LIGO Laboratory / LIGO Scientific Collaboration

LIGO- E1000312 *LIGO* January, 2011

aLIGO HAM-ISI, Pre-integration Test Report, Phase I,

LHO Unit 3 – HAM10 (post-assembly, before storage, after replacement of faulty parts)

E1000312 – V4

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Distribution of this document:
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Introduction

HAM-ISI Unit #3 (HAM10) was built and tested in October 2010. Since then, it has been disassembled and reassembled due to faulty parts that needed to be replaced. The replacement of these parts implied the need of going through the testing process again, which has been performed early December 2011, and is presented here.

Final GS13 were not available during tests. *Test* GS13 were used instead. They will be replaced before the in-vacuum installation.

Stage-0 L4Cs were not installed during tests.

The procedure document used to perform this test is:

- E1000309–V9 - aLIGO HAM-ISI, Pre-Integration Testing Procedure, Phase I (post assembly, before storage)

The report done prior to HAM-ISI Unit #3 disassembly/reassembly is posted under V1:

- E1000312_aLIGO_SEI_Testing_Report_HAM-ISI_LHO_Unit_3_V1

Other useful information can be found in:

- E1000300 - HAM-ISI LLO test stand: software and electronic check

Remark regarding SVN paths:

Units used to be called per the order of assembly (i.e. LHO HAM-ISI Unit #3, for the third unit assembled at LHO).

Since we are re-doing the testing of these LHO HAM-ISI units and we now know in which chamber they will be used (Unit #3 will go in HAM10), we have created folders in the SVN named after the chamber:

seismic/HAM-ISI/X1/HAM10/

All the data related to the Phase I testing of this unit is stored in this folder and sub-folders. The data name and exact location of each test result is specified all along the document.

I. Pre-Assembly Testing

- ***Step 1: Position Sensors***

Note: The back panel reads 0.508V/0.001"

S/N sensor	S/N board	ADE Gap Standoff(mm)	Location on the Jig	Gap Standoff on Jig(mm/in)	Voltage before zeroing	Voltage after zeroing. Prebake	Voltage after zeroing. Post bake
11988	11846	NR	1	2.007mm/0.079"	-1	0.02	NR
12004	11836	NR	1	2.007mm/0.079"	NR	0.01	NR
11989	11842	NR	1	2.007mm/0.079"	-1	0.01	NR
11997	11829	NR	1	2.007mm/0.079"	-1	0.01	NR
12029	11867	NR	1	2.057mm/0.081"	NR	0.01	NR
12040	11893	NR	1	2.057mm/0.081"	NR	0.01	NR

NR: not recorded

Sensors noise spectra measured before baking, and before shielding per procedure T1000636:

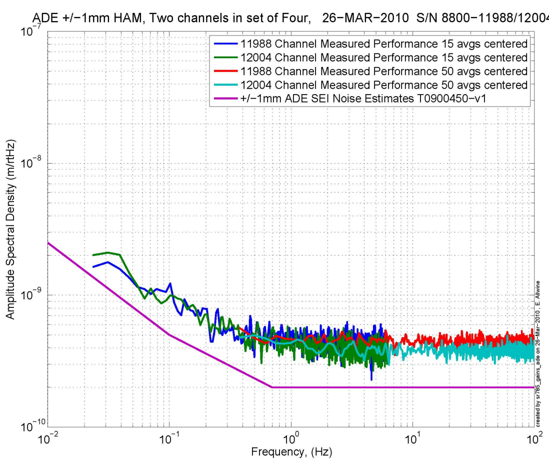

Figure - H1 and V1 sensor noise

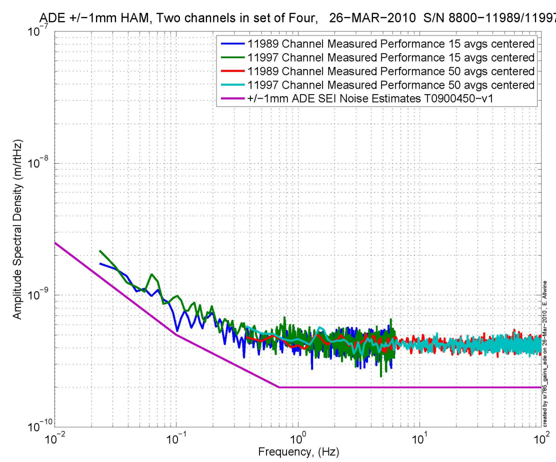

Figure - H2 and V2 sensor noise

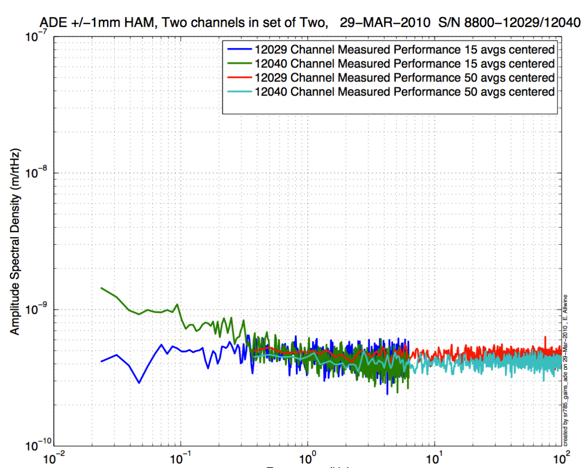

Figure - H3 and V3 sensor noise

Issues/difficulties/comments regarding this test:

- Values of sensor gaps and zeroing were not recorded. Waived for this unit.
- BNC feedthrough connectors have been diagnosed defective and replaced. *Voltage after zeroing post brake* was not recorded since then. Previous results can still be found in DCC document E100237-V2, *Capacitive Position Sensor Testing*.

Acceptance Criteria:

- Power spectrum magnitudes must be lower than:
  - 9.e-10 m/√Hz at 0.1Hz
  - 6.e-10 m/√Hz at 1Hz

Test result: **Passed:** _X_ **Failed:** ___

- ***Step 2: 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_LHO\

aLIGO GS13 Testing page is E1100367. It contains links to:

- LIGO-E1000058: aLIGO GS-13 Status Chart
- LIGO-E1100393: aLIGO GS-13 as received testing results
- LIGO-E1100394: aLIGO GS-13 prior shipping testing results
- LIGO-E1100395: aLIGO GS-13 Post Modification testing results
- LIGO-F0900070: GS-13 Inspection Checklist

Issues/difficulties/comments regarding this test:
Temporary test GS13 mounted. They are not referenced in the post-podding testing spreadsheet (E1000058-V39). However they have already been successfully used for the 3 previous HAM-ISI testings.

Several issues were encountered and summarized in:

- Vincent Lhuillier, alog #1801: Detection of a malfunctioning horizontal GS13 and description of it symptoms.
- Greg Grabeel, alog #1832: Repairing the horizontal GS13. It seems that the instrument was tilted inside its pod by whether a loose jam nut or an insufficiently tightened crossbar.

Geophones installed in this unit have been used for 3 previous HAM-ISI tests.

Acceptance Criteria:

- GS13 have been already tested at LLO. GS-13 Inspection/Pod Assembly is described in document D047810. Checklist is defined in F090070-v6
- After reception the geophones at LHO ASDs of the geophones must confirm that they are still functioning after shipping.

Test result: **Passed:** ___ **Failed:** _X_

These pods will be replaced prior insertion.

- ***Step 3: Actuators***

Actuator data can be found at: T0900564-V2. Actuator inventory is made at Section II – Step 1.

Actuator Serial #: L036 Operator Name: Gordon, Matt Date: 9/23/2009 Time: 5:54 PM Actuator Coil Resistance: 6.33 Ohms, PASS Ambient Temperature: 71.8 F Hi Pot Test Results: 1000 MOhms, PASS X Travel Limit (inches): 0.531 Y Travel Limit (inches): 0.205 Z Travel Limit (inches): 0.508	Actuator Serial #: L053 Operator Name: Gordon, Matt Date: 9/24/2009 Time: 4:23 PM Actuator Coil Resistance: 6.36 Ohms, PASS Ambient Temperature: 76.0 F Hi Pot Test Results: 1000 MOhms, PASS X Travel Limit (inches): 0.527 Y Travel Limit (inches): 0.205 Z Travel Limit (inches): 0.501
Actuator Serial #: L039 Operator Name: Gordon, Matt Date: 9/24/2009 Time: 5:00 PM Actuator Coil Resistance: 6.33 Ohms, PASS Ambient Temperature: 75.8 F Hi Pot Test Results: 1000 MOhms, PASS X Travel Limit (inches): 0.525 Y Travel Limit (inches): 0.205 Z Travel Limit (inches): 0.506	Ac Actuator Serial #: L042 Operator Name: Gordon, Matt Date: 9/24/2009 Time: 4:39 PM Actuator Coil Resistance: 6.34 Ohms, PASS Ambient Temperature: 76.1 F Hi Pot Test Results: 1000 MOhms, PASS X Travel Limit (inches): 0.526 Y Travel Limit (inches): 0.205 Z Travel Limit (inches): 0.502
Actuator Serial #: L033 Operator Name: Gordon, Matt Date: 9/23/2009 Time: 2:41 PM Actuator Coil Resistance: 6.42 Ohms, PASS Ambient Temperature: 74.7 F Hi Pot Test Results: 1000 MOhms, PASS X Travel Limit (inches): 0.523 Y Travel Limit (inches): 0.205 Z Travel Limit (inches): 0.506	Actuator Serial #: L057 Operator Name: Gordon, Matt Date: 9/23/2009 Time: 6:23 PM Actuator Coil Resistance: 6.37 Ohms, PASS Ambient Temperature: 71.8 F Hi Pot Test Results: 1000 MOhms, PASS X Travel Limit (inches): 0.530 Y Travel Limit (inches): 0.205 Z Travel Limit (inches): 0.503

Issues/difficulties/comments regarding this test:

- Inventory was done after assembly. Vertical actuators serial numbers were not visible then.
- Vertical actuators' serial numbers come from the previous report (E1000312-V1).

Acceptance Criteria:

- Actuators were previously tested and results are reported in T0900564-V2.

Test result: **Passed: _X_** **Failed: ___**

- ***Capacitive Position Sensor noise investigaion***

Subject of investigation:
After measuring few amplitude spectral densities of CPS and GS13 on the HAM-ISI, we were surprised by the high density of narrow peaks between 10Hz and 100Hz (cf figure *ASD CPS on locked HAM-ISI*). Since these peaks are less visible on GS13 spectra (cf step 6, GS13 ASD figure), we thought that electronic noise could create the high Q peaks on the CPSs. Since measurements are taken with the HAM-ISI in the so-called "locked" position, we should not see any stage 0 to stage 1 relative motion. Hence, we got concerned by the grounding of the new shielding installed on the CPS cables.

Data in SVN at:
/opt/svncommon/seisvn/seismic/HAM-ISI/X1/HAM10/Data/Spectra/Undamped/
- LHO_ISI_HAM10_ASD_m_CPS_T240_L4C_GS13_Locked_vs_Unlocked_2011_12_14.mat

Figures in SVN at:
/opt/svncommon/seisvn/seismic/HAM-ISI/X1/HAM10/Data/Figures/Spectra/Undamped
- LHO_ISI_HAM10_ASD_m_CPS_Locked_Zoom_2011_12_14.fig

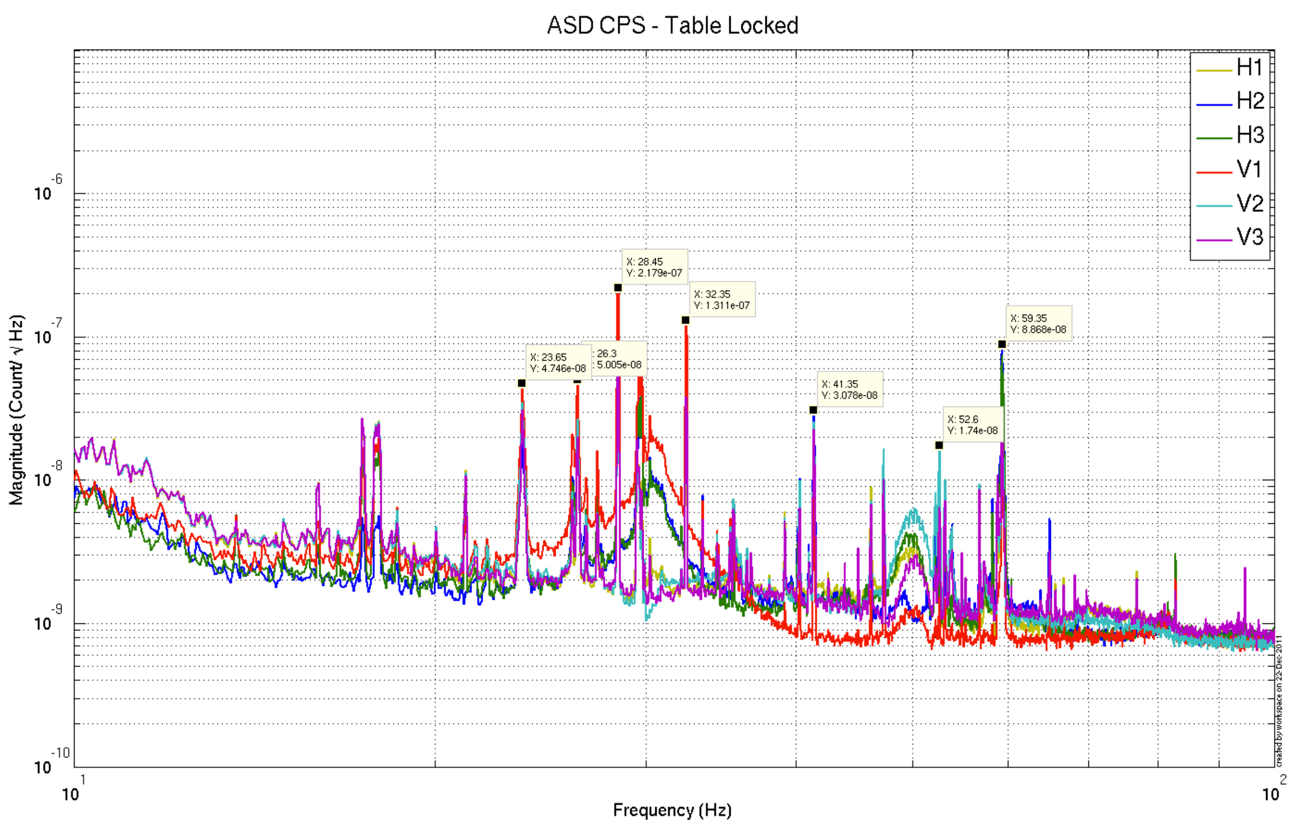

Figure –ASD CPS on locked HAM-ISIs

Extra tests:
We took measurements in different configurations to find the source of the peaks:
- CPS spectra fans ON vs fans OFF: We only saw minor differences

- Spectra of a locked CPS using the jig in several configurations:
    - Shield not connected to the ground
    - Shield connected to the ground

The two spectra (shield not grounded, and shield grounded) are identical and without any features in the 10-100Hz bandwidth (Noise floor at 5e-10 m/sqrt Hz). It confirms that CPSs are not picking up electric noise but are actually seeing a real motion.

The figure below is the calibrated ASD of the CPS on the jig.

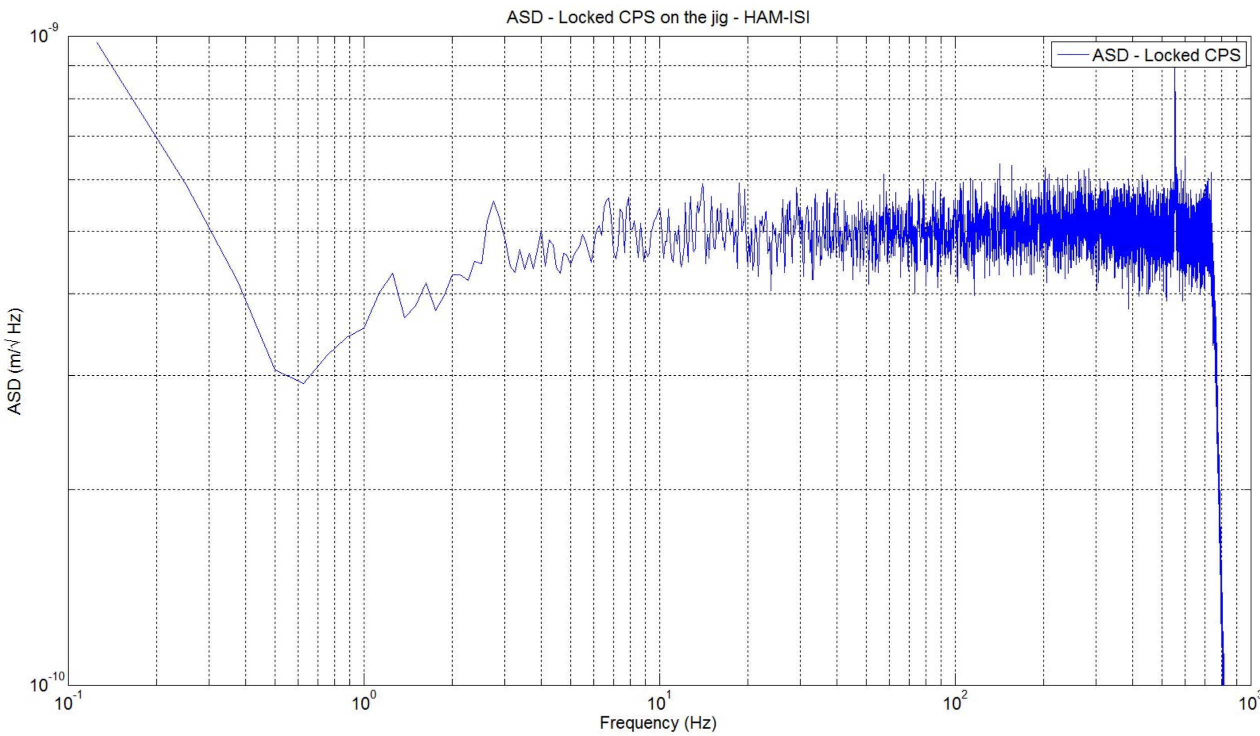

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Figure –ASD locked CPS on the jig

Ground motion measurement

A L4C was set on the ground to confirm that the peaks seen on HAM-ISI CPS ASD, in the so-called "locked" position, comes from ground motion itself. Due to the passive isolation provided by the ISI above 1Hz, amplitudes of the narrow peaks (probably motors) are reduced on GS13 (in the unlocked and the so-called locked configurations).

