpose. The allan variances were extremely long for both the RF power and the temperature and the fourier analysis also showed no strong peaks in the spectrums. The changes made by increasing the resistance of the feedback for the integrator worked well increasing the stability of the controller.

5 Acknowledgments

The CTT fabricated IF amplifier was supplied by Jacob Kooi. The temperature controller was designed by Richard Chamberlain.

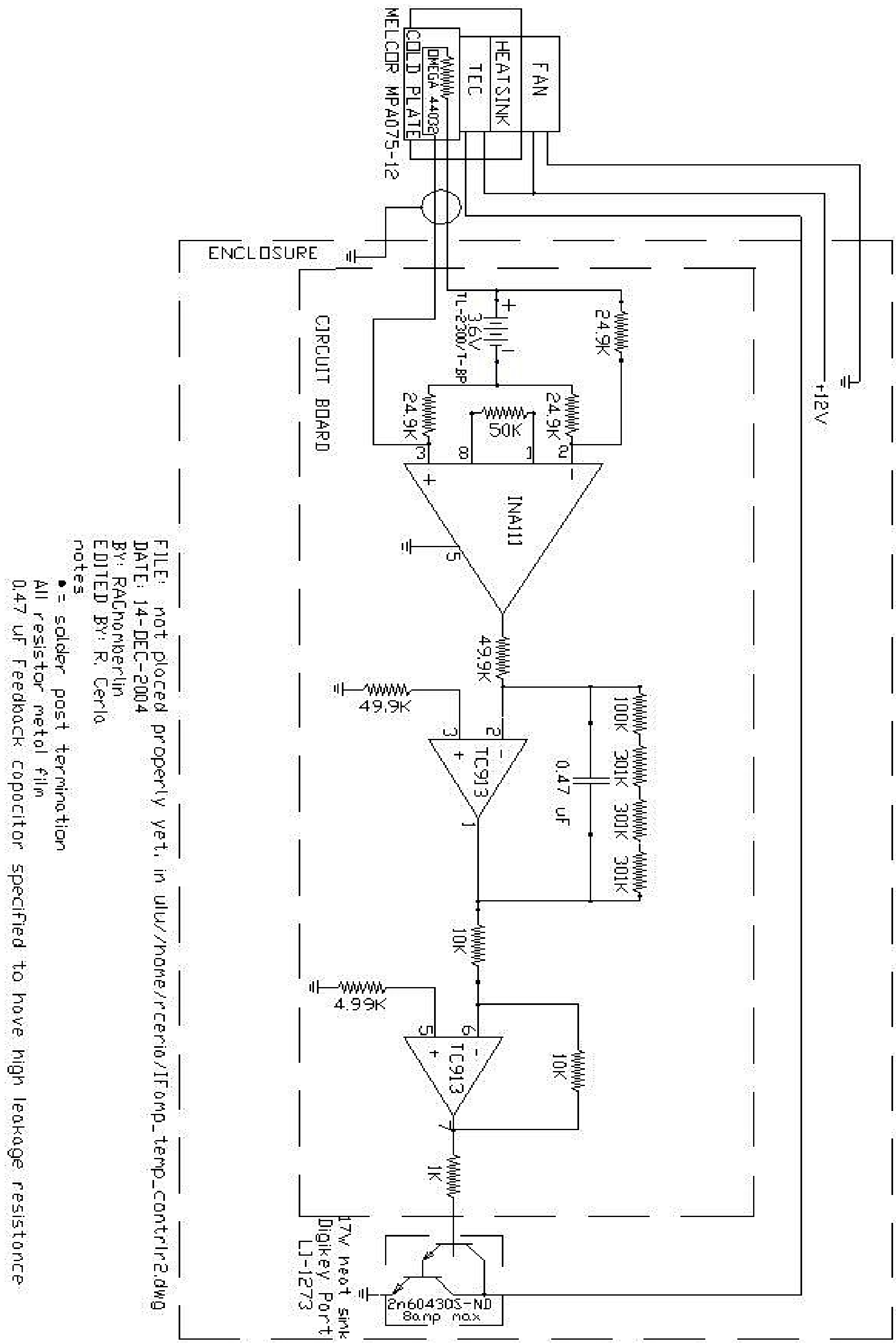

Figure 1:
Schematic for the Temperature Controller Circuit

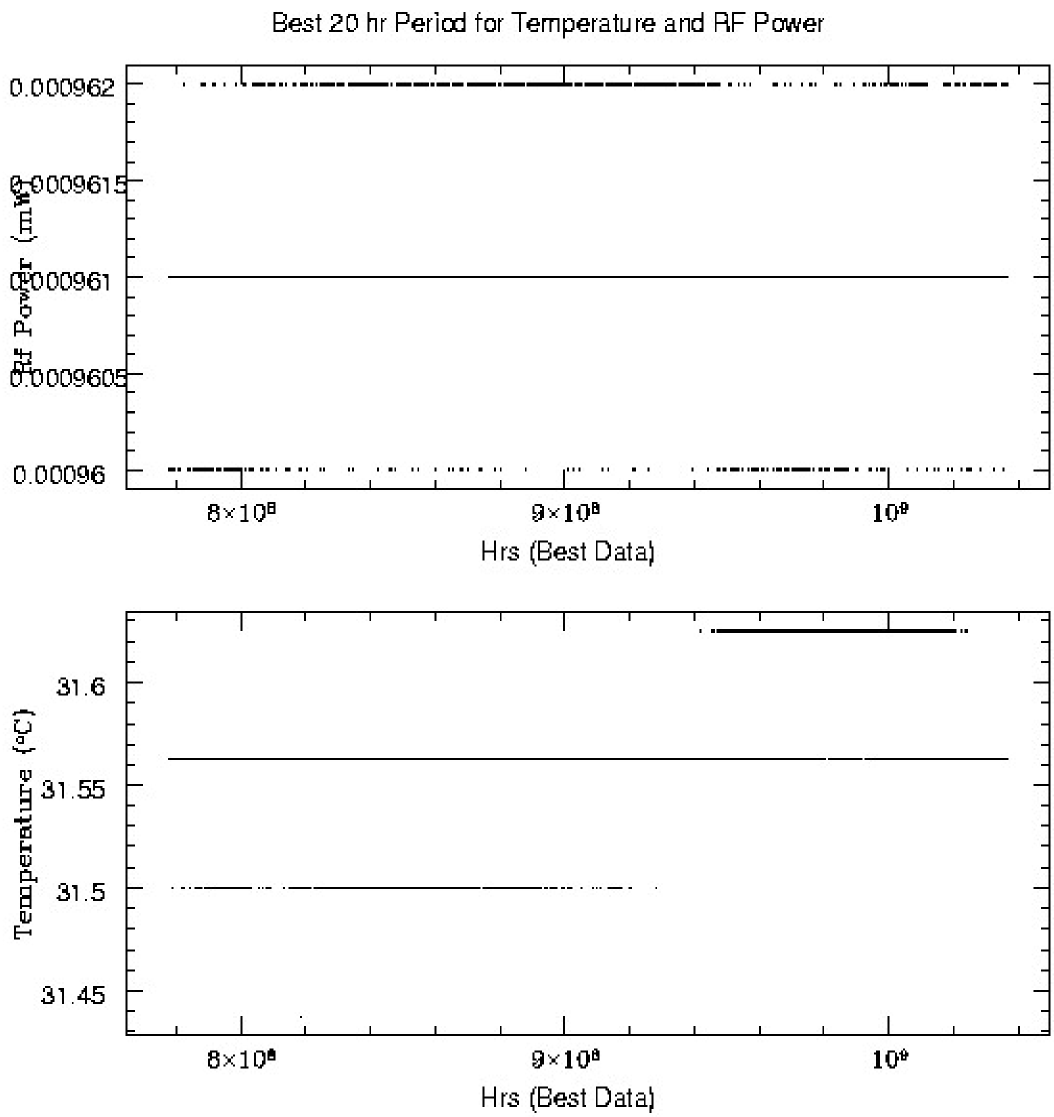

Figure 1
Plots of the best 30 hr period for the new temperature controller. On the top is the plot of the RF power output and the bottom is the plot of the temperature of the amplifier.

