LIGO Laboratory / LIGO Scientific Collaboration

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aLIGO HAM-ISI, Pre-integration Test Report, Phase I, LHO Unit #6 (post-assembly, before storage)

E1000323 – v3

Hugo Paris, Fabrice Matichard, Vincent Lhuillier
Hugh Radkins, Jim Warner, Robinson Mitchel, Corey Gray, Gregory Grabeel, Eric Allwine

Distribution of this document:
Advanced LIGO Project

This is an internal working note
of the LIGO Laboratory

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

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

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

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Introduction

HAM-ISI Unit #6 was assembled during June 2012. The testing of this Unit is presented here. It started on June 18th and lasted until July 14th. Production GS13s and Stage-0 L4Cs were installed during tests.

Testing was delayed due to omissions in assembly, instrument failure and strong temperature changes:

- Due to forgotten barrel nuts, GS13s had to be removed and re-installed (LHO aLOG #3193).
- Even though GS13s were working properly at reception from LLO, one of the GS13s broke during the reinstallation process (LHO aLog # 3198). It was quickly replaced with a functional instrument (LHO aLog #3193).
- The replacement GS13 was not fully torqued down to the ISI (diagnosis details in LHO aLOG #3328).
- In air cables mismatched sensors/corners.
- Electrical connections on X1-SEI electronics rack, and on the in-air cable extensions, were found loose after electronic maintenance was performed on the rack, causing the gain on some instruments to be suddenly divided by 2. (LHO aLog #3328)
- 1/3 of the outer walls' bolts of the ISI were left non-torqued.
- The ISI went down of -0.09mm (appox. 3000cts down) when the temperature dramatically rose on site (30 degrees Fahrenheit, see figure below, LHO aLog # 3370, and comments). CPSs and Lockers were left as they were initially set before the temperature rise. They might have to be reset for the in-chamber installation of the ISI, depending on the temperature in the LVEA.
- Data loggers (temperature/humidity) were set in the staging building, in order to assess future strong temperature changes (LHO aLog #3431).

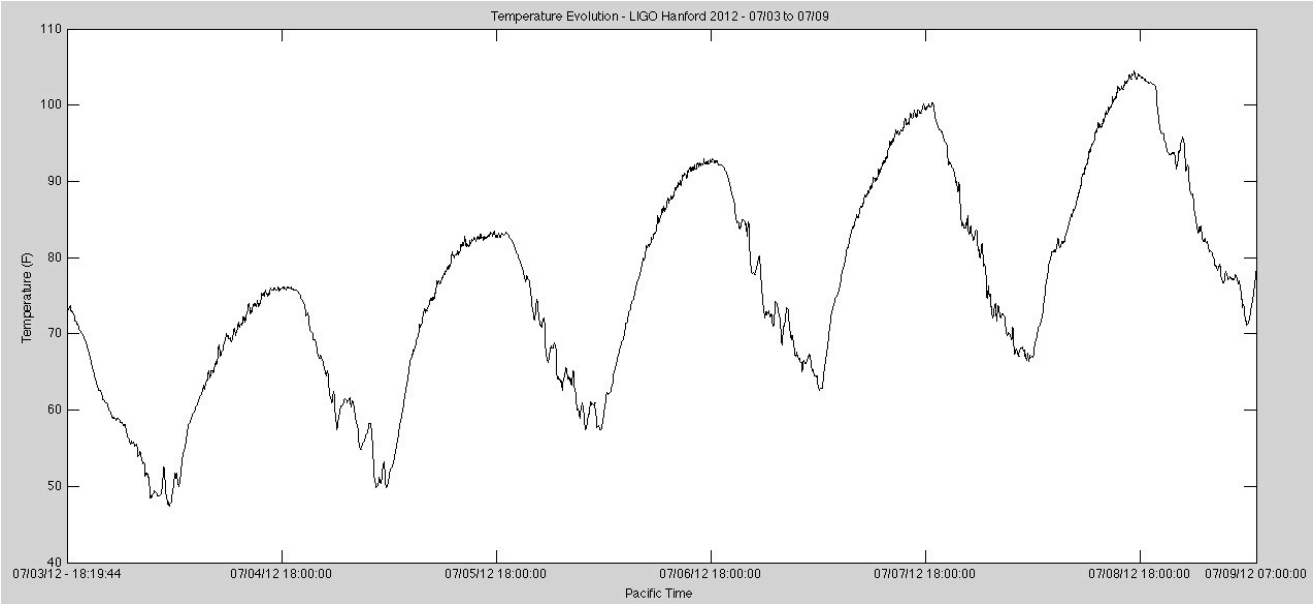


Figure –Evolution of outside temperature at LIGO HANFORD – 07/03 to 07/09

The procedure document used to perform these tests is:

- E1000309–V12 - aLIGO HAM-ISI, Pre-Integration Testing Procedure, Phase I (post assembly, before storage)

Other useful information can be found in:

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

Remark regarding SVN paths:
Units need to be tested under a folder that matches medm channels' names. Since MEDM channels' names all refer to HAMX during this phase of testing, units are all tested under:

/SeiSVN/seismic/HAM-ISI/X1/HAMX/

Once a unit is tested, a folder called after its order of assembly is created. For Unit #6, the name of this folder will be:

/SeiSVN/seismic/HAM-ISI/X1/Unit_6/

Test data is then moved from HAMX testing folder to this final folder. All the data related to the Phase I testing of this unit is then stored in this folder. The data set names, the location of the test results, and the locations of the programs used to obtain them are specified along this document.

Even if they are tested under HAMX, units are called per their order of assembly in programs, figures and data files.

I. Pre-Assembly Testing

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

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
12032	11961	NR	NR	~2.057	1	~.01	NR
12051	11965	NR	NR	~2.057	1.5	~.01	NR
12050	11963	NR	NR	~2.057	0.4	~.01	NR
12053	11962	NR	NR	~2.057	1.2	~.01	NR
11994	NR	NR	NR	NR	NR	NR	NR
11980	NR	NR	NR	NR	NR	NR	NR

NR: Not recorded

The back panel reads 0.508V/0.001"

Sensors noise spectra measured before baking E1000257, and before shielding per procedure T1000636:

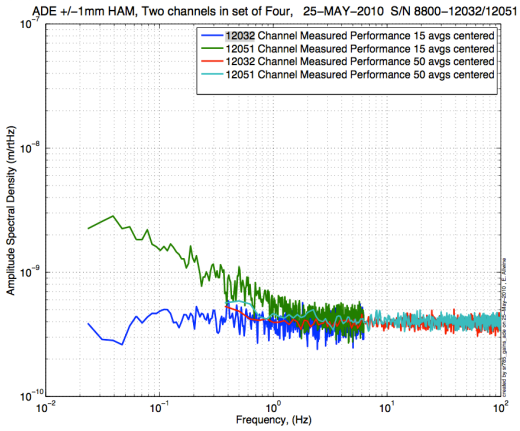


Figure - H1 and V1 sensor noise

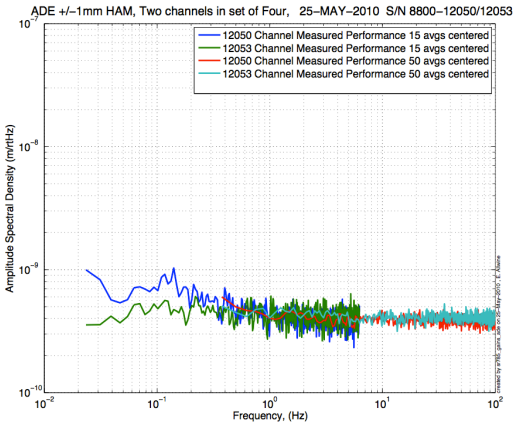


Figure - H2 and V2 sensor noise

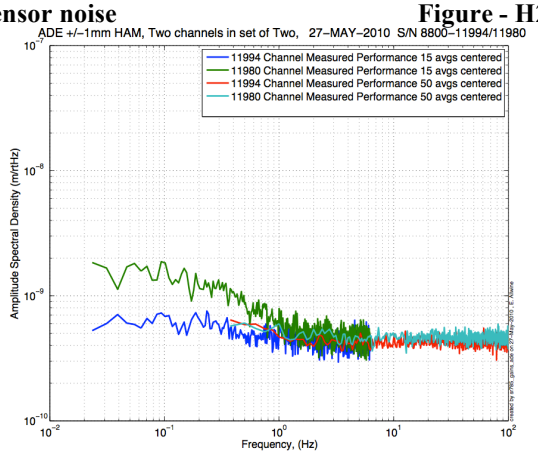


Figure - H3 and V3 sensor noise

Issues/difficulties/comments regarding this test:

- Sensors #12051 and #11980 were initially discarded because of their high noise level below 1Hz. These sensors were then sent back to be repaired. The spectra presented here were measured before their repair. No spectra was taken afterward.
- No testing information available for sensors #11994 and #11990.

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:** ___ **Failed:** __X__

Comment: Test failed due to the lack of information available. However, further tests (i.e. step 6, spectra of CPSs) show that the instruments are functional.

- ***Step 2: GS13 testing prior to shippement***

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.
Power spectra measured at reception, after shipment from LLO, can be found 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-24: 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

		Corner 1	Corner 2	Corner 3
H	Pod	018	058	066
	Instrument	810	854	817
V	Pod	049	069	023
	Instrument	708	737	751

Table- GS13 instrument and Pod S/Ns

- ***Step 2.1 – Horizontal GS-13s***

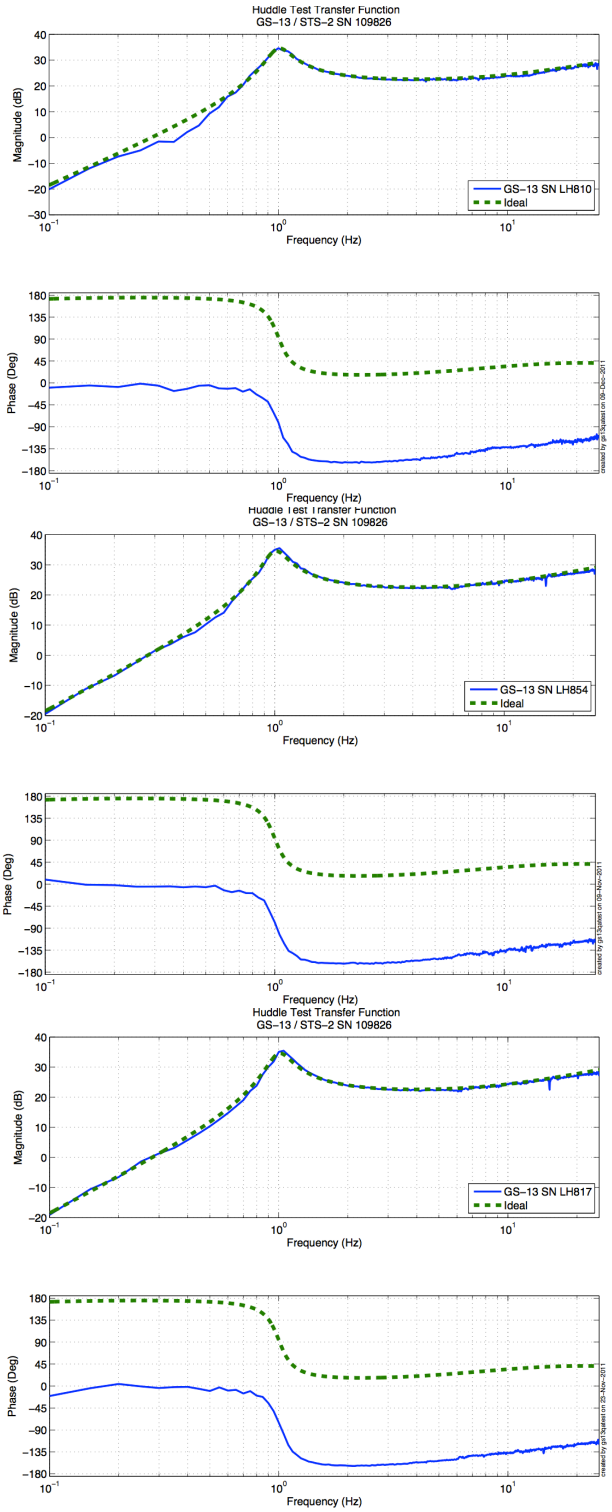


Figure - Huddle testing of Horizontal GS-13 810(H1), 854(H2), and 817(H3) after aLIGO modifications

- ***Step 2.2 – Vertical GS-13s***

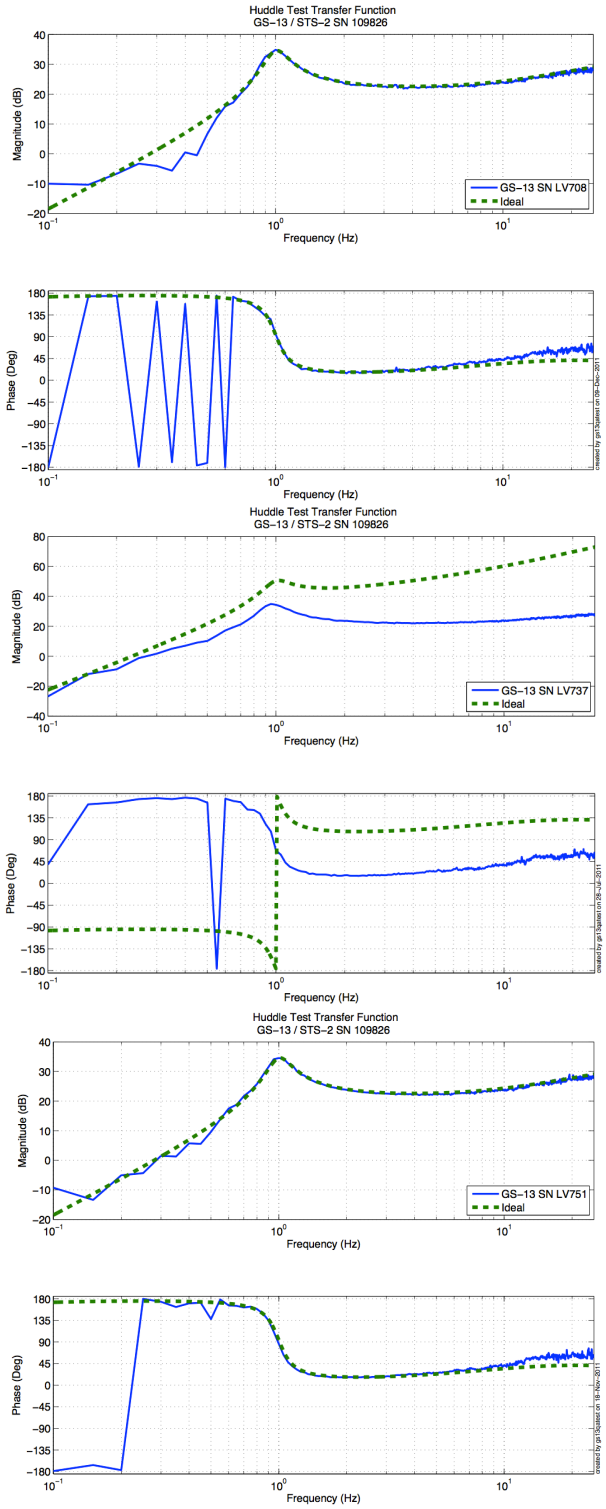


Figure - Huddle testing of Vertical GS-13 708(V1), 737(V2), and 751(V3) after aLIGO modifications