Narrow peaks agree with ASD of CPS in "locked configuration"

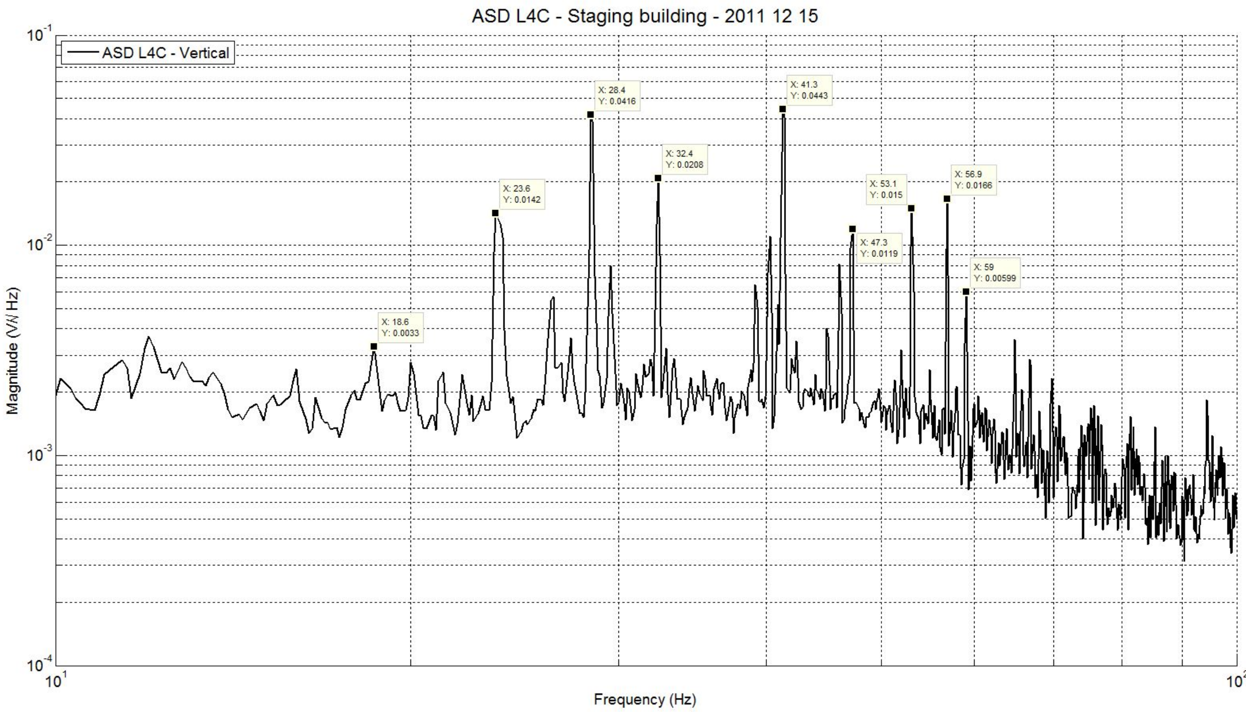

Figure – ASD of L4C on the ground in LHO staging building

<u>Conclusions regarding this test:</u>
This last measurement confirms that the peaks seen on the ASD of the CPS when the HAM-ISI is locked are due to ground motion.

II. Tests to be performed during assembly

- ***Step 1: Parts Inventory (E1000052)***

DCC Number	Part name	Configuration	Corner 1 S/N	Corner 2 S/N	Corner 3 S/N
D071001	Stage 0 base	NA	008		
D071051	Stage 1 base	NA	008		
D071050	Optical table	NA	7		
D071002	Spring Post	NA	036	440	030
D071100	Spring	NA	NR	NR	NR
D071102	Flexure	NA	NR	NR	NR
ADE	Position sensor	Horizontal	11988 master 0	11989 slave 180	12029 slave 0
		Vertical	12004 slave 180	11997 salve 0	12040 slave 180
D047812	GS-13 pod	Horizontal	058	013	068
		Vertical	049	040	059
D047823	L4C pod	Horizontal	NA	NA	NA
		Vertical	NA	NA	NA
D0902749	Actuator	Horizontal	L053	L057	L042
		Vertical	L036	L039	L033

Table – Parts inventory

Cable Connects		Cable S/N		
Part Name	Configuration	Corner 1	Corner 2	Corner 3
GS13	Horizontal	S1106672	~~S1106661~~ S1104679	~~S1104776~~ S1104673
GS13	Vertical			
L4C	Horizontal	NA	NA	NA
L4C	Vertical	NA	NA	NA
Actuator	Horizontal	S1104491	S1104766	S1104769
	Vertical	S1104488	S1104482	S1104755

Table – Cables inventory

NR: Not recorded; NA: Not applicable
Stricken-out S/N are cables that were discarded after failure.
Highlighted S/N are supposed S/N. They need to be checked at the beginning of the chamber-side testing.

Issues/difficulties/comments regarding this test:
Inventory was done after assembly. Some serial numbers were not visible then: flexure rod and spring. GS13 have been identified after removal.

This unit should have L4C pods but those were not ready at the time. They will be added before the in-vacuum installation.

The serial numbers given for GS13 are correspond to *test* versions of the sensor. They will be replaced as soon as the definitive GS13 are shipped.

ADE board serial # differ due to disassembly/reassembly.

- ***Step 2: Check torques on all bolts***

Acceptance Criteria:

- All bolts should trip the wrench, and start moving immediately after. If any bolts in a pattern move before torque is reached, recheck after all bolts are brought to spec.

Test result: **Passed: __X__** **Failed: ___**

- ***Step 3: Check gaps under Support Posts***

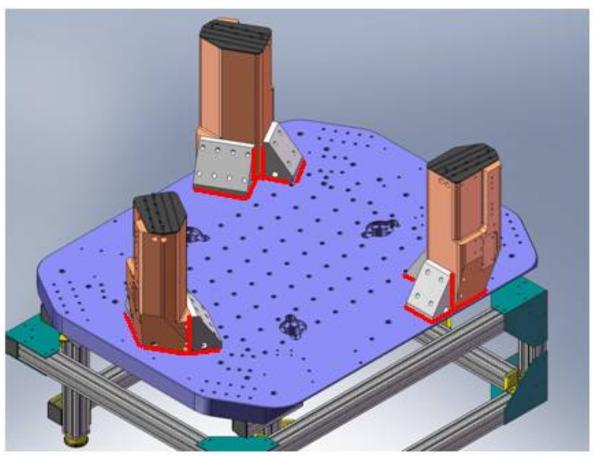

Figure - Showing edges that need checked on support posts and gussets

Acceptance Criteria:

- A 0.001 inch shim cannot be passed freely through any connection to Stage 0 or between post and gussets. If shim can pass through, loosen all constraining bolts, and then retighten iteratively from the center of the part to the edges. Retest.
-

Test result: **Passed: __X__** **Failed: ___**

- ***Step 4: Pitchfork/Boxwork flatness before Optical Table install***

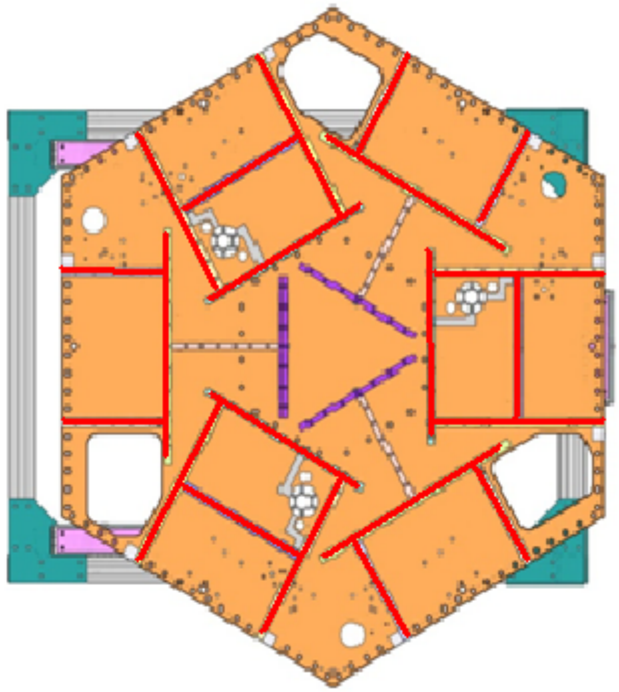

Figure – Showing what needs to be checked on Boxworks and Pitchforks

Acceptance Criteria:

- Shim inserted won't pass between parts.

Test result: **Passed:** __X__ **Failed:** ___

- ***Step 5: Blade spring profile***

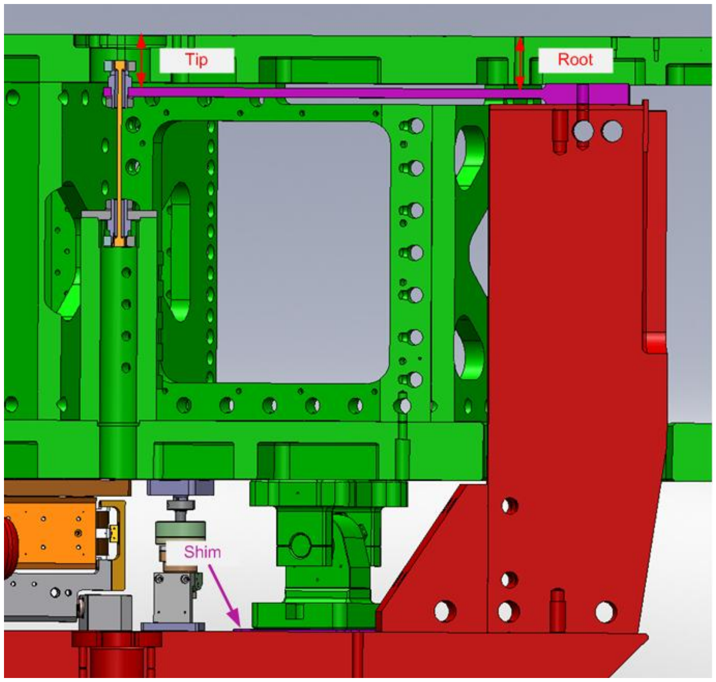

figure – Blade spring profile measurement points

Blade #	Base (")	Tip(")	Flatness (mils)
1	0.384	0.377	0.007
2	0.387	0.385	0.002
3	0.381	0.3785	0.0025

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***

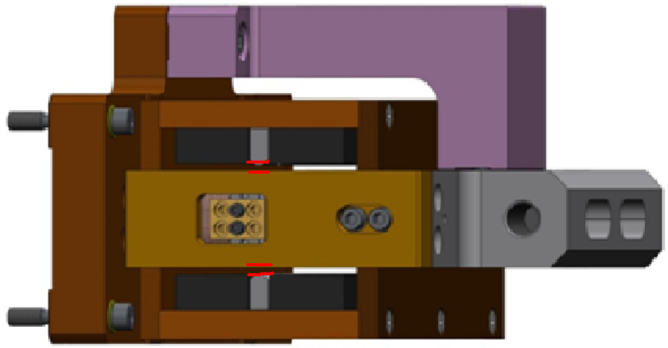

Figure - Showing gaps that need to be checked on actuators.

Issues/difficulties/comments regarding this test:
Test hasn't been performed since previous testing of this unit.

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: Check level of Stage 0***

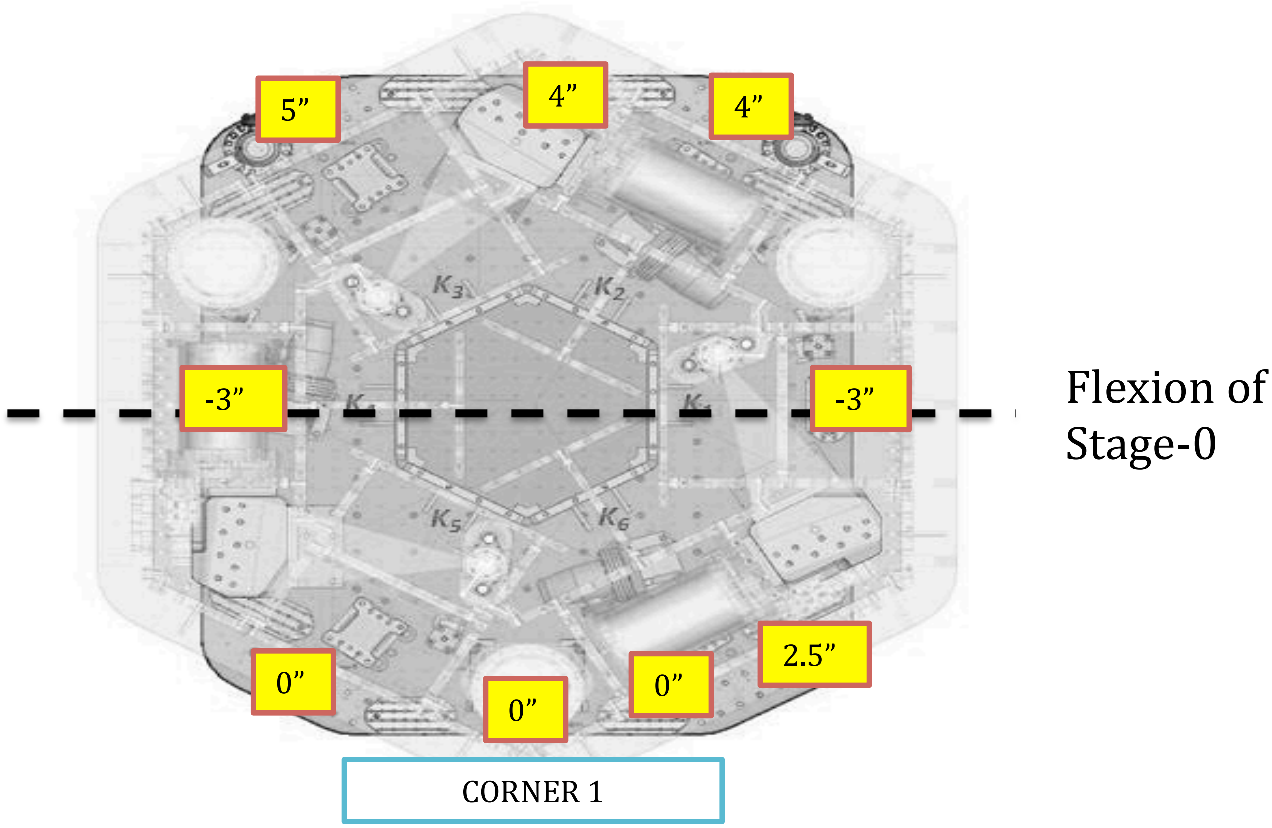

Figure – Level measured on Stage 0

Issues/difficulties/comments regarding this test:
Stage 0 appears to be flexing along the median line which is facing corner 1.

Max angle=(0.005)/(72/2)= 141µrad

Acceptance Criteria

- The maximum angle of the table with the horizontal mustn’t exceed ~100µrad

Test result: **Passed:** ____ **Failed:** __X__

Note:
This test doesn't meet our stringent requirement, however this leveling value is sufficient for all the tests being performed.