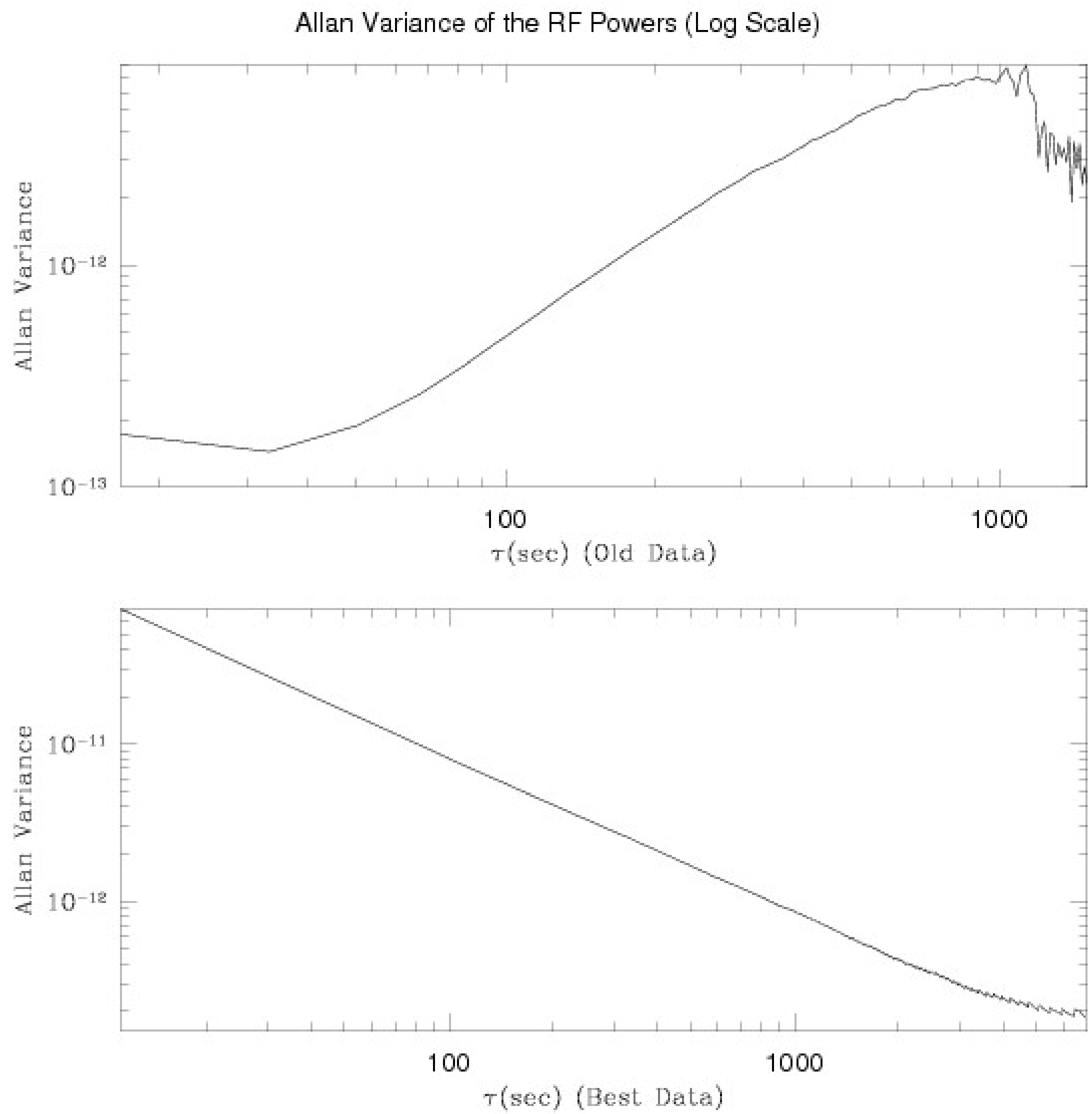

Figure 2
Allan Variance plots of the old data and the new data for the RF Power output. The top plot is the Allan Variance from the previous termperature controller. It reaches its first minimum at around 38 seconds, then rises quickly to show that there is some type of periodic structure. The bottom plot never reaches a minimum for the whole plot showing that the new controller is stable for at least 6000 seconds.