Driven testing

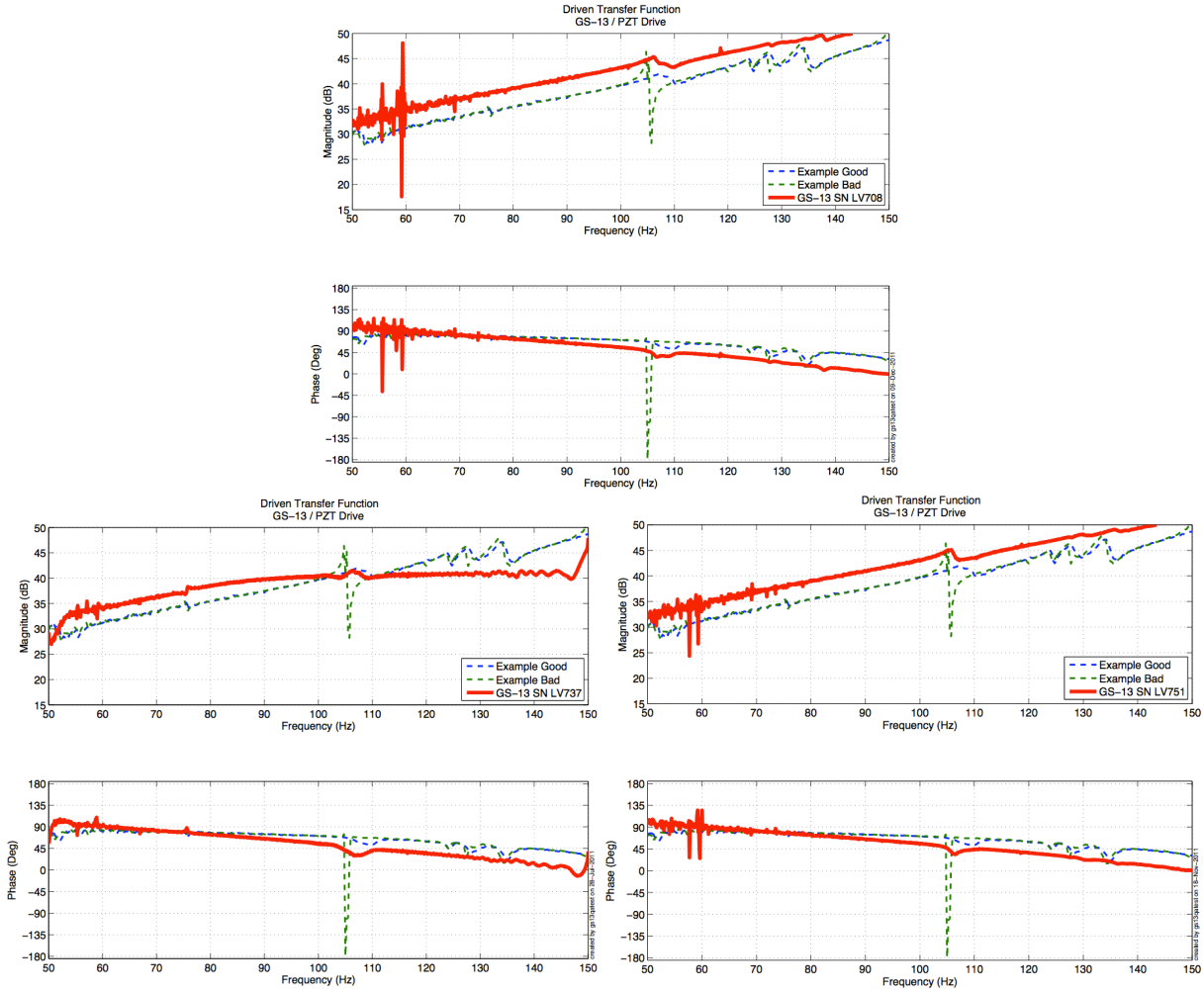


Figure - Driven testing of Vertical GS-13 708(V1), 737(V2), and 751(V3) after aLIGO modifications

Acceptance Criteria:

- GS13 have already been tested at LLO. GS13 Inspection/Pod Assembly is described in document D047810. Checklist is defined in F090070-v6

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

- ***Step 3: Actuators***

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

Actuator Serial #: L019 Operator Name: Smith, Lane Date: 8/12/2009 Time: 1:44 PM Actuator Coil Resistance: 6.37 Ohms, PASS Ambient Temperature: 70.0 F Hi Pot Test Results: 1000 MOhms, PASS X Travel Limit (inches): 0.522 Y Travel Limit (inches): 0.205 Z Travel Limit (inches): 0.505	Actuator Serial #: L014 Operator Name: Smith, Lane Date: 8/12/2009 Time: 3:58 PM Actuator Coil Resistance: 6.34 Ohms, PASS Ambient Temperature: 72.0 F Hi Pot Test Results: 1000 MOhms, PASS X Travel Limit (inches): 0.517 Y Travel Limit (inches): 0.205 Z Travel Limit (inches): 0.505
Actuator Serial #: L006 Operator Name: Smith, Lane Date: 8/12/2009 Time: 7:20 AM Actuator Coil Resistance: 6.39 Ohms, PASS Ambient Temperature: 68.0 F Hi Pot Test Results: 1000 MOhms, PASS X Travel Limit (inches): 0.517 Y Travel Limit (inches): 0.214 Z Travel Limit (inches): 0.484	Actuator Serial #: L002 Operator Name: Hartmann, Donna Date: 8/12/2009 Time: 5:30 PM Actuator Coil Resistance: 6.33 Ohms, PASS Ambient Temperature: 72.7 F Hi Pot Test Results: 1000 MOhms, PASS X Travel Limit (inches): 0.527 Y Travel Limit (inches): 0.205 Z Travel Limit (inches): 0.506
Actuator Serial #: L0094 Operator Name: Gordon, Matt Date: 11/20/2009 Time: 5:22 PM Actuator Coil Resistance: 6.34 Ohms, PASS Ambient Temperature: 71.1 F Hi Pot Test Results: 1000 MOhms, PASS X Travel Limit (inches): 0.530 Y Travel Limit (inches): 0.205 Z Travel Limit (inches): 0.508	Actuator Serial #: L001 Operator Name: Smith, Lane Date: 8/11/2009 Time: 5:37 PM Actuator Coil Resistance: 6.42 Ohms, PASS Ambient Temperature: 72.0 F Hi Pot Test Results: 1000 MOhms, PASS X Travel Limit (inches): 0.530 Y Travel Limit (inches): 0.196 Z Travel Limit (inches): 0.478

TBC: To Be Completed once horizontal actuators' S/N are retrieved (GS13 door opened)

Issues/difficulties/comments regarding this test:
- Actuators S/Ns were recorded after assembly.

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

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

- ***Step 5 – Seismometer inspection after shipping***

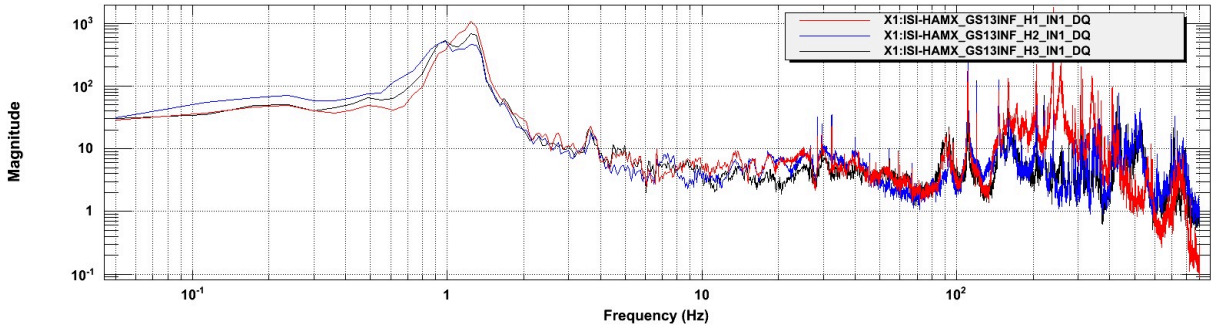


Figure – Horizontal Geophones inspection after reception at LHO

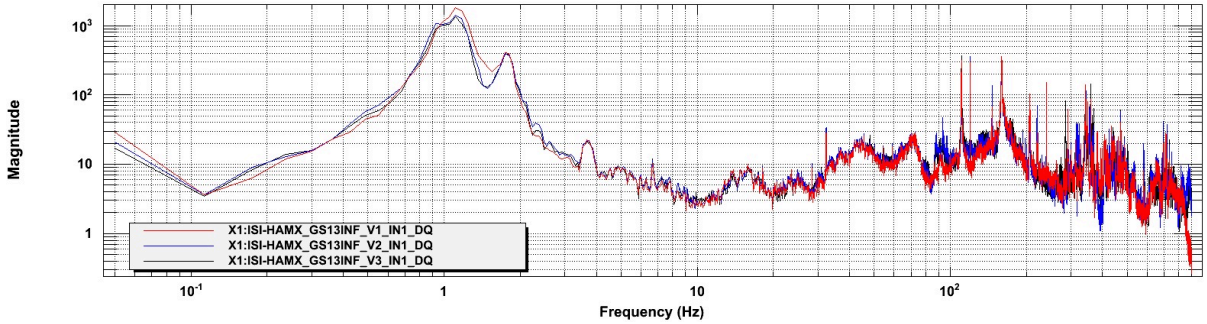


Figure – Vertical Geophones inspection after reception at LHO

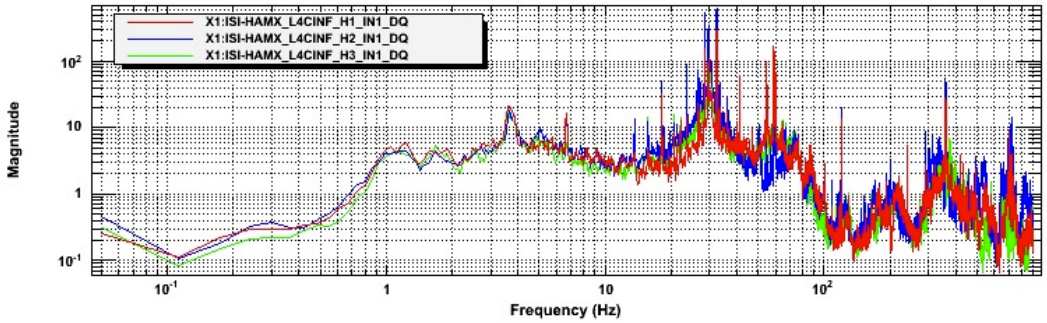


Figure – Horizontal L4C inspection after reception at LHO

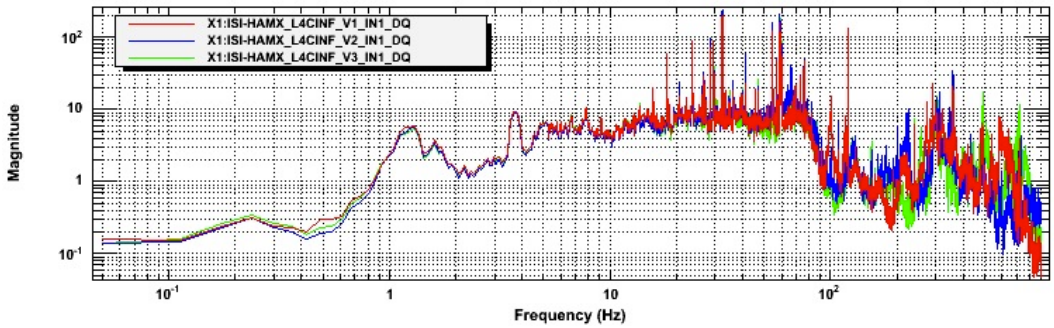


Figure – Vertical L4C inspection after reception at LHO

Results saved under the SVN at:
/SeiSVN/seismic/Common/Data/aLIGO_GS13_TestData_LHO/
/SeiSVN/seismic/Common/Data/aLIGO_L4C_TestData_LHO/

Acceptance Criteria:

- Geophones must have been tested after reception the geophones at LHO
- ASDs of the geophones must confirm that they are still functioning after shipping.
- Results must be available in the SVN

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

Note:
Horizontal GS13s have *nylon patches* on their flexure's screws.

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	009		
D071051	Stage 1 base	NA	009		
D071050	Optical table	NA	005		
D071002	Spring Post	NA	11	04	20
D071100	Spring	NA	10	18	11
D071102	Flexure	NA	19	06	30
ADE	Position sensor	Horizontal	12032	12050	11994
		Vertical	12051	12053	11980
D047812	GS-13 pod	Horizontal	018	058	066
		Vertical	049	069	023
D047823	L4C pod	Horizontal	134	089	060
		Vertical	132	087	073
D0902749	Actuator	Horizontal	019	006	094
		Vertical	014	002	001

Table – Parts inventory

Cable Connects		Cable S/N		
Part Name	Configuration	Corner 1	Corner 2	Corner 3
GS13	Horizontal	S1106665	S1106670	S1104701
GS13	Vertical			
L4C	Horizontal	S1106653	S1104709	S1104602
L4C	Vertical			
Actuator	Horizontal	S1106673	S1104097	S1104099
	Vertical	S1104096	S1106676	S1104101

Table – Cables inventory

- ***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***

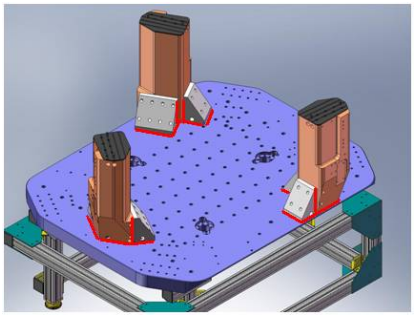


Figure - Showing edges that need checked on support posts and gussets

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***

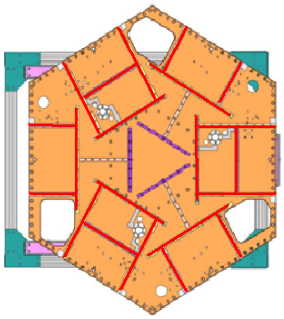


Figure – Showing what needs to be checked on Boxworks and Pitchforks

Acceptance Criteria:

- Shim inserted won't pass between parts.