- ***Step 8: Check level of Stage 1 Optical Table***

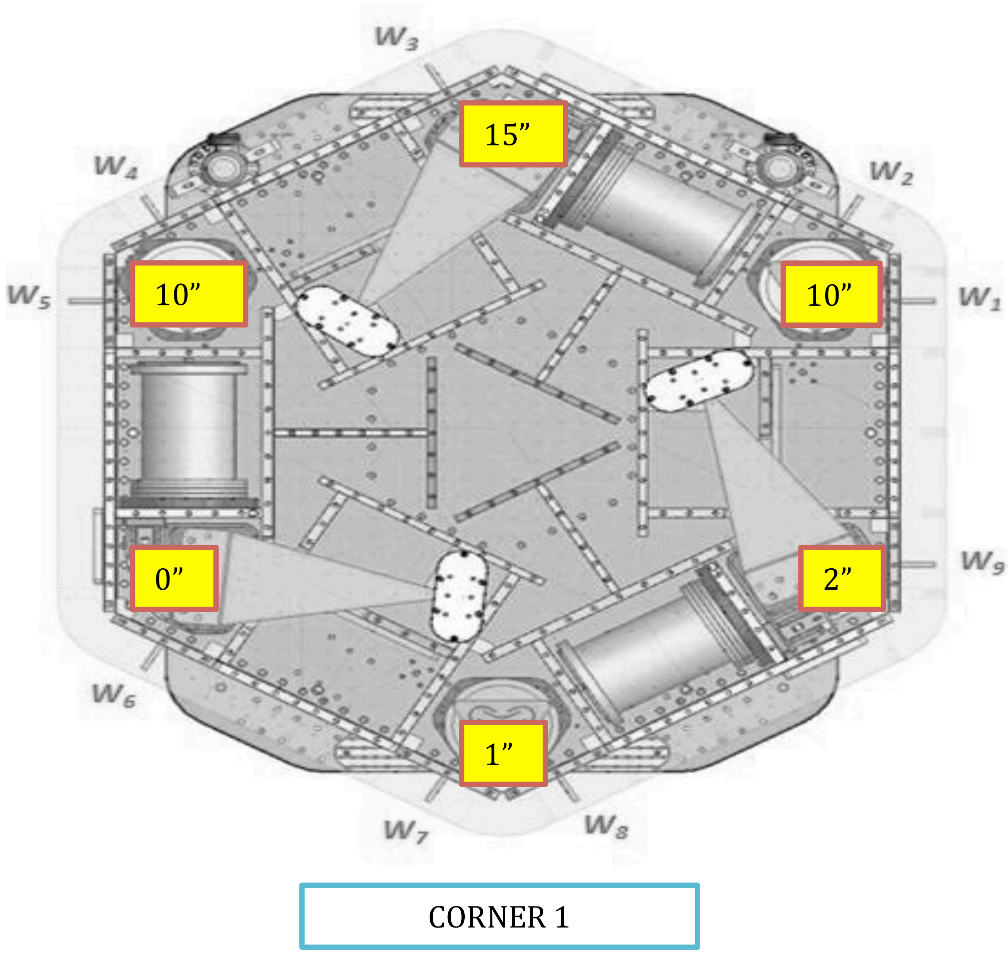

Figure – Level measured on Stage 1

Issues/difficulties/comments regarding this test:
The optical table appears tilted with corner 1 the lower point.

Max angle = (0.014)/85.59 = 164 µrad

Max angle $_{\textbf{stage 0 inclination removed from recorded values}}$ **= (0.014-0.005)/85.59 = 105 µrad**

Acceptance Criteria

- The maximum angle of the table with the horizontal mustn't exceed ~100µrad

Test result: **Passed:** ____ **Failed:** __X__

Note:
This test doesn't meet our stringent requirement, however this leveling value is sufficient for all the tests being performed.

- ***Step 9: Mass budget***

	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		1	40.2	18.23
w1		1		1	1		1	40.7	18.46
w2				1		1	1	47.3	21.45
w3	1			1	1		1	40.2	18.23
w4		1		1	1		1	40.7	18.46
w5				1		1	1	47.3	21.45
w6		1		1	1		1	40.7	18.46
w7		1		1	1		1	40.7	18.46
w8				1		1	1	47.3	21.45
Side Masses Total	2	4	0	9	6	3	9	385.1	174.68

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						2		31.2	14.15
k3					1		1	35.1	15.92
k4						2		31.2	14.15
k5					1		1	35.1	15.92
k6						2		31.2	14.15
Keel Masses Total	0	0	0	0	3	6	3	198.9	90.22

Table – Keel masses distribution

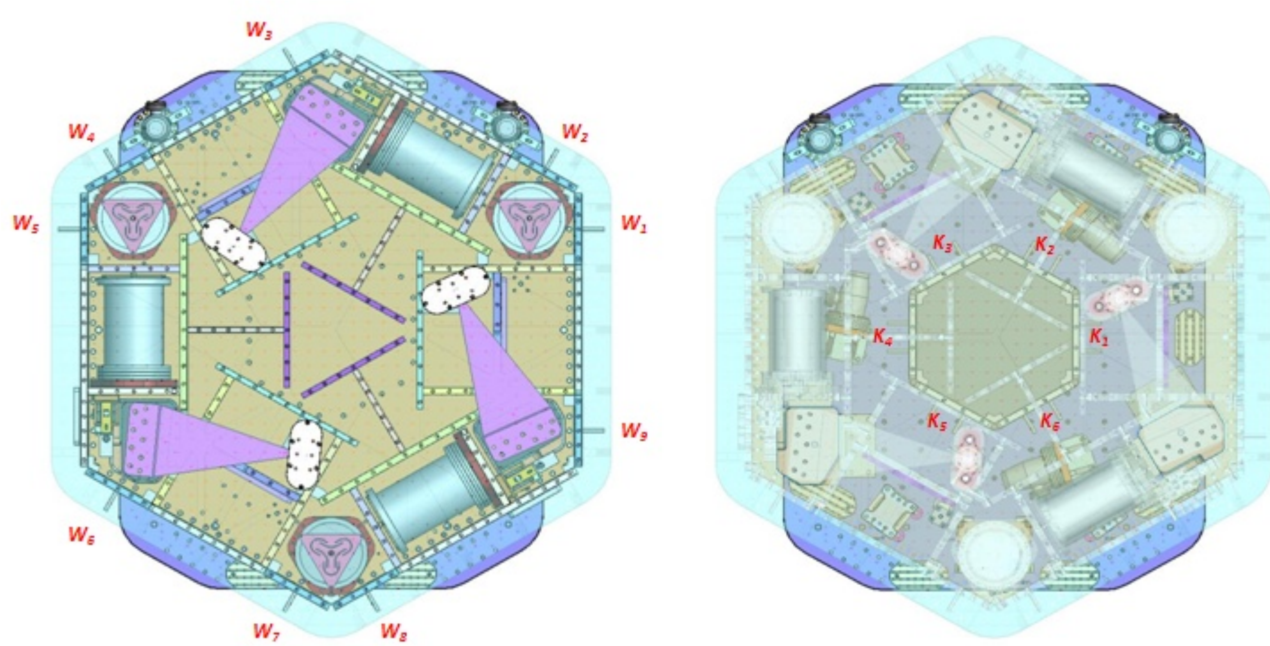

Figure – Wall Masses(W) and Keel masses (K) location. ***South of picture = corner 1***

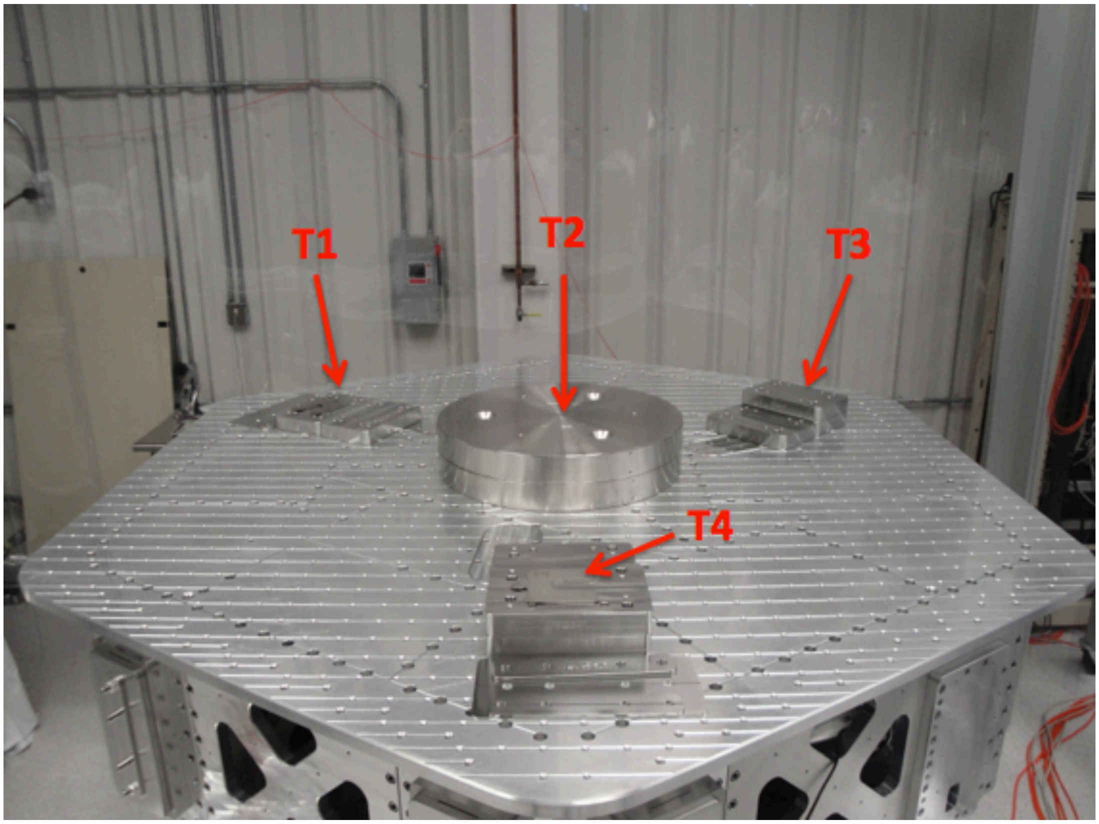

Figure – Optical table masses distribution

	Mass (kg)
T1	22.31
T2	211.37
T3	30.00
T4	31.77
Total	295.46

Table – Optic table masses distribution

	Side	Keel	Top	Total
Weigh (kg)	174.68	90.22	295.46	560.35

Table – Mass budget sum up

Issues/difficulties/comments regarding this test:

- T2 masses evaluated at nominal value: 233lbs each. Gauge not available for measurement yet.
- The previous version of this report (E1000312-V1) featured a total mass of 568.23kgs.
  - Side masses total was 1.1 kg lower.
  - Keel masses total was 0.57 kg lower.
  - Top masses total was 9.54 kg higher.

  …which makes the new mass budget 7.88kg lighter than during the first series of tests prior disassembly/re-assembly.

Acceptance Criteria

The Mass budget must be

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

Test result: **Passed: __X__** **Failed: ____**

- ***Step 10: Shim thickness***

Lockers	Shim thickness (mils)
A	130
B	128
C	121
D	127

Table – Shims Thickness

<u>Issues/difficulties/comments regarding this test:</u>
Shims could be used to adjust stage-1 level previously measured out of spec.

Acceptance Criteria

- The shim thickness should be 125 mils +/-5

Test result: **Passed: __X__** **Failed: ___**

III. Tests to be performed after assembly

- *Step 1 - Electronics Inventory*

Hardware	LIGO reference	S/N
Coil driver	D0902744	S1000266
		S1000269
Anti Image filter	D070081	S1000250
Anti aliasing filter	D1000269	S1102694
		S1102679
Interface chassis	D1000067	1102223
		1102224
		1102214

Table - Inventory electronics

Acceptance Criteria

- Inventory is complete

Test result: **Passed:** __X__ **Failed:** ___

- *Step 2 - Set up sensors gap*

	10 Kg masses at each corners		Locked /no mass		Unlocked /no mass	
Table locked	ADE boxes on		ADE boxes on		ADE boxes on	
Sensors	Offset (Mean)	Std deviation	Offset (Mean)	Std deviation	Offset (Mean)	Std deviation
H1	-500.33	8.82	-377.58	15.81	-98.63	52.75
H2	-3.51	9.43	-161.00	13.90	240.42	46.43
H3	-188.21	8.01	-296.29	26.04	-181.82	94.86
V1	-167.76	6.61	219.86	18.72	-284.90	28.06
V2	-348.55	9.18	66.61	16.21	-26.16	21.86
V3	-122.92	6.09	134.64	16.19	96.82	31.93

Capacitive position sensor readout after gap set-up

Issues/difficulties/comments regarding this test:
High standard deviation required to do extra test on the jig (see below)

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:** ___ **Failed:** __X__

Failed because of standard deviation but a CPS set on a jig was measured and gave 4.3 counts, which is within specs. Hence, the high standard deviations measured are correlated to the 10Hz-100Hz peaks observed on the locked/unlocked GS13 and CPS ASDs. As shown earlier, these peaks are caused by ground motion. Hence, high standard deviations should not be associated with sensor noise.

- ***Step 3 - Measure the Sensor gap***

Issues/difficulties/comments regarding this test:
Measured in the previous version of this report (E1000312-V1, p11) .Waived to avoid scratching targets.

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 4 - Check Sensor gaps after the platform release***

	Locked /no mass		Unlocked /no mass		
Table locked	ADE boxes on		ADE boxes on		
Sensors	Offset (Mean)	Std deviation	Offset (Mean)	Std deviation	difference
H1	-377.58	15.81	-98.63	52.75	278.95
H2	-161.00	13.90	240.42	46.43	401.41
H3	-296.29	26.04	-181.82	94.86	114.47
V1	219.86	18.72	-284.90	28.06	-504.77
V2	66.61	16.21	-26.16	21.86	-92.77
V3	134.64	16.19	96.82	31.93	-37.82

Table – Sensor gaps after platform release

Acceptance criteria:

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

Test result: **Passed:** _X_ **Failed:** ___

- ***Step 5 – Performance of the limiter***

- ***Step 5.1 - Test Nº1 - Push "in the general coordinates"***

Pushing Z,-Z	CPS read out		Calculated after calibration		
Sensors	**UP (Counts)**	**Down (Counts)**	**UP (mil)**	**Down (mil)**	ROM (Counts)
V1	21100	-19500	25.2	-23.3	40600
V2	20900	-19750	24.9	-23.6	40650
V3	20900	-19350	24.9	-23.1	40250

Pushing RZ, -RZ	**CPS read out**		**Calculated after calibration**		
Sensors	**CCW (+RZ)**	**CW(-RZ)**	**CW (mil)**	**CCW (mil)**	ROM (Counts)
H1	-21400	21020	-25.5	25.1	42420
H2	-22800	22550	-27.2	26.9	45350
H3	-22500	20750	-26.9	24.8	43250

Table - Optic table range of motion

ROM: Range Of Motion

- ***Step 5.2 - Test Nº2 – Push "locally"***

Pushing Locally	**Push in positive direction**	**Push in negative direction**	**Railing**	**Actuator Gap Check**	ROM (Counts)
H1	-24650	24900		**x**	49550
H2	-25250	23950		**x**	49200
H3	-24600	24950		**x**	49550
V1	21150	-19850		**x**	41000
V2	32000	-32000		**x**	64000
V3	21000	-20000		**x**	41000

Table - Optic table range of motion

Acceptance criteria:

- The vertical sensor readout must be positive when the optic table is pushed in the +Z direction
- The horizontal sensor readout must be negative when the optic table is pushed in the +RZ direction
- **Step 5.1**
  - Absolutes value of all estimated motions must be higher than 16000counts (~0.020")
- **Step 5.2**
  - No contact point on sensors
  - Absolute value of sensor read out must be higher than 16000counts (~0.020")
  - No contact point on actuators

Test result: **Passed: _X__** **Failed: ___ .**

- ***Step 6 - Position Sensors unlocked/locked Power Spectrum***

Scripts files for processing and plotting in SVN at:
/opt/svncommon/seisvn/seismic/HAM-ISI/Common/Testing_Functions_HAM_ISI/
- ASD_Measurements_Locked_Unlocked_HAM_ISI.m

Data in SVN at:
/opt/svncommon/seisvn/seismic/HAM-ISI/X1/HAM10/Data/Spectra/Undamped/
- LHO_ISI_HAM10_ASD_m_CPS_T240_L4C_GS13_Locked_vs_Unlocked_2011_12_14.mat

Figures in SVN at:
/opt/svncommon/seisvn/seismic/HAM-ISI/X1/HAM10/Data/Figures/Spectra/Undamped
- LHO_ISI_HAM10_ASD__m_GS13_Requirements_Locked_vs_Unlocked_2011_12_14.fig
- LHO_ISI_HAM10_ASD__m_CPS_Requirements_Locked_vs_Unlocked_2011_12_14.fig
- LHO_ISI_HAM10_ASD__m_GS13_Locked_vs_Unlocked_2011_12_14.fig
- LHO_ISI_HAM10_ASD__m_CPS_Locked_vs_Unlocked_2011_12_14.fig
- LHO_ISI_HAM10_ASD__CT_GS13_Locked_vs_Unlocked_2011_12_14.fig
- LHO_ISI_HAM10_ASD__CT_CPS_Locked_vs_Unlocked_2011_12_14.fig
- LHO_ISI_HAM10_ASD_m_CPS_Locked_Zoom_2011_12_14.fig