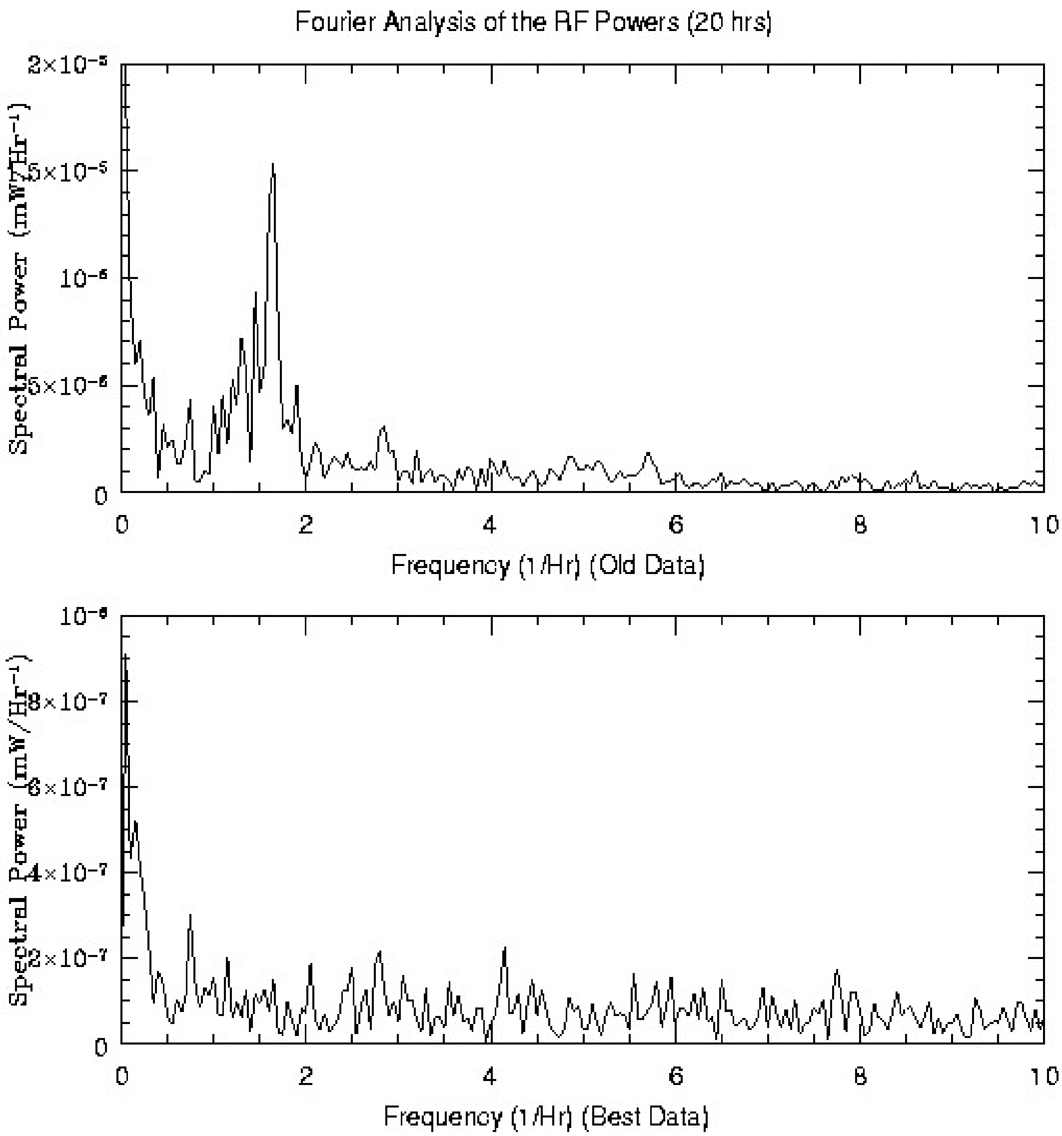

Figure 3

Fourier analysis of the RF power output using the old controller and the new controller,. The spectrum using the old controller is on top, while the spectrum on the bottom represents the output using the new controller. The top plot has a large peak at around $1.6Hr^{-1}$, showing an oscillation of period 38 minutes. This reinforces the allan varaince which showed a period structure. The bottom plot is mainly even showing that there is no strong periodic structure, reinforcing the allan varaince which showed no periodic sturcture.