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

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

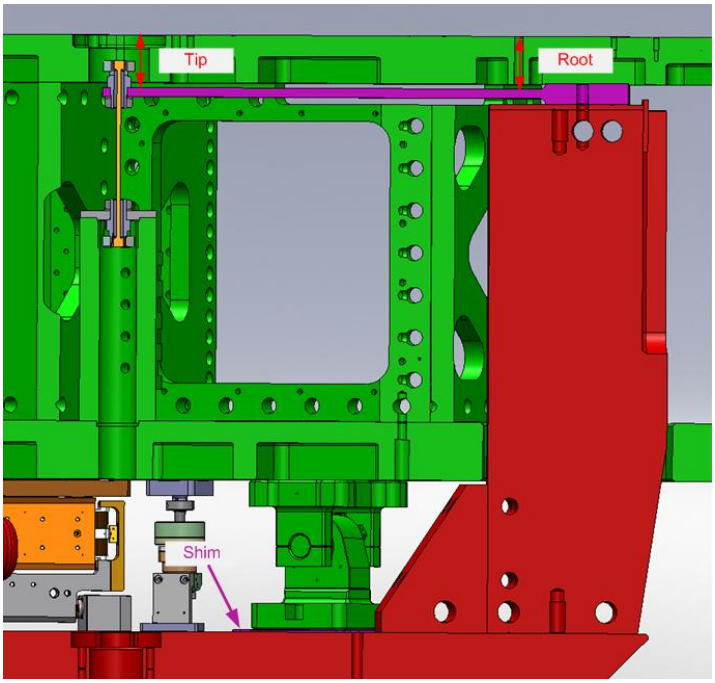


figure – Blade spring profile measurement points

Blade #	Root (Mils)	Tip(Mils)	Flatness (mils)
1	615	625	10
2	623	628	5
3	620	627	7

Table - Blade profile

Issues/difficulties/comments regarding this test:
Measurement was taken after the ISI level was lowered by about 0.9mm, due to temperature increase.

Acceptance Criteria:

- Blades must be flat within 0.015" inches.

Note that the tip measurement should be constant and that root value can be impacted by shims change.

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

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

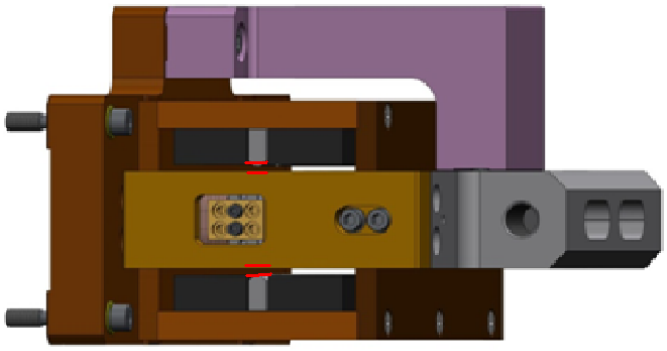


Figure - Showing gaps that need to be checked on actuators.

Issues/difficulties/comments regarding this test:
Since layers of shims are difficult to use accurately, a Go (70mils shim set) vs. No Go (90 mils shim set) technique was used for this test. To pass the test an actuator gap has to allow the 70mils shim set to be inserted and refuse the 90mils shim set.

The gaps on the backside of horizontal actuators are hard to access.

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***

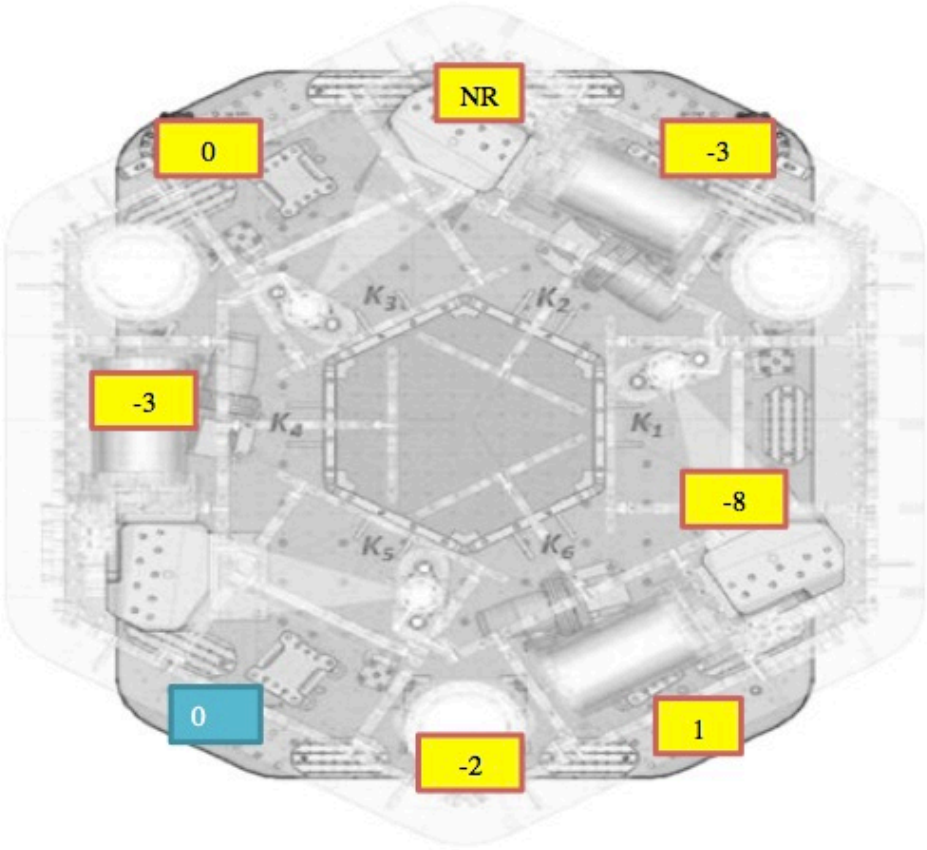


Figure – Level measured on Stage 0

Issues/difficulties/comments regarding this test:
The accuracy of the measurement limited by the measurement tool: optical level + ruler on a block. The ruler only has 1/100" graduations. Values are deduced from the relative distance to graduations. The uncertainty is about 1mil.

Max angle is calculated between the opposite points that have the most different level.

Max angle=0.005/57.5 (± 0.001/57.5) = 86.95 (±17.39) µrad

Acceptance Criteria

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

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

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

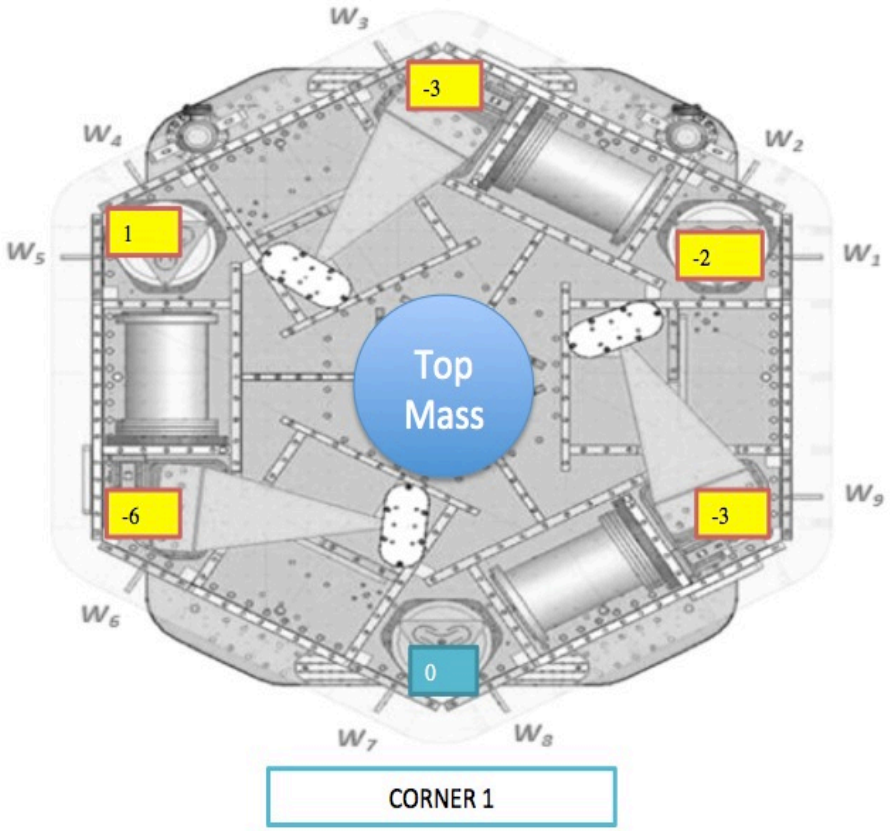


Figure – Level measured on Stage 1

Issues/difficulties/comments regarding this test:
The accuracy of the measurement is limited by the measurement tool: optical level + ruler on a block. The ruler only has 1/100" graduations. Values are deduced from the relative distance to graduations. The uncertainty is about 1mil.

Max angle is calculated between the opposite points that have the most different level.

Max angle = 0.003/86 (± 0.001/86) = 34.88 (± 11.7) µrad

Acceptance Criteria

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

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

- ***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	2	1		1	46.3	21.00
W1		1		1	1		1	40.7	18.46
W2			1	1	1		1	41.8	18.96
W3			1	1	1		1	41.8	18.96
W4		1		2	1		1	45.2	20.50
W5				1	1		1	39.6	17.96
W6			1				1	29.4	13.34
W7		2			1		1	37.3	16.92
W8		1	1	1	1		1	42.9	19.46
Side Masses Total	0	5	5	9	8	0	9	365	165.56

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						2		31.2	14.15
K2					1		1	35.1	15.92
K3						2		31.2	14.15
K4					1		1	35.1	15.92
K5						2		31.2	14.15
K6					1		1	35.1	15.92
Keel Masses Total	0	0	0	0	3	6	3	198.9	90.22

Table – Keel masses distribution

	Mass (kg)
T1	$20.00
T2	$270.79
T3	$25.00
T4	5.00
Total	320.79

Table – Optic table masses distribution

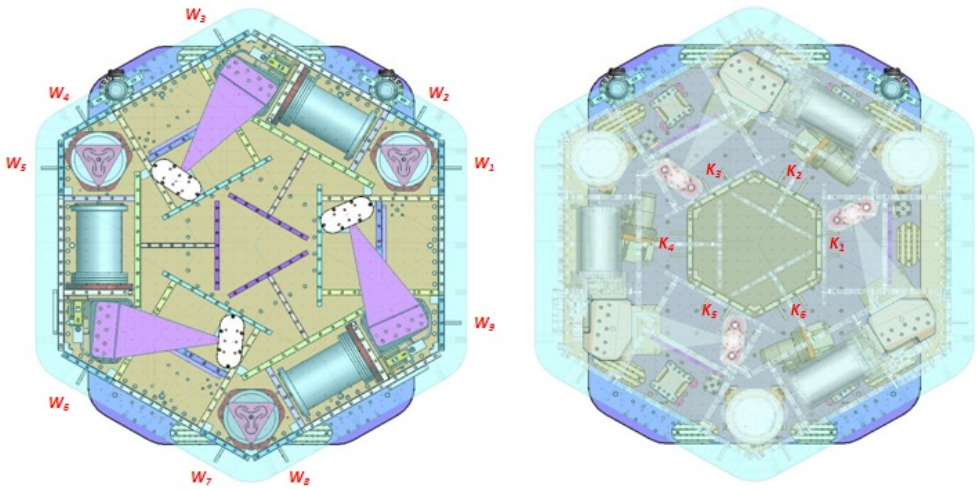


Figure – Wall Masses (W) and Keel masses (K) location. ***South of picture = corner 1***

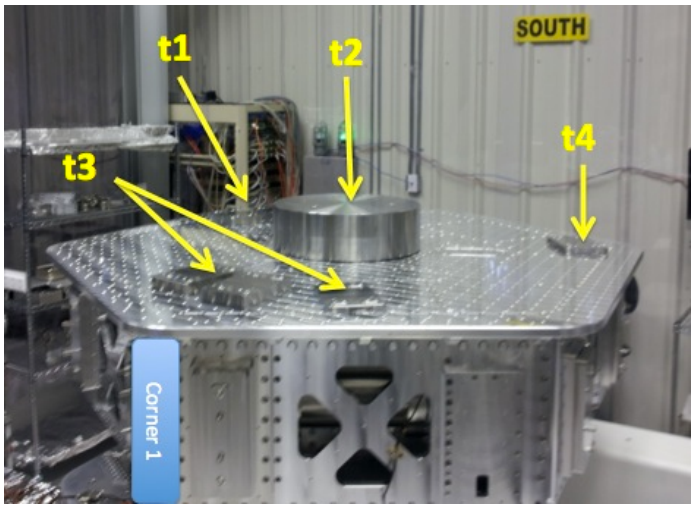


Figure – Optic table masses distribution

	Side	Keel	Top	Total
Weight (kg)	165.56	90.22	320.79	576.57

Table – Mass budget sum up

Issues/difficulties/comments regarding this test:

- T2's big mass evaluated at nominal value: 270.79kg. Gauge not available for measurement.
- A few shims were used for balancing. Their weight is negligible in comparison with the mass budget. Hence their weight is not reported in the mass budget.

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	125
B	124
C	122
D	124

Table – Shims Thickness

Acceptance Criteria

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

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

- ***Step 11: Lockers adjustment***

D.I. at Locker	Vertical D.I.	Horizontal D.I.
A	0	0
B	0	1
C	-1	0
D	-1	-1

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

Issues/difficulties/comments regarding this test:
Lockers might have to be reset once the ISI is installed in the interferometer.

Acceptance Criteria

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

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

- ***Step 2 - Set up sensors gap***

	Locked, 10 Kg masses at each corners	
Table locked	ADE boxes on	
Sensors	Offset (Mean)	Std deviation
H1	235.95	7.35
H2	-212.87	8.08
H3	-266.46	8.58
V1	220.75	7.21
V2	194.15	9.29
V3	9.19	8.52

Capacitive position sensor readout after gap set-up

Acceptance criteria:

- All mean values must be lower than +/-400 cts (a bit less than .0005").
- All standard deviations below 20 counts.
- No cross talk

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

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

Issues/difficulties/comments regarding this test:
Measured in the previous step. Waived to avoid scratching targets.

