HAM ISI Modeling Abstract

Brian Lantz, T0810042-v1

Dec. 17, 2008

1 Summary

We have written a simple modeling program to predict the performance of the HAM ISI, and help design the complementary filters for the sensor blending. The modeling is based on the equations derived in 'Simple Calculation of Active Platform Performance', LIGO T080119-01, by Brian Lantz.

2 Implementation and Location

The modeling system uses a script to set up a large data structure which contains all the known information about the system, including the plant model, the various noise inputs (ground motion and sensor noise), the model of the control loops, the HAM requirements, and the complementary filters for the sensor blending. The most recent script to build this data structure is HAM_modelv2.m. There is a copy in the seismic SVN at ∼repository/HAM-ISI/Stanford/HAM_design/HAM_modelv2.m. Currently, this script builds the data structures, defines new trial complementary filters, and calls the calculation functions.

There are four calculation functions. Two are used to estimate the system performance: HAM_perf_model_XrY.m and HAM_perf_model_ZrZ.m. These take the noise inputs, multiply them by the various coupling terms defined by the plant, the controls, and the complementary filters, and generate estimated table motion. There are also two functions to help design the complementary filters: blend_filter_reqs_XrY.m and blend_filter_reqs_ZrZ.m. These use the same data structure as the performance estimators, but instead use the noise inputs, plant and open loop gain data, and motion requirement to calculate the limits on the complementary filters. They will also plot trial filters, and they plot and the noise coupling in the open loop case to estimate how the complementary filters will impact the measurements of the open loop plant data.

3 A Few Performance Prediction Plots

The modeling is no better than the input data, and the input data is still a bit suspect. We are also still working on the best way to display the useful data, so some of the output plots (in particular the X performance plot) are hard to understand, and will certainly be evolving as we use the new tools. An exhaustive analysis of the performance will be included in Jeff Kissel's thesis, and this document is not meant to steal that thunder. Rather we try to show here that we have some useful tools.

First we can plot the estimated performance. We are using loops with an upper unity gain frequency of 25 Hz, ground motion estimated from LLO when it is windy, and reasonable estimates for the sensor noise. ADC noise for the sensors is assumed to be included as part of the sensor noise. This needs further investigation at frequencies below 1 Hz.

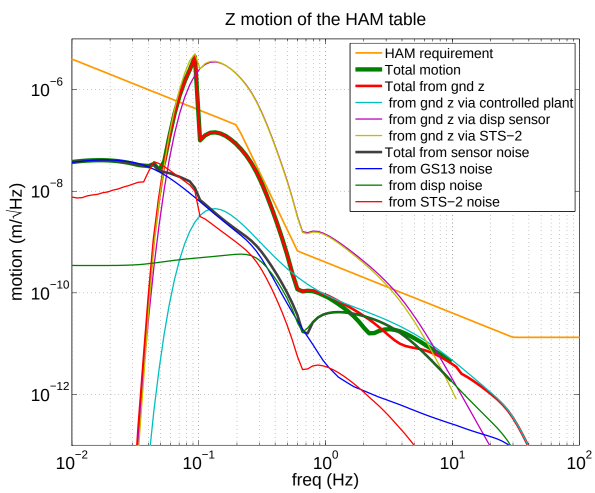

Figure 1: Modeled Z performance

This figure indicates that we should probably go back to the IIR filters for the Z sensor correction, since the peak of Z motion from floor motion is everywhere below, or well below, the HAM requirement, except right at 0.1 Hz where the FIR filter has a big feature.

The RZ figure is the simplest one to follow.