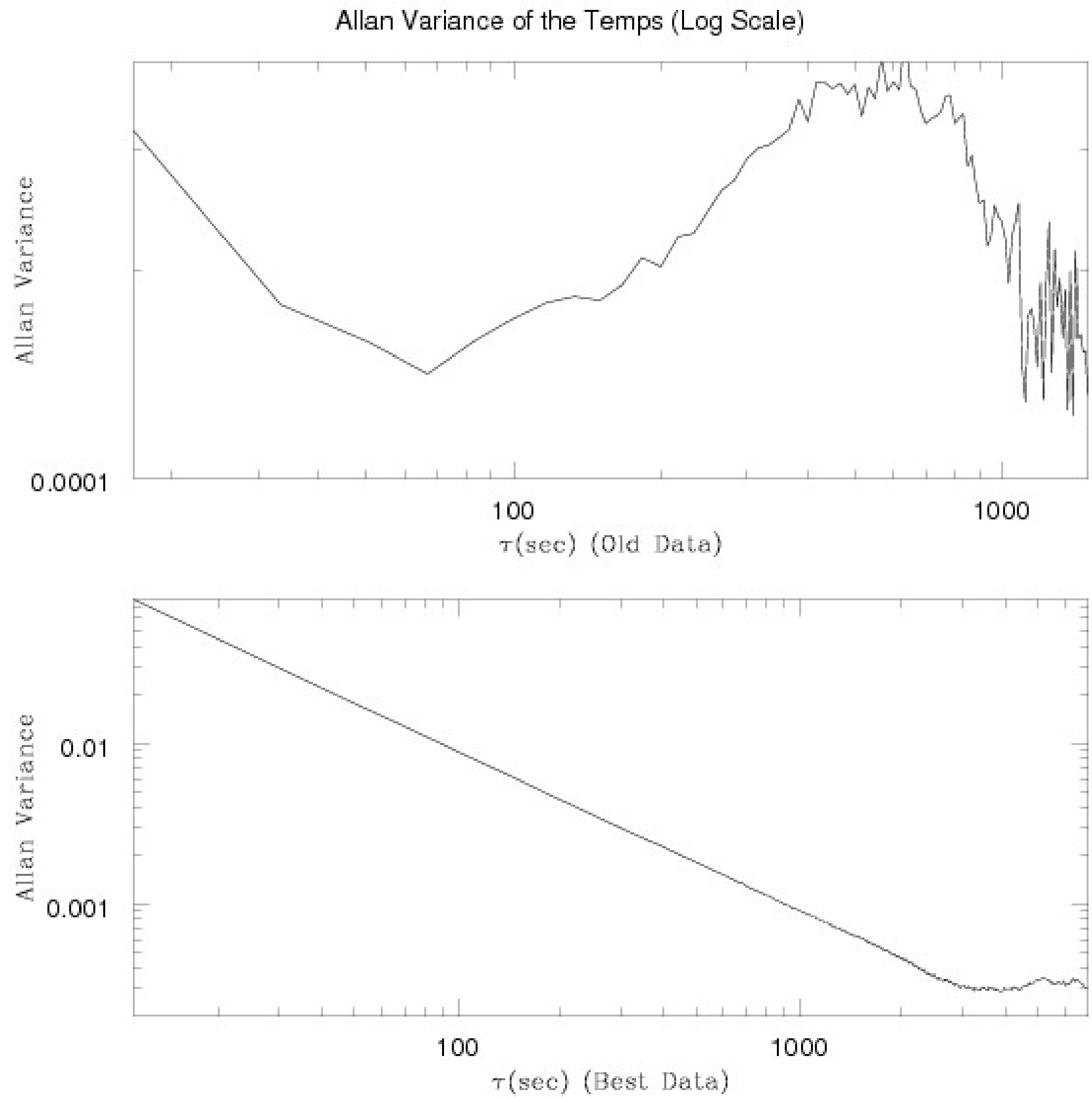

Figure 4
Allan Variance plots for the temperature of the amplifier, the old controller data is on top, while the new controller data is on the bottom. We can see that the temperature from the old controller had a periodic structure and that it was stable for around 66 seconds. The new controller kept the temperature stable and reached its minimum at around 3500 seconds.

