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**aLIGO HAM-ISI, Installation Test Report, Phase II,
LLO HAM 3**

E1200104-V6

Joe Hanson, Celine Ramet, Michael Vargas, Adrien Le Roux, Fabrice Matichard

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This is an internal working note
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California Institute of Technology
LIGO Project – MS 18-34
1200 E. California Blvd.
Pasadena, CA 91125
Phone (626) 395-2129
Fax (626) 304-9834
E-mail: info@ligo.caltech.edu

LIGO Hanford Observatory
P.O. Box 1970
Mail Stop S9-02
Richland WA 99352
Phone 509-372-8106
Fax 509-372-8137

Massachusetts Institute of Technology
LIGO Project – NW22-295
185 Albany St
Cambridge, MA 02139
Phone (617) 253-4824
Fax (617) 253-7014
E-mail: info@ligo.mit.edu

LIGO Livingston Observatory
P.O. Box 940
Livingston, LA 70754
Phone 225-686-3100
Fax 225-686-7189

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Introduction

This document presents the tests performed to characterize and validate the “HAM-ISI LLO Unit #3”. This unit was the 3rd unit assembled for aLIGO at LLO. This unit was partially assembled in Fall 2010, but following the discovery of unauthorized repairs in the parts, the assembly was interrupted. All parts in questions were disassembled. This unit was the 1st to be re-assembled when the assembly started back in Spring 2011.

This was the first unit pulled out from storage for installation at Livingston in January 2012, to be installed in HAM 3 chamber. Horizontal seismometers, springs tuned mass dampers, and final cables were installed. Also, the Capacitive Position Sensors cables were shielded.

This document is thought as the follow-up of the previous test document, written after assembly. Only modifications and basic functionalities were tested at that time.

There are 4 distinctive parts:

- Part I: side chamber testing results
- Part II: post insertion testing results
- Part III: Transfer functions taken during optics installation
 - 3.1 transfer functions after first triple install
 - 3.xx
- Part IV: Tests in final configuration

I. SIDE CHAMBER TESTING

- *Step 1: GS13*

All the data related to GS-13 post podding testing can be found in the SVN at :
 SeismicSVN\seismic\Common\Data\aLIGO_GS13_TestData\PostMod_TestResults_PDFs.
 E1000058 spreadsheet provides the status of each individual GS-13 at LLO site during aLIGO HAM assembly

Data files in SVN at:

/opt/svncommon/seisvn/seismic/Common/Data/aLIGO_GS13_TestData/PostMod_TestResults_Raw ASCII

Scripts files for processing and plotting in SVN at:

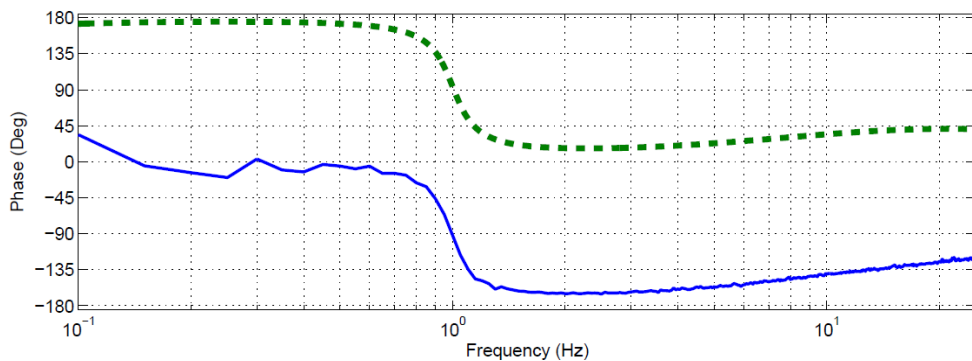
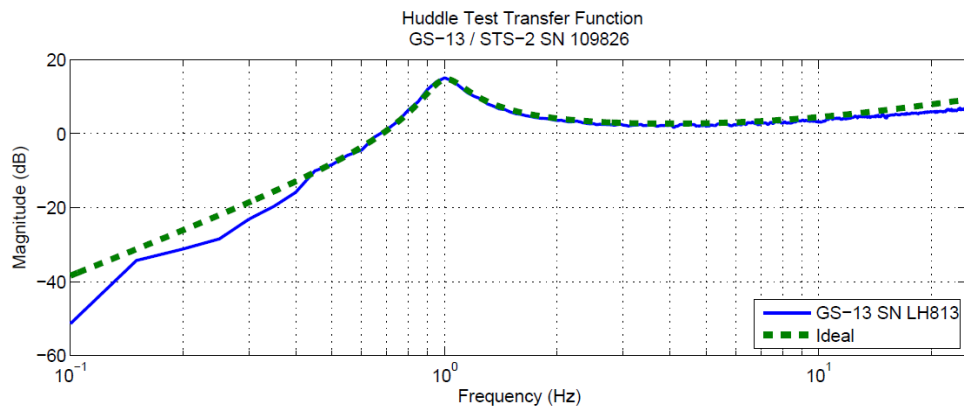
/opt/svncommon/seisvn/seismic/Common/MatlabTools
 - gs13qatest.m

Figures in SVN at:

/opt/svncommon/seisvn/seismic/Common/Data/aLIGO_GS13_TestData/PostMod_TestResults_PDFs

- *Step 1.1 – Horizontal GS-13s*

Huddle testing



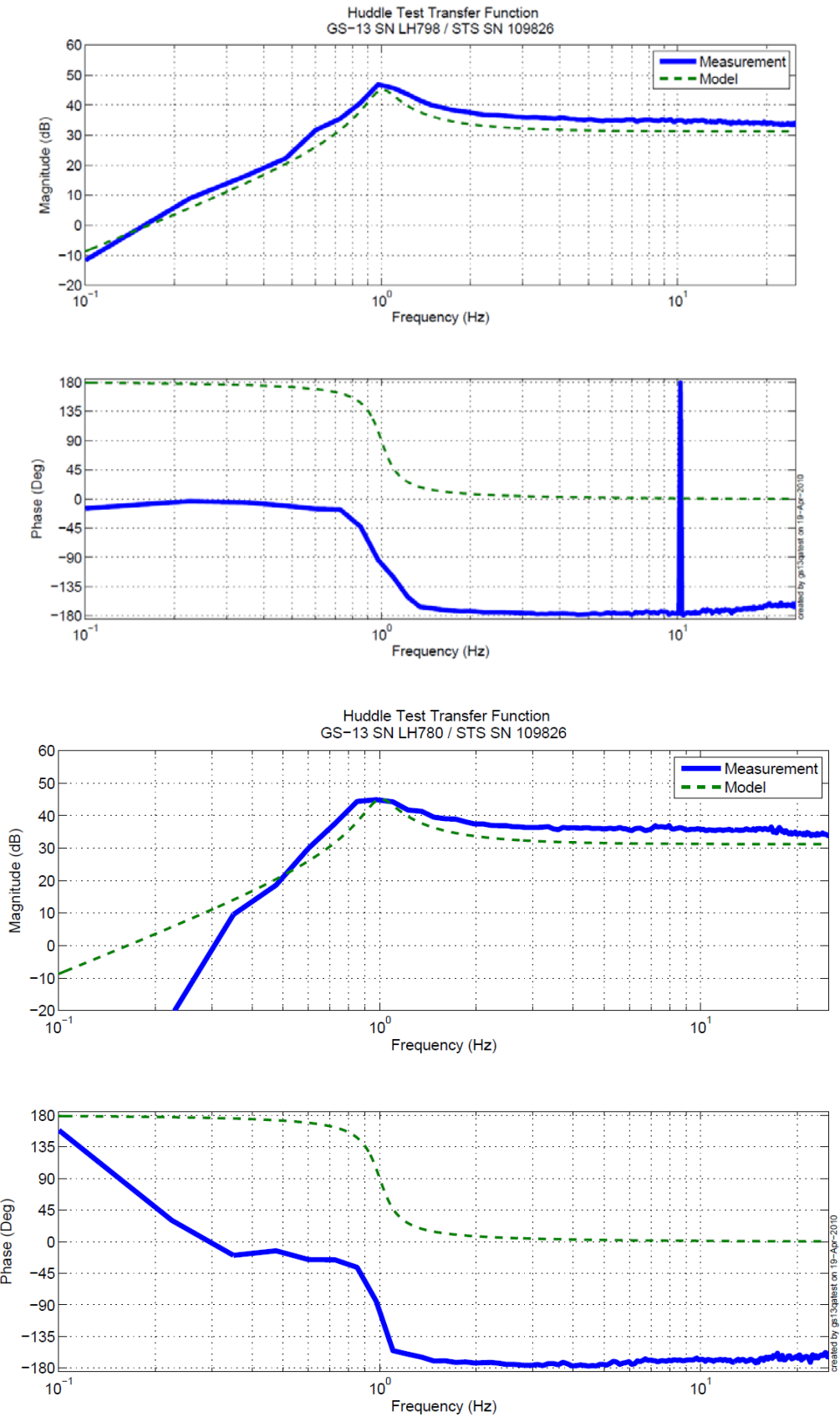


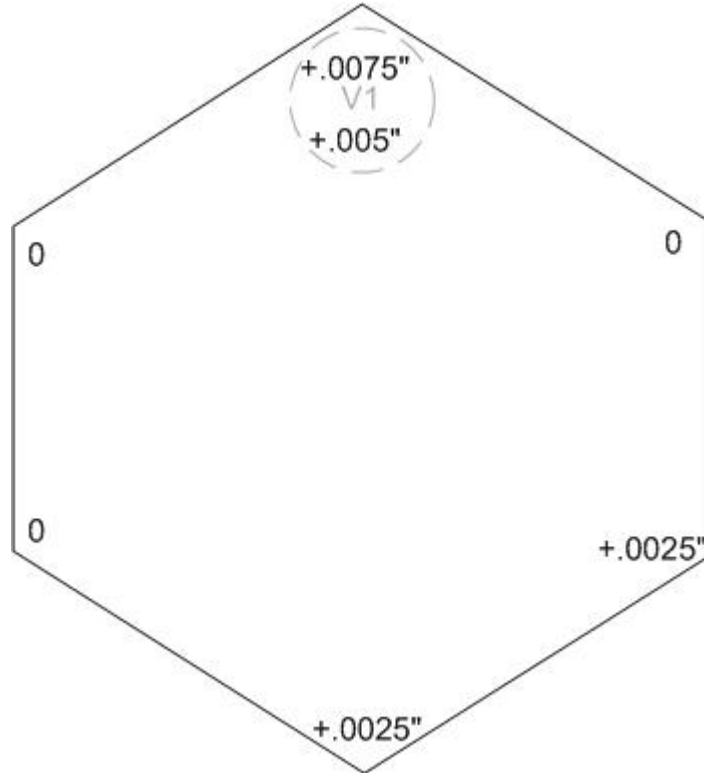
Figure - Huddle testing of Horiz GS-13 813,798, and 780 after aLIGO modifications

▪ **Step 3: Check level of Stage 1 Optical Table**

Issues/difficulties/comments regarding this test:

Initially this test was failed, but we adjusted the shim thickness to pass this test (see following step for new locker shims).

Optical Level measurement of Stage 1 at large (12 - 15) number of points.



The table here does not appear to be really tilted. Most of the difference can be included within the .005” flatness of the table.

Acceptance Criteria

- The maximum angle of the table with the horizontal mustn't exceed $\sim 100\mu\text{rad}$

Test result: Passed: X Failed: ___

▪ **Step 4: Shim thickness**

Issues/difficulties/comments regarding this test: Those shims were adjusted -in comparison to Phase I- to meet level requirements.

Lockers	Shim thickness (mil)
A	130
B	125
C	120
D	125

Table – Shims Thickness

Acceptance Criteria

- Inventory is complete

Test result:

Passed: X

Failed:

▪ **Step 5: Blade spring profile**

Because we adjusted the shims, we retook this measurement:

Blade #	Base (")	Tip (")	Flatness (mils)
1	.4982	.4909	+7.3
2	.5024	.4890	+13.4
3	.4922	.4881	+4.1

Table 1 - Blade profile

Acceptance Criteria:

- Blades must be flat within 0.015" inches.

Test result:

Passed: X

Failed:

▪ *Step 6: Gap checks on actuators-after installation on Stage 1*

The actuator positions were also adjusted.

Actuator	Front Gap (1/1000")	Back Gap (1/1000")
V1	85	80
V2	80	85
V3	90	80
H1	85	85
H2	85	85
H3	85	85

Acceptance Criteria

- Gaps must be within 0.010" of design (i.e. 0.090" and .070" pass, but 0.095" and 0.065" doesn't).

