Some thoughts on Controlling SRCL

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1 Introduction

During O1 and O2, the signal recycling cavity length (SRCL), was close to limiting the performance of differential arm length (DARM) [1]. SRCL itself is limited above 10 Hz by shot noise, the controller for the SRCL cavity has a UGF of around 40 Hz. The bandwidth of this controller is limited by the optic motion in the SRC. This system couples shot noise into the SRCL optics above 10 Hz, injecting noise into the real cavity length signal. To eliminate this shot noise coupling into DARM, the bandwidth of the controller must be reduced while maintaining the same RMS performance.

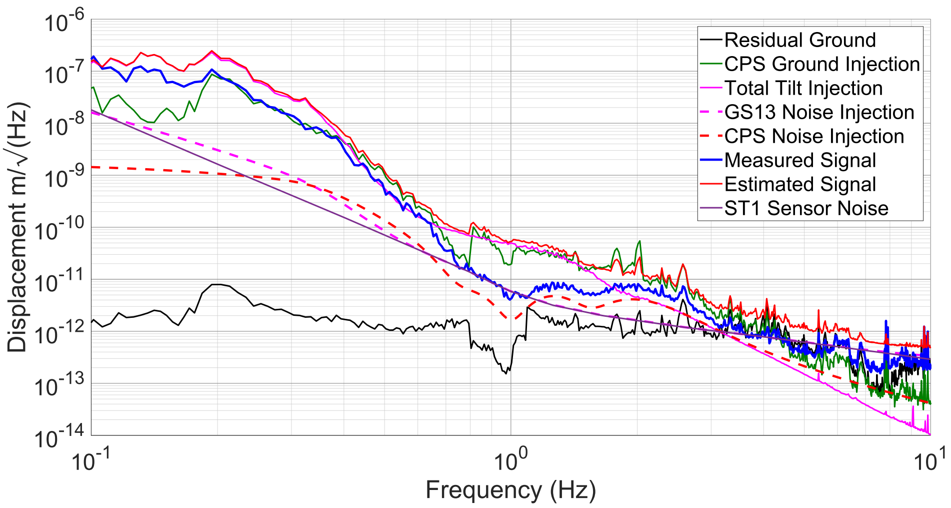

Figure 1: Figure showing the individual contributions that sum together to form the estimated motion of the HAM 4 ISI in Y, highlighting the limiting noise sources.

To reduce the bandwidth of the SRCL controller, the suspension point motion of the SRCL cavity needs to be reduced. This in turn is limited by the ISI motion of HAM 4 and HAM 5 between 0.7 and 4 Hz shown by FIG 5 of [1]. The ISI motion is limited by a combination of CPS ground injection from 1.5 to 4 Hz and tilt to translation coupling from 0.7 to 1.5 Hz. Using the HAM model described in [2], the RX and RY motion is limited by CPS noise injection.

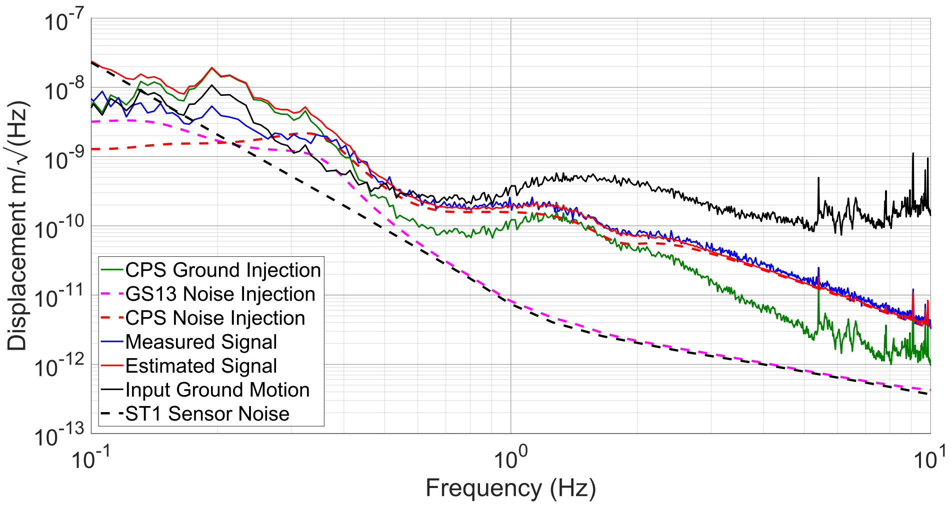

Figure 2: Figure showing the individual contributions that sum together to form the estimated motion of the HAM 4 ISI in RX, highlighting the limiting noise sources.