Test result: **Passed: ____ Failed: ____ Waived: __X_**

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

	Table locked		Table unlocked		
Sensors	Mean	Std Deviation	Mean	Std Deviation	Difference
H1	403.87	7.34	280.22	22.43	123.65
H2	-127.51	7.35	-109.21	24.04	18.30
H3	-238.54	7.84	107.51	29.86	346.05
V1	353.46	7.41	41.85	40.92	311.61
V2	377.52	9.94	9.60	22.05	367.92
V3	49.43	7.92	-34.61	46.81	84.04

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")
- 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 - Pushing "in the general coordinates"***

Pushing Z,-Z	CPS read out		Calculated after calibration		ROM
Sensors	UP (Counts)	Down (Counts)	UP (mil)	Down (mil)	
V1	20500	-19500	24.6	-23.4	40000
V2	18000	-18500	21.6	-22.2	36500
V3	20000	-20000	24.0	-24.0	40000

Pushing RZ, -RZ	CPS read out		Calculated after calibration		ROM
Sensors	CCW (+RZ)	CW(-RZ)	CW (mil)	CCW (mil)	
H1	-20000	21100	-24.0	25.3	41100
H2	-22200	21800	-26.7	26.2	44000
H3	-22300	21300	-26.8	25.6	43600

Table - Optic table range of motion

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

Pushing Locally	Push in positive direction	Push in negative direction	Railing	Actuator Gap Check	ROM
H1	-23500	21550		X	45050
H2	-19500	22150		X	41650
H3	-22400	22100		X	44500
V1	21100	-19900		X	41000
V2	32300	-32300	X	X	64600
V3	23000	-24800		X	47800

Table - Optic table range of motion

Issues/difficulties encountered during this test:

- Contact points are difficult to check on vertical actuators.
- V2 railing.
- Horizontal motion (Rz) was computed in mils from the vertical CPS calibration (Step 11).

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 Spectra***

Locked/Unlocked Power Spectra are presented below.

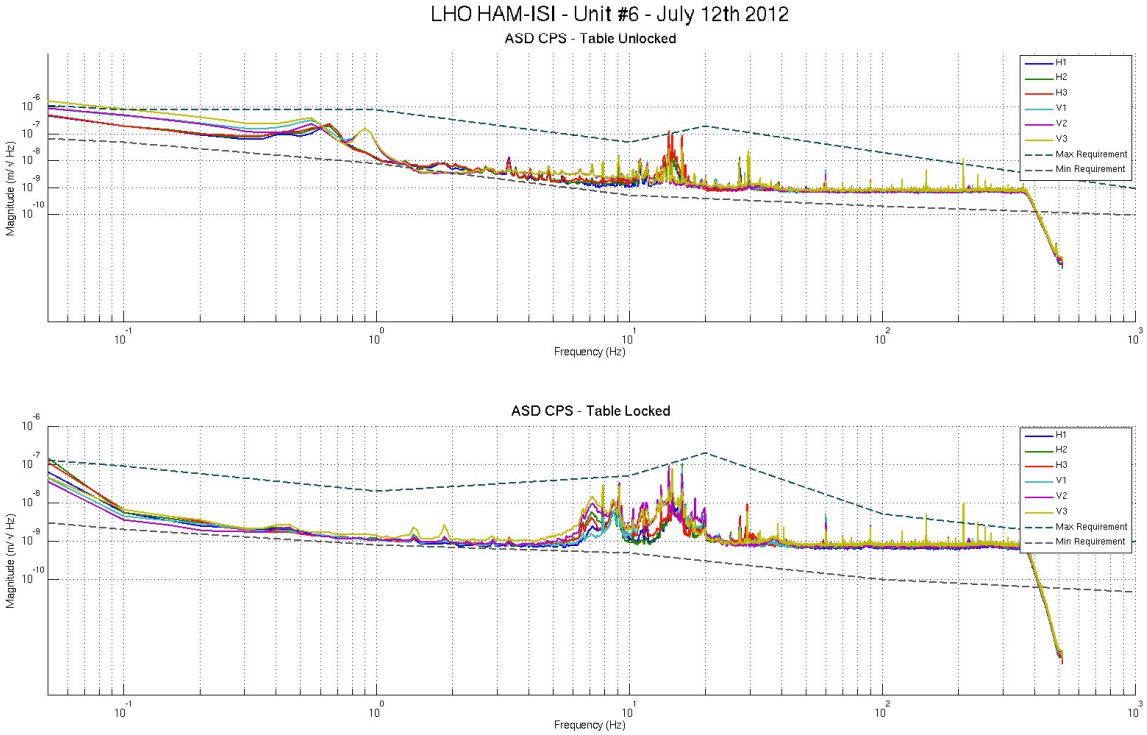


Figure - Calibrated CPS power spectra

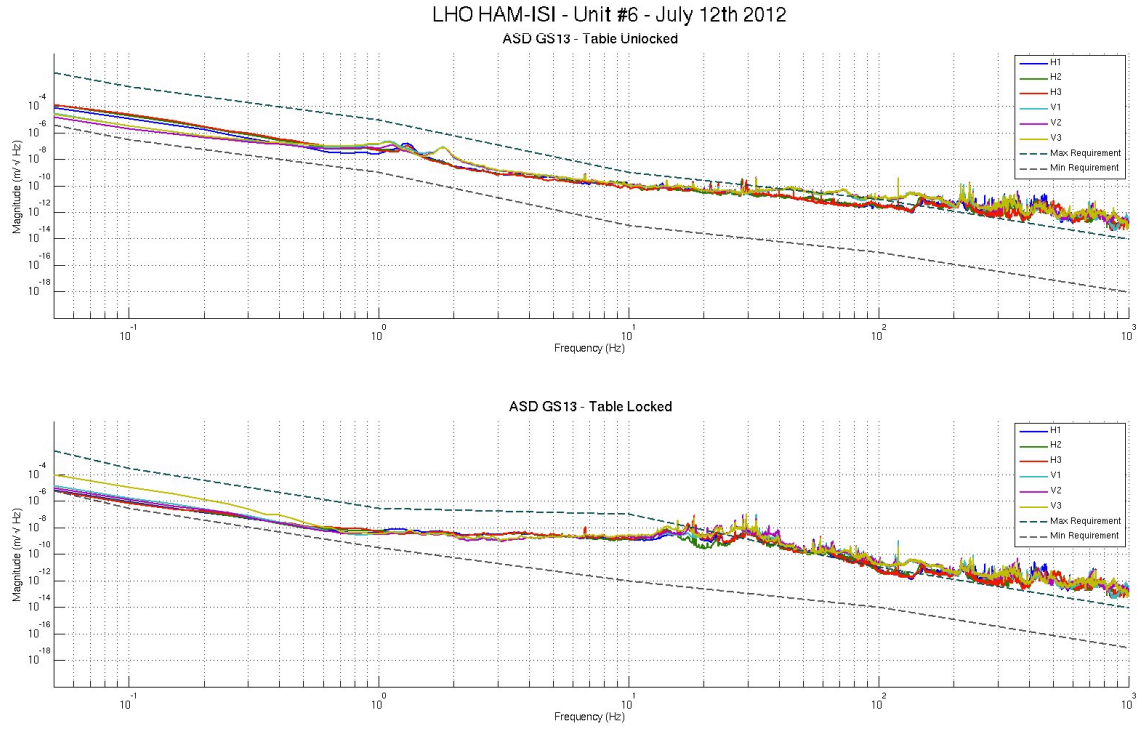


Figure – Calibrated GS13 Power spectra

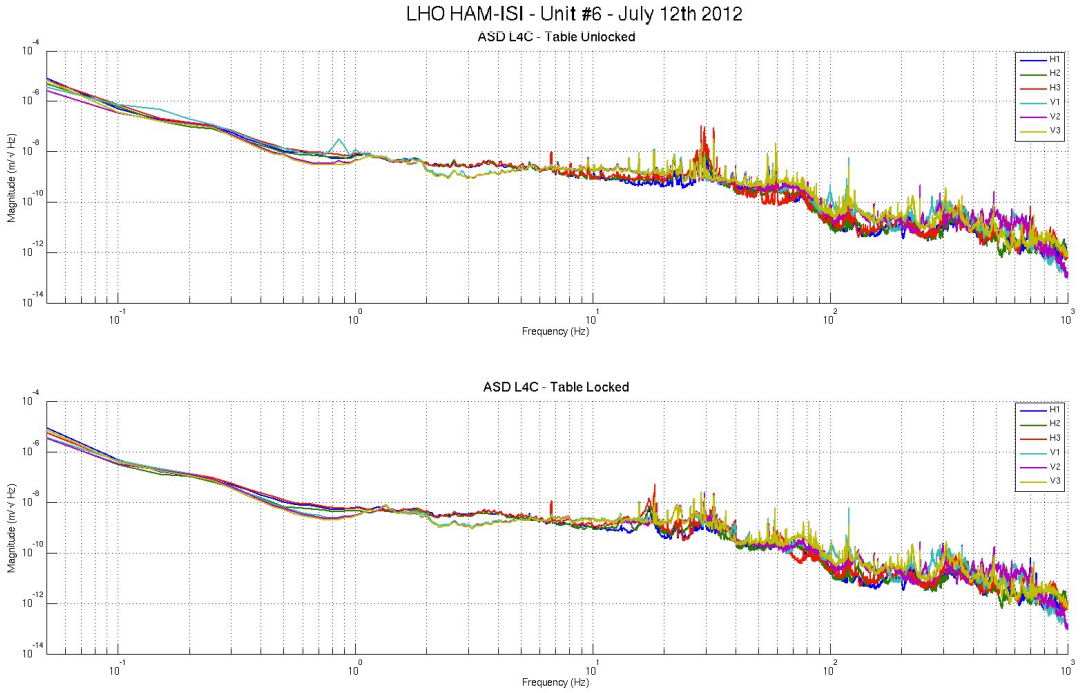


Figure – Calibrated L4C Power spectra

Scripts files for processing and plotting in SVN at:
/SeiSVN/seismic/HAM-ISI/Common/Testing_Functions_HAM_ISI/

- ASD_Measurements_Locked_Unlocked_HAM_ISI.m

Data in SVN at:
SeiSVN/seismic/ HAM-ISI/X1/HAMX/Data/Spectra/Undamped/

- LHO_ISI_UNIT_6_ASD_m_CPS_T240_L4C_GS13_Locked_vs_Unlocked_2012_07_13.mat

Figures in SVN at:
/SeiSVN/seismic/HAM-ISI/X1/HAMX/Data/Figures/Spectra/Undamped

- LHO_ISI_UNIT_6_ASD_m_L4C_Requirements_Locked_vs_Unlocked_2012_07_13
- LHO_ISI_UNIT_6_ASD_m_GS13_Requirements_Locked_vs_Unlocked_2012_07_13
- LHO_ISI_UNIT_6_ASD_m_CPS_Requirements_Locked_vs_Unlocked_2012_07_13

Issues/difficulties/comments regarding this test:

- 10Hz-100Hz peaks on CPS spectra were investigated for the testing phase I of Unit #3, and reported in Part 1, last step: *Capacitive Position Sensor Investigation*, of the related report (Document #E1000312-v3)

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: ____**

Note: When a seismometer fails, its low frequency response is affected. Spectra are within requirements in low frequency. The production GS13s installed on this unit are functional.

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

GS13 spectra when the table is tilted are presented below.

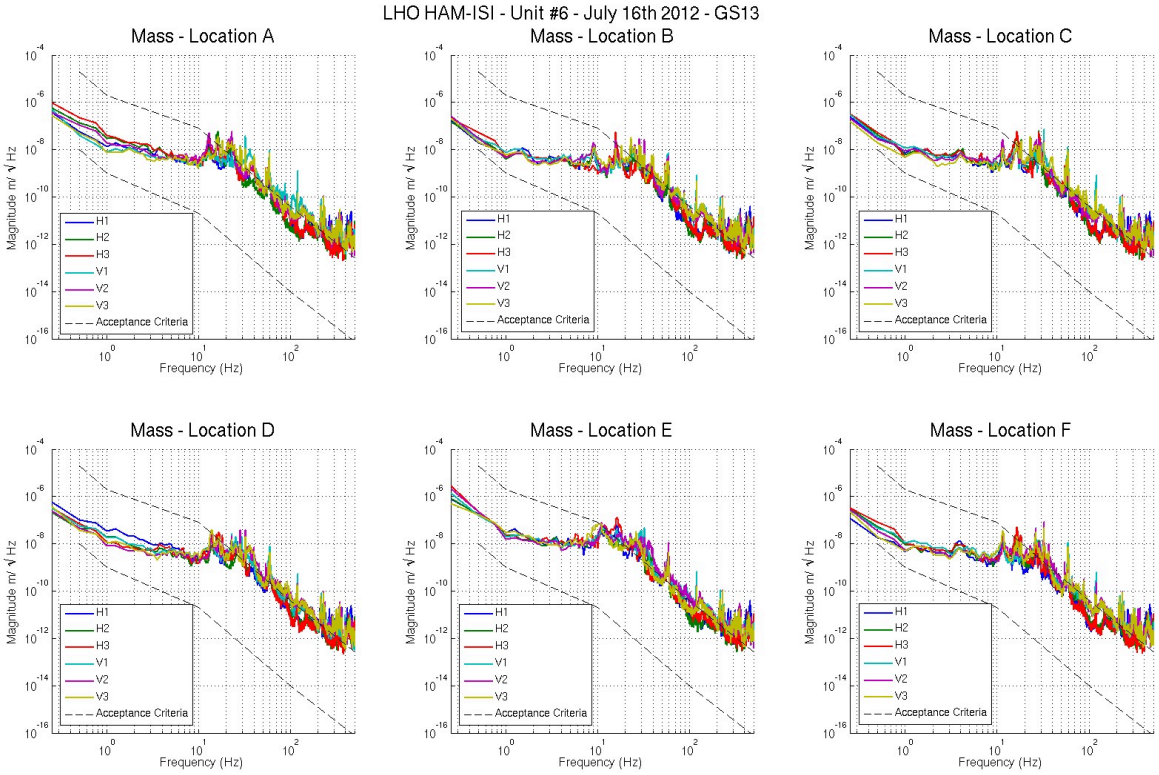


Figure – Power spectrum Calibrated GS13 with mass at corners A to F

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

Data in SVN at:
SeiSVN/seismic/ HAM-ISI/X1/HAMX/Data/Spectra/Undamped/
- LHO_ ISI_UNIT_6_ASD_m_GS13_Stage_Tilted_2012_07_16

Figures in SVN at:
SeiSVN/seismic/HAM-ISI/X1/HAMX/Data/Figures/Spectra/Undamped
- LHO_ISI_UNIT_6_m_PSD_GS13_Tilted_2012_07_16

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

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

Note:
When a seismometer fails, its low frequency response is affected. Spectra are within requirements in low frequency. The production GS13s installed on this unit are functional.