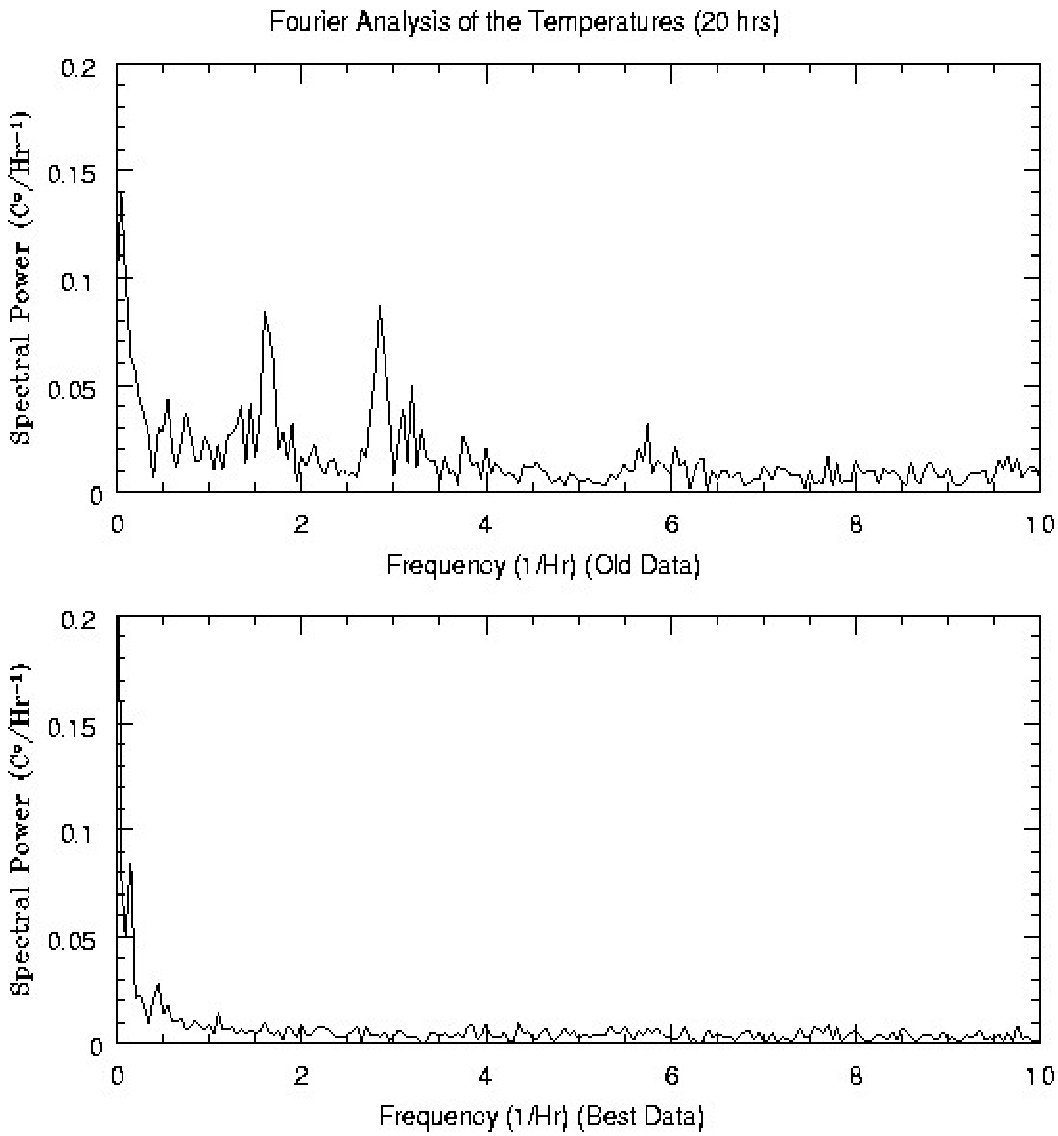

Figure 5

Fourier analysis of the temperature of the IF amplifier. The spectrum on top came from using the data from the previous controller and the spectrum on the bottom was obtained using data from the new controller. We can see that the old controller had a periodic structure and two different frequencies. The new controller on the other hand was very stable and the spectrum was mainly even. There is on small peak at around 0.5 Hr^{-1}, but it is minimal.