Test result:

Passed: X

Failed:

▪ *Step 7: Mass budget*

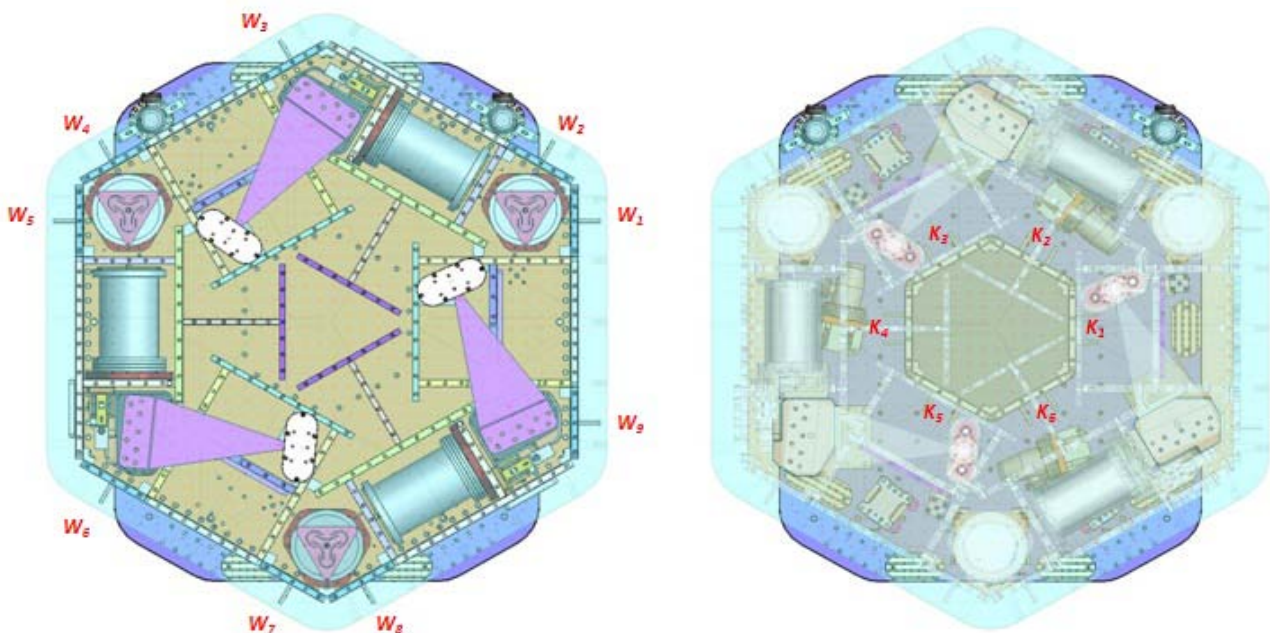


Figure – Keel Masses and Wall masses location



Figure - Optical table masses distribution

	00	01	02	03	04	05	06		
	0.6	1.1	2.2	4.5	7.9	15.6	27.2	lbs	kgs
w9	1	1				1		17.3	7.85
w1						1	1	42.8	19.41
w2						1	1	42.8	19.41
w3						1	1	42.8	19.41
w4		2		1		1	1	49.5	22.45
w5	1	2				1	1	45.6	20.68
w6		3				1	1	46.1	20.91
w7		3				1	1	46.1	20.91
w8						1	1	42.8	19.41
Side Masses									
Total	2	11	0	1	0	9	8	375.8	170.46

Table – Wall masses distribution

	00	01	02	03	04	05	06		
	0.6	1.1	2.2	4.5	7.9	15.6	27.2	lbs	kgs
k1					1		1	35.1	15.92
k2	1	1	1				1	31.1	14.11
k3					1		1	35.1	15.92
k4	1	1	1				1	31.1	14.11
k5					1		1	35.1	15.92
k6	1	1	1				1	31.1	14.11
	3	3	3	0	3	0	6	198.6	90.08

Table – Keel masses distribution



	D972213	D972215	D0901075				
			2.5 kg	5 kg	10 kg		
	610	230	5.5	11	22	lbs	kgs
A	1			1		621	281.68
B				1		11	4.99
C				1		11	4.99
D				1		11	4.99
E-1				1		11	4.99
E-2				1		11	4.99
E-3				1		11	4.99
Top Masses				1		0	0

Table - Optical Table Masses distribution

	Side	Keel	Top	Total
Weigh (kg)	170.46	90.08	311.62	572.16

Table - Masses distribution (computed using T1100261)

Acceptance Criteria

The Mass budget must be

- 579.1 Kg (cf E1100427)+/-25Kg (5%)

Test result:

Passed: X

Failed:

- *Step 8: Lockers adjustment*

D.I at Lockers	Dial indicators V	Dial indicators H
A	0	1
B	1.5	-2
C	0	0.5
D	-1	-1

Table – Dial indicators read-out (in thousands of an inch)

Acceptance Criteria

- Vertical and horizontal displacement near the lockers must be lower than 2 mils (0.002”)

Test result:

Passed: X

Failed:

- *Step 9 - Electronics Inventory*



Hardware	LIGO reference	S/N
Coil driver	D0902744	S1103306
		S1103304
Anti Image filter	D070081	S1104573
Anti aliasing filter	D1000269	S1104632
		S104635
Interface chassis	D1000067	S1107436
		S1107437

Table - Inventory electronics

Acceptance Criteria

- Inventory is complete

Test result:**Passed: X****Failed:**

- *Step 10 – Cables inventory – E1100822*

The location of all cables must be reported in the spreadsheet E1100822.

Cable Connects		Cable S/N		
Part Name	Configuration	Corner 1	Corner 2	Corner 3
GS13	Horizontal	S1104692- S1104657	S1104607- S1104648	S1104597- S110650
GS13	Vertical			
L4C	Horizontal	N/A	N/A	N/A
L4C	Vertical	N/A	N/A	N/A
Actuator	Horizontal	S1106680	S1104748	S1104718
	Vertical	S1104749	S1104498	S1104483

Table – Cables inventory

Acceptance Criteria

- Cable inventory completed
- E110082 spreadsheet updated

Test result:**Passed: X****Failed:**

▪ *Step 11 - Set up sensors gap*

Table locked	10 Kg masses at each corners		No mass	
	ADE boxes on		ADE boxes on	
Sensors	Offset (Mean)	Std deviation	Offset (Mean)	Std deviation
H1			190	
H2			-370	
H3			5	
V1			-490	
V2			460	
V3			-180	

Table – Capacitive position sensor readout after gap set-up

Issues/difficulties/comments regarding this test: HAM-ISI – LLO HAM 3 uses synchronized boxes, with power boards installed on their back.

Note that the position sensors were originally set up this way but that later adjustments to the lockers brought them to the level shown in Step 5, then judged acceptable.

Acceptance criteria:

- All mean values must be lower than 400 cts (a bit less than .0005”).
- All standard deviations below 5 counts.
- No cross talk

Test result:

Passed: X

Failed: __

▪ *Step 12 - Measure the Sensor gap*

Sensors	Gap measured on the Jig	Gap measured on the table
H1	NR	80
H2	NR	80
H3	NR	85
V1	NR	80
V2	NR	85
V3	NR	85

Acceptance criteria:

Sensors gap measured on the jig and on the optic table must be:

- 0.080” +/-0.002”

Test result:

Passed: __

Failed: X

▪ *Step 13 - Check Sensor gaps after the platform release*

Sensors	Table locked		Table unlocked	
	Offset (Mean)	Std deviation	Offset (Mean)	Difference
H1	-2230.9		-2086.9	144
H2	-636.48		-66.072	570.408
H3	-1300.2		-459.22	840.98
V1	-728.31		-607.66	120.65
V2	797.89		825.84	27.95
V3	-715.5		-1386.5	-671

Table – Sensor gaps after platform release

Acceptance criteria:

- Absolute values of the difference between the unlocked and the locked table must be below:
 - o 1600 cts for horizontal sensors (~0.002")
 - o 1600 cts for vertical sensors (~0.002")
- Considering the acceptance criteria of step 4, all mean values must be lower than
 - o 2000 cts for horizontal sensors (~0.0025")
 - o 2000 cts for vertical sensors (~0.0025")

Test result:

Passed: X

Failed:

▪ *Step 14– Performance of the limiter*

▪ *Step 14.1 - Test N°1 - Push “in the general coordinates”*

We conducted this test because locker C would not unlock all the way. We believe that the table was completely free but ran that test in order to measure whether this was true or not.

Numbers could not recorded because of a workstation issue, but in all instances, they were > 18,000 counts. (which is superior to the 16,000 counts criteria)
Also, the direction were right.

Test result:

Passed: X

Failed: .

▪ **Step 15 - Position Sensors unlocked/locked Amplitude Spectral Densities**

As scheduled, we installed new horizontal GS-13 seismometers on the ISI. As the table was still locked (because weight repartition had not been finalized), we took Amplitude Spectral Density measurements and noticed that the H3 sensor did not have a normal response. We switched the pod used in H3.

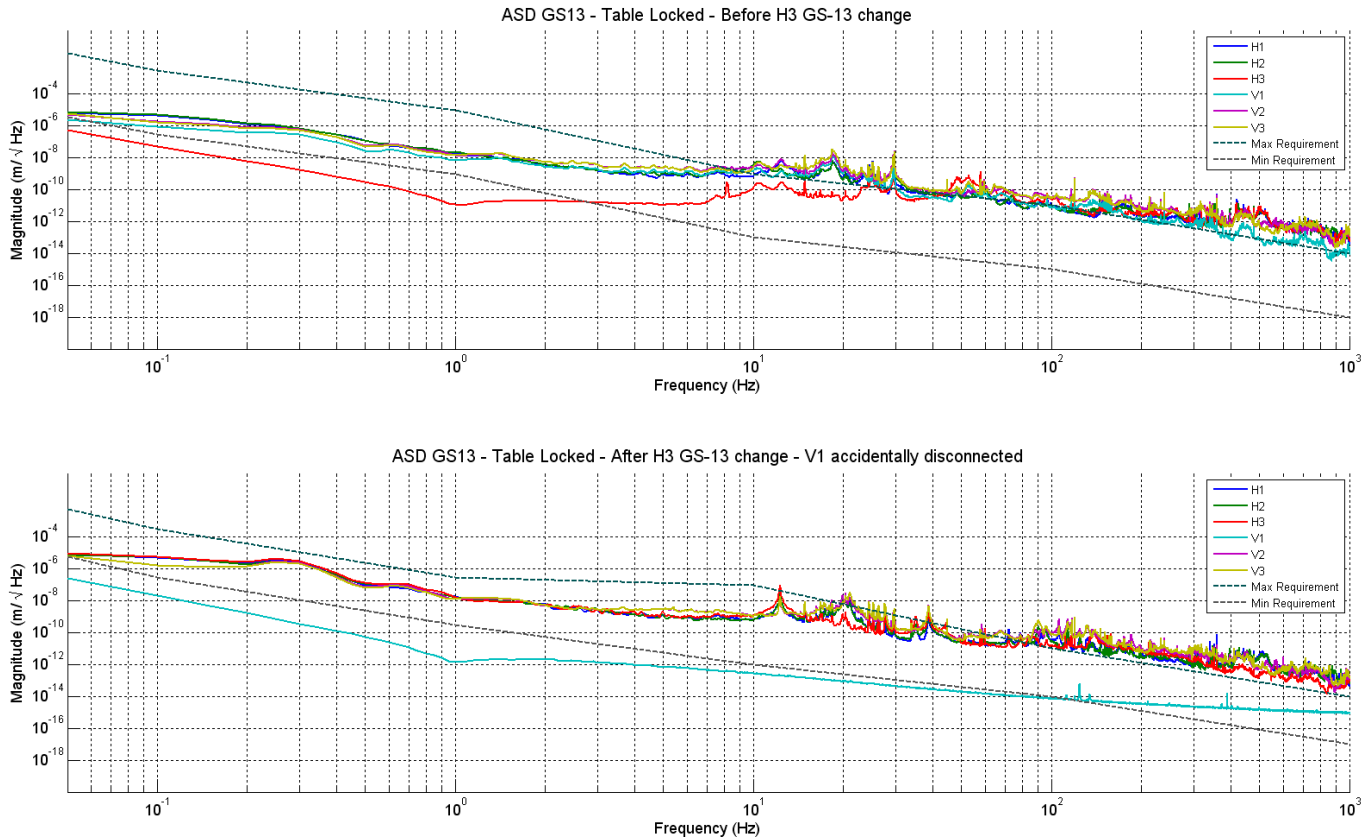


Figure 1 Calibrated GS-13 ASD plot- Broken Sensor behavior

As we can see in the top plot, the seismometer had a normal behavior down to ~13 Hz, had a somewhat low answer between 2 and 13 Hz, and was downright not working at any lower frequencies.

On the lower plot, we can see the ASD when a pod is disconnected (which happened on V1 as we were working on switching the H3 pod). So, the cyan line in this plot displays the ASD of the GS-13 electronics (from the feedthrus up), and the calibration.