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

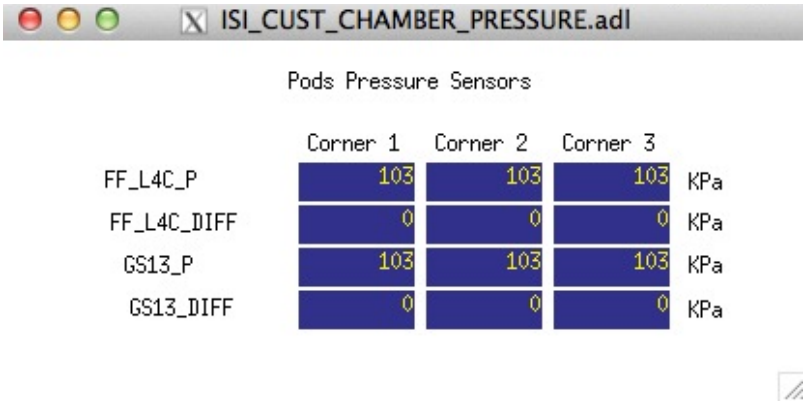


Figure – Pressure Readouts (07/16/2012)

Acceptance criteria:
- The pressure on *GS13_P* channels must be 102KPa +/-8 KPa (25000 counts +/- 3000 counts)
- *GS13_P* must vary the same way in each corner and *GS13_DIFF* must be constant (channels follow comparable trend)

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

Note: Pressure fluctuated a lot with the recent changes of temperature. The drift observed on CPS readouts appears well correlated to the evolution of pressure (See figure below. More details in LHO aLOG #3371).

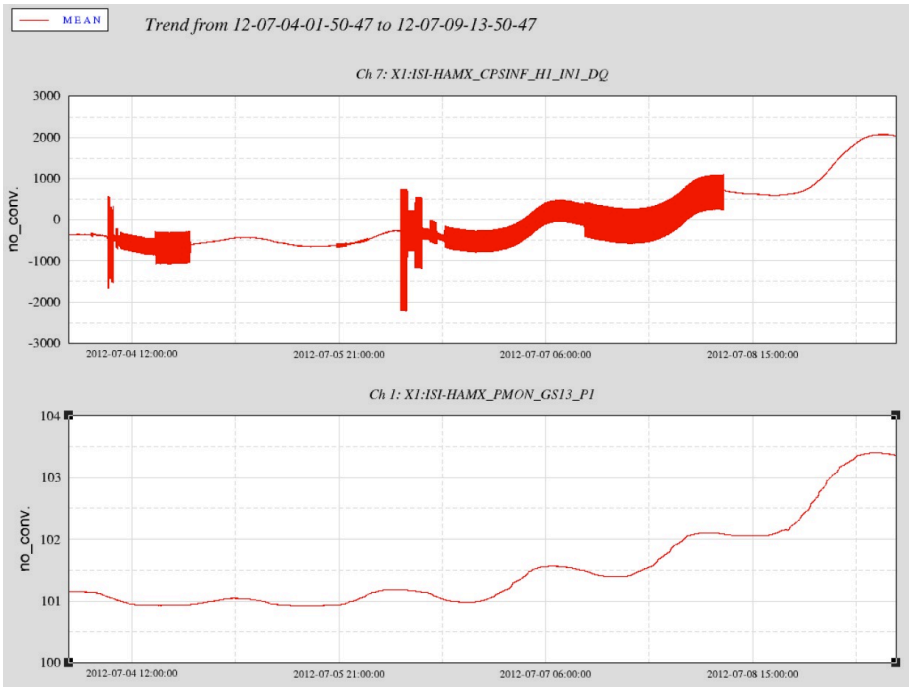


Figure – CPS vs Pressure readouts – Over 5 ½ days (UTC time)

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

Actuator	V1		H1		V2	
Coil driver	S1000266 - Coarse 2		S1000266 - Coarse 1		S1000269 - Coarse 2	
Cable #	S1104096		S1106673		S1106676	
Resistance (Ohm)	P1 - P2	P2 - P3	P1 - P2	P2 - P3	P1 - P2	P2 - P3
	O.L (infinity)	6.8	O.L (infinity)	6.8	O.L (infinity)	6.9
MEDM offset (1000 counts)	Measurement P2 (+) ; P1&P3 (-)		Measurement P2 (+) ; P1&P3 (-)		Measurement P2 (+) ; P1&P3 (-)	
	0.3070V		0.3117V		0.3115V	

Actuator	H2		V3		H3	
Coil driver	S1000269 - Coarse 1		S1102692 - Coarse 2		S1102692 - Coarse 1	
Cable #	S1104097		S1104101		S1104099	
Resistance (Ohm)	P1 - P2	P2 - P3	P1 - P2	P2 - P3	P1 - P2	P2 - P3
	O.L (infinity)	6.9	O.L (infinity)	6.9	O.L (infinity)	6.9
MEDM offset (1000 counts)	Measurement P2 (+) ; P1&P3 (-)		Measurement P2 (+) ; P1&P3 (-)		Measurement P2 (+) ; P1&P3 (-)	
	0.3138V		0.3044V		0.3106V	

Table - Actuators resistance check

Issues/difficulties/comments regarding this test:

- Voltages measured from Pin #2 (+) to pin #3 (-) with compensation filters engaged.
- Resistances are given +/-0.2V

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 #3 (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 #1 (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)	-23224	355	24555	47779
H2 readout (count)	-24092	-1	23617	47709
H3 readout (count)	-24503	245	24654	49157
V1 readout (count)	-18817	157	19937	38754
V2 readout (count)	-25768	297	26901	52669
V3 readout (count)	-22341	257	21736	44077

Table - Range of motion - Local drive

Issues/difficulties/comments regarding this test:

- Test performed BEFORE the dramatic temperature changes that caused Stage-1 to be lowered.
- Compensation filters are ON.
- Symmetrization filters are OFF

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	-18.50	0.00	19.00
B	-18.00	0.00	18.00
C	-18.50	0.00	18.50
D	-19.10	0.00	19.00
Average	-18.53	0.00	18.63

Sensors	Counts	Counts	Counts	Difference
V1	-14856.00	679.18	16031.00	30887.00
V2	-14643.00	1063.20	16808.00	31451.00
V3	-14656.00	471.94	15795.00	30451.00

Vertical Sensibility	
832.56	Count/mil
0.51	V/mil
30.51	nm/count
-0.89	% from ref (840count/mil)

Issues/difficulties/comments regarding this test:

- Test performed AFTER the dramatic temperature changes that caused Stage-1 to be lowered.

Acceptance criteria:

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

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

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

Sensors	Mean diff counts	Mean diff m	K (N/m)	Error with average
V1	-7784	-2.351E-04	85182	2.09%
V2	-8033	-2.426E-04	82537	-1.08%
V3	-8027	-2.424E-04	82602	-1.00%
		Average (N/m)	250321	
			1.33	% variation from nominal

Table - Vertical spring constant

Issues/difficulties/comments regarding this test:

- Test performed AFTER the dramatic temperature changes that caused Stage-1 to be lowered. Hence, blade stiffness might be underestimated.

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

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

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

	Sensors (counts)					
	H1	H2	H3	V1	V2	V3
H1	2097	1318	1310	-13	2	13
H2	1277	2056	1293	-14	4	10
H3	1281	1286	2054	0	-5	-6
V1	186	191	-387	1496	-39	-661
V2	-410	204	199	-662	1510	-56
V3	189	-392	204	-49	-651	1444

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	2.05	2241.39	2.02	1.65
H2	2.01	2443.47		-0.33
H3	1.99	2636.76		-1.32
V1	1.44	906.31	1.43	0.70
V2	1.44	453.42		0.36
V3	1.42	596.87		-1.06

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

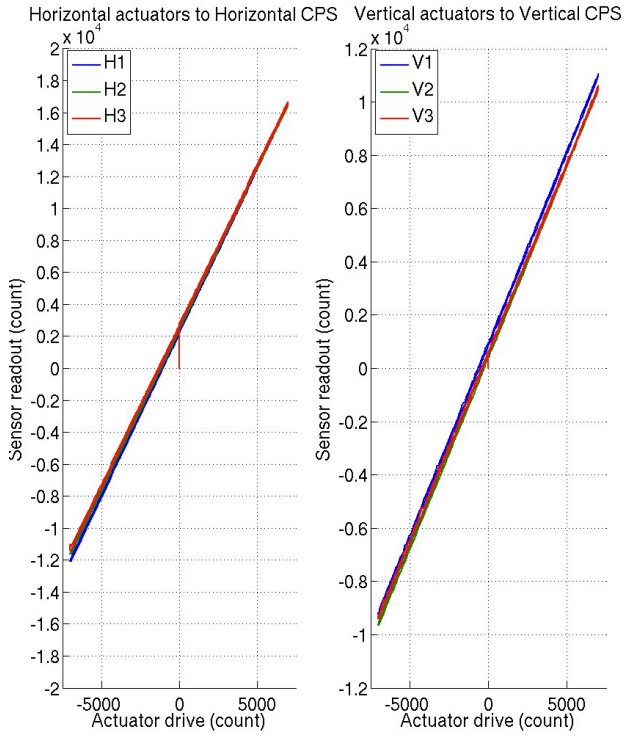


Figure - Linearity test on the triplet 'actuators - HAM-ISI – sensors' in both Horizontal and vertical directions

Issues/difficulties encountered during this test:

- H1, slightly out of requirements.
- Unusual noise on H3 around 200cts. Minor issue. Measurement good enough to compute the linearity of the actuators. Peak not featured on previous linearity measurements of this Unit.
- The tendencies on linearity test slopes seem to match the tendencies on cable resistance (coildriver to feedthrough section). Cable resistance, which is proportional to cable length, would then be a possible explanation for the linearity results obtained.
- Test performed AFTER the dramatic temperature changes that caused Stage-1 to be lowered.

Acceptance criteria:

- Horizontal and vertical slopes of the triplet actuators x HAM-ISI x sensors: Average slope +/- 1.5%

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

Note: we will check that these values are 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	282.27	271.86	-512.8	10.458	6.8598	-15.222	514.77
Y Drive	-470.12	429.42	-18.594	-7.767	-11.684	-4.3266	513.37
Z Drive	-9.2672	6.2335	-3.7407	257.35	284.18	244.57	262.78
Rx Drive	-466.56	480.49	-8.7913	-500.86	1740.2	-1237.2	2655.6
Ry Drive	-273.13	-264.37	547.21	-1741.3	419.16	1271.8	2659
Rz Drive	-2011.7	-2008.9	-2007.5	-11.823	-11.107	2.1088	2546.9

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	-	-	-				+

1000 counts Drive	X	Y	Z	RX	RY	RZ	Direction read out
X Drive	514.77	-3.1062	-5.7654	-18.763	-17.896	-18.709	514.77
Y Drive	-3.0346	513.37	-1.6451	24.245	-9.781	24.22	513.37
Z Drive	-5.6827	4.7914	262.78	11.13	10.43	5.086	262.78
Rx Drive	3.7762	4.7105	-13.145	2655.6	-2.5031	3.5096	2655.6
Ry Drive	4.8097	1.631	-16.182	13.652	2659	4.0995	2659
Rz Drive	-6.8198	1.2627	4.4958	-4.3493	36.663	2546.9	2546.9

Table – Cartesian static testing reference table

Issues/difficulties/comments regarding this test:

- Test performed BEFORE the dramatic temperature changes that caused Stage-1 to be lowered.

Acceptance criteria:

For a positive drive in the Cartesian basis:

- Local sensor readout must have the same sign that the reference table
- Cartesian sensors read out must be positive 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	Estimated duration (min)
0.01	0.1	0.01	3500	3500	620	10	103.3
0.1	0.5	0.02	420	420	320	30	160
0.5	5	0.025	24.5	24.5	260	55	238.3
5	200	0.1	140	140	80	50	66.7
200	1000	0.2	140	140	50	150	125
					Estimated Measurement Time (h)		11.6

Table – Transfer function settings, by frequency band

Data collection script files:
/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

Data files in SVN at:
/SeiSVN/seismic/HAM-ISI/X1/HAMX/Data/Transfer_Functions/Measurements/Undamped/
- LHO_ISI_HAM_Unit_6_Data_TF_L2L_200Hz_1000Hz_20120713-174342.mat'
- LHO_ISI_HAM_Unit_6_Data_TF_L2L_5Hz_200Hz_20120713-190116.mat'
- LHO_ISI_HAM_Unit_6_Data_TF_L2L_500mHz_5Hz_20120713-195449.mat'
- LHO_ISI_HAM_Unit_6_Data_TF_L2L_100mHz_500mHz_20120713-234425.mat'
- LHO_ISI_HAM_Unit_6_Data_TF_L2L_10mHz_100mHz_20120714-022604.mat'

Scripts files for processing and plotting in SVN at:
/SeiSVN/seismic/HAM-ISI/X1/HAMX/Scripts/Control_Scripts/Version_0/
- Step_1_TF_Loc_to_Loc_X1_ISI_HAMX

Figures in SVN at:
/SeiSVN/seismic/HAM-ISI/X1/HAMX/Data/ Figures/Transfer_Functions/Measurements/Undamped/
- X1_ISI_HAMX_TF_L2L_Raw_from_ACT_to_CPS_2012_07_13.fig
- X1_ISI_HAMX_TF_L2L_Raw_from_ACT_to_GS13_2012_07_13.fig

Storage of measured transfer functions in the SVN at:
/SeiSVN/seismic/HAM-ISI/X1/HAMX/Data/Transfer_functions/ Simulations/Undamped/
- X1_ISI_HAMX_TF_L2L_Raw_2012_07_13.mat