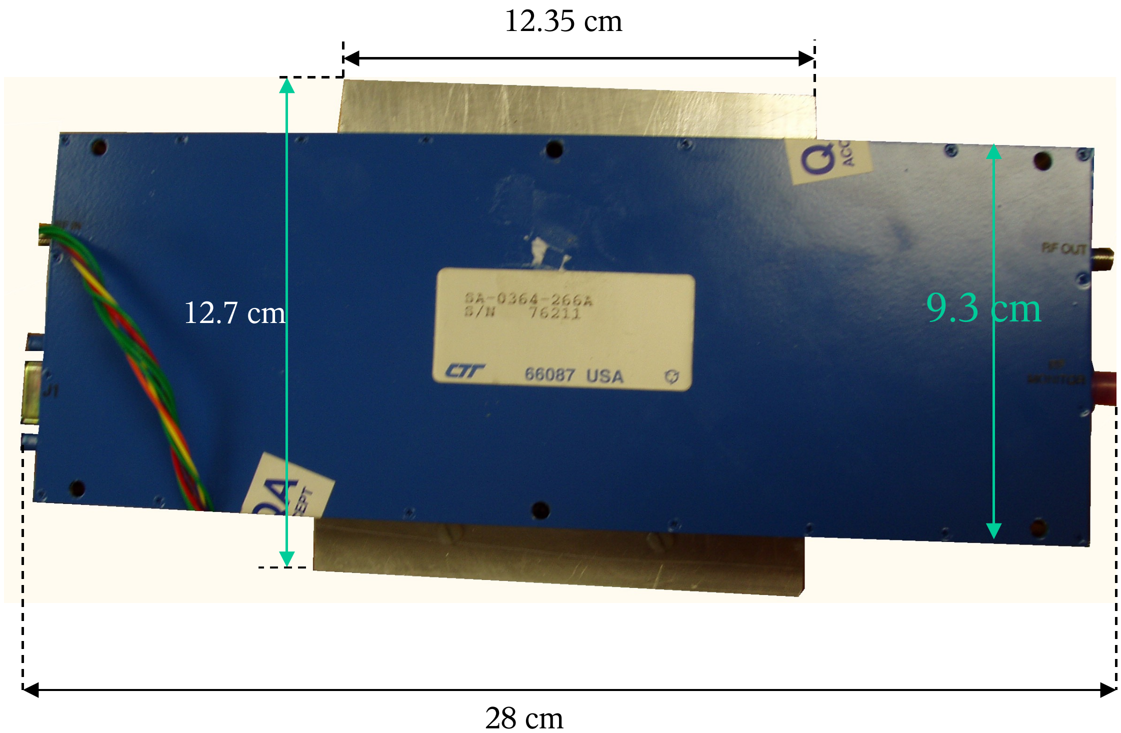

Figure 6: Top View of TEC with CTT Amplifier Setup

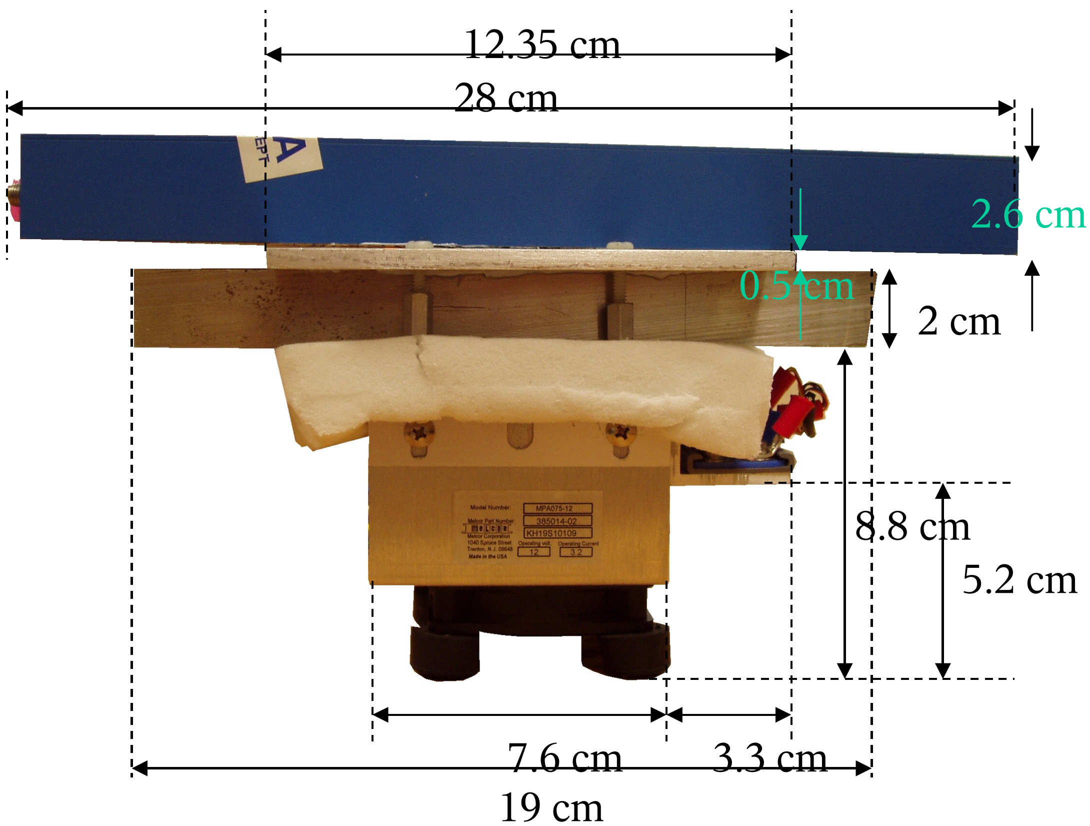