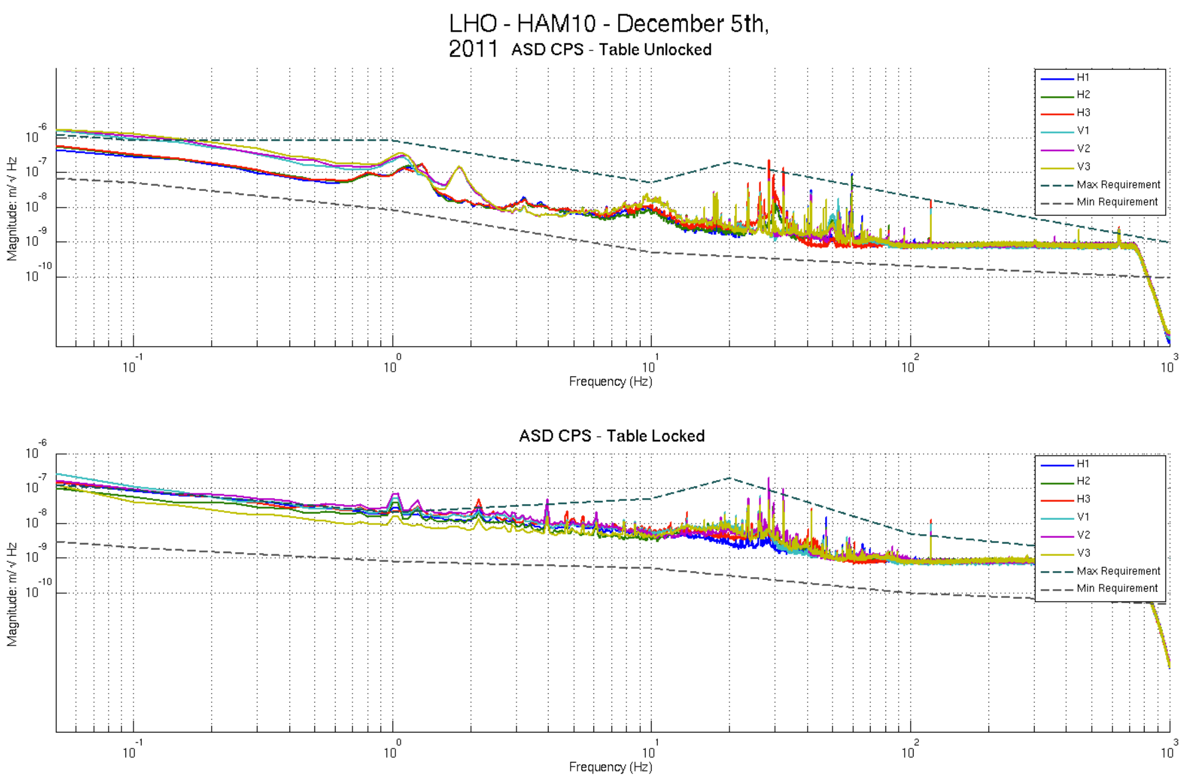

Figure - Calibrated CPS power spectrum

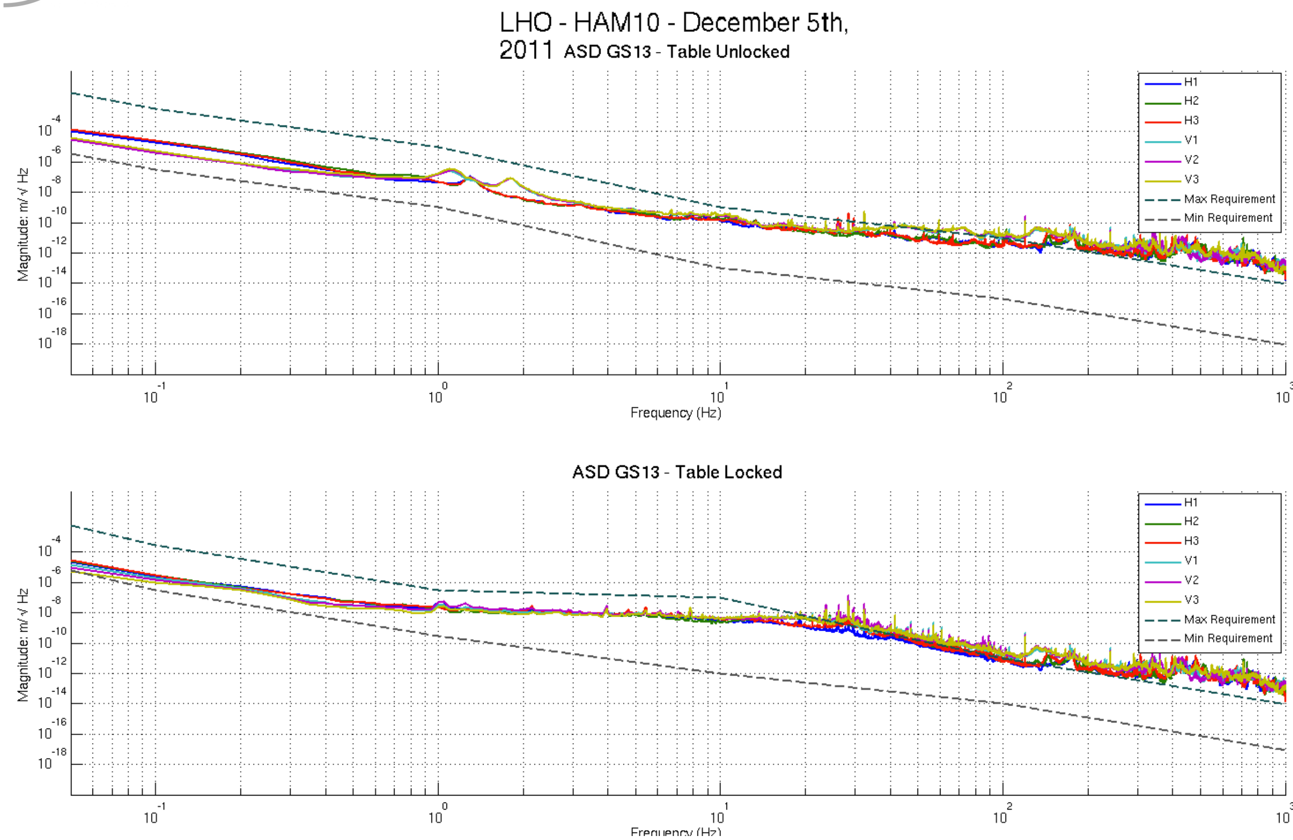

Figure – Power spectrum Calibrated GS13

Issues/difficulties/comments regarding this test:
10Hz-100Hz peaks investigated above in Part 1, last step: *capacitive position sensor investigation*.

Acceptance criteria:

- No cross talk (peaks at low frequencies + harmonics on measurements)
- Magnitudes of power spectra must be between requirement curves

Test result: **Passed: __X__** **Failed: ____**

- ***Step 7 - GS13 power spectrum -tabled tilted***

Scripts files for processing and plotting in SVN at:
/opt/svncommon/seisvn/seismic/HAM-ISI/Common/Testing_Functions_HAM_ISI/
- ASD_Measurements_Stages_Tilted_HAM_ISI.m

Figures in SVN at:
/opt/svncommon/seisvn/seismic/HAM-ISI/X1/HAM10/Data/Figures/Spectra/Undamped
- LHO_ISI_HAM10_m_PSD_GS13_Tilted_ 2011_12_06.fig
- LHO_ISI_HAM10_CT_PSD_GS13_Tilted_ 2011_12_06.fig

The figure below presents the GS13 power spectrum when the table is unlocked and loaded with a 10Kg mass at each of its corner.

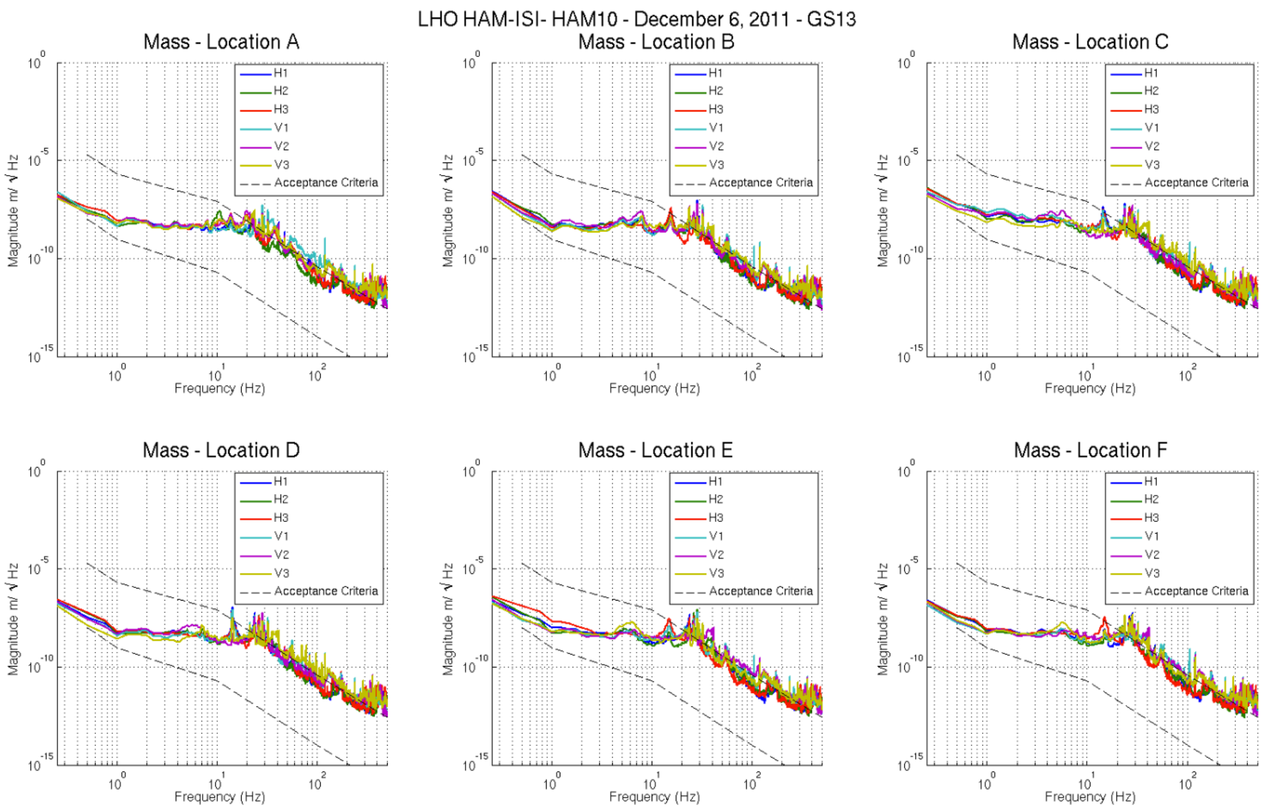

Figure – Power spectrum Calibrated GS13 with mass at corners A to F

Issues/difficulties/comments regarding this test:
Test GS13 are used, so borderline values are acceptable.

Acceptance criteria:
- With table unlocked and tilted, magnitudes of power spectra must be fully included within requirement curves.

Test result: **Passed: __X__** **Failed: ____**

- ***Step 8- GS13 pressure readout***

Test GS13 used. Step to be performed o the final GS13s

- ***Step 9 - Coil Driver, cabling and resistance check***

Actuator	V1		H1		V2	
Coil driver	S1000266 - Coarse 2		S1000266 - Coarse 1		S1000269 - Coarse 2	
Cable #	S1104488		S1104491		S1104482	
Resistance (Ohm)	P1 - P2	P2 - P3	P1 - P2	P2 - P3	P1 - P2	P2 - P3
	O.L (infinity)	6.7	O.L (infinity)	6.7	O.L (infinity)	6.7
MEDM offset (1000 counts)	Measurement P2 (+) ; P1&P3 (-)		Measurement P2 (+) ; P1&P3 (-)		Measurement P2 (+) ; P1&P3 (-)	
	0.303V		0.299V		0.299V	

Actuator	H2		V3		H3	
Coil driver	S1000269 - Coarse 1		S1102692 - Coarse 2		S1102692 - Coarse 1	
Cable #	S1104766		S1104755		S1104769	
Resistance (Ohm)	P1 - P2	P2 - P3	P1 - P2	P2 - P3	P1 - P2	P2 - P3
	O.L (infinity)	6.6	O.L (infinity)	6.8	O.L (infinity)	6.8
MEDM offset (1000 counts)	Measurement P2 (+) ; P1&P3 (-)		Measurement P2 (+) ; P1&P3 (-)		Measurement P2 (+) ; P1&P3 (-)	
	0.297V		0.306V		0.3V	

Table - Actuators resistance check

Issues/difficulties/comments regarding this test:
Voltages measured from Pin #1 (-) to pin #2 (+) with compensation filters engaged.

Acceptance criteria:
- The measured resistance between the middle pin and one side pin must be 6.5 +/-1 ohms
- Actuator neutral pins must be connected on pin #1 (left side pin of the plug)
- Actuator drive pins must be connected on pin #2 (middle pin of the plug)
- Actuator ground shield pins must be connected on pin #3 (right pin of the plug)
- All LEDs on the coil driver front panel must be green

Test result: **Passed:** _X__ **Failed:** ____

- ***Step 10 - Actuators Sign and range of motion (Local drive)***

	Negative drive	No Drive	Positive drive	ROM (Counts)
H1 readout (count)	-24556	-194	23770	48326
H2 readout (count)	-24400	368	23750	48150
H3 readout (count)	-24860	-63	24375	49235
V1 readout (count)	-19195	-445	20330	39526
V2 readout (count)	-26044	212	26435	52479
V3 readout (count)	-21303	58	22458	43761

Table - Range of motion - Local drive

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 11 - Vertical Sensor Calibration***

Lockers	D.I readout with for a negative drive	D.I readout without any drive	D.I readout with for a positive drive
A	18.80	0.00	-18.00
B	18.00	0.00	-18.00
C	16.50	0.00	-16.50
D	17.30	0.00	-17.20
Average	17.65	0.00	-17.43

Sensors	Counts	Counts	Counts	Difference
V1	-15186.26	-112.32	15052.02	30238.28
V2	-14101.07	778.67	15608.16	29709.23
V3	-13685.56	304.07	14526.27	28211.83

Vertical Sensibility	
837.82	Count/mil
0.51	V/mil
30.32	nm/count
-0.26	% from nominal value (840nm/count)

Table - Calibration of capacitive position sensors

Acceptance criteria:

- Deviation from nominal value < 2%. Nominal value is 840 count/mil.

Test result: **Passed:** _X_ **Failed:** ____

- ***Step 12 - Vertical Spring Constant***

Results presented below are obtained after the initial sensors calibration.

Sensors	Mean diff counts	Mean diff m	K (N/m)	Error with average
V1	-8086	-2.44E-04	8.03E+04	-1.35%
V2	-8004	-2.42E-04	8.12E+04	-0.34%
V3	-7843	-2.37E-04	8.28E+04	1.70%
		Average (N/m)	2.44E+05	
		Total Stiffness (N/m)	2.47E+05	

Table - Vertical spring constant

Acceptance criteria:

- +/-2 % of 2.4704e5 N/m (i.e. between 2.421e5 and 2.520e5 N/m)
- +/- 5% of variation between each spring and the average

The measured error on the vertical stiffness is **-1.09 %**

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

- ***Step 13 - Static Testing (Tests in the local basis)***

	Sensors (counts)					
	H1	**H2**	**H3**	**V1**	**V2**	**V3**
H1	2011	1231	1215	-5	16	6
H2	1208	1973	1206	-22	12	40
H3	1226	1202	1968	-4	-3	43
V1	142	149	-387	1386	27	-556
V2	-388	154	133	-594	1418	14
V3	141	-373	153	-58	-591	1441

Table - Main couplings and cross couplings

Acceptance criteria:

- **Vertical**
  For a +1000 count offset drive on vertical actuators
  - Collocated sensors must be 1400 counts +/- 10%

- **Horizontal**
  For a +1000 count offset drive on horizontal actuators
  - Collocated sensors must be 2000 counts +/- 10%
  - Non-collocated horizontal sensors must be 1250 counts +/-10%

Test result: **Passed:** _X_ **Failed:** ___

- ***Step 14 - Linearity test***

	Slope	Offset	Average slope	Variation from average(%)
H1	2.11	-22.86	2.09	1.09
H2	2.08	475.60		-0.34
H3	2.08	-119.54		-0.75
V1	1.49	146.15	1.46	2.02
V2	1.47	238.46		0.44
V3	1.43	51.40		-2.46

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

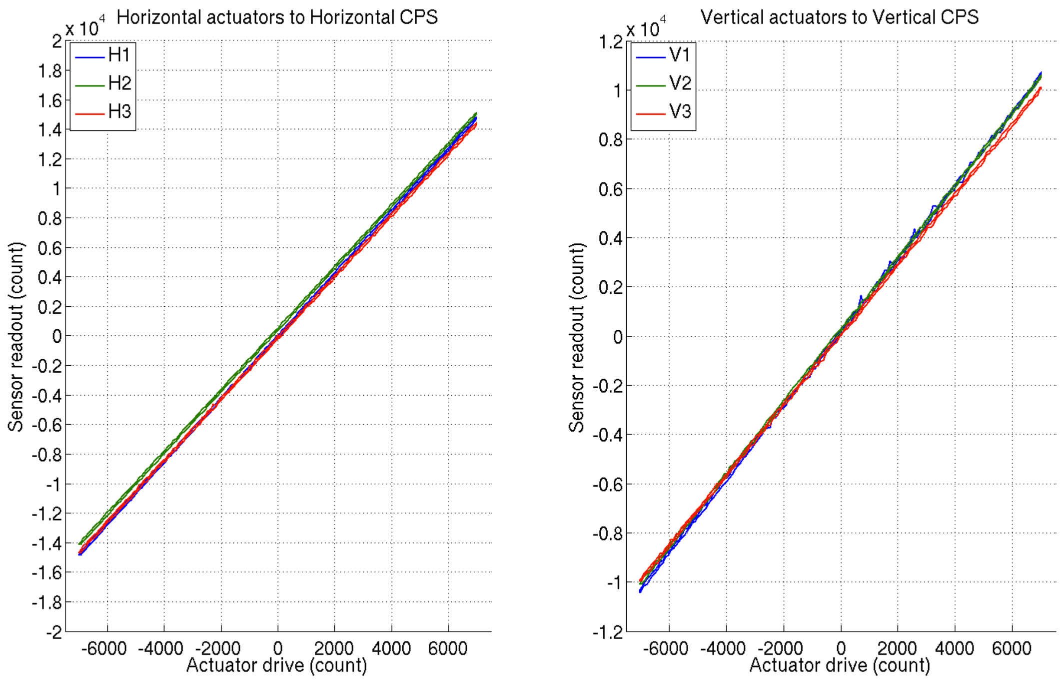

Figure - Linearity test on the triplet 'actuators - HAM-ISI – sensors' in both Horizontal and vertical directions

<u>Issues/difficulties/comments regarding this test:</u>

- A cable was rubbing initially and caused V1 and V3 to be 5% off average.
- No cable rubbing anymore. Still, we observe 2% off average for these sensors.
- Cables lengths vary from one corner to another. They are:
  - Corner 1: 26ft
  - Corner 2: 42ft
  - Corner 3: 48ft

  …which corresponds to a 0.1ohm resistance difference between the longest and the shortest cable. A 0.1 Ohm resistance difference would induce a 1.5% voltage drop on actuators of 6.5 Ohm resistance. Hence, having out of spec variations from average slopes, in linearity tests, can be associated with inhomogeneous cable length, as long as difference with requirements remains under 1.5%.