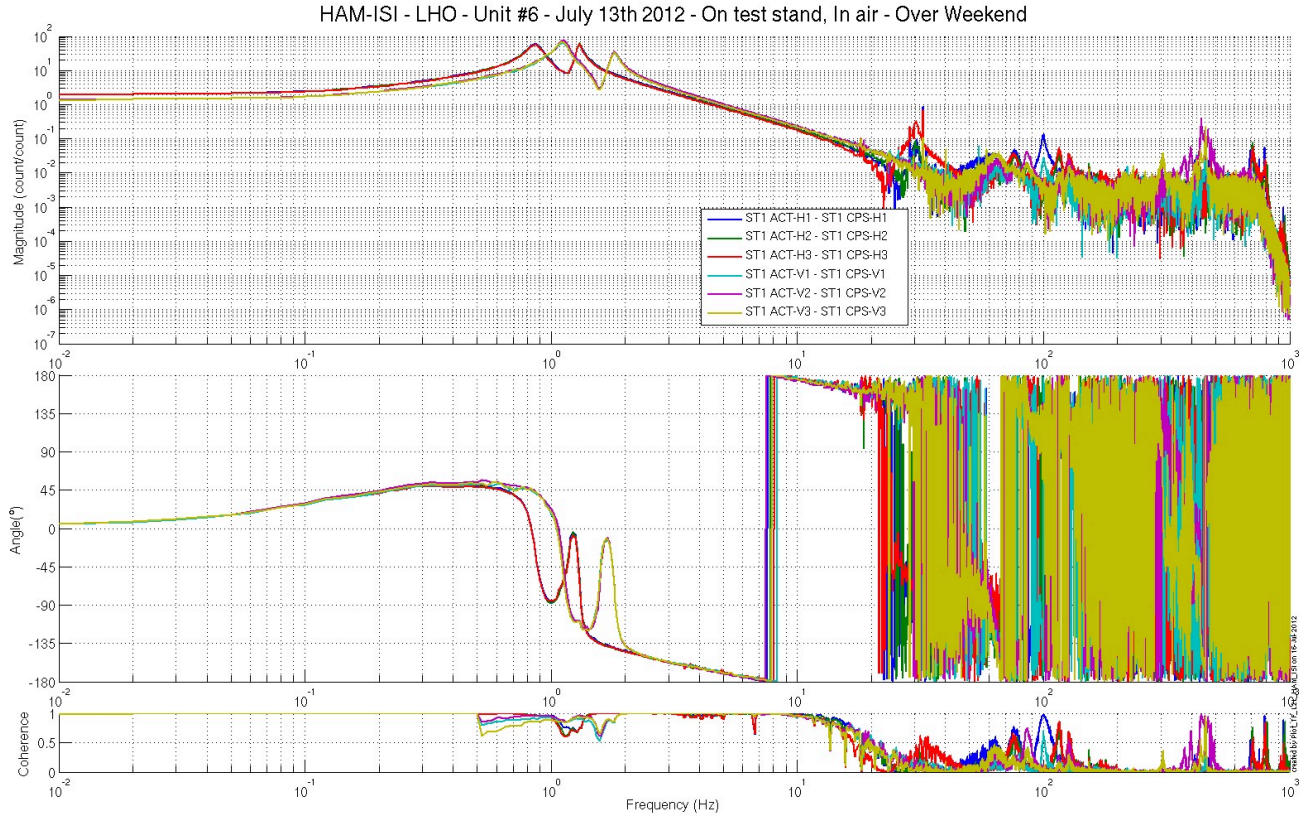


Figure - local-to-Local Measurements – Capacitive sensors

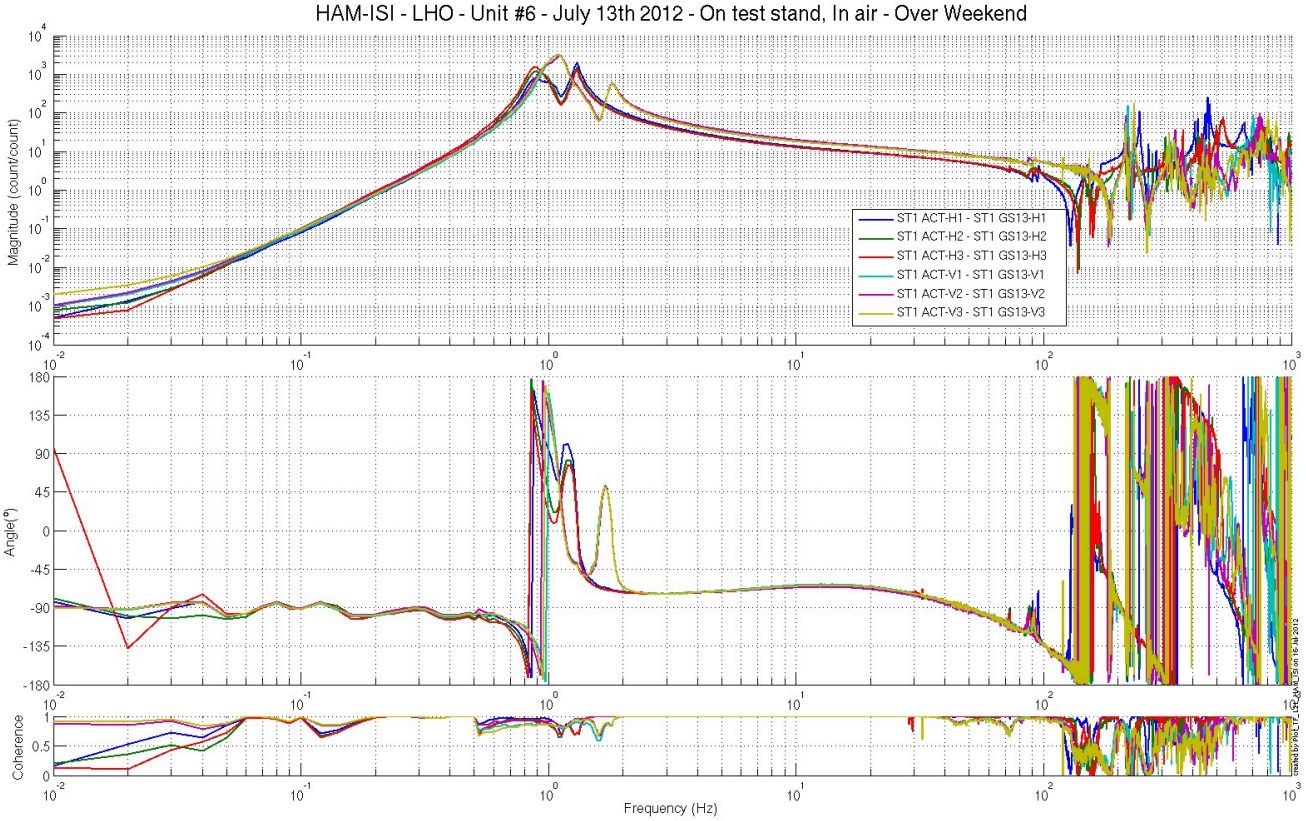


Figure - local-to-Local Measurements – Inertial sensors

Issues/difficulties/comments regarding this test:
Around 1Hz, H1-GS13 Transfer Function is very different from the transfer functions measured with the other horizontal GS13s. It comes from the response of GS13-H1 whose resonance frequency is significantly higher.

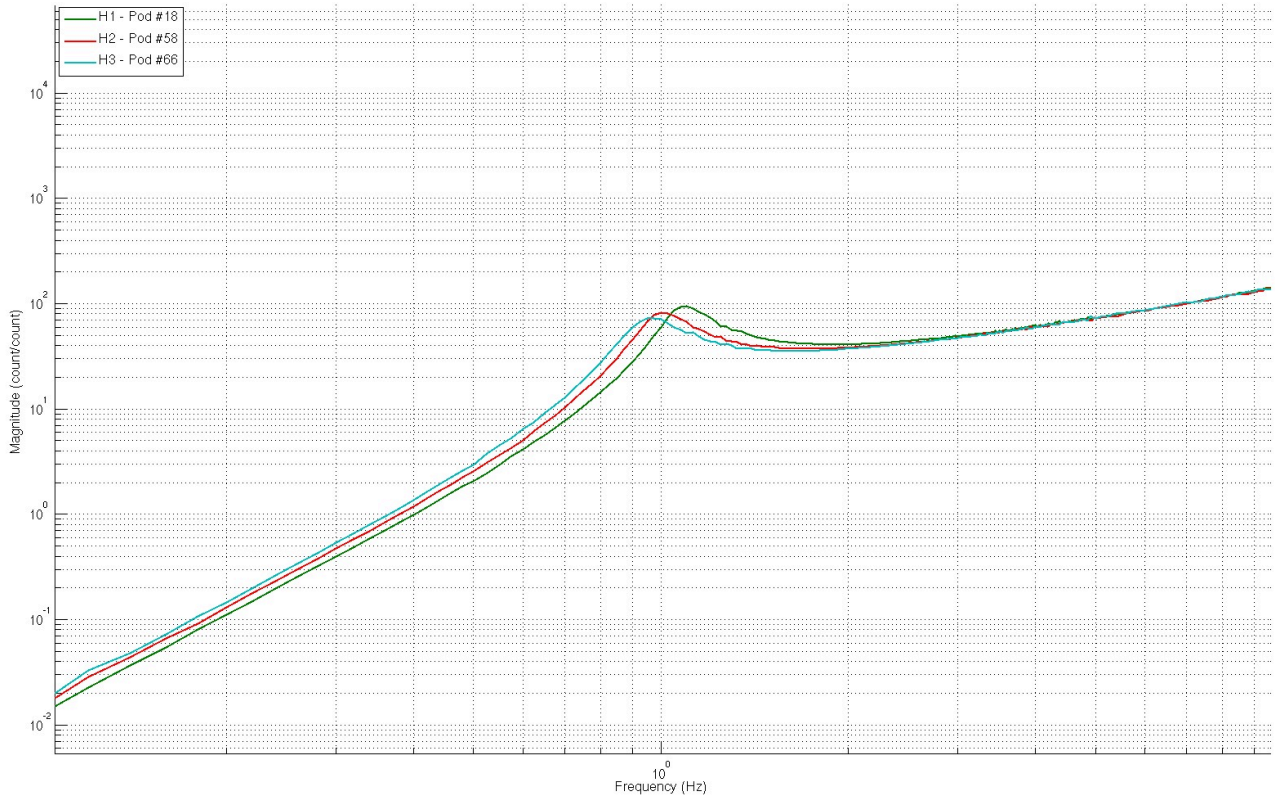


Figure – Extracted Instrument Responses – Horizontal Inertial sensors

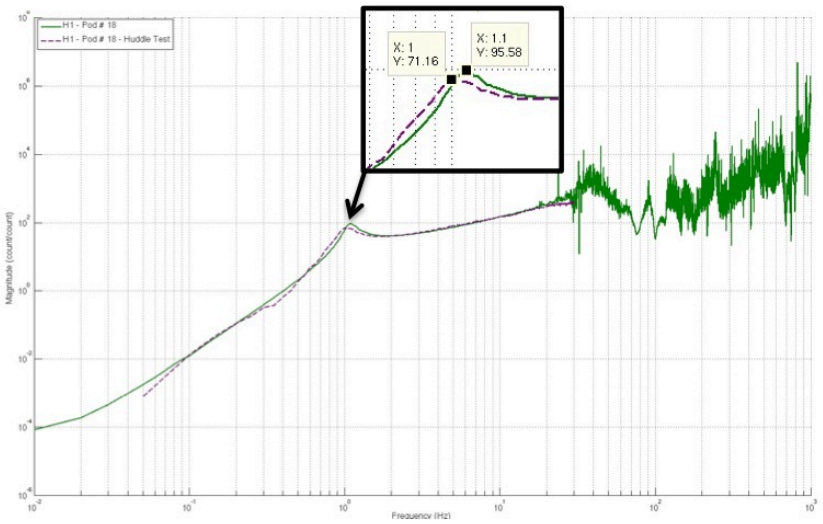
Acceptance criteria:

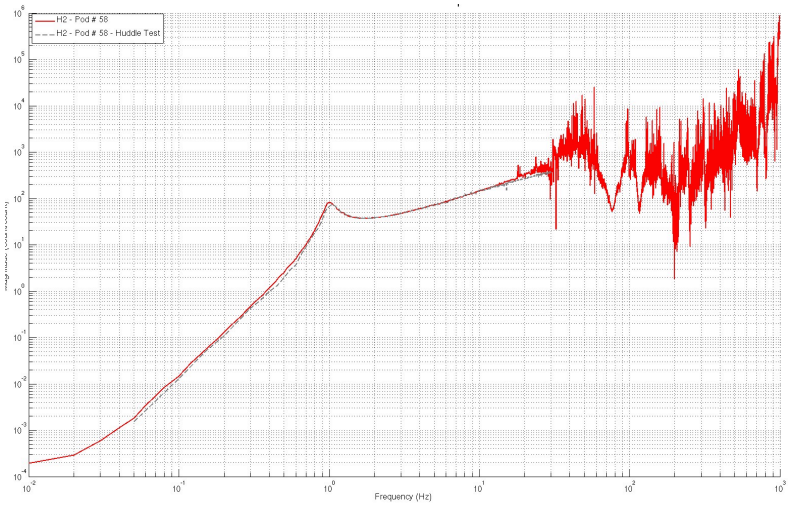
- Local to local measurements
  - On CPS, the phase must be 0º at DC
  - On Geophones, the phase must be -90º at DC
  - Identical shape in each corner

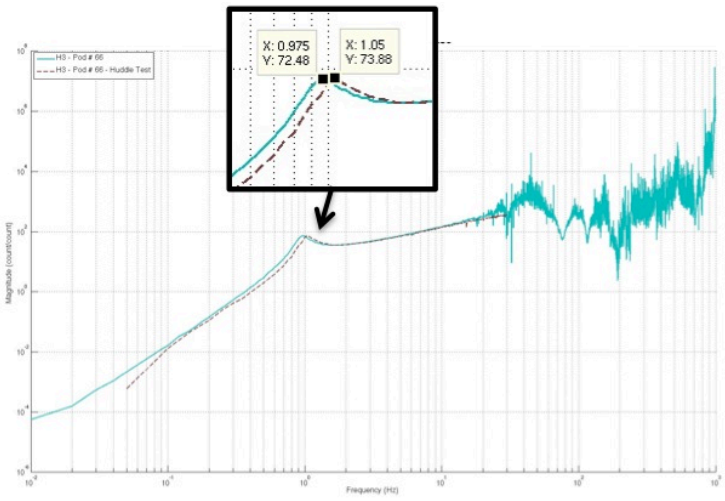
Test result: **Passed: X** **Failed: ____**

- ***Step 16.2 – GS13 Response extraction***

Plots for the extracted responses are presented below.