Things start to get ugly when we look at the tilt (RY) figure. We include the impacts of the noise which will be correlated from one platform to the next (ie from ground motion) which is only sort-of bad, and also separately consider the impact of the uncorrelated noise from the sensor noise, which will result in differential motion between the platforms, which is really bad. We also plot the motion times g/ω^2, which is how the tilt motion will couple into the horizontal seismometers, and will generate excess motion to the extent that the

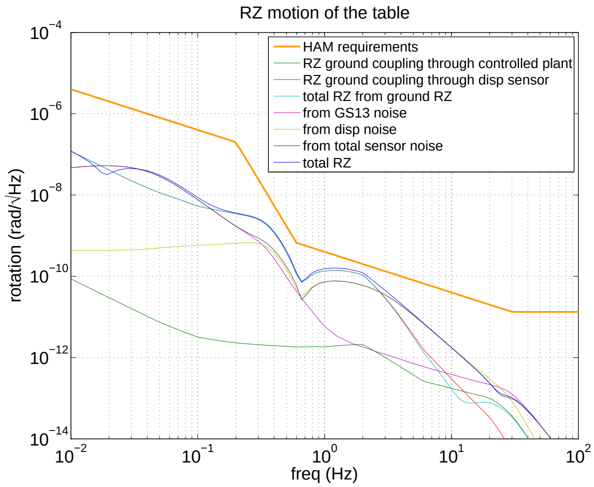

Figure 2: Modeled RZ performance

servos follow the seismometer signals, as determined by the complementary filters for the sensor blending (and the loop gain).

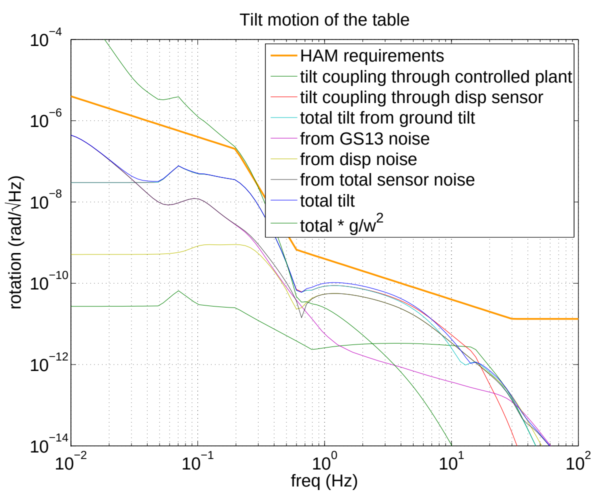

Figure 3: Modeled RY (tilt) performance

Once we have the tilt performance estimates, we can generate the horizontal performance. This plot is still too busy to be easy to follow, something we will be working on. It is clear that the ground tilt is going to be a problem, though, when it is windy.

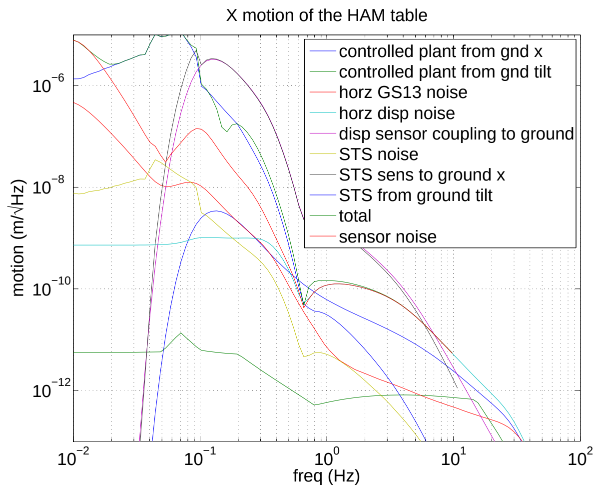

Figure 4: Modeled X performance

4 Some Blend Filter Design Plots

We also have new tools to help with the blend filter design. The highlights of the complementary blend design plots are shown below. First, we show the Z plot, are here again we see the issue of the peak in the FIR filter for Z.

Next we see the blend for RZ, which is pretty straightforward.

The difficult blends are the ones for tilt and translation. To meet the requirements for translation in an absolute sense, we need either less ground tilt or a good tilt sensor.