Data files in SVN at:

/seismic/HAM-ISI/L1/HAM3/Data/Spectra/Undamped/
 - LLO_ISI_HAM3_ASD_m_CPS_T240_L4C_GS13_Locked_vs_Unlocked_2012_01_31.pdf

Scripts files for taking and processing the data, and plotting it in SVN at:

seismic/HAM-ISI/Common/Testing_Functions_HAM_ISI/
 - Plot_ASD_Unlocked_Locked_HAM_ISI.m
 - Plot_ASD_Unlocked_Locked_Group_HAM_ISI.m

Figures in SVN at:

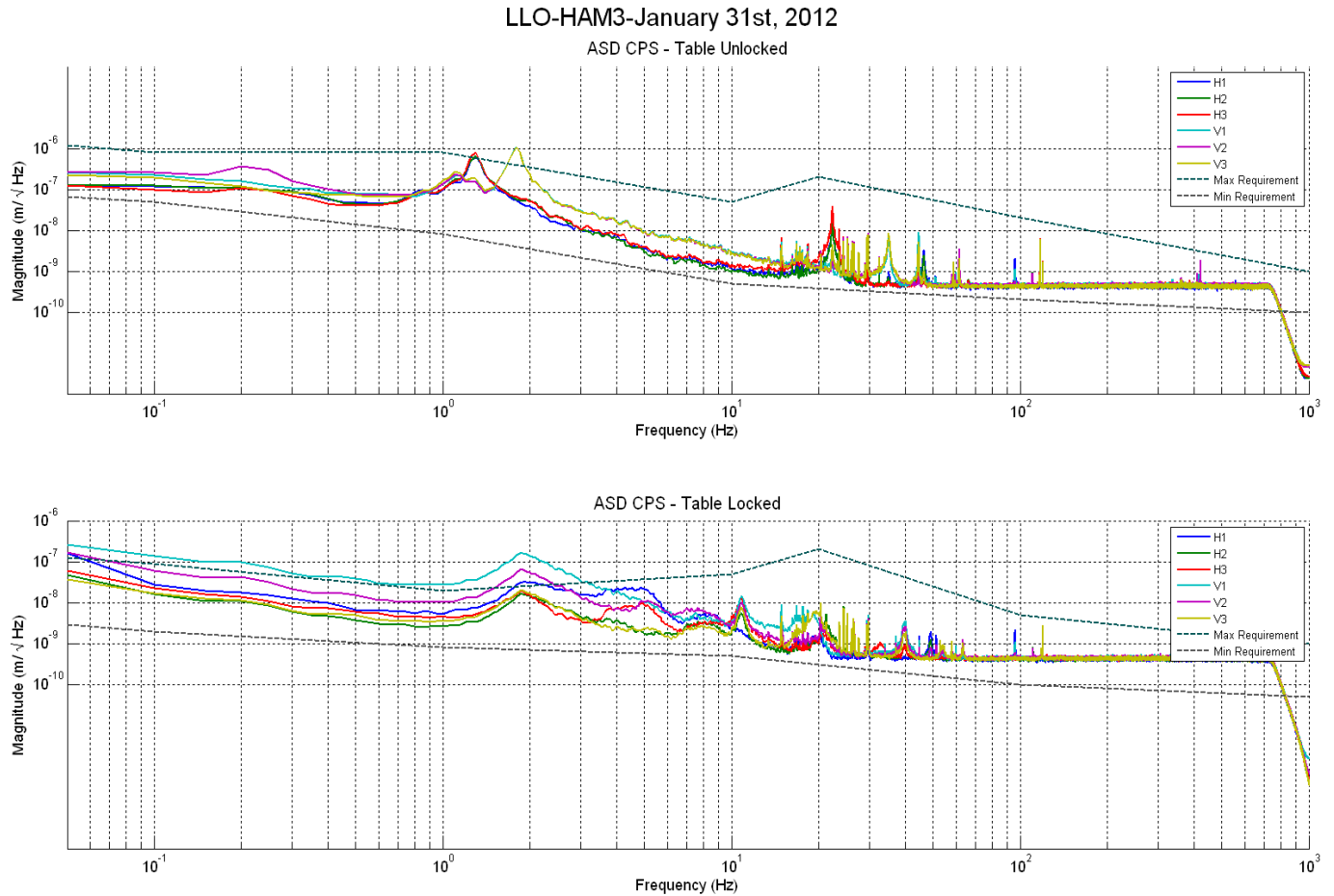
seismic/HAM-ISI/L1/HAM3/Data/Figures/Spectra/Undamped/

- LLO_ISI_HAM3_ASD_m_CPS_Requirements_Locked_vs_Unlocked_2012_01_31.pdf

- LLO_ISI_HAM3_ASD_m_GS13_Requirements_Locked_vs_Unlocked_2012_01_31.pdf

CPS calibration:

The CPS power spectrums are calibrated by using a sensitivity of 30.2 nm/count.



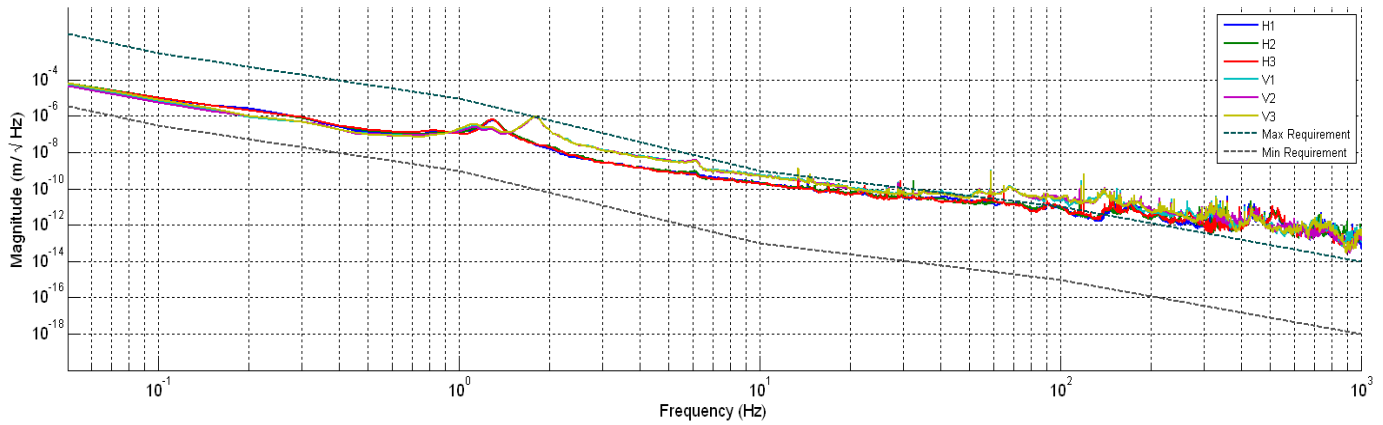
Measurement length: 1010s - Sample window: 20s - Overlap: 50% - Frequency resolution: 50mHz - Averages: 100 - Measurement start (GPS): 1012062615

Figure - Calibrated CPS power spectrum

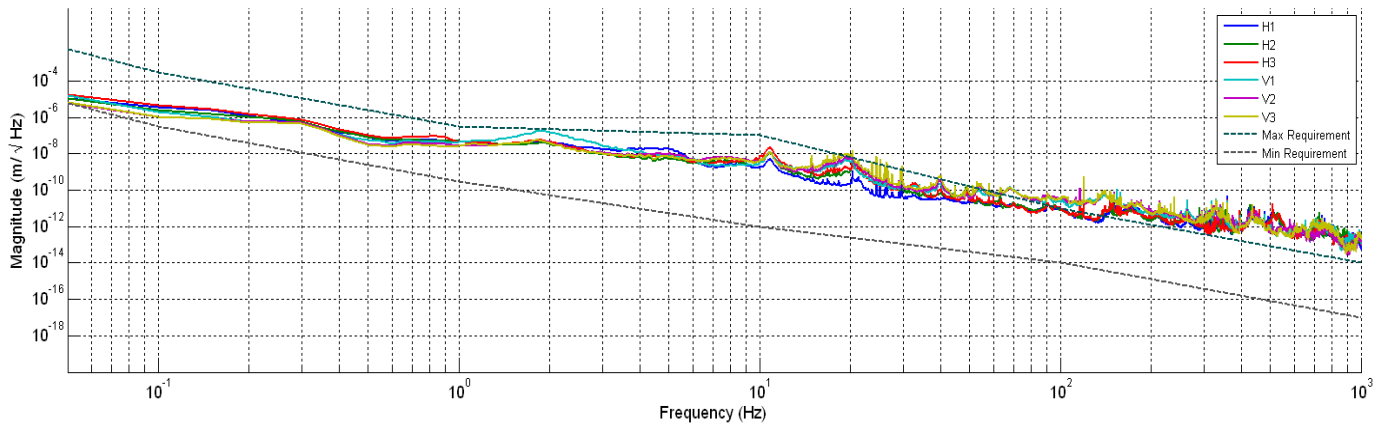


LLO-HAM3-January 31st, 2012

ASD GS13 - Table Unlocked



ASD GS13 - Table Locked



Measurement length: 1010s - Sample window: 20s - Overlap: 50% - Frequency resolution: 50mHz - Averages: 100 - Measurement start (GPS): 1012062615

Figure – Power spectrum Calibrated GS13

Acceptance criteria:

- No cross talk (peaks at low frequencies + harmonics on measurements)
- Magnitudes of power spectra must be between requirement curves such as in the following figures (dashed lines)

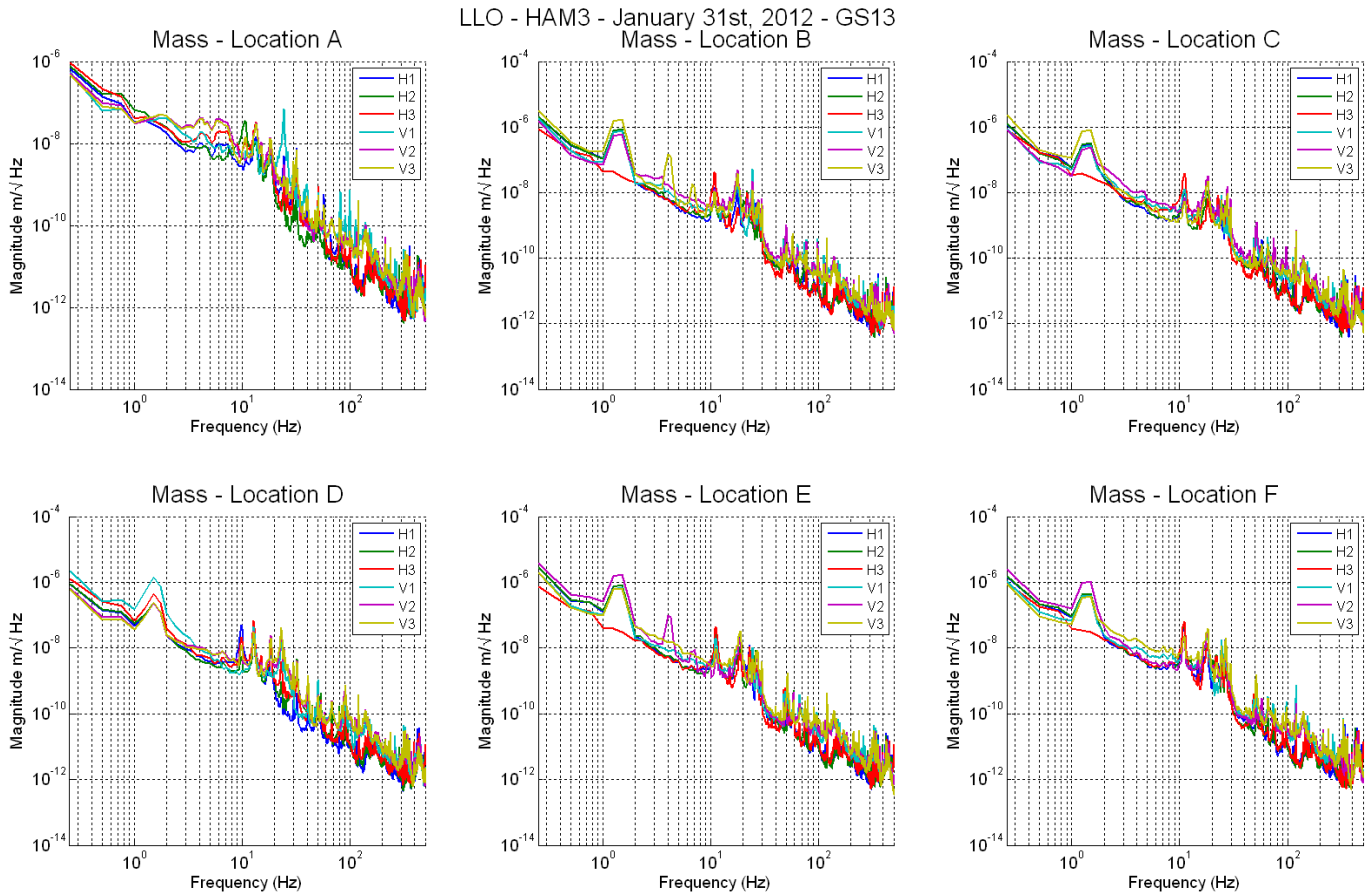
Test result:

Passed: X

Failed:

▪ **Step 16 - GS13 ASD -tabled tilted**

The figure below presents the GS13 power spectrum when the table is unlocked and loaded with a 20Kg mass at one of its corner.