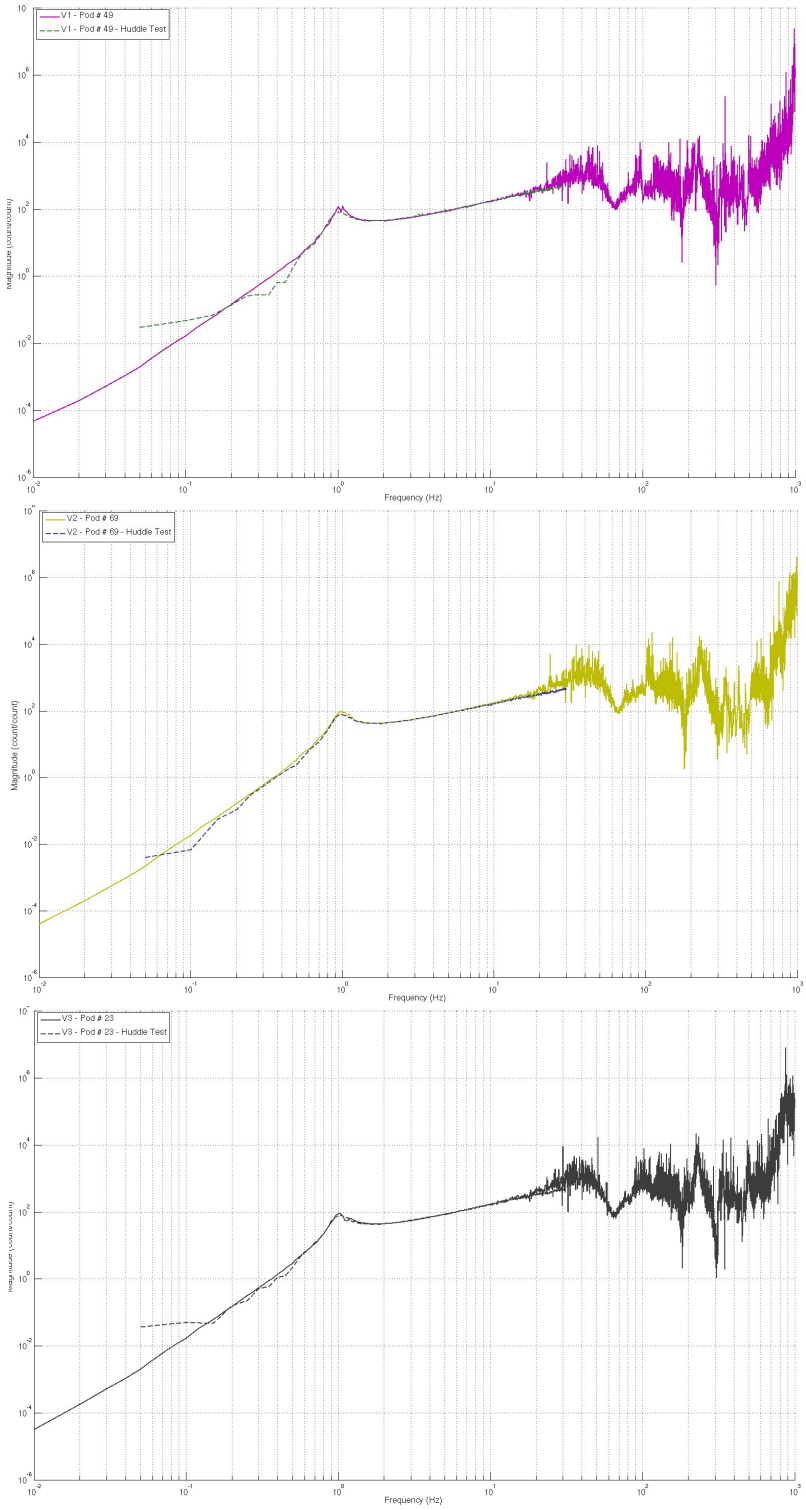


figure – GS13 extracted responses VS Huddle test responses

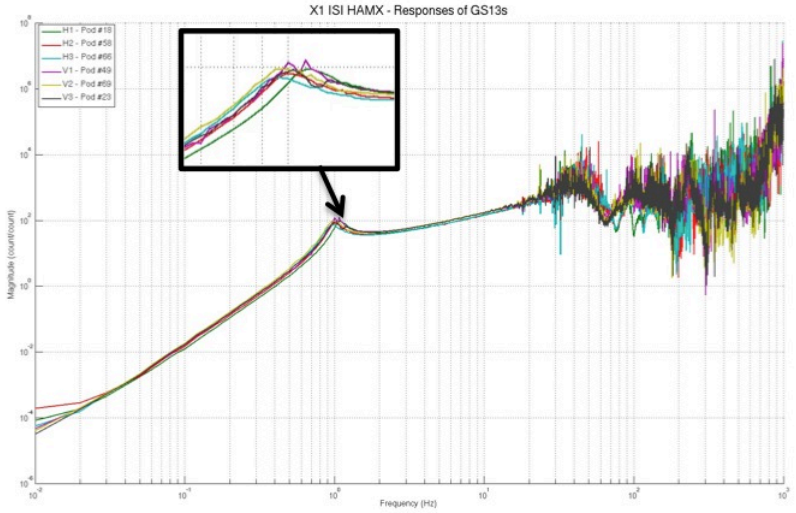


figure – Extracted GS13 responses comparison

Issues/difficulties encountered during this test:

- The extraction process does not appear optimal at the resonance on V1 and V3.
- Horizontal GS13s were taken apart and reassembled after their initial huddle test to install *Nylon Patch Screws* on the flexures mounts.
- Vertical GS13s were taken apart and reassembled after their initial huddle test to insert *Loctite*® on the screws holding the flexures.
- The Electronics and/or Digital filters used for the initial huddle testing seem to have varied along the huddle testing campaign. Gains vary from one sensor to another. Resonance frequencies are, however, unaffected which allow us to analyze their evolution.
- Lots of pods have encountered rework since the huddle testing campaign. The rework operations, such as flexure replacement or preamplifier replacement, did most likely affect the frequency responses of the instruments. Hence, these modifications would be a good explanation for the resonance frequency shifts observed between the huddle test and the extracted response of some pods.

GS13 response extraction plots under the SVN at:
/SeiSVN/seismic/HAM-ISI/X1/HAMX/Data/Figures/Instrument_Responses/GS13/

- X1_ISI_HAMX_Fitted_Responses_Comparison.fig
- X1_ISI_HAMX_GS13_H1_Pod_18_Extracted_Response_VS_Huddle.fig
- X1_ISI_HAMX_GS13_H2_Pod_58_Extracted_Response_VS_Huddle.fig
- X1_ISI_HAMX_GS13_H3_Pod_66_Extracted_Response_VS_Huddle.fig
- X1_ISI_HAMX_GS13_V1_Pod_49_Extracted_Response_VS_Huddle.fig
- X1_ISI_HAMX_GS13_V2_Pod_69_Extracted_Response_VS_Huddle.fig
- X1_ISI_HAMX_GS13_V3_Pod_23_Extracted_Response_VS_Huddle.fig

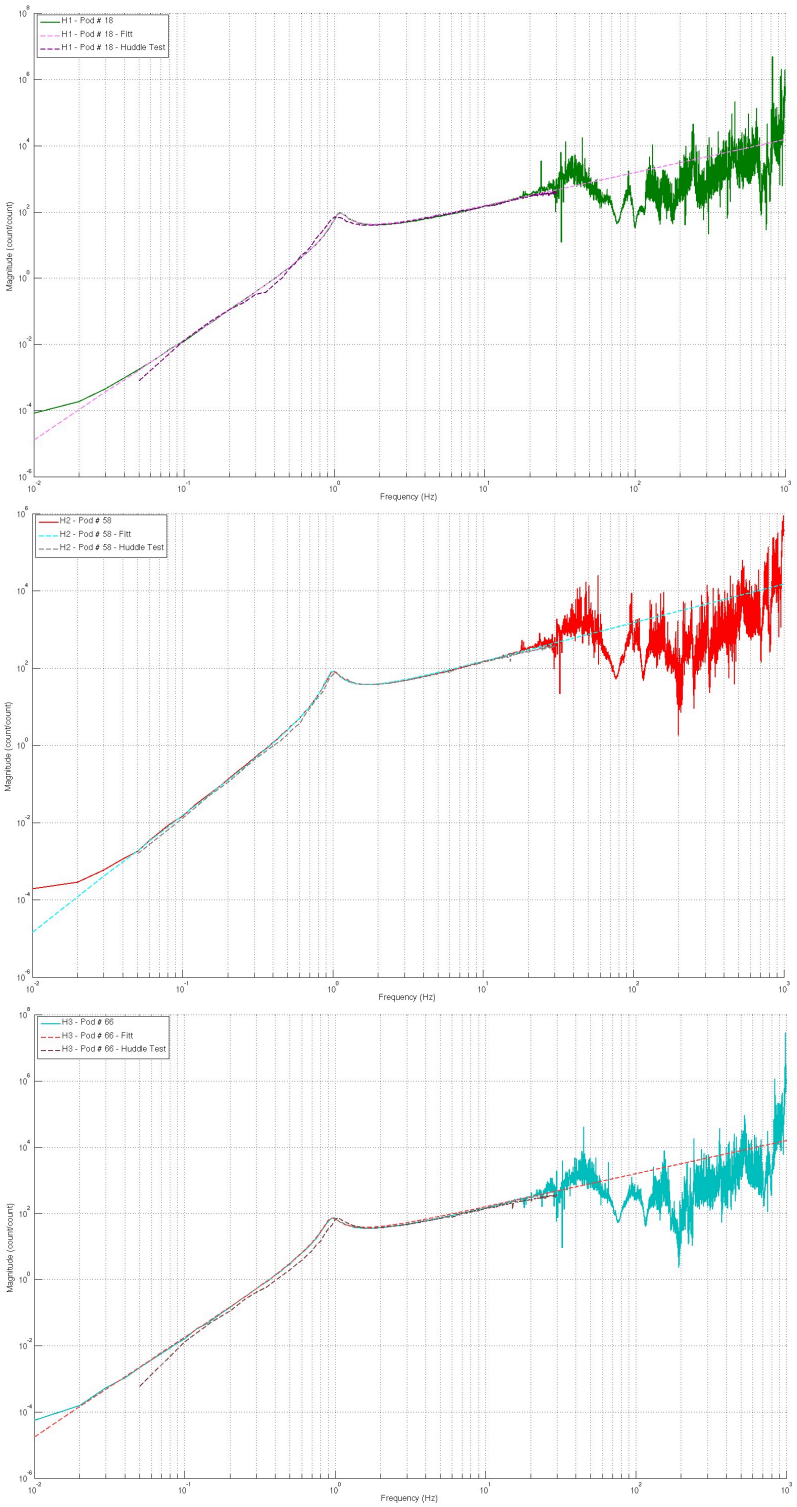
Acceptance criteria:

- The resonance frequency shift between the initial huddle test measurement and the extracted response must be lower than 15%

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

- ***Step 16.3 GS13 response fitting***

Fitted responses for the GS13s are presented below.



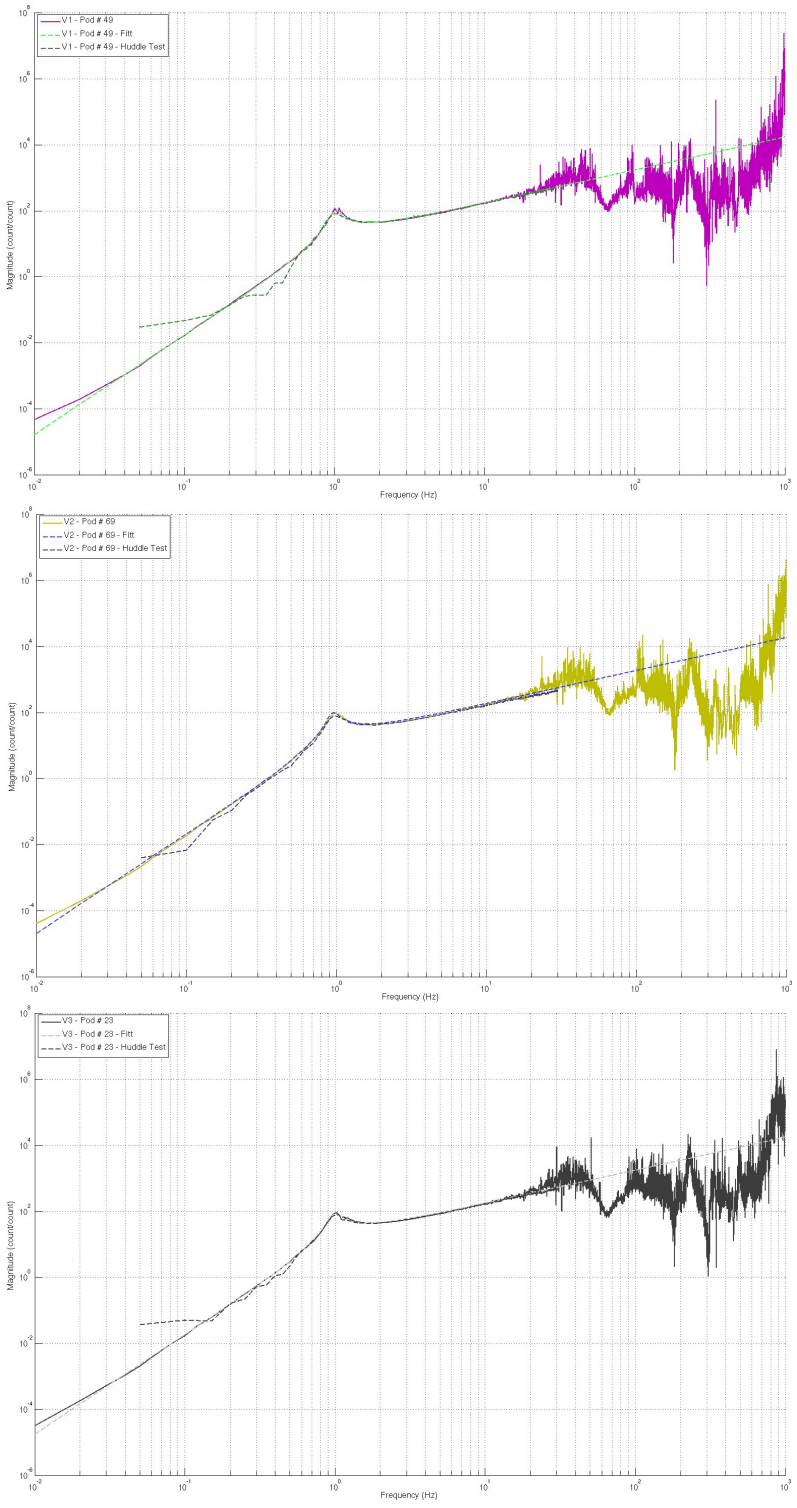


figure – Fitted responses of the GS13s

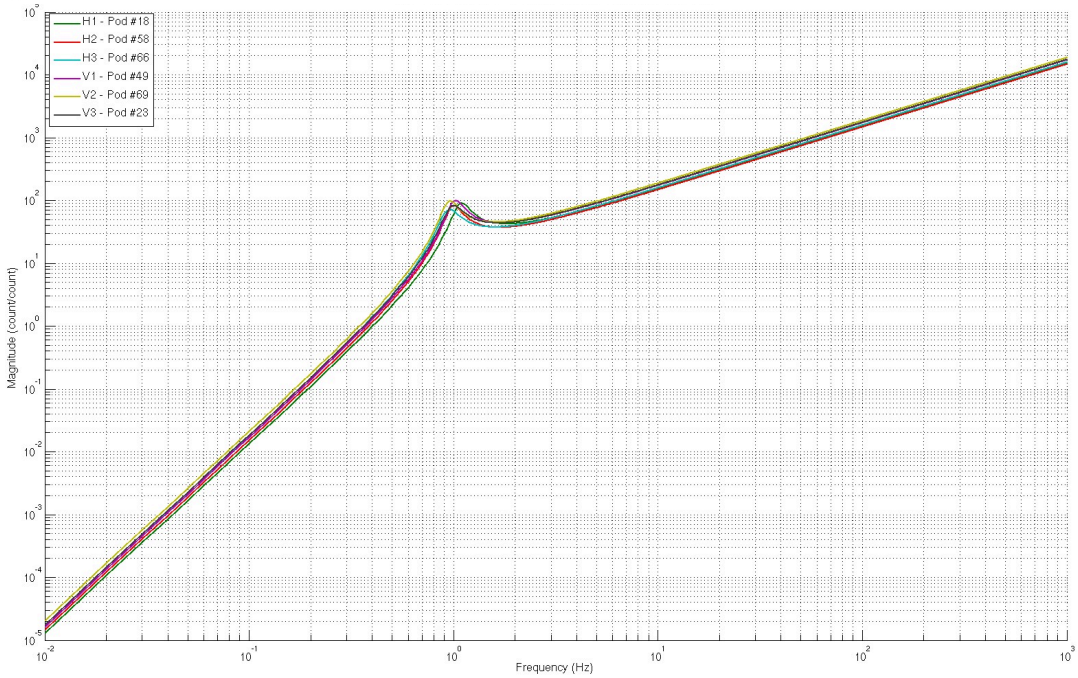


figure – Comparison of the fitted responses for the GS13s

GS13 response fitting plots under the SVN at:
/SeiSVN/seismic/HAM-ISI/X1/HAMX/Data/Figures/Instrument_Responses/GS13/

- X1_ISI_HAMX_Fitted_Responses_Comparison.fig
- X1_ISI_HAMX_GS13_H1_Pod_18_Extracted_Response_VS_Fitt_VS_Huddle.fig
- X1_ISI_HAMX_GS13_H2_Pod_58_Extracted_Response_VS_Fitt_VS_Huddle.fig
- X1_ISI_HAMX_GS13_H3_Pod_66_Extracted_Response_VS_Fitt_VS_Huddle.fig
- X1_ISI_HAMX_GS13_V1_Pod_49_Extracted_Response_VS_Fitt_VS_Huddle.fig
- X1_ISI_HAMX_GS13_V2_Pod_69_Extracted_Response_VS_Fitt_VS_Huddle.fig
- X1_ISI_HAMX_GS13_V3_Pod_23_Extracted_Response_VS_Fitt_VS_Huddle.fig

Acceptance criteria:

- The resonance frequency difference between the extracted response and the fitted response must be less than 5%
- The amplitude shift between the extracted response and the fitted response must be less than 10% between 0.1Hz and 100Hz.