Figure 7: Side View of TEC and CTT Amplifier Setup.

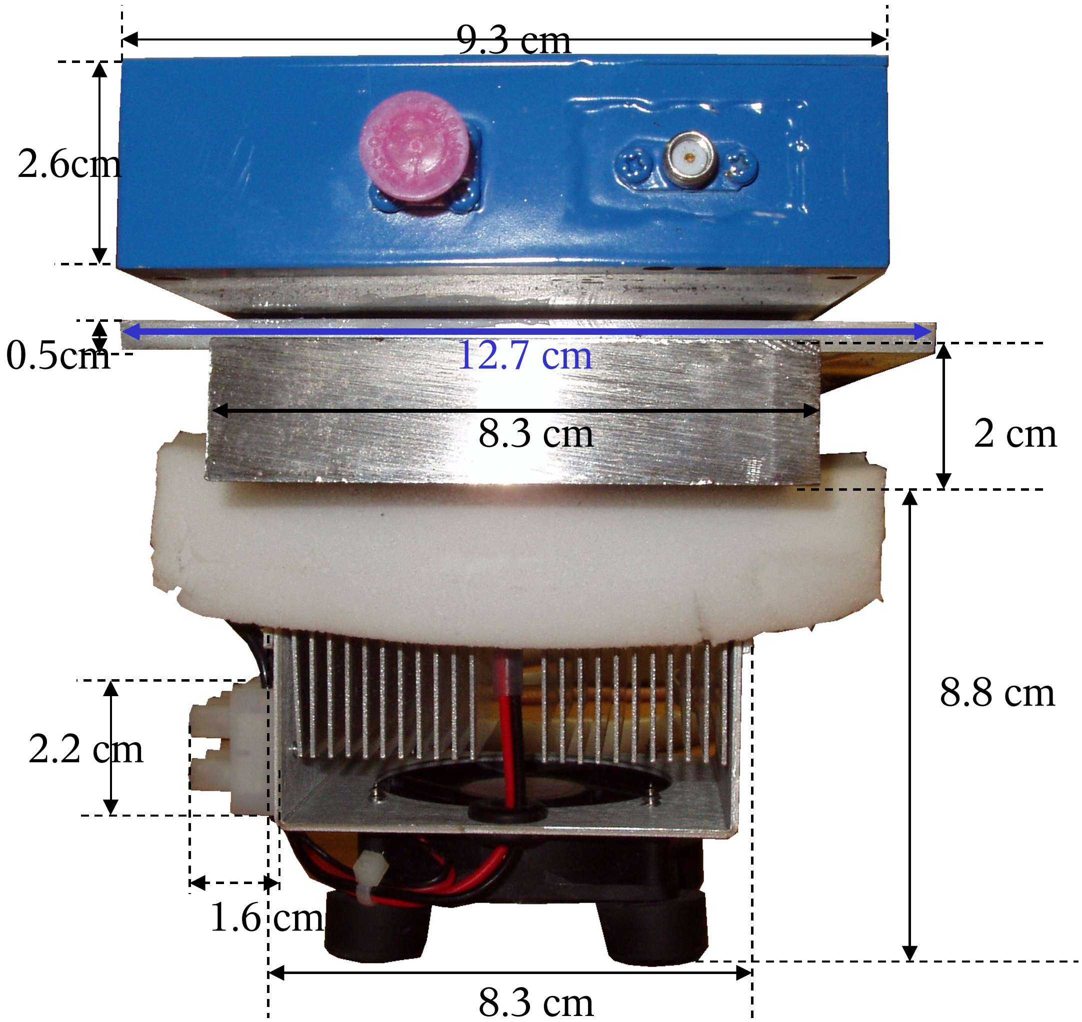

Figure 8: Front view of the TEC and CTT Amplifier Setup