LLO - HAM3 - January 31st, 2012 - GS13
Mass - Location B

Measurement length: 102s - Sample window: 4s - Overlap: 50% - Frequency resolution: 250mHz - Averages: 50 - Measurement start (GPS): 1012077720

Figure – ASD Calibrated GS13 with mass at corner

Data files in SVN at:

/seismic/HAM-ISI/L1/HAM3/Data/Spectra/Undamped/
- LLO_HAM_ISI_Unit_3_Calibrated_PSD_GS13_Table_Tilted_2011-03-31.mat

Scripts files for taking and processing the data, and plotting it in SVN at:

seismic/HAM-ISI/Common/Testing_Functions_HAM_ISI/
- Plot_ASD_Tilted_Stage_HAM_ISI.m

Figures in SVN at:

seismic/HAM-ISI/L1/HAM3/Data/Figures/Spectra/Undamped/
- LLO_ISI_HAM3_ASD_CT_GS13_Tilted_2012_01_31.pdf

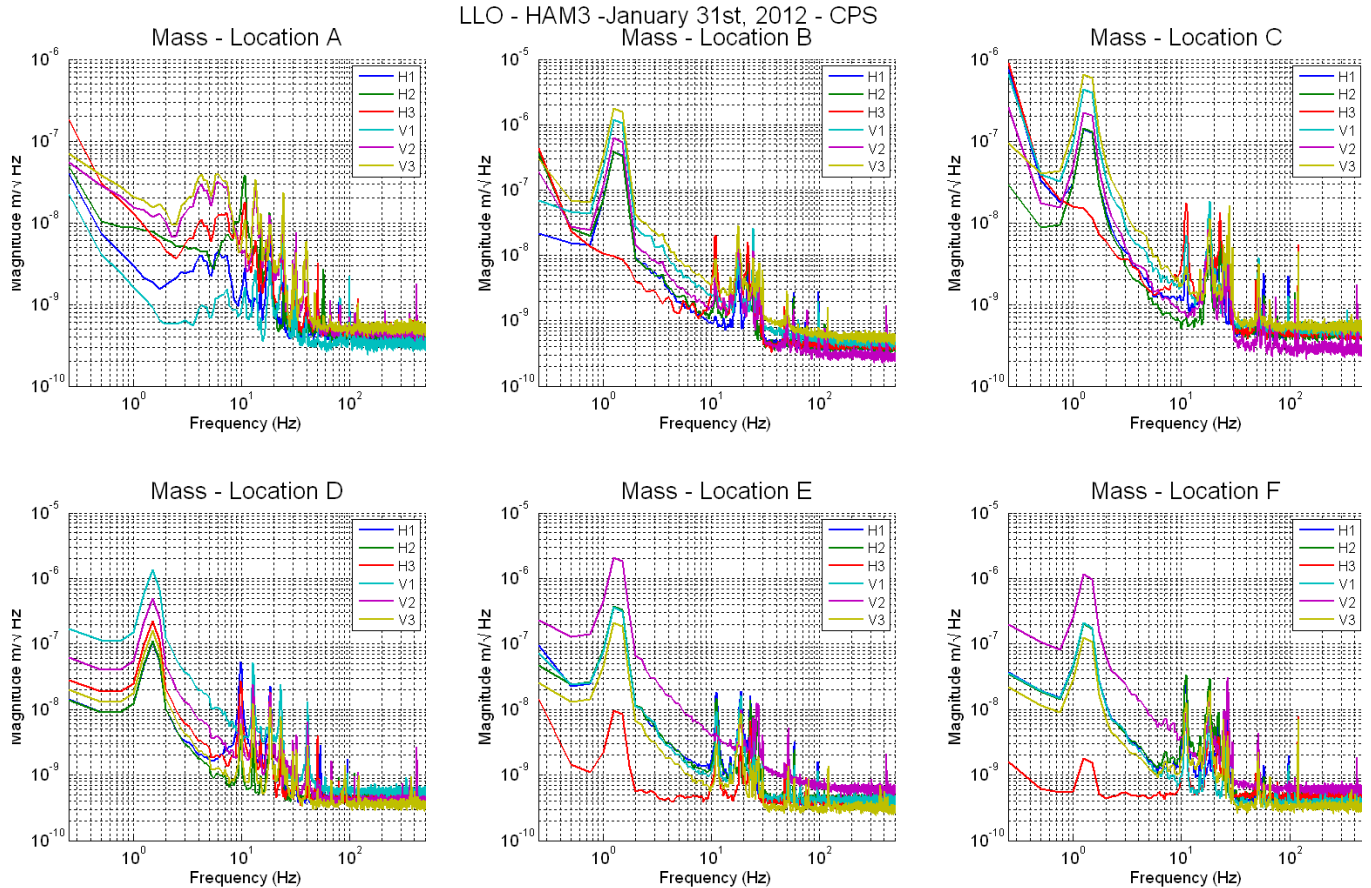
Acceptance criteria:

- With table unlocked and tilted, magnitudes of power spectra must be fully included within:

Issues/difficulties/comments regarding this test:

As can be seen on the plot, in 4/6 tilted table configurations, the H3 seismometer does not follow the same trend around the 1Hz resonance (of the system). We confirmed those results on 02/02/12 by taking similar measurements.

Then, to ensure that this was describing actual motion and a sensor issue, we plotted the corresponding graphs for the CPS sensors:



Measurement length: 102s - Sample window: 4s - Overlap: 50% - Frequency resolution: 250mHz - Averages: 50 - Measurement start (GPS): 1012077720

Figure – ASD Calibrated CPS with mass at corner

Those confirmed that we had a strong motion reduction on H3 with a mass added on locations B, C, E and F, confirming our suspicions that the H3 inertial sensor was working fine.

We also ran 2 additional tests, slowly adding mass on corners E and F, and taking ASD at each additional mass added. These 2 tests additionally confirmed that at some level when adding the mass, the table got locked in a position in which the H3 sensors would not see any motion.

Test result:

Passed: X

Failed:

▪ *Step 17- GS13 pressure readout*

All vertical seismometers were reading 77 or 78 kPa, whereas the differential readout was consistently reading 0.

Test result: Passed: X Failed:

▪ *Step 18 - Actuators Sign and range of motion (Local drive)*

	Negative drive	Initial offset	Positive drive
H1 readout (count)	15600	-2086.6	-23674
H2 readout (count)	22696	-66.07	-23804
H3 readout (count)	22721	-459.22	-26017
V1 readout (count)	18674	-607.66	-20239
V2 readout (count)	26334	825.84	-23952
V3 readout (count)	21736	-1386.5	-21546

Table - Range of motion - Local drive

Data files in SVN at:

/seismic/HAM-ISI/L1/HAM3/Data/Static_Tests/
 - LLO_ISI_HAM3_Range_Of_Motion_20120131.mat

Scripts files for taking and processing the data, and plotting it in SVN at:

seismic/HAM-ISI/Common/Testing_Functions_HAM_ISI/
 - Range_Motion_HAM_ISI.m

Acceptance criteria:

- Main couplings sensors readout must be at least 16000 counts (~0.02")
- A positive offset drive on one actuator must give positive sensor readout on the collocated sensor. Signs will also be tested when measuring local to local transfer functions.

Test result: Passed: X Failed:

▪ *Step 19 - Static Testing (Tests in the local basis)*

	H1	H2	H3	V1	V2	V3
H1	-1882.9	-1176.2	-1170.8	0.06016	21.654	7.3542
H2	-1202.1	-1914.3	-1199.1	5.6833	9.6504	10.663
H3	-1160.7	-1163.2	-1868.4	13.998	-26.884	6.3794
V1	-181.36	-177.29	341.02	-1351.9	54.534	578.36
V2	339.77	-173.64	-170.13	560.06	-1308.2	48.246
V3	-169.88	357.92	-166.17	16.386	592.07	-1347.9

Table - Main and cross coupling

Data files in SVN at:

/seismic/HAM-ISI/L1/HAM3/Data/Static_Tests/

- LLO_ISI_HAM3_Offset_Local_Drive_20120130.mat

Scripts files for taking data in SVN at:

seismic/HAM-ISI/Common/Testing_Functions_HAM_ISI/

- Static_Test_Local_Basis_HAM_ISI.m

Acceptance criteria:

- **Vertical**

For a +1000 count offset drive on vertical actuators

- o Collocated sensors must be 1400 counts +/- 10%

- **Horizontal**

For a +1000 count offset drive on horizontal actuators

- o Collocated sensors must be 2000 counts +/- 10%
- o Non-collocated horizontal sensors must be 1250 counts +/-10%

Test result:

Passed: X

Failed: ___

▪ *Step 20 - Linearity test*

	Slope	Offset	Average slope	Variation from average(%)
H1	-1.877	-2115.5	-1.8847	-0.4068
H2	-1.9143	-85.46		1.5723
H3	-1.8627	-469.99		-1.1655
V1	-1.3472	-590.08	-1.3396	0.5648
V2	-1.3273	843.02		-0.9206
V3	-1.3444	-1365.5		0.3558

Table - Slopes and offset of the triplet Actuators - HAM-ISI - Sensors

Scripts files for taking data in SVN at:

/opt/svncommon/seisvn/seismic/HAM-ISI/X2/Scripts/Data_Collection

- Linearity_Test_Awgstream_HAM_ISI.m

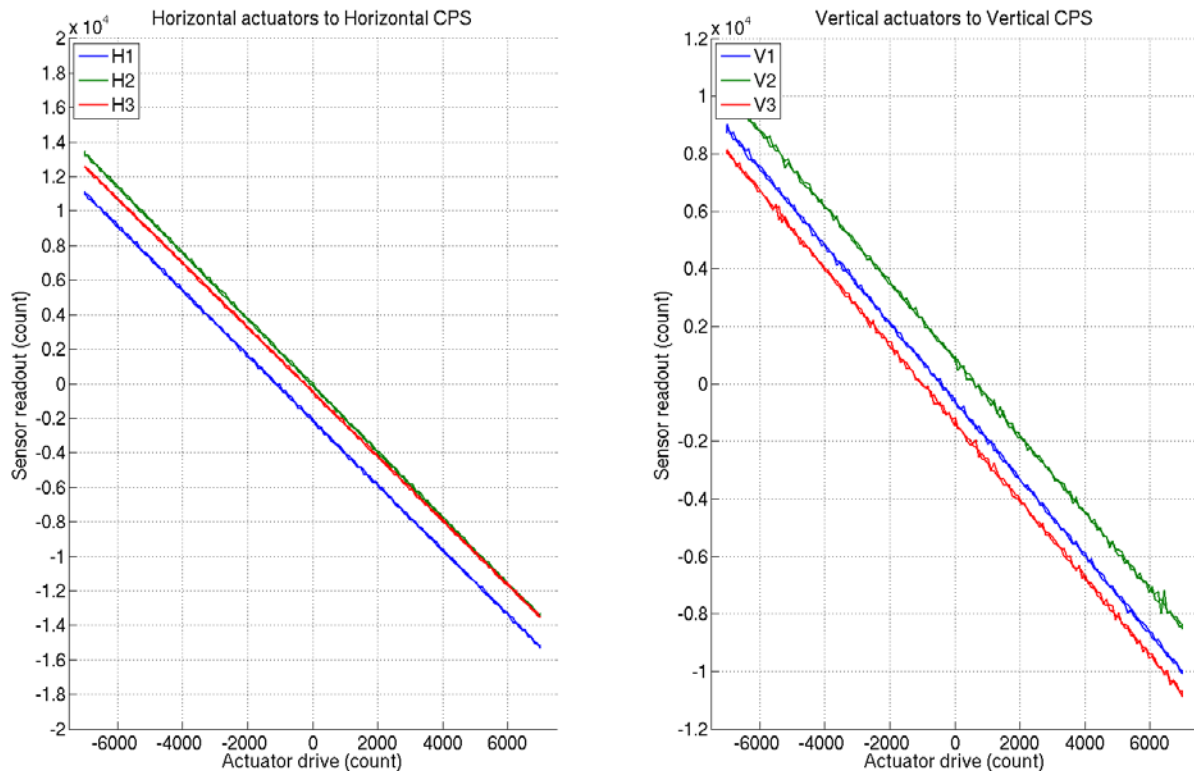


Figure - Horizontal and vertical actuators x HAM-ISI x sensors

Data files in SVN at:

seismic/HAM-ISI/L1/HAM3/Data/Linearity_Test/
 - LLO_ISI_HAM3_Linearity_test_20120131.mat

Figures in SVN at:

seismic/HAM-ISI/L1/HAM3/Data/Figures/Linearity_Test/
 - LLO_ISI_HAM3_Linearity_test_20120131.pdf

**Acceptance criteria:**

- Horizontal and vertical slopes of the triplet actuators x HAM-ISI x sensors: Average slope +/- 1%

Test result:**Passed:** **Failed:**

- *Step 21 Cartesian Basis Static Testing*

	X	Y	Z	RX	RY	RZ
H1	-472.35	-1.7679	-6.7007	13.167	4.7942	25.002
H2	1.3471	-473.4	-4.806	0.92872	-11.246	-18.996
H3	-2.1291	0.84794	-246.99	6.1198	-9.5124	-4.2034
V1	-1.6534	-3.7937	4.1602	-2364.5	-14.492	-9.5828
V2	4.6829	-11.945	5.5404	5.6792	-2381.4	-12.592
V3	5.1331	-7.8399	-1.1317	15.98	7.2418	-2316.4
X	388.56	-427.79	-15.8	-3.4236	-7.9464	14.627
Y	249.67	252.97	-445.2	-6.0781	-7.758	8.5452
Z	-7.4222	1.1952	7.3504	-253.53	-247.55	-243.74
RX	251.95	245.72	-472.21	1530.6	-372.92	-1152.6
RY	-424.04	442.4	15.501	-432.73	1551	-1113.1
RZ	1827.2	1832.1	1829.9	-4.8145	1.428	11.102

Table - Tests in the general coordinate basis

Issues/difficulties/comments regarding this test:

This is the first ISI oriented in the Y direction. Matrices were redesigned for that purpose.