Acceptance criteria:

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

Test result: **Passed: ___** **Failed: _X_**

Comment: we'll check it is within tolerance when we'll use the final field cables.

- ### *Step 15 - Cartesian Basis Static Testing*

1000 counts Drive	H1	H2	H3	V1	V2	V3	Direction read out
X Drive	271.3	270.6	-507.7	-0.8	3.9	-9.8	520.0
Y Drive	-471.0	444.6	-10.4	-9.6	12.4	8.7	526.0
Z Drive	1.7	4.7	-20.2	265.9	304.8	247.1	274.3
Rx Drive	-439.1	470.4	8.6	-472.9	1680.6	-1211.1	2549.3
Ry Drive	-254.0	-245.9	551.0	-1709.3	448.3	**1250.6**	2613.8
Rz Drive	-2024.6	-2007.5	-2022.4	-2.4	14.7	-10.8	2551.5

Table – Static testing: Drive in the Cartesian basis, response in the Local basis

1000 counts Drive	X	Y	RZ	Z	RX	RY
X Drive	520.0	-1.7	-8.0	-36.3	-22.8	-17.9
Y Drive	0.3	526.0	-1.9	-15.8	7.6	13.1
Z Drive	3.0	3.4	274.3	-14.2	2.8	-6.1
Rx Drive	8.6	4.9	7.3	2549.3	8.8	-15.8
Ry Drive	-10.6	0.2	-17.5	-2.6	2613.8	-23.6
Rz Drive	2.0	0.3	-8.3	-7.0	11.8	2551.5

Table – Static testing: Drive in the Cartesian basis, response in the Cartesian basis

Issues/difficulties/comments regarding this test:
Tables reviewed as new display (drive in lines, response in columns) required transposition.

1000 counts Drive	H1	H2	H3	V1	V2	V3	Direction read out
X Drive	+	+	-				+
Y Drive	-	+	0				+
Z Drive				+	+	+	+
Rx Drive				-	+	-	+
Ry Drive				-	**+**	+	+
Rz Drive	-	-	-				+

Table – Cartesian static testing reference table

Acceptance criteria:
For a positive drive in the Cartesian basis:

- Local sensor readout must have the same sign that the reference table (**CONT2ACT check**)
- Cartesian sensors read out must be positive (**DISP2CEN check**) in the drive direction

Test result: **Passed: __X__** **Failed: ___**

- ***Step 16- Frequency response***
- ***Step 16.1 - Local to local measurements***

FREQ. RANGE			DRIVE		MEAS. TIME		
Min	Max	Freq. Res. (Hz)	H	V	Time for 1 Rep. (s)	Number of Reps	Time (min)
0.01	0.1	0.01	10500.0	10500.0	620.0	**10.0**	103.3
0.1	0.5	0.02	600.0	600.0	320.0	**30.0**	160.0
0.5	5	0.025	35.0	35.0	260.0	**55.0**	238.3
5	100	0.1	300.0	300.0	80.0	**50.0**	66.7
100	1000	0.2	135.0	135.0	50.0	**150.0**	125.0
					Total Meas. time(h)		**11.6**

Table – Transfer function settings, by frequency band

Data files in SVN at:
/opt/svncommon/seisvn/seismic/HAM-ISI/X1/HAM10/Data/Transfer_Functions/Measurements/Undamped/
- LHO_ISI_HAM10_Data_TF_L2L_10mHz_100mHz_20111210-021010.mat
- LHO_ISI_HAM10_Data_TF_L2L_100mHz_500mHz_20111209-232830.mat
- LHO_ISI_HAM10_Data_TF_L2L_500mHz_5Hz_20111212-175710.mat
- LHO_ISI_HAM10_Data_TF_L2L_5Hz_100Hz_20111209-184516.mat
- LHO_ISI_HAM10_Data_TF_L2L_100Hz_1000Hz_20111209-172743.mat

Data collection script files:
opt/svncommon/seisvn/seismic/HAM-ISI/Common//Transfer_Function_Scripts/
- Run_TF_L2L_10mHz_100mHz.m
- Run_TF_L2L_100mHz_500mHz.m
- Run_TF_L2L_500mHz_5Hz.m
- Run_TF_L2L_5Hz_100Hz.m
- Run_TF_L2L_100Hz_1000Hz.m

Scripts files for processing and plotting in SVN at:
/opt/svncommon/seisvn/seismic/HAM-ISI/X1/HAM10/Scripts/Control_Scripts/
- Step_1_Plot_TF_L2L_HAM_Testing.m

Figures in SVN at:
opt/svncommon/seisvn/seismic/HAM-ISI/X1/HAM10/Data/
Figures/Transfer_Functions/Measurements/Undamped/
- LHO_ISI_HAM10_TF_L2L_Raw_from_ACT_to_CPS_2011_12_12.fig
- LHO_ISI_HAM10_TF_L2L_Raw_from_ACT_to_GS13_2011_12_12.fig

Storage of measured transfer functions in the SVN at:
opt/svncommon/seisvn/seismic/HAM-ISI/X1/HAM10/Data/Transfer_functions/ Simulations/
Undamped/
- LHO_ ISI_HAM10_ TF_L2L_RAW_2011_12_12.mat

The local to local transfer functions are presented below.