Finally, we show the X complementary blend filters, where we can really see the impact of the ground tilt. We also can get a feel for the trades which can be made in the blend design for

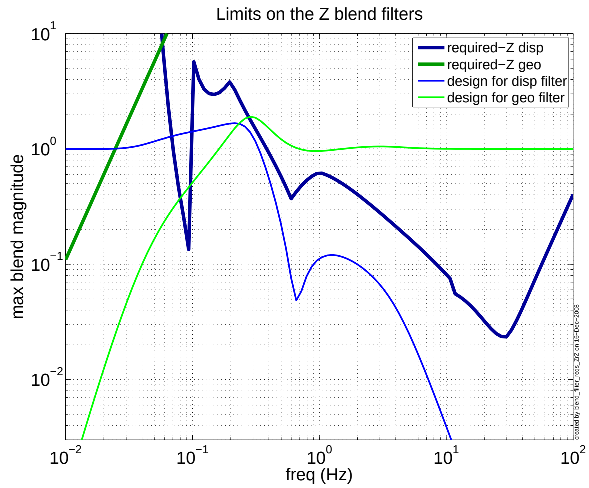

Figure 5: Complementary blend design plot for Z

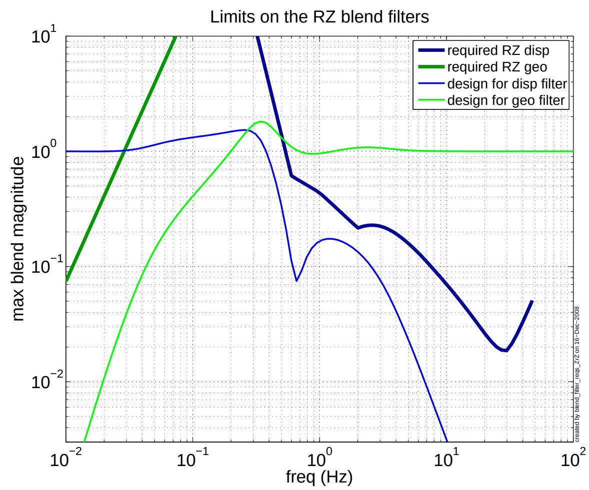

Figure 6: Complementary blend design plot for RZ

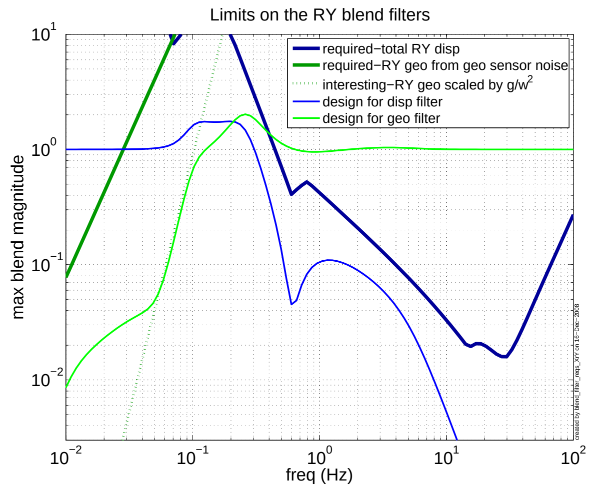

Figure 7: Complementary blend design plot for RY (tilt). The dotted line for the g/ω^2 coupling didn't pdf very well.

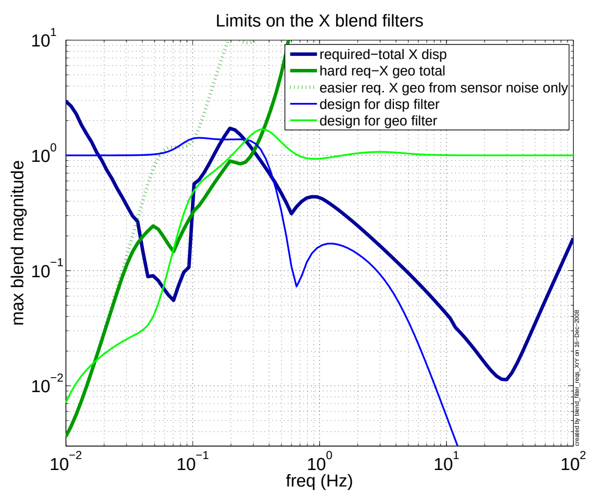

Figure 8: Complementary blend design plot for X