FIG 1 shows the different contributions from each individual paths in the HAM ISI control loop, shown by FIG 3 [3], showing that platform tilt is one of the dominant noise sources at 1 Hz. FIG 2 shows contributions for the RX platform motion, in the frequency region of 0.7 to 4 Hz, CPS noise, that is injected through the low pass filter is shown to be a dominant noise source.

2 Reducing motion

To rectify this problem we can either change the high and low pass blends in RX to attempt to suppress this noise and potentially sacrifice performance at lower frequency or replace sensors capacitive sensors on the ISI with higher resolution sensors, described in [?]. The reduction in platform motion using both these options has been evaluated using the HAM ISI model by suspension point motion of the signal recycling mirror and HAM 4 and 5 in RX and Y.

2.1 Changing RX blend filters

FIG 3 shows the current high and low pass blending filters currently in use at LHO compared with a new set of blending filters designed to reduce the CPS injection in this degree of freedom.

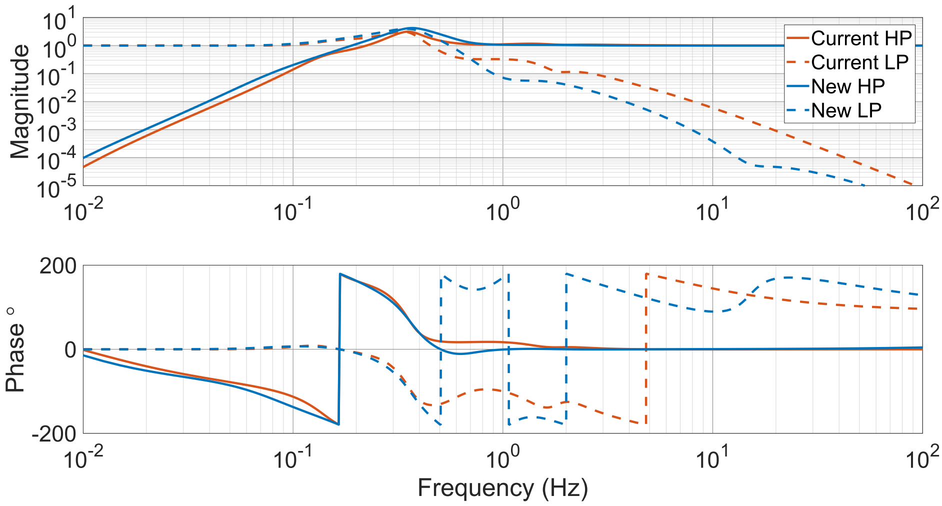

Figure 3: Figure showing the comparison of the new (blue) and old (red) low and high pass blends shown by the dashed and un-dashed lines respectively.

2.2 Replacing Sensors

Replacing sensors in the ham model is relatively straight forward, with the replacement displacement sensors, both the ADE 0.25 mm sensors and the HoQI interferometric sensors [4] are evaluated with a couple of different blending filters. These new displacement sensors will function identically to the CPS sensors they replace, as they still measure the difference between platform and ground motion, we can just directly replace the sensor noise curves with new sensors and project these through the HAM model. FIG 4 shows a comparison between sensors used in this evaluation.

3 Noise projections

The HAM model was run to calculate each permutation of the SR3 suspension point motion on HAM 5, using different blending filters and sensors to replace the CPS, shown in FIG 3 and 4. The model was configured using the following parameters shown in table 3.

To quantify the the reduction in platform motion we have estimated the displacement spectra of the third signal recycling mirror, SR3 on HAM 5 in length, as this is the dominant coupling into DARM