Acceptance criteria:

For a positive drive in the Cartesian basis:

- Local sensor readout must have the same sign that the reference table (**CONTACT check**)
- Cartesian sensors read out must be positive (**DISP2CEN check**) in the drive direction

Test result:**Passed:** **Failed:**

- **Step 22- Frequency response**

Compensation filters of the new GS13 interface chassis are located in the geophone pre-filters bank.

- **Step 22.1 - Local to local measurements**

Local to local transfer functions have been measured with 90 repetitions.

Data files in SVN at:

seismic/HAM-ISI/L1/HAM3/Data/Transfer_Functions/Measurements/Undamped/
- LLO_ISI_HAM3_Data_TF_L2L_50mHz_500mHz_20120201-000859.mat
- LLO_ISI_HAM3_Data_TF_L2L_500mHz_5Hz_20120131-213926.mat
- LLO_ISI_HAM3_Data_TF_L2L_5Hz_200Hz_20120131-205053.mat
- LLO_ISI_HAM3_Data_TF_L2L_200Hz_800Hz_20120131-191720.mat

Data collection script files:

seismic/HAM-ISI/L1/HAM3/Scripts/Data_Collection/
- Run_Exc_Batch_L1ISIHAM3.m

Scripts files for processing and plotting in SVN at:

seismic/HAM-ISI/L1/HAM3/Scripts/Control_Scripts/
- Step_1_TF_L2L_L1_ISI_HAM3.m

Figures in SVN at:

/seismic/HAM-ISI/L1/HAM3/Data/Figures/Transfer_Functions/Measurements/Undamped/
- LLO_ISI_HAM3_TF_L2L_Raw_from_ACT_to_CPS_2012_01_31.fig
- LLO_ISI_HAM3_TF_L2L_Raw_from_ACT_to_GS13_2012_01_31.fig

Storage of measured transfer functions in the SVN at:

opt/svncommon/seisvn/seismic/HAM-ISI/X2/Data/Unit_3/Transfer_functions/Measurements/
Undamped/
- LLO_HAM_ISI_Unit_3_Data_TF_L2L_2011_04_06.mat

The local to local transfer functions are presented below.

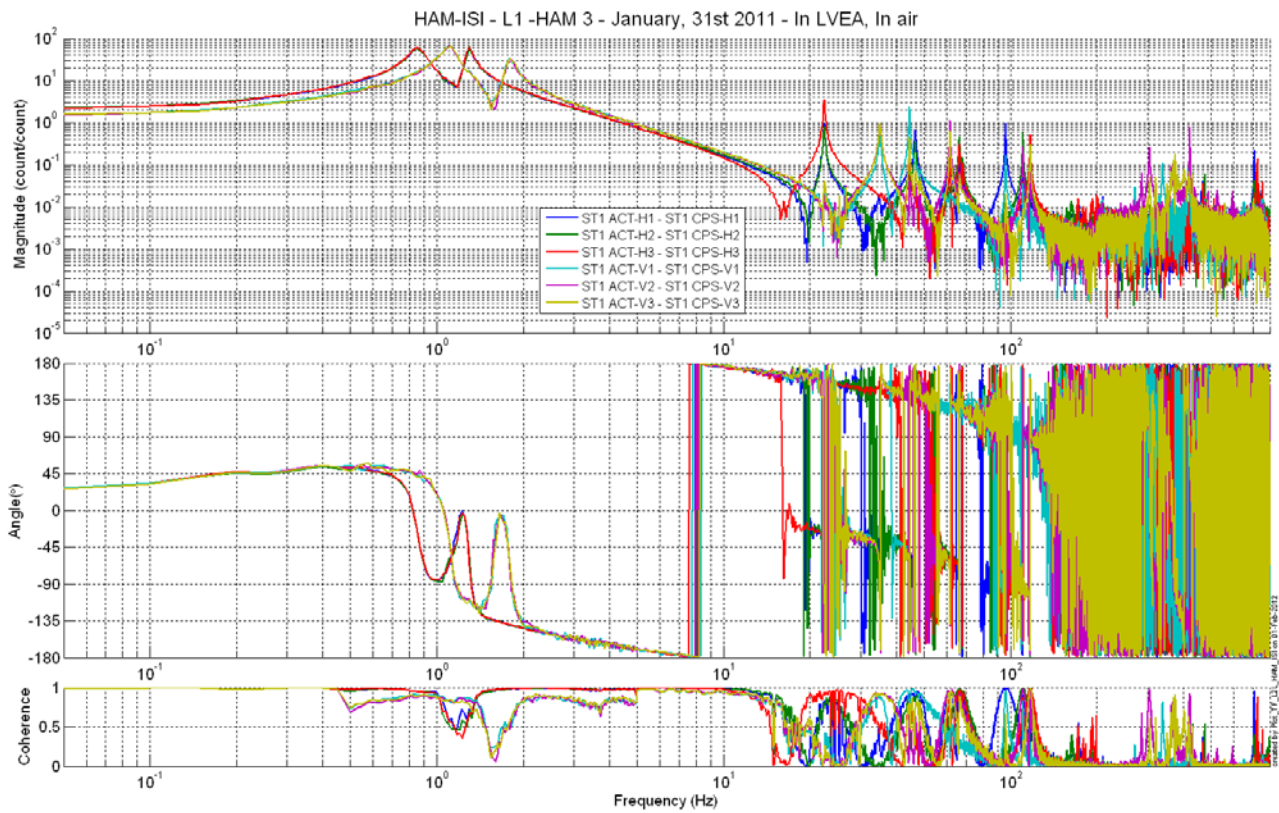


Figure - Local to Local Measurements –Capacitive Position Sensors

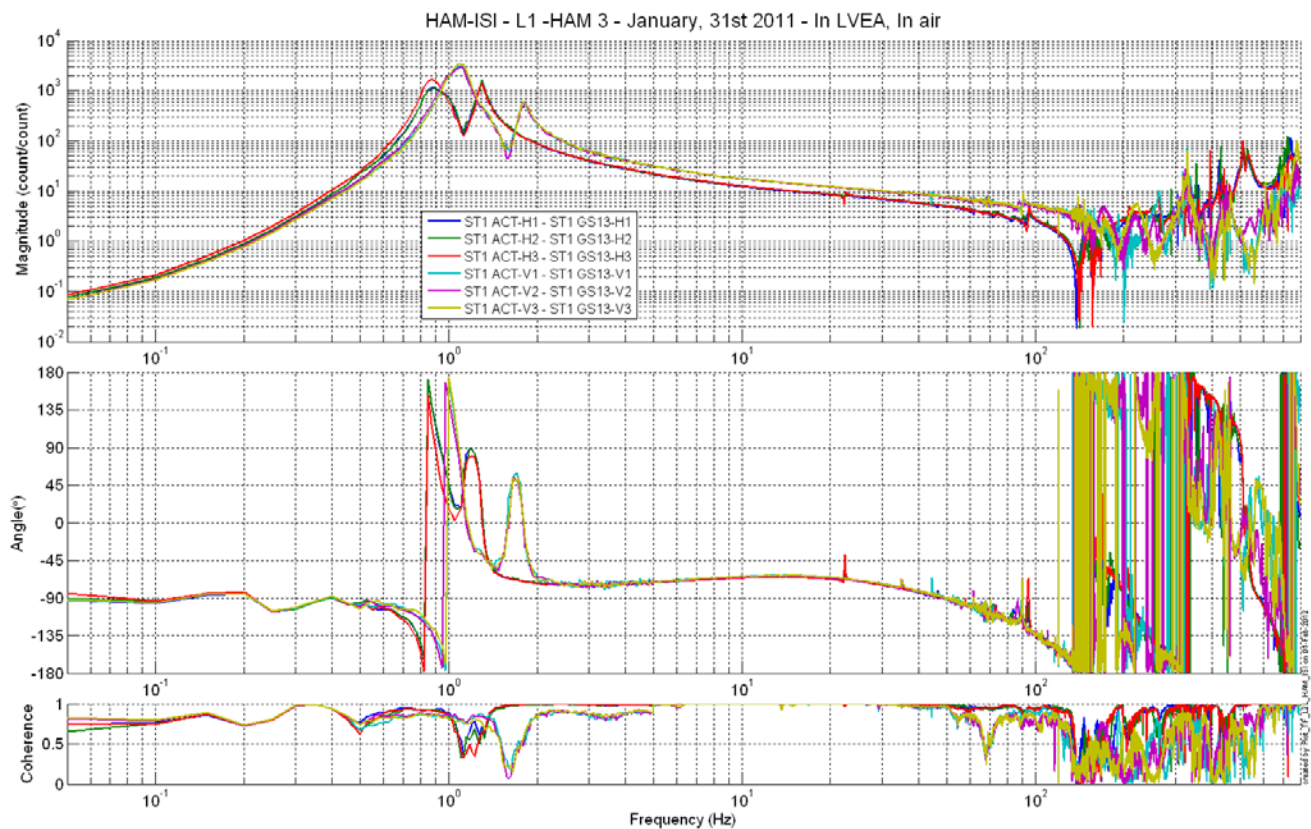


Figure - Local to Local Measurements – Inertial sensors

Issues/difficulties/comments regarding this test:

Around 1 Hz, the H2 inertial sensor seems to indicate different behaviors of each corner.

▪ ***Step 23 - Lower Zero Moment Plane***

Based from results of Phase I where the measurement was taken with, we wanted to retake this measurement. The measurements were run but data processing issues have so far prevented us from getting the results.

Test result:

Passed: X

Failed: ___

Conclusion of Side Chamber testing

Very few issues were found during the testing of this unit. The known issues are summed up here:

- The Linearity test gives a slightly different slope on the H2 actuator (1.5% from average for a 1% criteria)
- The H3 GS-13 gives a slightly different response around 1 Hz when the table is tilted.
- We have a slight offset of 2 CPS: H1 and V3.
- The locked table measurements seem to indicate that the table was not completely locked.

Issues unchanged since the Phase I testing:

- sensor gaps not recorded on the jig
- Vertical spring constant: one spring appears to have a much lower constant than the others (-8.91% than the average of the 3).
- LZMP measurements were done with only 1 average (high uncertainty), they should be redone inside the chamber

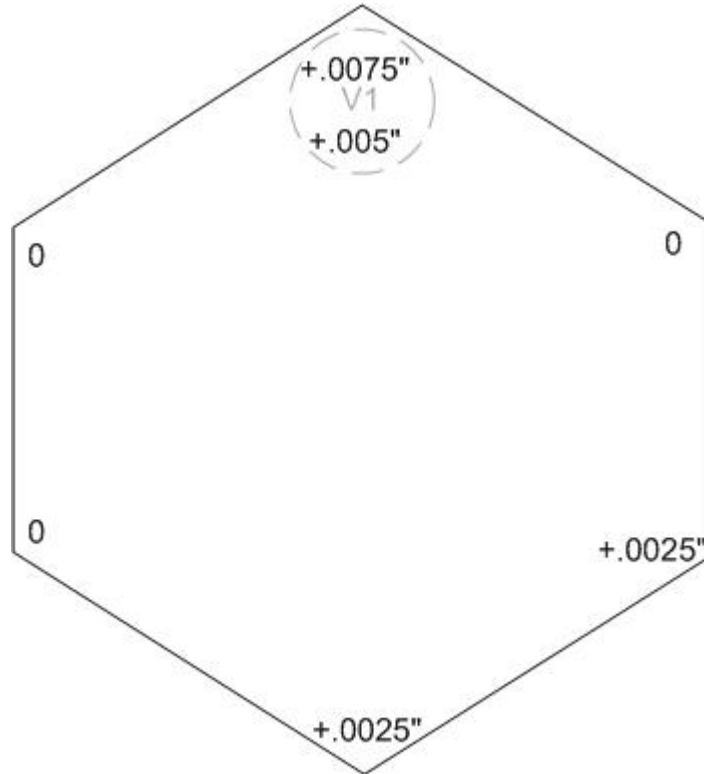
II. INITIAL IN CHAMBER TESTING

The HAM-ISI was installed in HAM 3 on February 3rd 2012. This initial in chamber testing was conducted in the following 2 weeks until we closed the chamber on February 17th 2012.

- **Step 1: Check level of Stage 1 Optical Table**

Issues/difficulties/comments regarding this test:

Initially this test was failed, but we adjusted the shim thickness to pass this test (see following step for new locker shims).



The table here does not appear to be really tilted. Most of the difference can be included within the $.005''$ flatness of the table.

Acceptance Criteria

- The maximum angle of the table with the horizontal mustn't exceed $\sim 100\mu\text{rad}$

Test result: Passed: X Failed:

▪ *Step 2: Shim thickness*

Issues/difficulties/comments regarding this test: Those shims were adjusted -in comparison to side chamber testing to meet level requirements. We believe it was due to 2 things: our level slightly out calibration and our test stand off.

Lockers	Shim thickness (mil)
A	130
B	125
C	120
D	125

Table – Shims Thickness

Acceptance Criteria

- Inventory is complete

Test result:

Passed: X

Failed:

▪ *Step 5: Blade spring profile*

Because we adjusted the shims, we retook this measurement:

Blade #	Base (")	Tip (")	Flatness (mils)
1	.4961	.4890	+7.1
2	.4986	.4914	+7.2
3	.4978	.4882	+9.6

Table 2 - Blade profile

Acceptance Criteria:

- Blades must be flat within 0.015" inches.