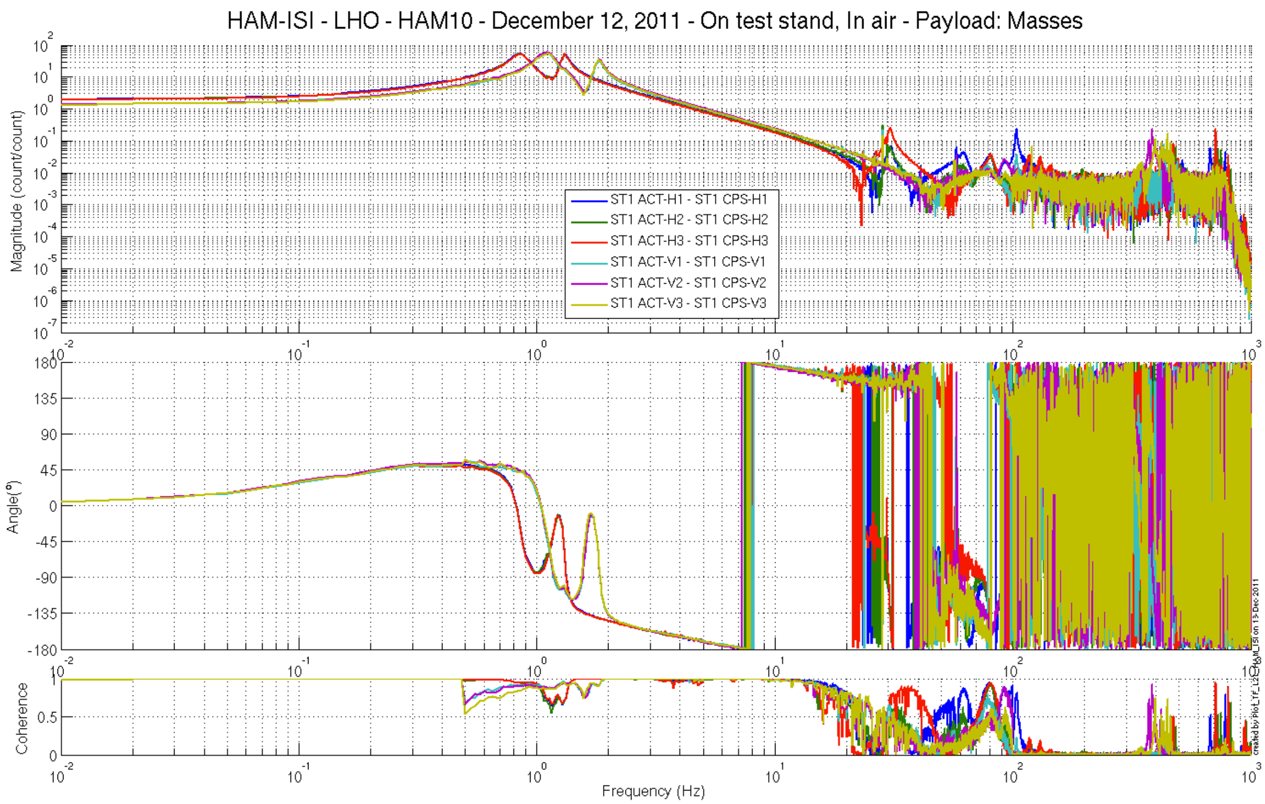

Figure - Local to Local Measurements – Capacitive sensors

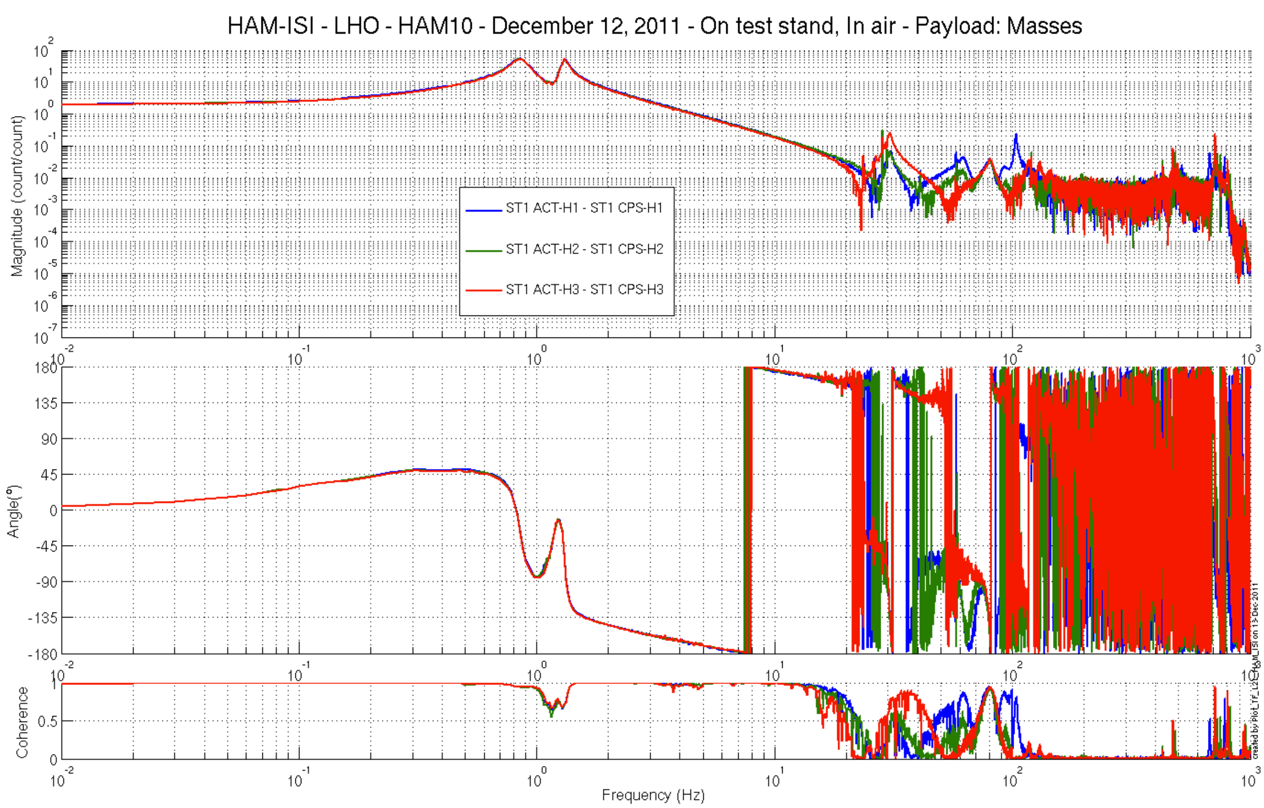

Figure - Local to Local Measurements – Capacitive sensors
Horizontal motion

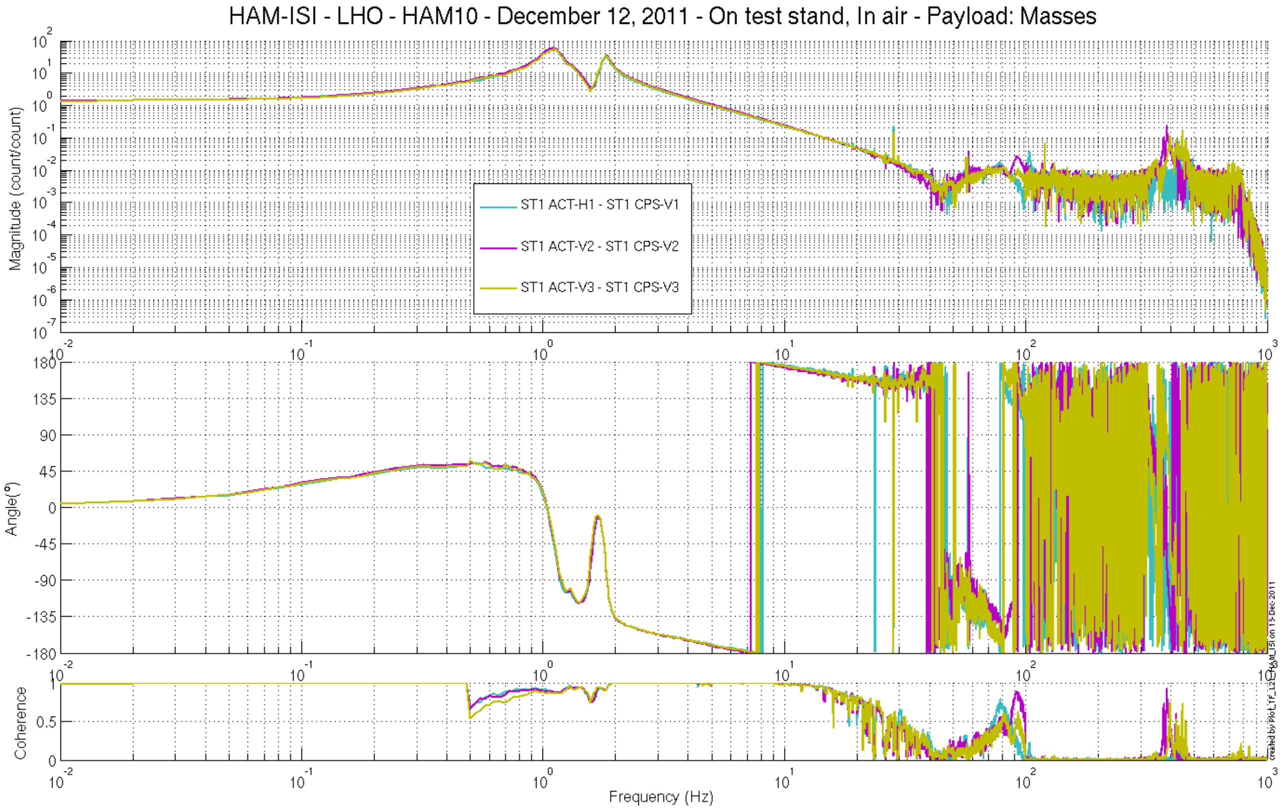

Figure - Local to Local Measurements – Capacitive sensors Vertical motion

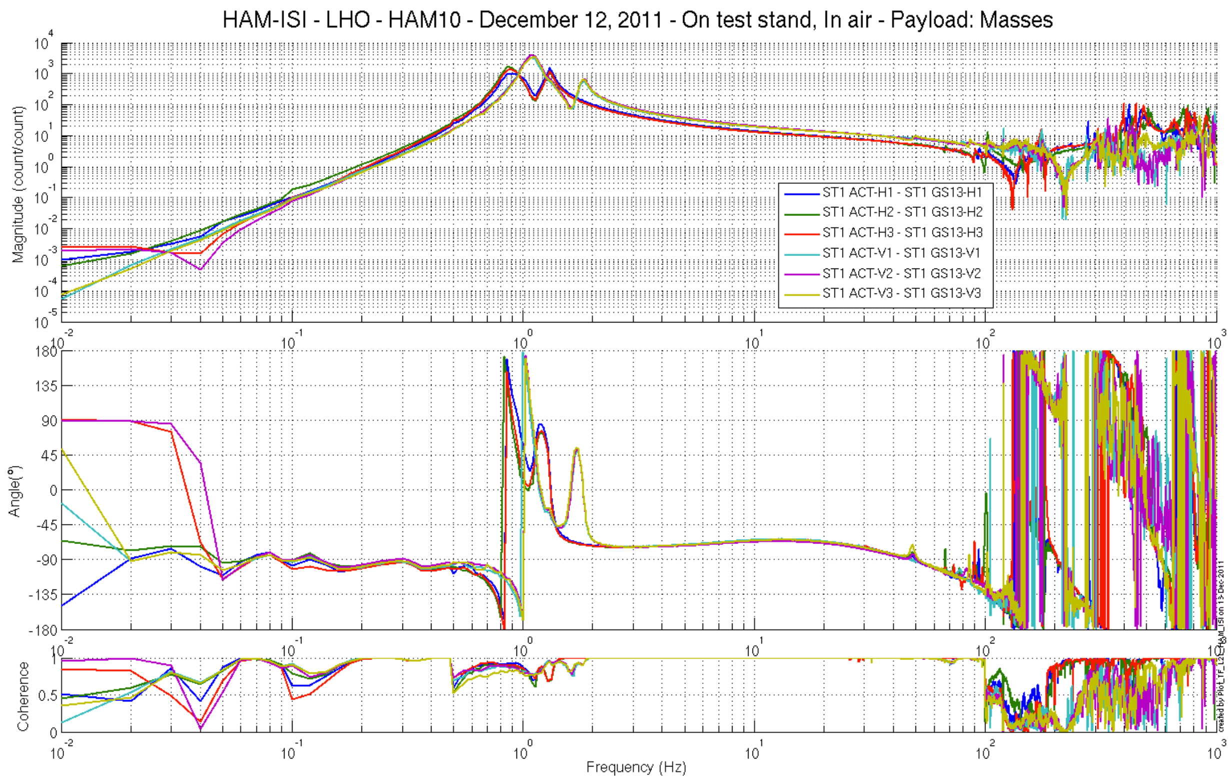

Figure - Local to Local Measurements – Inertial sensors

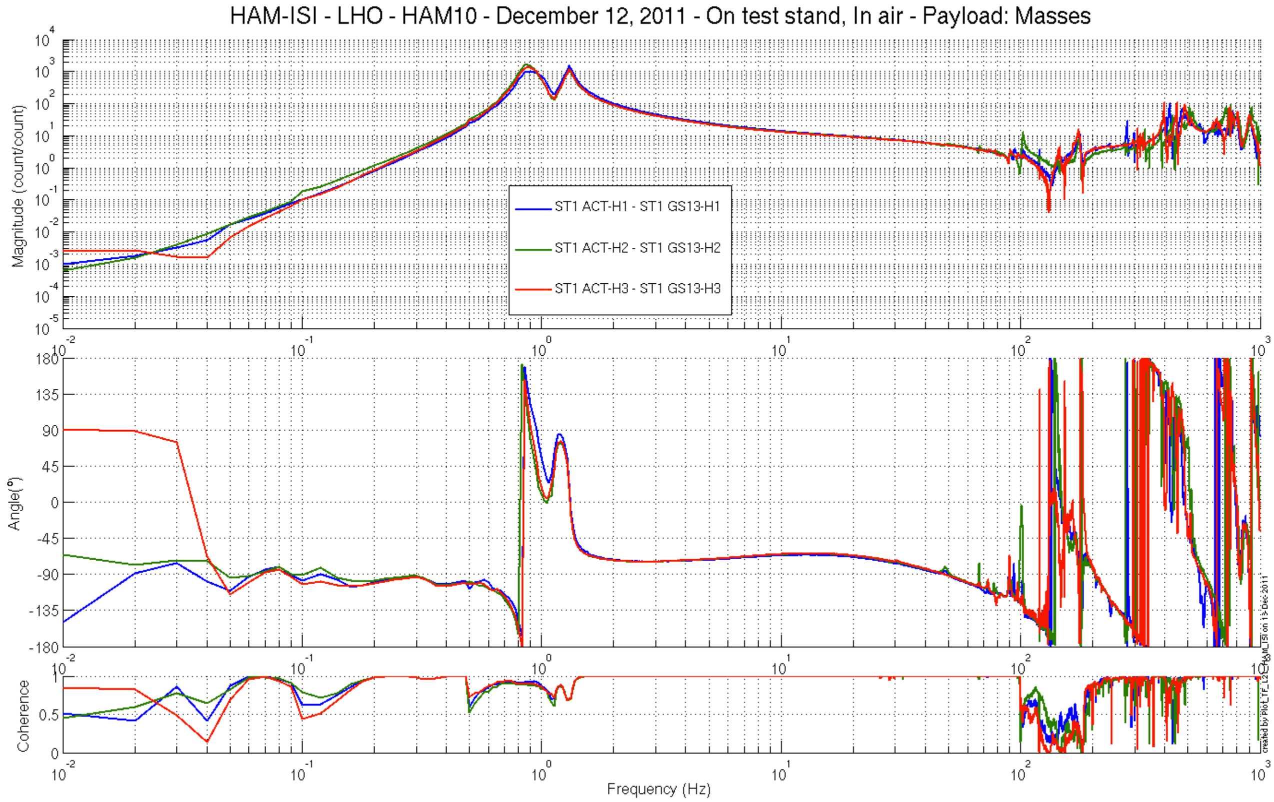

Figure - Local to Local Measurements – Inertial sensors
Horizontal motion

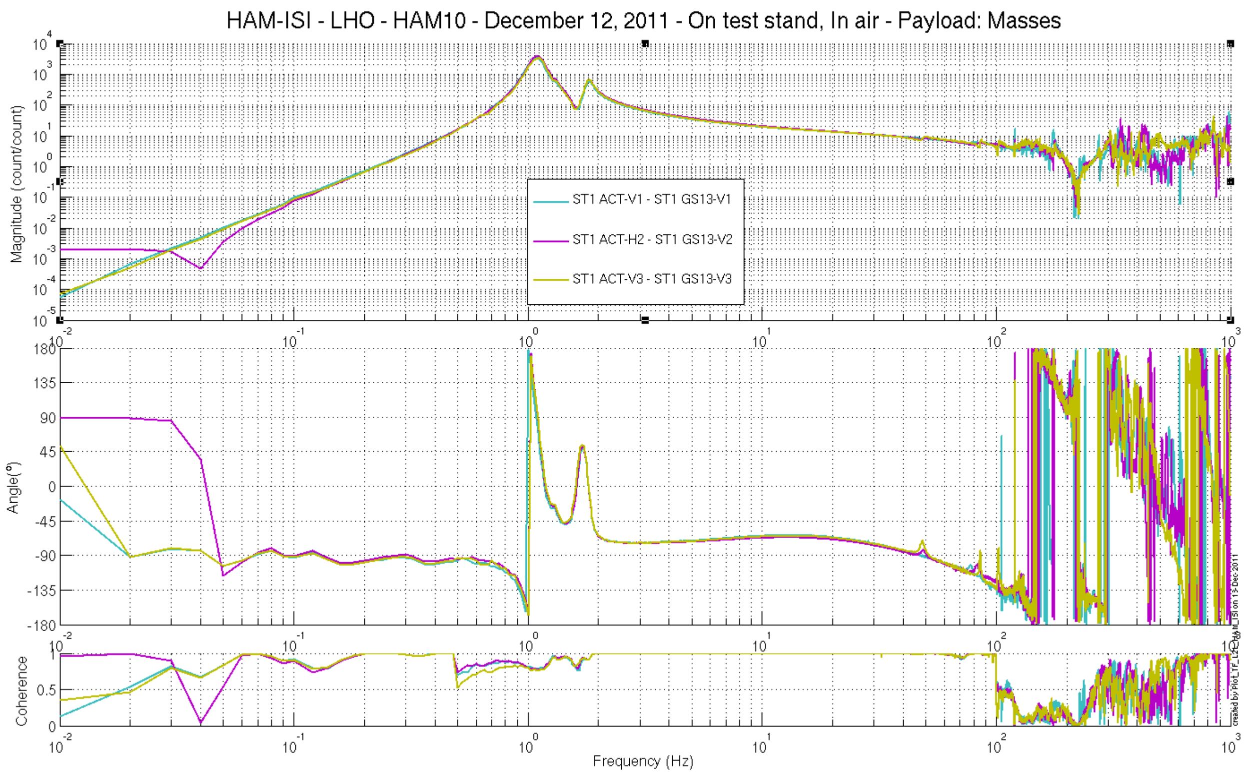

Figure - Local to Local Measurements – Inertial sensors
Vertical motion

- ***Step 16.2 - Cartesian to Cartesian measurements***

FREQ. RANGE			DRIVE						MEAS. TIME		
Min	Max	Freq. Res. (Hz)	X	Y	RZ	Z	RX	RY	Time for 1 Rep. (s)	Number of Reps	Time (min)
0.01	0.1	0.01	7000	7000	7000	7000	7000	7000	620.0	**10.0**	103.3
0.1	0.5	0.02	740	740	740	740	740	740	320.0	**30.0**	160.0
0.5	5	0.025	30	30	35	45	12	12	260.0	**55.0**	238.3
5	100	0.1	680	680	450	1200	560	450	80.0	**50.0**	66.7
100	1000	0.2	300	300	360	525	225	200	50.0	**150.0**	125.0
									Total Meas. time(h)		**11.6**

Table – Transfer function settings, by frequency band

Data files in SVN at:
/opt/svncommon/seisvn/seismic/HAM-ISI/X1/HAM10/Data/Transfer_Functions/Measurements/Undamped/
- LHO_ISI_HAM10_Data_TF_C2C_10mHz_100mHz_20111217-044713.mat
- LHO_ISI_HAM10_Data_TF_C2C_100mHz_500mHz_20111217-020534.mat
- LHO_ISI_HAM10_Data_TF_C2C_500mHz_5Hz_20111219-114314.mat
- LHO_ISI_HAM10_Data_TF_C2C_5Hz_100Hz_20111216-212221.mat
- LHO_ISI_HAM10_Data_TF_C2C_100Hz_1000Hz_20111216-200448.mat

Data collection script files:
opt/svncommon/seisvn/seismic/HAM-ISI/Common//Transfer_Function_Scripts/
- Run_TF_C2C_10mHz_100mHz.m
- Run_TF_C2C_100mHz_500mHz.m
- Run_TF_C2C _500mHz_5Hz.m
- Run_TF_C2C _5Hz_100Hz.m
- Run_TF_C2C _100Hz_1000Hz.m

Scripts files for processing and plotting in SVN at:
/opt/svncommon/seisvn/seismic/HAM-ISI/X1/HAM10/Scripts/Control_Scripts/
- Step_1_Plot_TF_L2L_HAM_Testing.m

Figures in SVN at:
opt/svncommon/seisvn/seismic/HAM-ISI/X1/HAM10/Data/Figures/Transfer_Functions/Measurements/Undamped/
- LHO_ISI_HAM10_TF_C2C_Raw_from_ACT_to_GS13_2011_12_19.fig
- LHO_ISI_HAM10_TF_C2C_Raw_from_ACT_to_GS13_2011_12_19.fig

Storage of measured transfer functions in the SVN at:
opt/svncommon/seisvn/seismic/HAM-ISI/X1/HAM10/Data/Transfer_functions/ Simulations/Undamped/
- LHO_ ISI_HAM10_ TF_C2C_RAW_2011_12_19.mat

The Cartesian to Cartesian transfer functions are presented below:

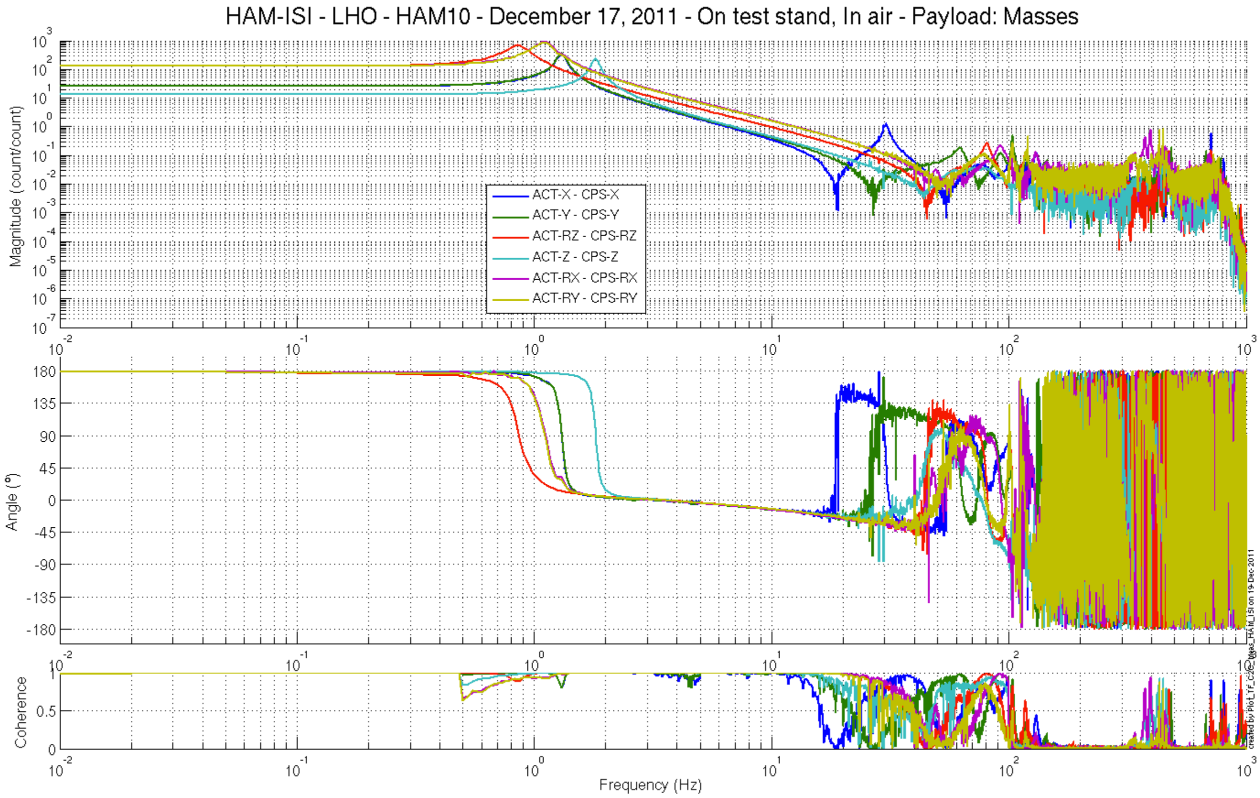

Figure – Cartesian to Cartesian Measurements – Capacitive sensors

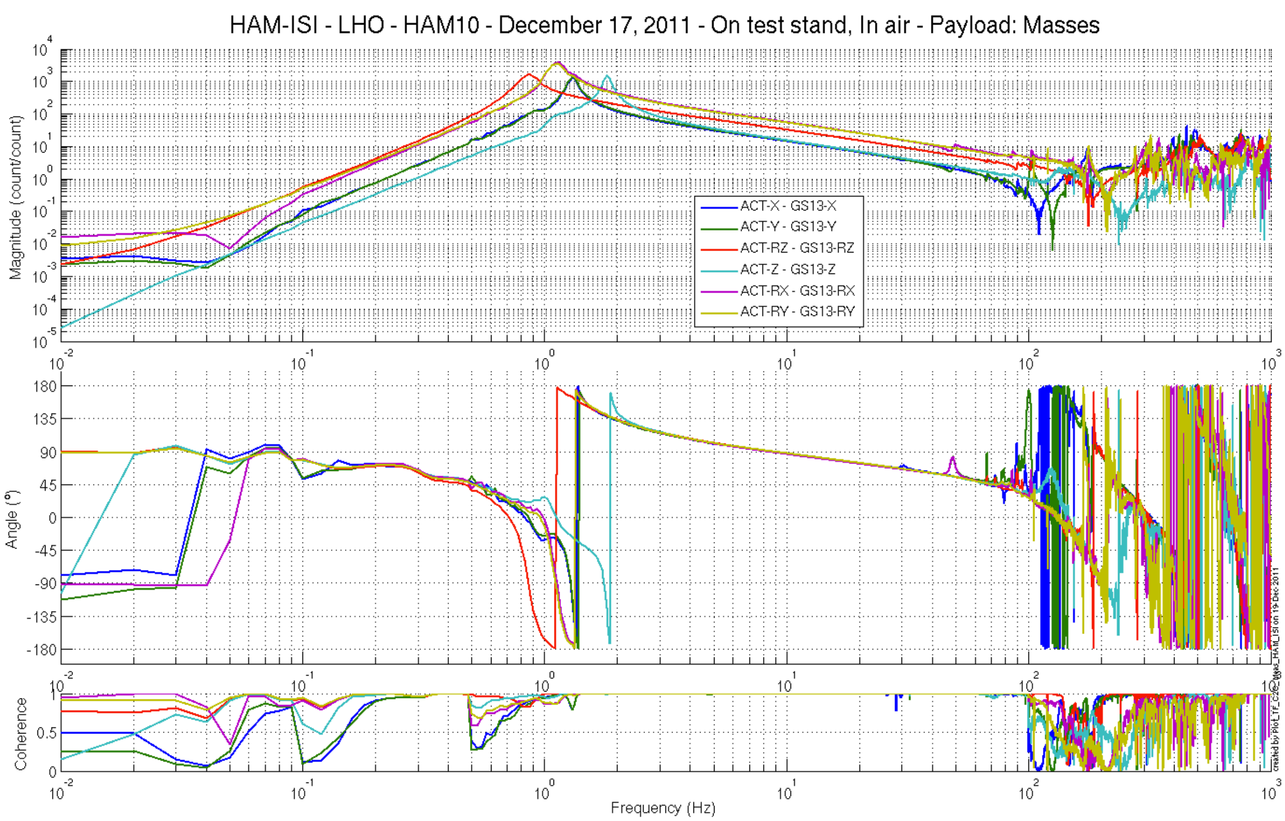

Figure – Cartesian to Cartesian Measurements – Inertial sensors

Issues/difficulties/comments regarding this test:
Damp gain set on -1 during measurements causing phase not starting at 0 degrees.