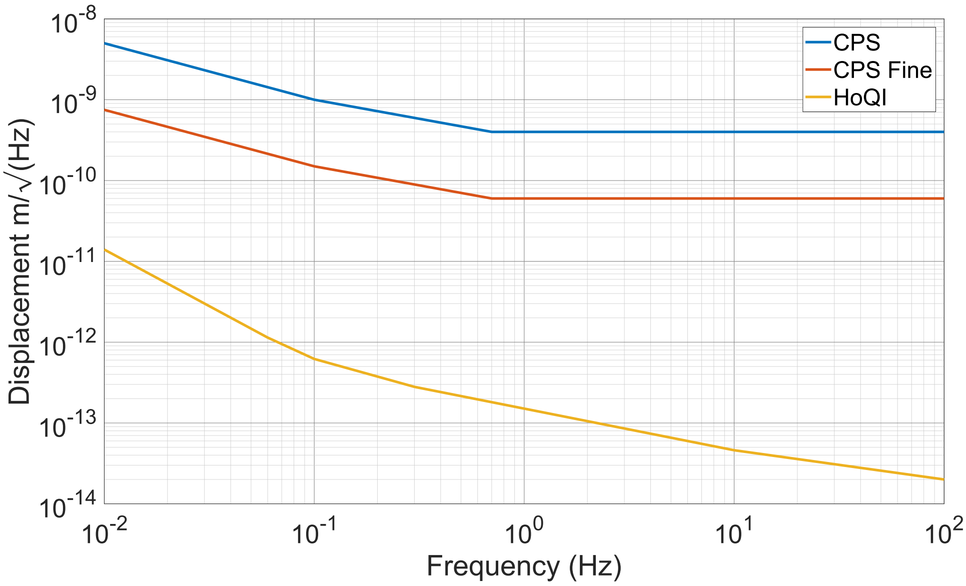

Figure 4: Figure showing the resolution of different sensor noises used in this comparison. CPS traces taken from [5], HoQI sensor noise taken from [4]

Parameter	Value
IFO	H1
Chamber	HAM5
Suspension Name	SR3 - L
Start Time	1185876018
Duration	3600 (s)
Data Rate	256 Hz
Control loops activated	All
Tilt estimation	On
Calculate suspoint	On
Ground L4C's	Stage 0

Table 1: Parameters that were used to generate the noise projections in the ham model

from 10 mHz to 100 Hz, though we have truncated the frequency axis for clarity. The model was run in two stages, first replacing just the RX sensor contributions and a second time replacing all the CPS sensor paths with sensors described above., the results of this are shown in FIG 5. The measured and estimated platform motion using current sensors are shown in blue and red respectively. The potential improvement due to replacing only the RX blending filters is shown in yellow, this filter change yields factor of 5 reduction in length suspension point motion between 0.7 and 4 Hz. This has a side effect of increasing the motion between 0.4 and 0.7 Hz by around 60%, due to the altered blend frequency. Replacing the displacement sensors in RX prevents the increase in motion in this frequency range, while reducing motion by a further factor of two between 0.7 and 4 Hz. Fine CPS (ADE_0.25mm) are just as effective as compact interferometers when placed on the ISI using these blending filters.

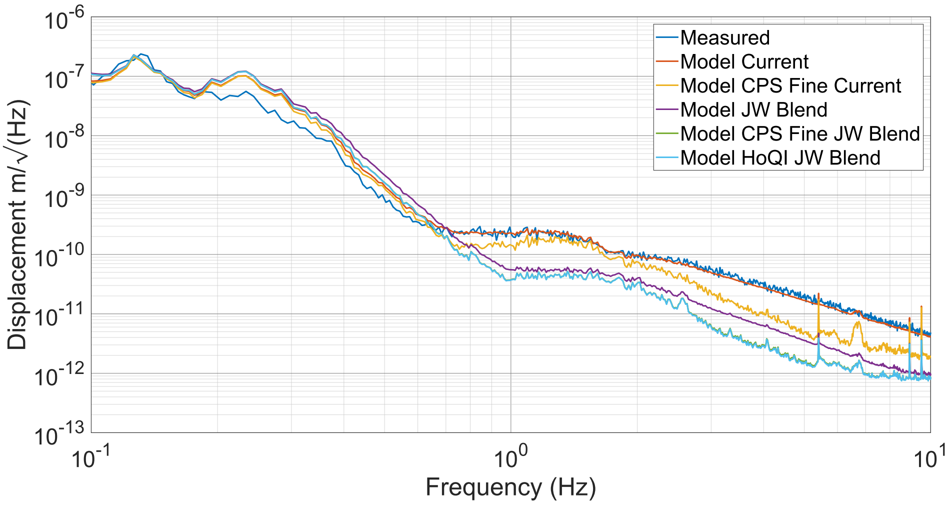

Figure 5: Fiugre showing the estimated reduction in platform motion by changing first, the blend filters and then CPS sensors on HAM5 and propogating these changes to calculate the expected suspension point motion with these changes. The blue and red trace show the measured (from site) and estimated (from the model) suspension point motion using current blending filters and sensors. The yellow trace is the result of changing the blending filter alone, while the green and purple traces are from changing both the blending filter and the displacement sensors used.

References

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