Test result:

Passed: X

Failed:

▪ *Step 7: Mass budget*

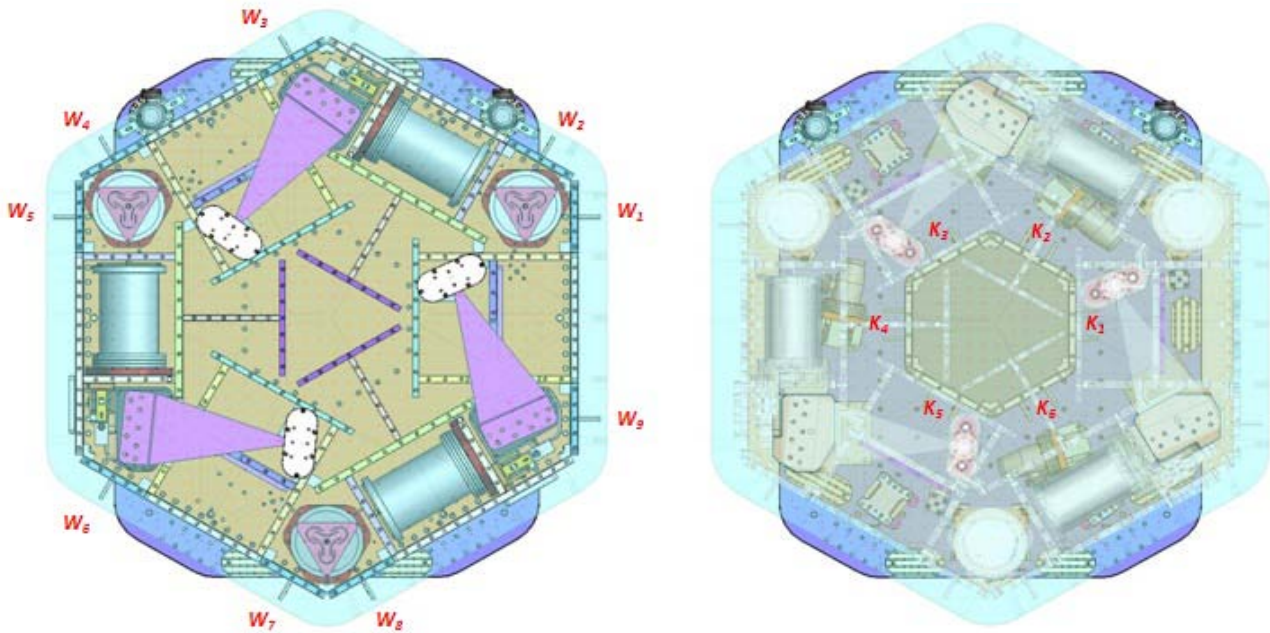


Figure – Keel Masses and Wall masses location



Figure - Optical table masses distribution

	00	01	02	03	04	05	06		
	0.6	1.1	2.2	4.5	7.9	15.6	27.2	lbs	kgs
w9		1	1			1		17.3	7.85
w1						1	1	42.8	19.41
w2						1	1	42.8	19.41
w3						1	1	42.8	19.41



w4		2		1		1	1	49.5	22.45
w5	1	2				1	1	45.6	20.68
w6		3				1	1	46.1	20.91
w7		3				1	1	46.1	20.91
w8						1	1	42.8	19.41
Side Masses									
Total	2	11	0	1	0	9	8	375.8	170.46

Table – Wall masses distribution

	00	01	02	03	04	05	06		
	0.6	1.1	2.2	4.5	7.9	15.6	27.2	lbs	kgs
k1					1		1	35.1	15.92
k2	1	1	1				1	31.1	14.11
k3					1		1	35.1	15.92
k4	1	1	1				1	31.1	14.11
k5					1		1	35.1	15.92
k6	1	1	1				1	31.1	14.11
	3	3	3	0	3	0	6	198.6	90.08

Table – Keel masses distribution

	D972213	D972215	D0901075			lbs	kgs
			2.5 kg	5 kg	10 kg		
	610	230	5.5	11	22		
A	1			1		621	281.68
B				1		11	4.99
C				1		11	4.99
D				1		11	4.99
E-1				1		11	4.99
E-2				1		11	4.99
E-3				1		11	4.99
Top Masses	1	0	0	7	0	687	311.62

Table - Optical Table Masses distribution

	Side	Keel	Top	Total
Weigh (kg)	170.46	90.08	311.62	572.16

Table - Masses distribution (computed using T1100261)

Acceptance Criteria

The Mass budget must be

- 579.1 Kg (cf E1100427)+/-25Kg (5%)



Test result:

Passed: X

Failed:

▪ *Step 8: Lockers adjustment*

- Not recorded but within.

Test result:

Passed: X

Failed:

▪ *Step 10 – Cables inventory – E1100822*

We noticed a few mistakes in our early installation of cables, so here is a corrected inventory

Cable Connects		Cable S/N		
Part Name	Configuration	Corner 1	Corner 2	Corner 3
GS13	Horizontal	S1104692- S1104657	S1104607- S1104648	S1104597- S110650
GS13	Vertical			
L4C	Horizontal	N/A	N/A	N/A
L4C	Vertical	N/A	N/A	N/A
Actuator	Horizontal	S1106680	S1104748	S1104486
	Vertical	S1104749	S1104718	S1104483

Table – Cables inventory

Acceptance Criteria

- Cable inventory completed
- E110082 spreadsheet updated

Test result:

Passed: X

Failed:

▪ *Step 11 - Set up sensors gap*

No mass

Table locked	ADE boxes on	
	Offset (Mean)	Std deviation
Sensors		
H1	190	
H2	-370	
H3	5	
V1	-490	
V2	460	
V3	-180	

Table – Capacitive position sensor readout after gap set-up

Issues/difficulties/comments regarding this test: HAM-ISI – LLO HAM 3 uses synchronized boxes, with power boards installed on their back.



Note that the position sensors were originally set up this way but that later adjustments to the lockers brought them to the level shown in Step 5, then judged acceptable.

Acceptance criteria:

- All mean values must be lower than 400 cts (a bit less than .0005”).
- All standard deviations below 5 counts.
- No cross talk

Test result:

Passed: X

Failed:

- *Step 13 - Check Sensor gaps after the platform release*

Sensors	Table locked		Table unlocked	
	Offset (Mean)	Std deviation	Offset (Mean)	Difference
H1	-2230.9		-2086.9	144
H2	-636.48		-66.072	570.408
H3	-1300.2		-459.22	840.98
V1	-728.31		-607.66	120.65
V2	797.89		825.84	27.95
V3	-715.5		-1386.5	-671

Table – Sensor gaps after platform release

Acceptance criteria:

- Absolute values of the difference between the unlocked and the locked table must be below:
 - o 1600 cts for horizontal sensors (~0.002”)
 - o 1600 cts for vertical sensors (~0.002”)
- Considering the acceptance criteria of step 4, all mean values must be lower than
 - o 2000 cts for horizontal sensors (~0.0025”)
 - o 2000 cts for vertical sensors (~0.0025”)

Test result:

Passed: X

Failed:

- *Step 15 - Position Sensors unlocked/locked Amplitude Spectral Densities*

Data files in SVN at:

/seismic/HAM-ISI/L1/HAM3/Data/Spectra/Undamped/
 - LLO_ISI_HAM3_ASD_m_CPS_T240_L4C_GS13_Locked_vs_Unlocked_2012_02_16.mat

Scripts files for taking and processing the data, and plotting it in SVN at:

seismic/HAM-ISI/Common/Testing_Functions_HAM_ISI/
 - Plot_ASD_Unlocked_Locked_HAM_ISI.m
 - Plot_ASD_Unlocked_Locked_Group_HAM_ISI.m

Figures in SVN at:

seismic/HAM-ISI/L1/HAM3/Data/Figures/Spectra/Undamped/

- LLO_ISI_HAM3_ASD_m_CPS_Requirements_Locked_vs_Unlocked_2012_02_16.pdf

- LLO_ISI_HAM3_ASD_m_GS13_Requirements_Locked_vs_Unlocked_2012_02_16.pdf

CPS calibration:

The CPS power spectrums are calibrated by using a sensitivity of 30.2 nm/count.

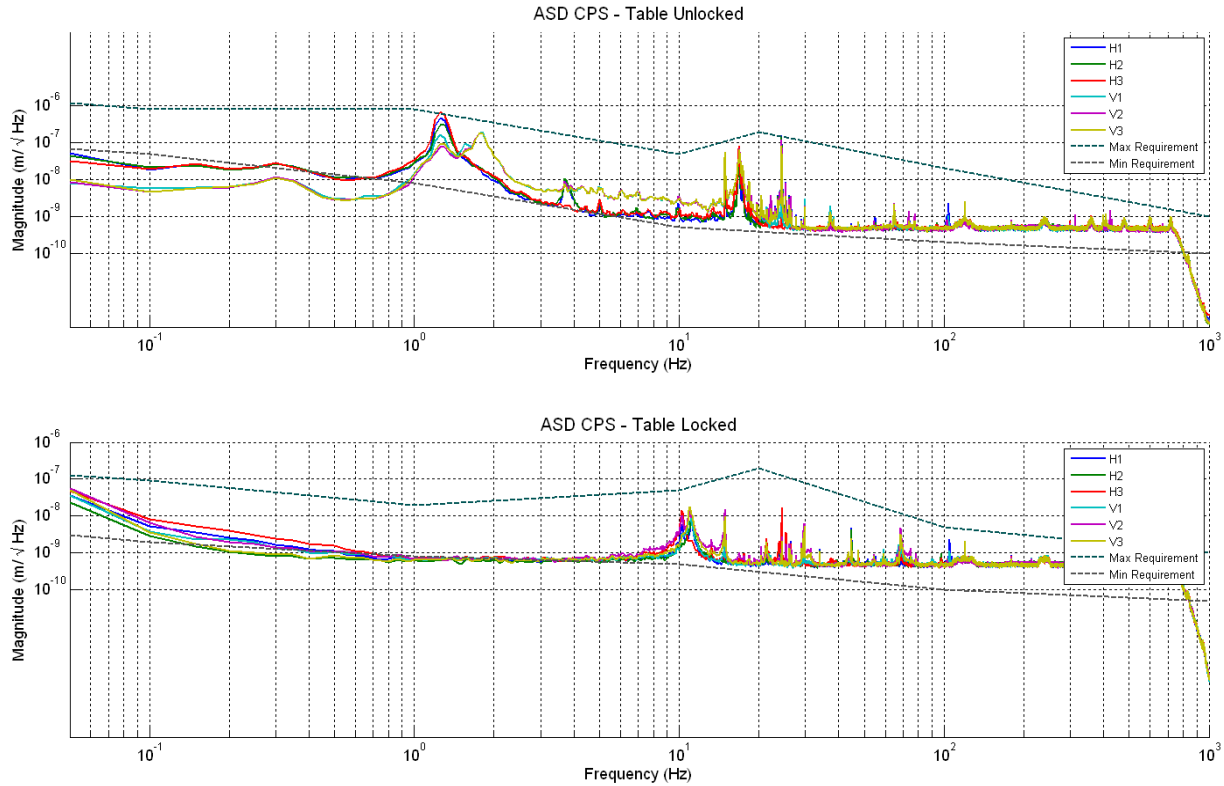


Figure - Calibrated CPS power spectrum

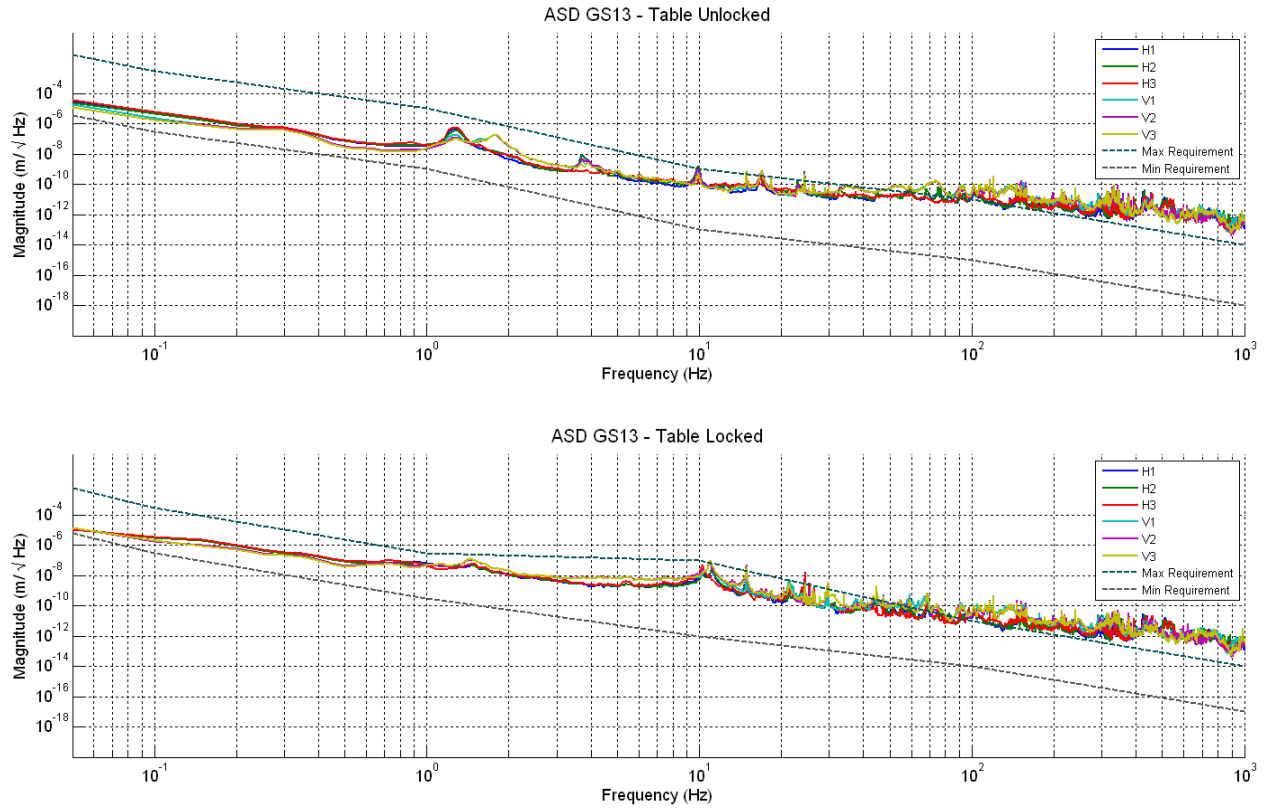


Figure – Power spectrum Calibrated GS13

Acceptance criteria:

- No cross talk (peaks at low frequencies + harmonics on measurements)
- Magnitudes of power spectra must be between requirement curves such as in the following figures (dashed lines)

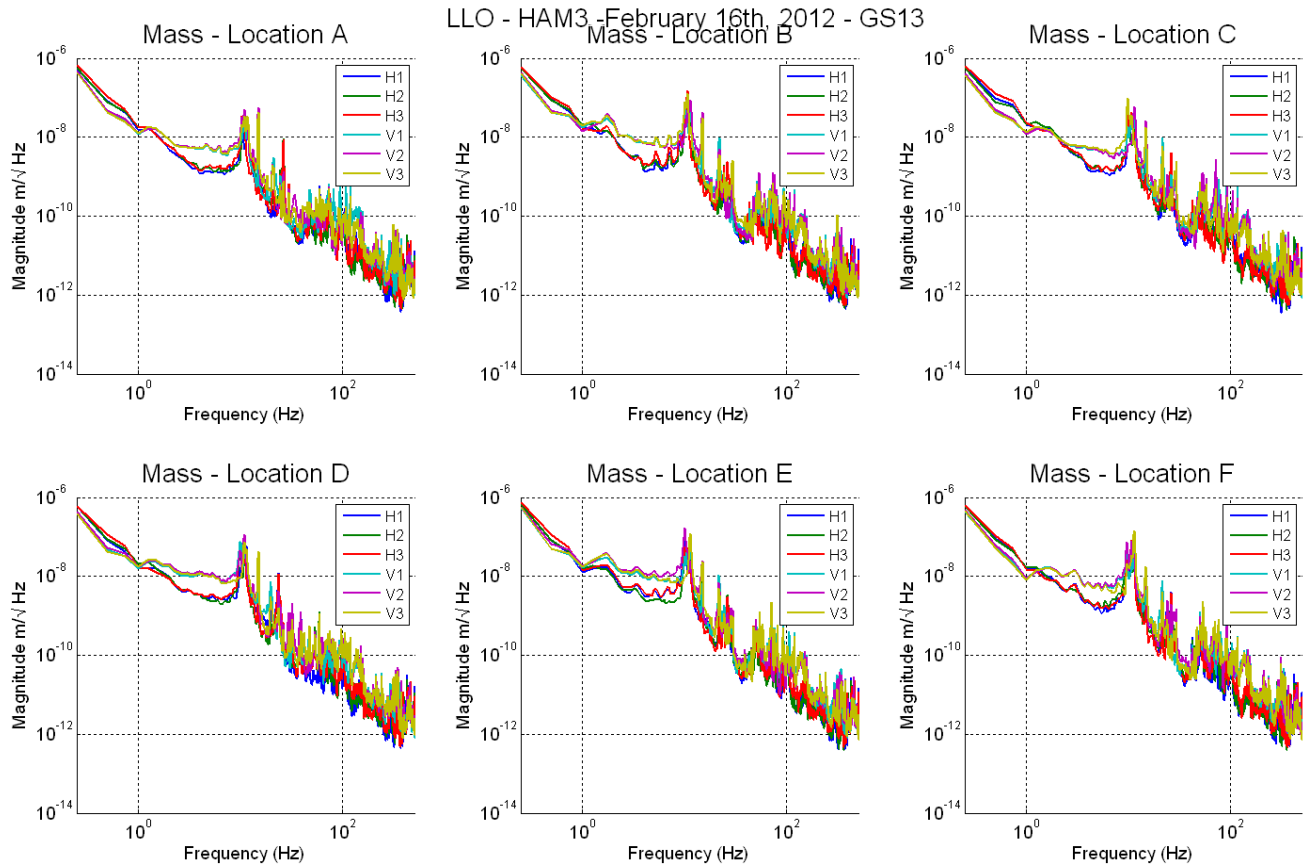
Test result:

Passed: X

Failed:

▪ **Step 16 - GS13 ASD -tabled tilted**

The figure below presents the GS13 power spectrum when the table is unlocked and loaded with a 20Kg mass at one of its corner.



Measurement length: 102s - Sample window: 4s - Overlap: 50% - Frequency resolution: 250mHz - Averages: 50 - Measurement start (GPS): 1013463090

Figure – ASD Calibrated GS13 with mass at corner

Data files in SVN at:

/seismic/HAM-ISI/L1/HAM3/Data/Spectra/Undamped/
 - LLO_HAM_ISI_Unit_3_Calibrated_PSD_GS13_Table_Tilted_2011-06_16.mat

Scripts files for taking and processing the data, and plotting it in SVN at:

seismic/HAM-ISI/Common/Testing_Functions_HAM_ISI/
 - Plot_ASD_Tilted_Stage_HAM_ISI.m

Figures in SVN at: seismic/HAM-ISI/L1/HAM3/Data/Figures/Spectra/Undamped/

- LLO_ISI_HAM3_ASD_CT_GS13_Tilted_2012_02_16.pdf

Issues/difficulties/comments regarding this test:

The issue that we had during side chamber testing was found to be combination of 2 factors:

- 1 peek cable clamp was too close to Stage 1 and making intermittent contact
- we were not using enough weight and used 20 lbs instead of 40.

Test result:

Passed: X

Failed:

▪ *Step 17- GS13 pressure readout*

All vertical seismometers were reading 77 or 78 kPa, whereas the differential readout was consistently reading 0.

Test result:

Passed: X

Failed: __

▪ *Step 18 - Actuators Sign and range of motion (Local drive)*

	Negative drive	Positive drive
H1 readout (count)	-21614	26101
H2 readout (count)	-22249	25593
H3 readout (count)	-24183	24696
V1 readout (count)	-20683	18431
V2 readout (count)	-28251	22259
V3 readout (count)	-21034	22066

Table - Range of motion - Local drive

Data files in SVN at:

/seismic/HAM-ISI/L1/HAM3/Data/Static_Tests/

- LLO_ISI_HAM3_Range_Of_Motion_20120215.mat

Scripts files for taking and processing the data, and plotting it in SVN at:

seismic/HAM-ISI/Common/Testing_Functions_HAM_ISI/

- Range_Motion_HAM_ISI.m

Issues/difficulties/comments regarding this test:

Signs are opposed to what we found side-chamber. This is due to the fact that we have here the compensation filters engaged in the actuators filter banks, as they should be.

Acceptance criteria:

- Main couplings sensors readout must be at least 16000 counts (~0.02")
- A positive offset drive on one actuator must give positive sensor readout on the collocated sensor. Signs will also be tested when measuring local to local transfer functions.

Test result:

Passed: X

Failed: __

▪ *Step 20 - Linearity test*

	Slope	Offset	Average slope	Variation from average(%)
H1	1.8600	2009.8	1.86276667	0.148524596
H2	1.8913	928.2430		-1.53177174
H3	1.8370	-1129.2		1.383247141
V1	1.3427	-2401.5	1.3388	-0.29130565
V2	1.3393	-26397		-0.03734688
V3	1.3344	3558.8		0.328652525

Table - Slopes and offset of the triplet Actuators - HAM-ISI - Sensors

Scripts files for taking data in SVN at: seismic/HAM-ISI/Common/Testing_Functions_HAM_ISI/
 - Linearity_Test_Awgstream_HAM_ISI.m

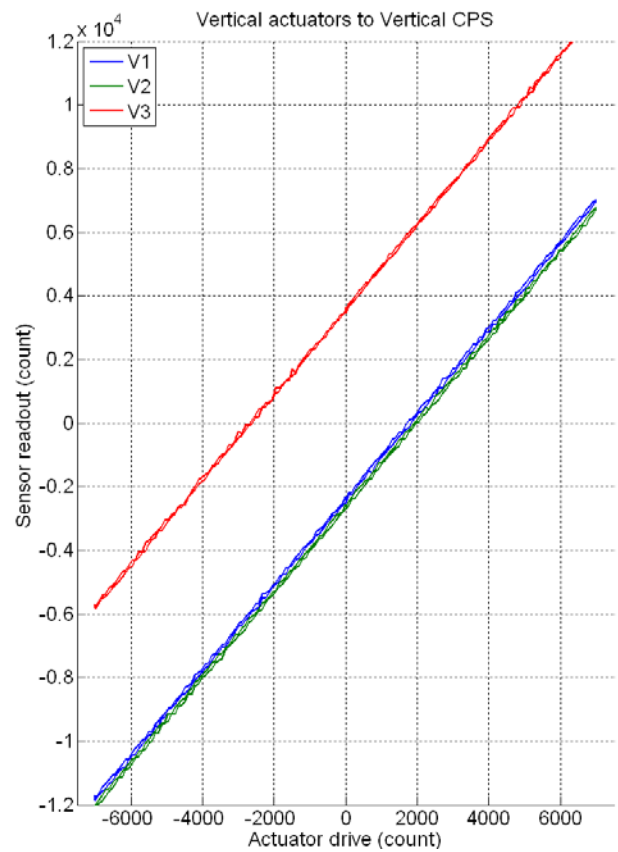
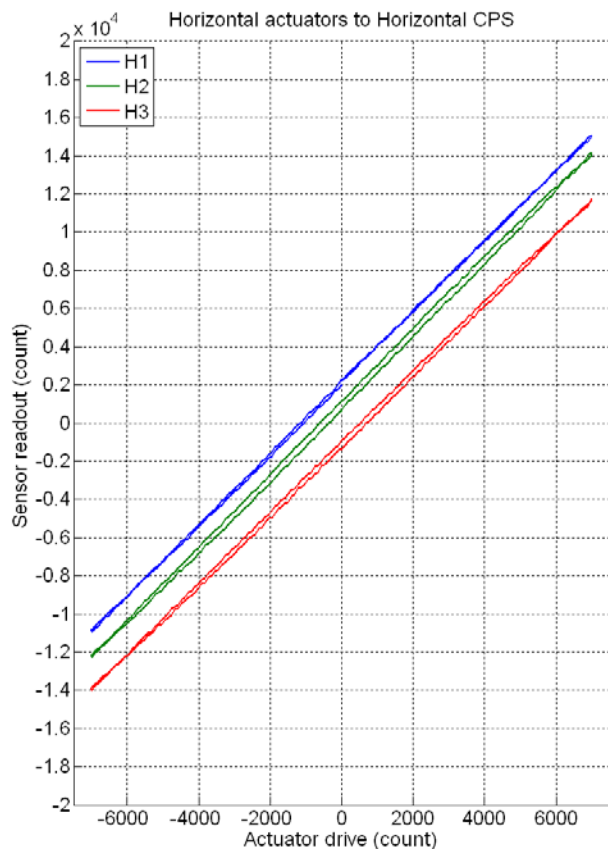


Figure - Horizontal and vertical actuators x HAM-ISI x sensors

Data files in SVN at: seismic/HAM-ISI/L1/HAM3/Data/Linearity_Test/
 - LLO_ISI_HAM3_Linearity_test_20120215.mat

Figures in SVN at:
 seismic/HAM-ISI/L1/HAM3/Data/Figures/Linearity_Test/
 - LLO_ISI_HAM3_Linearity_test_20120215.pdf

Issues/difficulties/comments regarding this test:

One can notice that the slopes are opposed to the ones in the same test side-chamber. This is due to the fact that we have here the compensation filters engaged in the actuators filter banks as they should be.

Acceptance criteria:

- Horizontal and vertical slopes of the triplet actuators x HAM-ISI x sensors: Average slope +/- 1%

Test result:Passed: Failed: X

- **Step 22- Frequency response**

Compensation filters of the new GS13 interface chassis are located in the geophone pre-filters bank.

- **Step 22.1 - Local to local measurements**

Local to local transfer functions have been measured with 90 repetitions, and those were taken once the door of the chamber had been closed..