Acceptance criteria:

- Local to local measurements
  - On CPS, the phase must be 0º at DC
  - On Geophones, the phase must be -90º at DC
  - Identical shape in each corner
- Cartesian to Cartesian measurements
  - On CPS, the phase must be 0º at DC
  - On Geophones, the phase must be -90º at DC
  - Identical shape X/Y and RX/RY

Test result: **Passed: _X_** **Failed: ___**

- ***Step 17 - Transfer function comparison with Reference***

- ***Step 17.1 - Local to local - Comparison with Reference***

This unit is compared to LLO HAM 6. Furthermore, units of a given site will be compared with the unit that has been tested the most recently on the site.

Scripts files for processing and plotting in SVN at:
/opt/svncommon/seisvn/seismic/HAM-ISI/X1/HAM10/Scripts/Control_Scripts/
- Step_1_Plot_TF_L2L_HAM_Testing.m

/opt/svncommon/seisvn/seismic/HAM-ISI/X1/HAM10/Misc/
- Plot_TF_L2L_HAM_Testing_With_HAM6_Reference.m

Local to local figures in SVN at:
opt/svncommon/seisvn/seismic/HAM-ISI/X1/HAM10/Data/
Figures/Transfer_Functions/Measurements/Undamped/
- LHO_ISI_HAM10_TF_L2L_Raw_from_ACT_V_to_CPS_V_vs_HAM6_2011_12_12.fig
- LHO_ISI_HAM10_TF_L2L_Raw_from_ACT_H_to_CPS_H_vs_HAM6_2011_12_12.fig
- LHO_ISI_HAM10_TF_L2L_Raw_from_ACT_V_to_GS13_V_vs_HAM6_2011_12_12.fig
- LHO_ISI_HAM10_TF_L2L_Raw_from_ACT_H_to_GS13_H_vs_HAM6_2011_12_12.fig

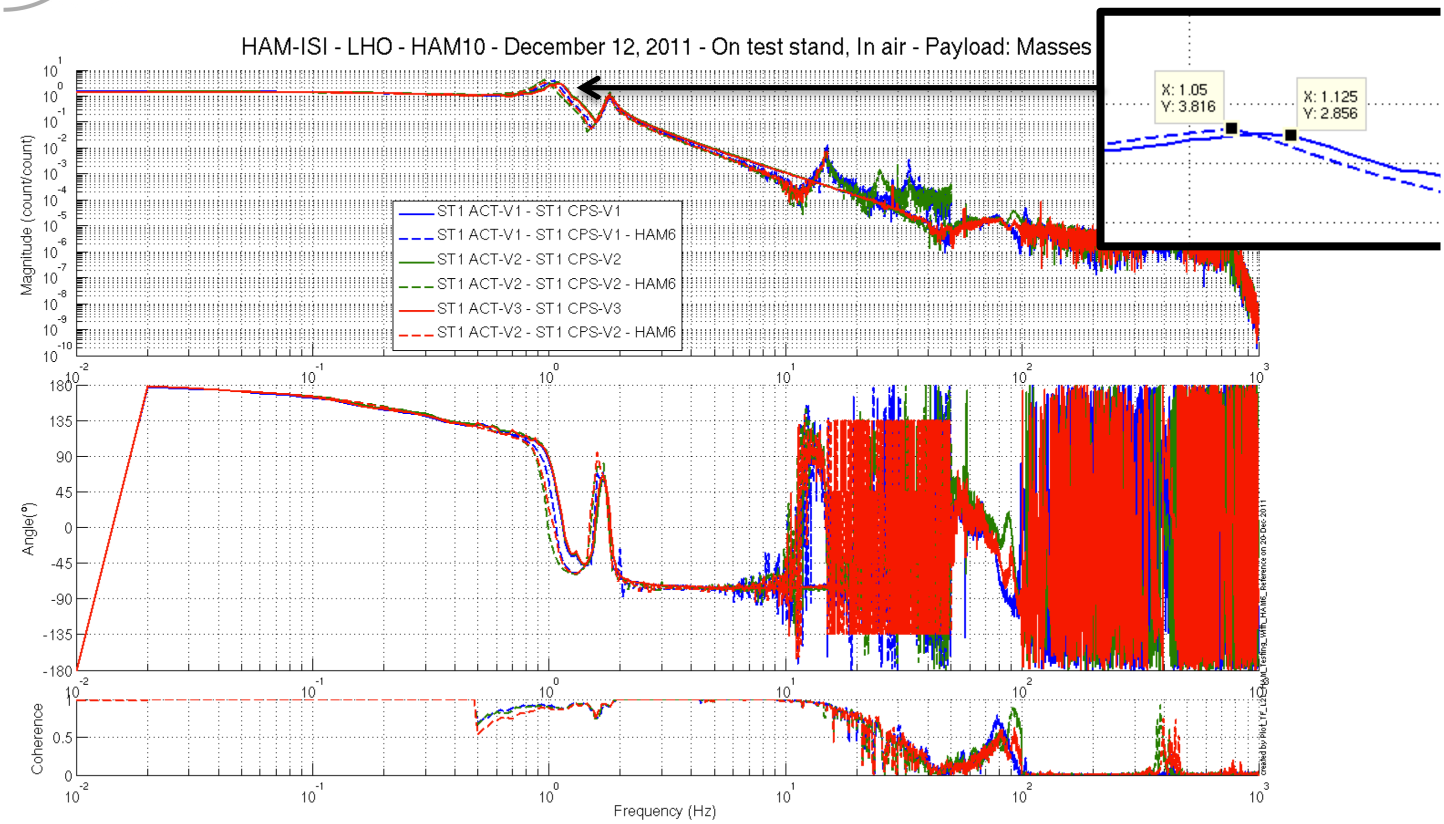

Figure – Local to Local measurements, comparison with HAM6 reference – Capacitive Position Sensors

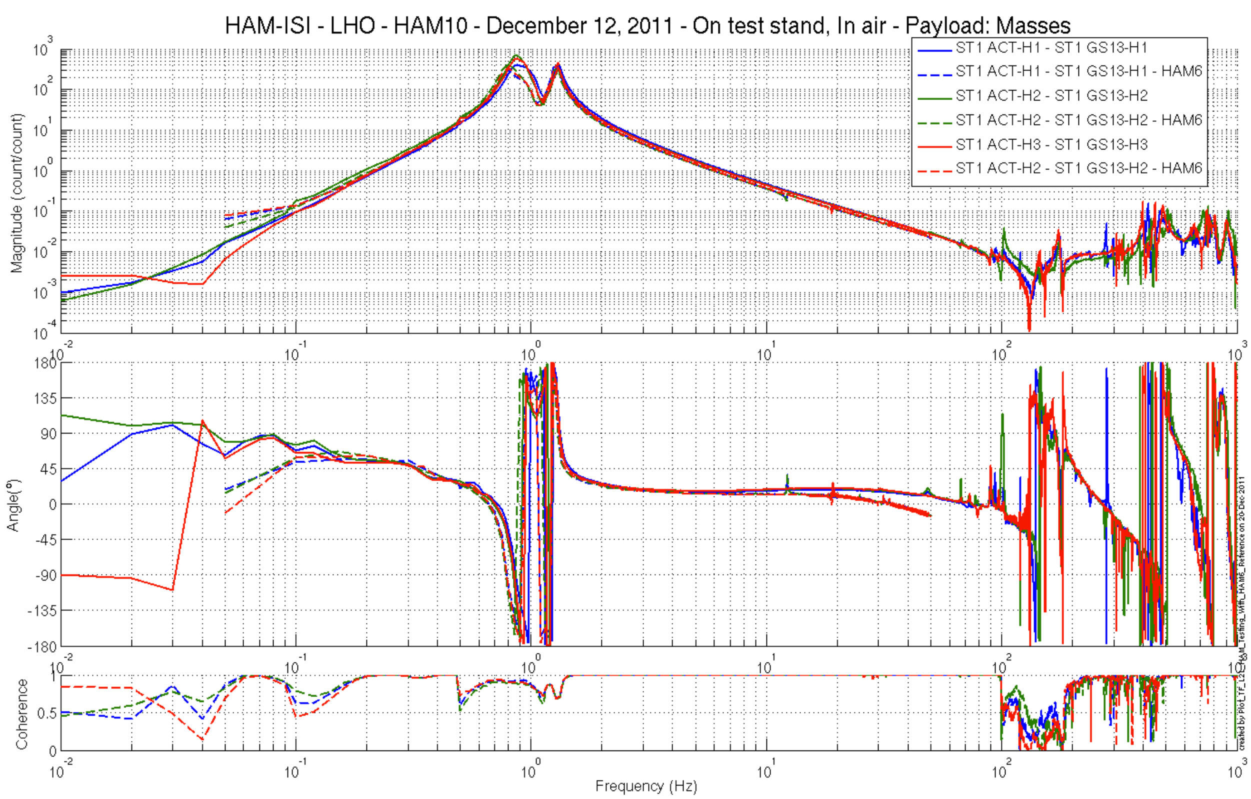

Figure – Local to Local measurements, comparison with HAM6 reference – Inertial sensors

- ***Step 17.2 - Cartesian to Cartesian - Comparison with Reference***

Scripts files for processing and plotting in SVN at:
/opt/svncommon/seisvn/seismic/HAM-ISI/X1/HAM10/Scripts/Control_Scripts/
- Step_3_Plot_TF_C2C_HAM_Testing.m

/opt/svncommon/seisvn/seismic/HAM-ISI/X1/HAM10/Misc/
- Plot_TF_C2C_HAM_Testing_With_HAM6_Reference.m

Cartesian to Cartesian figures in SVN at:
opt/svncommon/seisvn/seismic/HAM-ISI/X1/HAM10/Data/
Figures/Transfer_Functions/Measurements/Undamped/
- LHO_ISI_HAM10_TF_C2C_Raw_from_ACT_H_to_GS13_H_vs_HAM6_2011_12_19.fig
- LHO_ISI_HAM10_TF_C2C_Raw_from_ACT_H_to_GS13_V_vs_HAM6_2011_12_19.fig
- LHO_ISI_HAM10_TF_C2C_Raw_from_ACT_H_to_CPS_H_vs_HAM6_2011_12_19.fig
- LHO_ISI_HAM10_TF_C2C_Raw_from_ACT_H_to_CPS_V_vs_HAM6_2011_12_19.fig

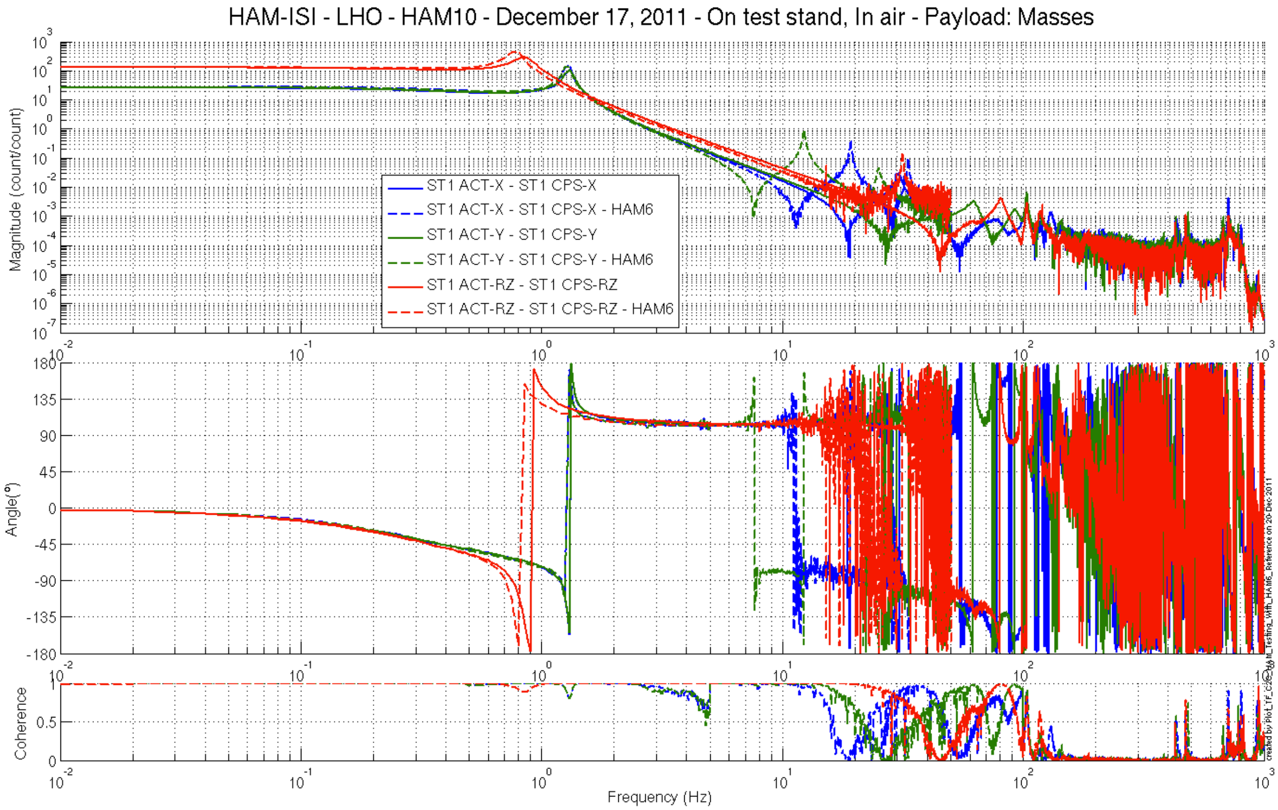

Figure – Cartesian to Cartesian measurements, comparison with HAM6 reference – Capacitive Position Sensors Horizontal motion

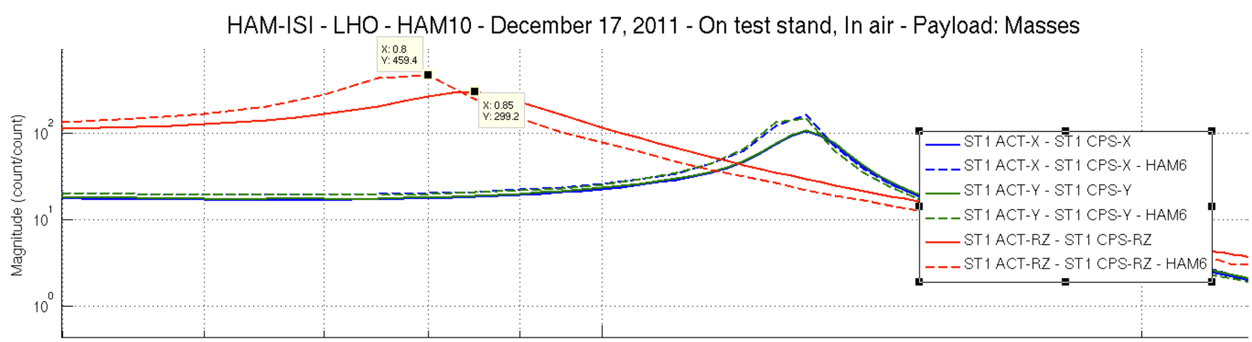

Figure – Cartesian to Cartesian measurements, comparison with HAM6 reference – Capacitive Position Sensors Horizontal motion-Zoomed on a resonance