Data files in SVN at:

seismic/HAM-ISI/L1/HAM3/Data/Transfer_Functions/Measurements/Undamped/

- LLO_ISI_HAM3_Data_TF_L2L_50mHz_500mHz_20120201-000859.mat
- LLO_ISI_HAM3_Data_TF_L2L_500mHz_5Hz_20120131-213926.mat
- LLO_ISI_HAM3_Data_TF_L2L_5Hz_200Hz_20120131-205053.mat
- LLO_ISI_HAM3_Data_TF_L2L_200Hz_800Hz_20120131-191720.mat

Data collection script files:

seismic/HAM-ISI/L1/HAM3/Scripts/Data_Collection/

- Run_Exc_Batch_L1ISIHAM3.m

Scripts files for processing and plotting in SVN at:

seismic/HAM-ISI/L1/HAM3/Scripts/Control_Scripts/

- Step_1_TF_L2L_L1_ISI_HAM3.m

Figures in SVN at:

/seismic/HAM-ISI/L1/HAM3/Data/Figures/Transfer_Functions/Measurements/Undamped/

- LLO_ISI_HAM3_TF_L2L_Raw_from_ACT_to_CPS_2012_02_18.fig
- LLO_ISI_HAM3_TF_L2L_Raw_from_ACT_to_GS13_2012_02_18.fig

Storage of measured transfer functions in the SVN at:

opt/svncommon/seisvn/seismic/HAM-ISI/X2/Data/Unit_3/Transfer_functions/Measurements/Undamped/

- LLO_HAM_ISI_Unit_3_Data_TF_L2L_2012.mat

The local to local transfer functions are presented below.

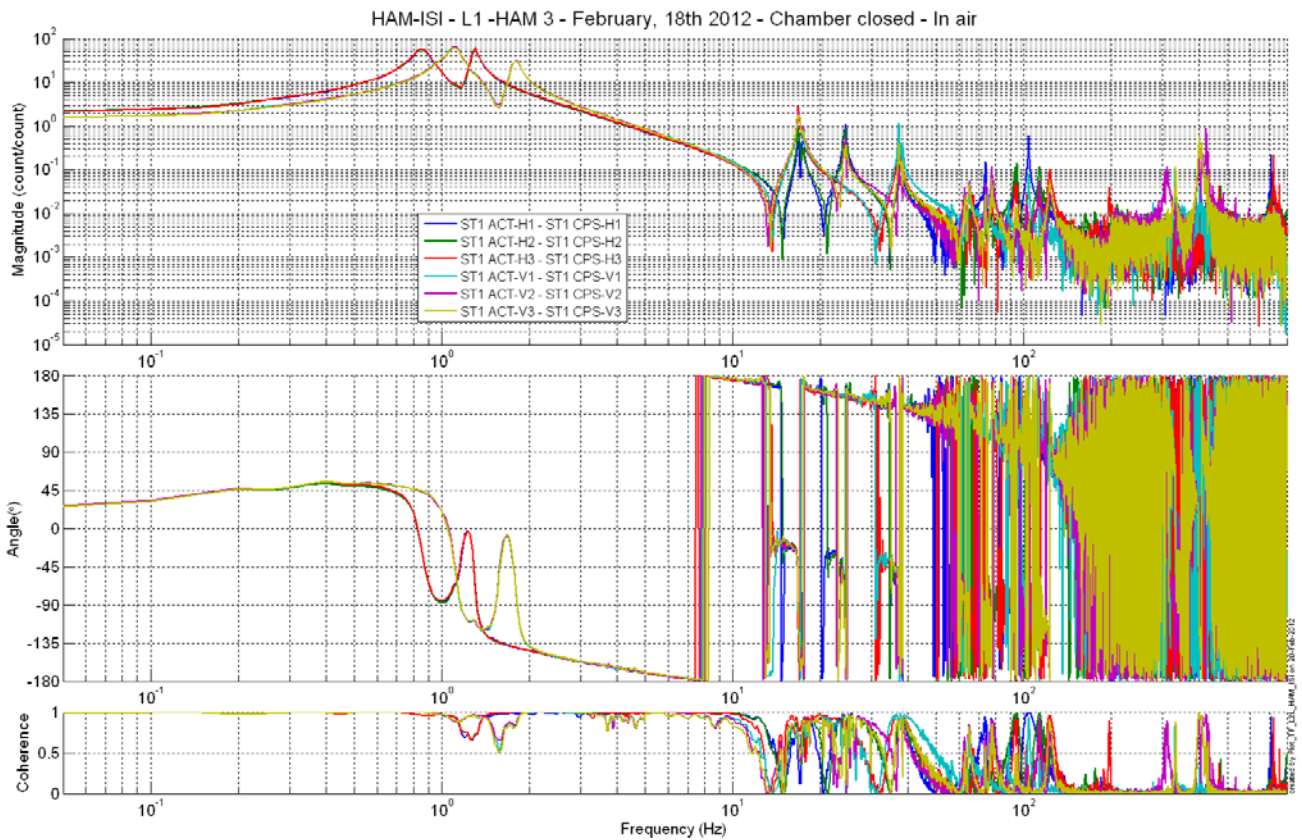


Figure - Local to Local Measurements –Capacitive Position Sensors

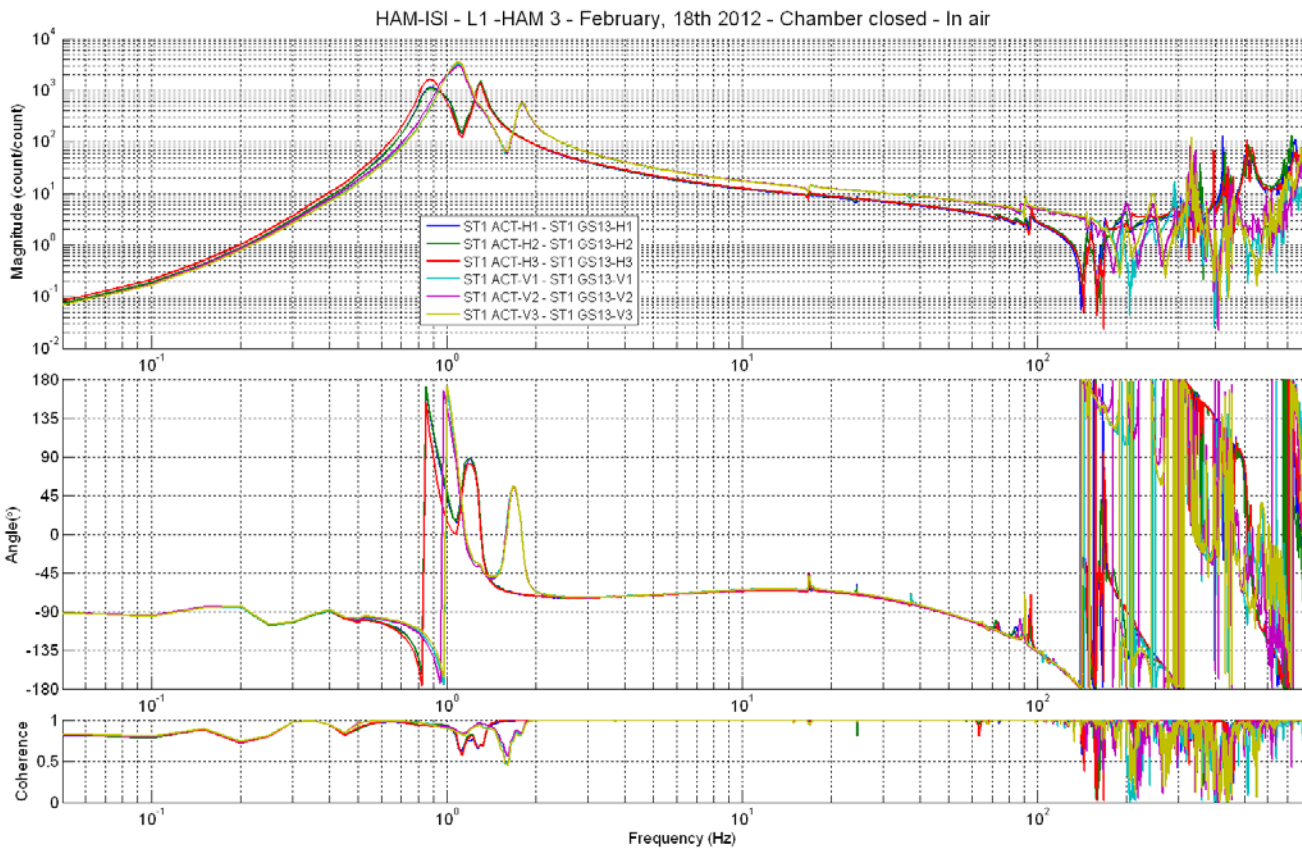


Figure - Local to Local Measurements – Inertial sensors



▪ **Step 23 - Lower Zero Moment Plane**

Data collection script files: seismic/HAM-ISI/Common/Transfer_Functions_Scripts

- Run_Cart2Cart_10mHz_100mHz.m

Data files in SVN at: seismic/HAM-ISI/L1/HAM3/Data/Transfer_Functions/Measurements/

Undamped

- LLO_ISI_HAM3_Data_TF_C2C_10mHz_100mHz_LZMP_20120218-185146.mat

Scripts files for processing and plotting in SVN at:

/seismic/HAM-ISI/X2/Data/Unit_3/Transfer_Functions/Measurements/Undamped/

- LZMP_2012.m

Figures in SVN at : seismic/HAM-ISI/L1/HAM3/Data/Figures/Transfer_Functions/

Measurements/Undamped

- LLO_ISI_HAM3_LZMP_20120218.fig

X & Y offsets:

X offset (mm)	1.2024
Y offset (mm)	0.22107

Table – Offset of the Lower Zero Moment Plane

The results from two measurements are presented on the figure below:

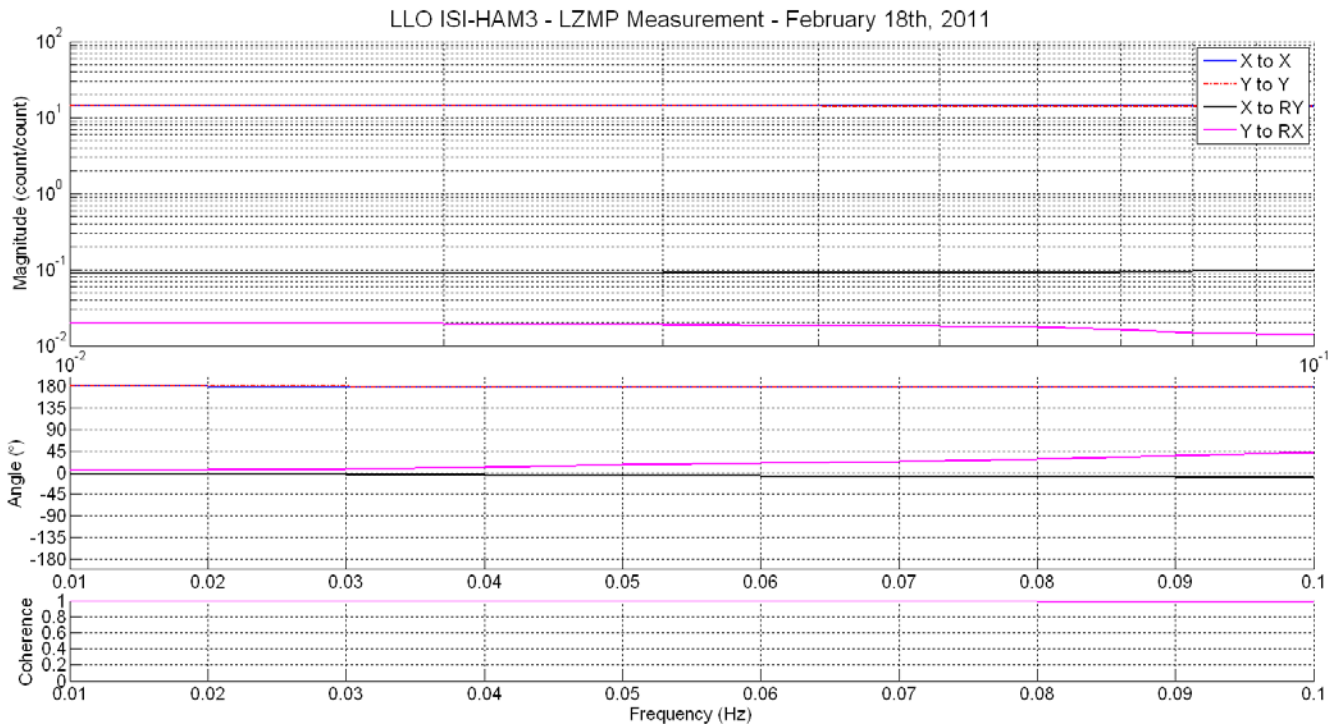


Figure - Lower Zero moment plane – Main and cross couplings at low frequency

Issues/difficulties/comments regarding this test

This measurement was done

**Acceptance criteria:**

- X offset must be less than 2 mm
- Y offset must be less than 2 mm

Test result:Passed: X Failed: ___ ***Conclusion of Initial In-Chamber testing***

Most issues found while side-testing were solved during this phase of the testing. Very few issues were found during the testing of this unit. The known issues are summed up here:

- The Linearity test gives a slightly different slope on the H2 actuator (1.5% from average for a 1% criteria)
- We have a slight offset of 2 CPS: H1 and V3.

Issues unchanged since the Phase I testing:

- sensor gaps not recorded on the jig
- Vertical spring constant: one spring appears to have a much lower constant than the others (-8.91% than the average of the 3).