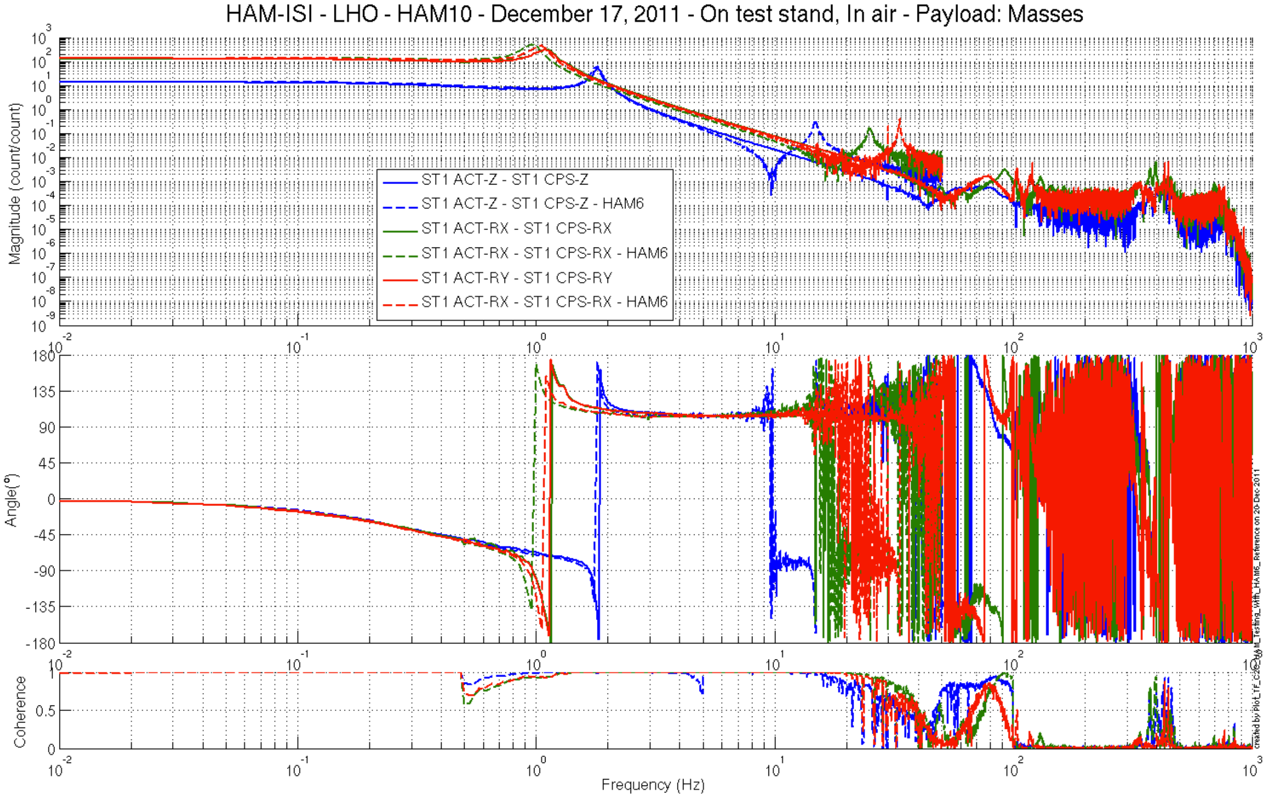

Figure – Cartesian to Cartesian measurements, comparison with HAM6 reference – Capacitive Position Sensors Vertical motion

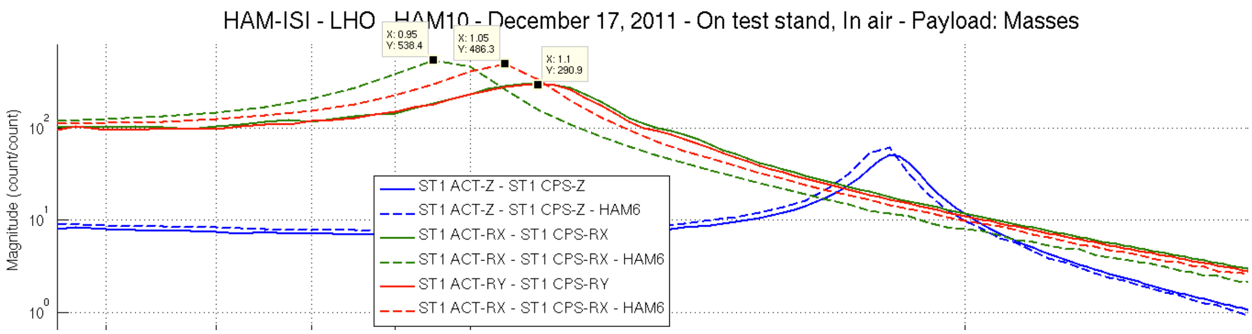

Figure – Cartesian to Cartesian measurements, comparison with HAM6 reference – Inertial Sensors Vertical motion-Zoomed on a resonance

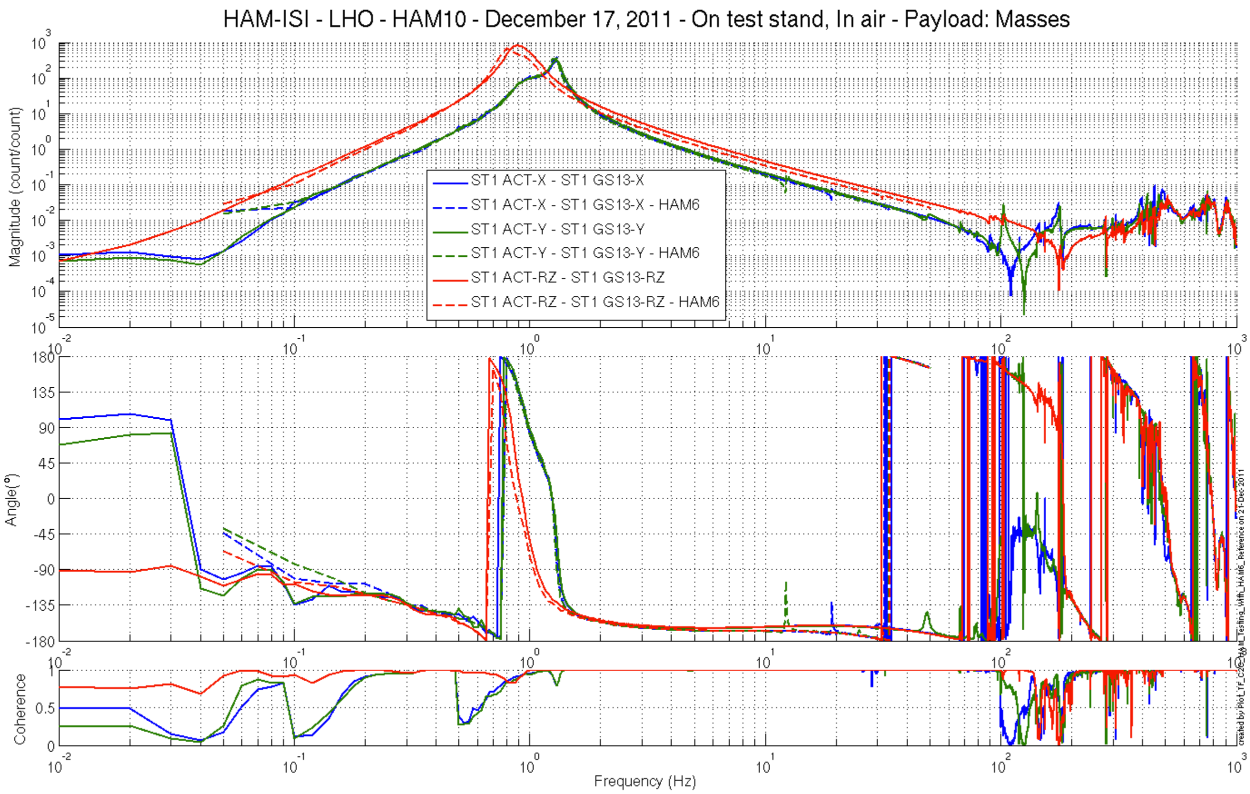

Figure – Cartesian to Cartesian measurements, comparison with HAM6 reference – Inertial Sensors Horizontal motion

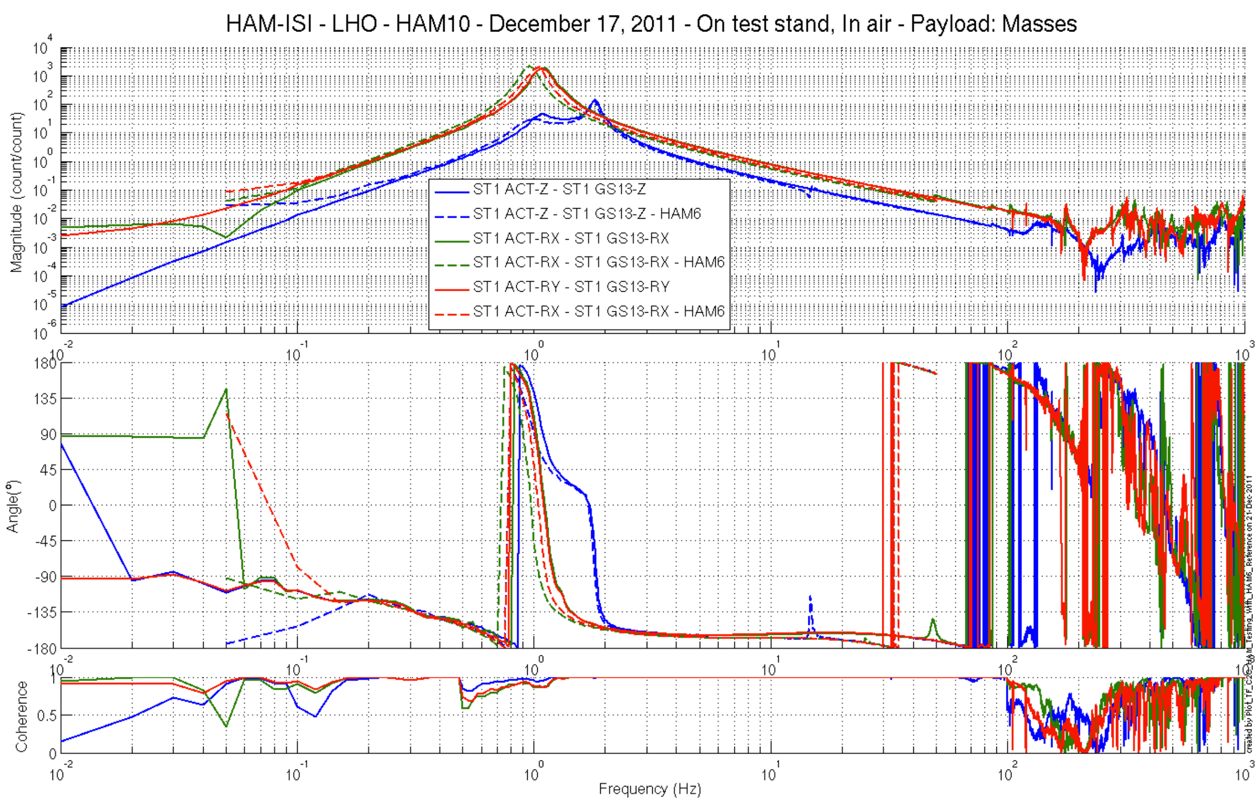

Figure – Cartesian to Cartesian measurements, comparison with HAM6 reference – Inertial Sensors Vertical motion

<u>Cartesian to Cartesian measurement configuration:</u>

- CPS *Calibration* filter: ON, but with bad gain (old version)
- GS13 *Calibration* filter: ON
- GS13 *Gain* filter: ON
- GS13 *De-whitening* filter: ON
- Actuators *Compensation* filter: ON
- *ISI_HAM10_Damp* channels' gain set on -1 during measurements.

<u>"Post-processing":</u>

- *De-whitening* filters cancelled on GS13 measurements.
- *Idealization* filters cancelled on GS13 Cartesian TF.
- Actuators' *compensation filter cancelled on measurement.*
- Gain applied on HAM6 CPS to adjust curves amplitudes for comparison.

<u>Issues/difficulties/comments regarding this test:</u>

- More than 10% out of phase for vertical (Z, RX, RY) geophones. However, test geophones are used.
- Plotting functions put in temporary folder.

Acceptance criteria:

- No difference with the reference transfer functions (SVN)
    - Phase – less than 10º - In Phase – Out of Phase
    - Damping (fit by eye with Reference transfer functions)
    - DC gain
    - Eigen frequencies shift less than 10%

Test result: **Passed: __X__** **Failed: ___**

- ***Step 18 - Lower Zero Moment Plane***

Data collection script files:
opt/svncommon/seisvn/seismic/HAM-ISI/Common/Transfer_Function_Scripts/
- Run_TF_C2C_10mHz_100mHz_LZMP_HAM_ISI.m

Data files in SVN at:
opt/svncommon/seisvn/seismic/HAM-ISI/X1/HAM10/Data/Transfer_Functions/Measurements/Undamped/
- LHO_ISI_HAM10_Data_TF_C2C_10mHz_100mHz_LZMP_20111219-170245.mat

Scripts files for processing and plotting in SVN at:
opt/svncommon/seisvn/seismic/HAM-ISI/Common/Testing_Functions_HAM_ISI/
- LZMP_HAM_ISI.m

Figures in SVN at:
opt/svncommon/seisvn/seismic/HAM-ISI/X1/HAM10/Data/ Figures/Transfer_Functions/Measurements/Undamped/
- LHO_ISI_HAM10_LZMP.fig

X & Y offsets:

X offset (mm)	**1.19**
Y offset (mm)	**1.52**

Table – Offset of the Lower Zero Moment Plane

<u>Issues/difficulties/comments regarding this test:</u>
Increasing the number of averages from 200 to 300 did not affect results.

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

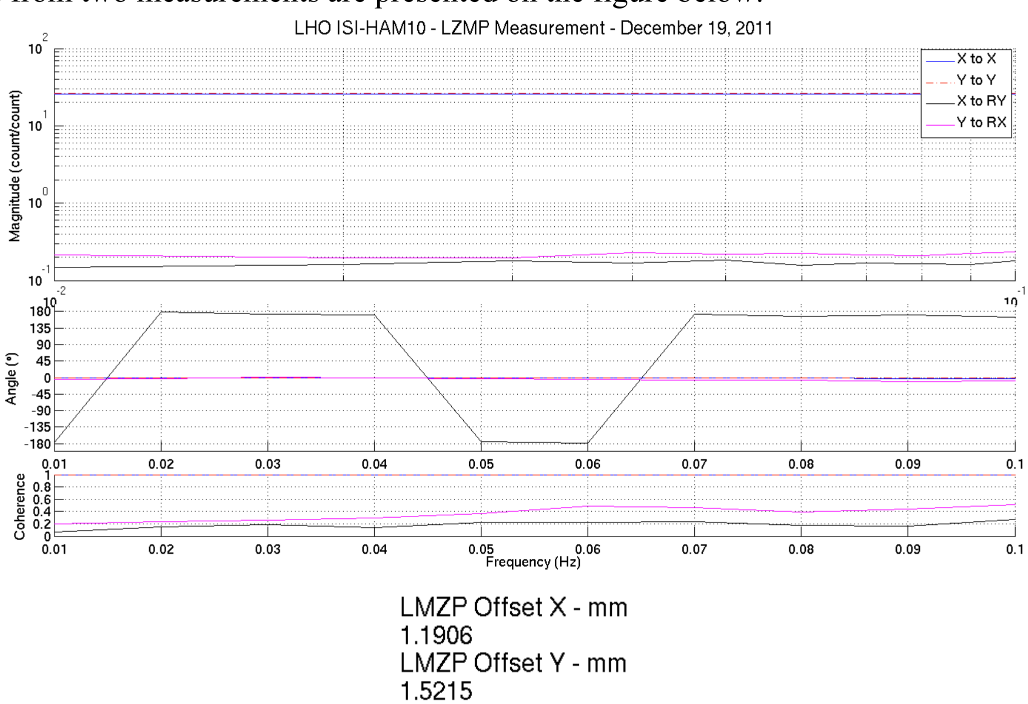

Figure - Lower Zero Moment Plane – Main and cross couplings at low frequency

Issues/difficulties/comments regarding this test
Run_Get_Batch.m needed a minor update in order to process large amounts of data.

Acceptance criteria:
- X offset must be less than 2 mm
- Y offset must be less than 2 mm

Test result: **Passed: __X__** **Failed: ____**

IV. HAM-ISI Unit #3 testing summary

HAM-ISI unit #3 was built and tested in October 2010. Faulty part replacement implied the need of disassembling and reassembling the unit. Once reassembled, the unit had to be re-tested. Tests presented here were performed between November 15th and December 23rd 2011. Tests were performed in accordance with E1000309-V9 procedure.

Particularities:
Test versions of the GS13 were used. Permanent GS13 will replace them as soon as received.
L4Cs were not installed for this first phase of testing.

Evolution from previous testing:
Mass budget is now lower of 7.88kg. That can be due to the blades leveling or in accuracy in our estimates of the balancing masses. That's within tolerance, so it's not a problem.

Complementary inquiries:
CPS shielding efficiency was investigated due to the high density of narrow peaks observed on their ASDs. Inquiry was performed and proved that the peaks were caused by the spectral characteristics of ground motion.

FAILED AND WAIVED TESTS

- ***List of tests that failed and don't need to be redone:***

Step II.7: Level of stage 0 was slightly out of requirements, but good enough for this phase of testing.
Step II.8: Same comments for the leveling of stage 1 (was out of spec because stage 0 was not leveled)
Step III.2: Excessive standard deviation associated to ground motion. Sensor noise is acceptable.
Step III.7: ASDs with table tilted are borderline. However the geophones will be replaced.

- ***Tests that failed and need to be done during phase II***

Step I.2: Test GS13 will be replaced with permanent ones. S/N should be recorded then.
Step III.14: Deviation from average slope out of spec. However this is associated with cable length. Make sure that linearity test results correlate with the final filed cables.

- ***List of test that were skipped and that we will not do because they are not essential***

Step III.3: Sensor gap measurement with a jig. Waved to avoid scratching targets. Distance between sensor and target has also been checked during the assembly while adjusting target distance.

- ***List of test that were skipped and need to be done during phase II:***

Step III.19: Damping loops
Step III.19.1: Transfer functions – Simulation
Step III.19.2: Powerspectra – Experimental