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

- ***16.4 Symmetrization Filters***

Symmetrized Local to Local TFs are presented below.

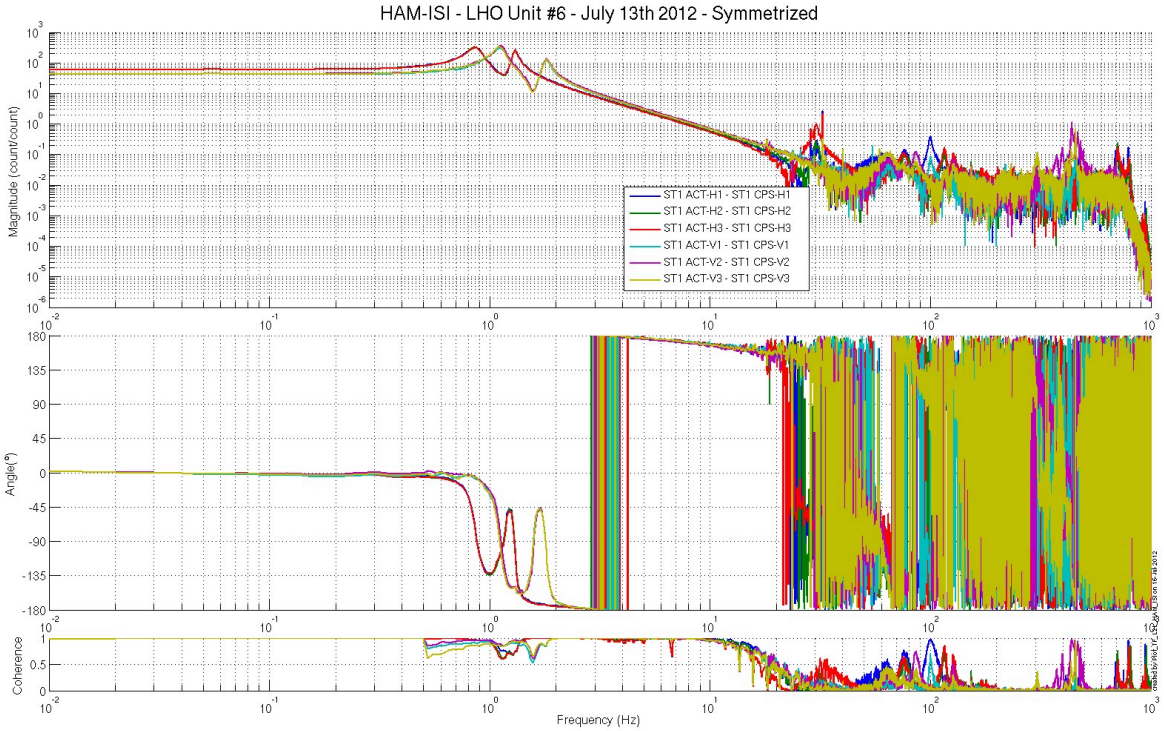


figure – Symmetrized L2L – Computed TFs – Capacitive sensors

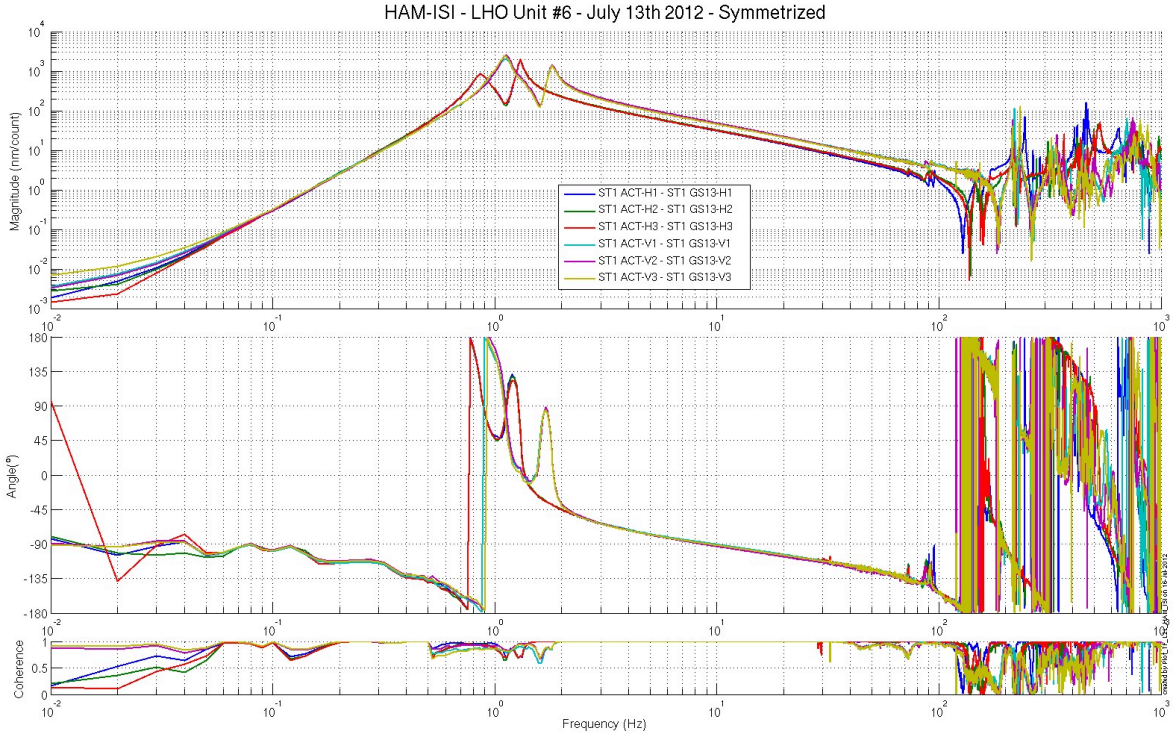


figure – Symmetrized L2L – Computed TFs – Inertial sensors

Symmetrization filters under the SVN at:
/SeiSVN/seismic/HAM-ISI/X1/HAMX/Filters/
- X1_ISI_HAMX_Filters_20120522-134354.mat

Symmetrized L2L TFs under the SVN at:
/SeiSVN/seismic/HAM-ISI/X1/HAMX/Data/Figures/Transfer_Functions/Simulations/Undamped/
- X1_ISI_HAMX_TF_L2L_Symmetrized_from_ACT_to_GS13_2012_05_22
- X1_ISI_HAMX_TF_L2L_Symmetrized_from_ACT_to_CPS_2012_05_22

Issues/difficulties encountered during this test:
- Symmetrization dilters substantially improved the symmetry of the GS13 Transfer Functions.

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

- ***Step 16.4 - Cartesian to Cartesian TF computation***

The Cartesian to Cartesian transfer functions are presented below:

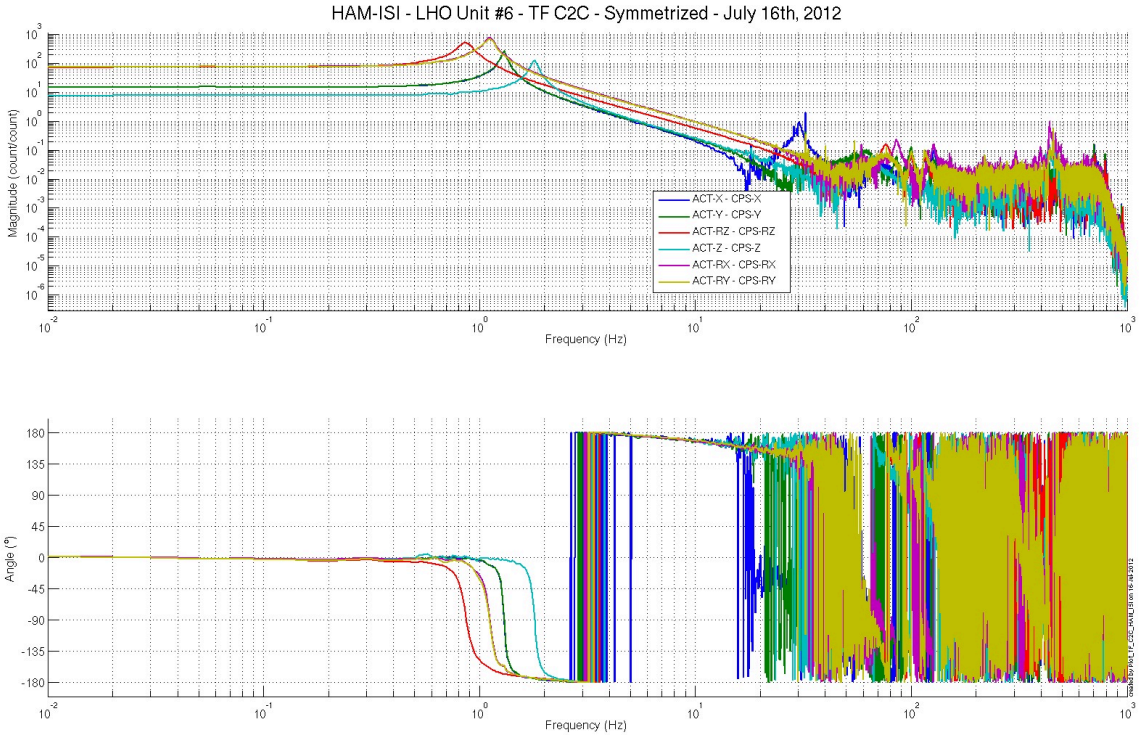


Figure – Cartesian to Cartesian – computed - Capacitive sensors

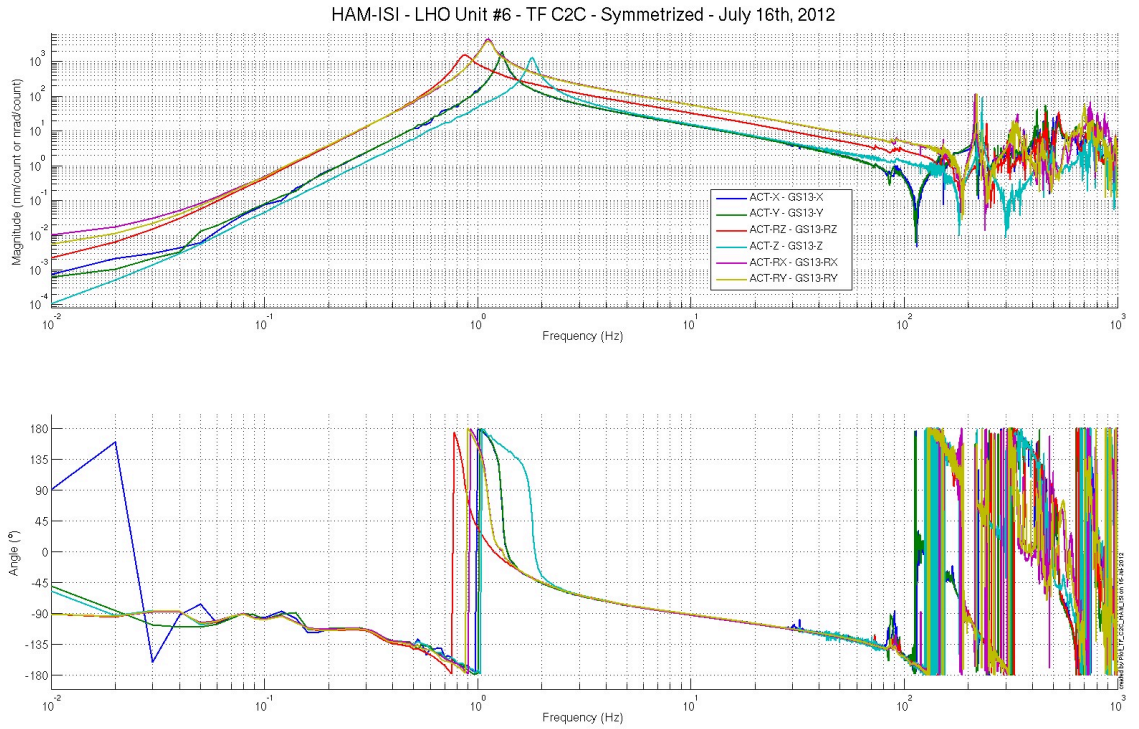


Figure – Cartesian to Cartesian - computed - Inertial sensors

Scripts files for processing and plotting in SVN at:
/SeiSVN/seismic/HAM-ISI/X1/HAMX/Scripts/Control_Scripts/
- Step_3_TF_Cart_to_Cart_X1_ISI_HAMX.m

Figures in SVN at:
/SeiSVN/seismic/HAM-ISI/X1/HAMX/Data/ Figures/Transfer_Functions/Simulations/Undamped/
- X1_ISI_HAMX_TF_C2C_Symmetrized_from_ACT_to_CPS_2012_07_13.fig
- X1_ISI_HAMX_TF_C2C_Symmetrized_from_ACT_to_GS13_2012_07_13.fig

Storage of measured transfer functions in the SVN at:
/SeiSVN/seismic/HAM-ISI/X1/HAMX/Data/Transfer_functions/Simulations/Undamped/
- X1_ISI_HAMX_TF_C2C_Raw_2012_07_13.mat

Acceptance criteria:
- 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***

Scripts files for processing and plotting in SVN at:
/SeiSVN/seismic/HAM-ISI/X1/HAMX/Scripts/Control_Scripts/
- Step_1_Plot_TF_L2L_HAM_Testing.m

/SeiSVN/seismic/HAM-ISI/Common/Testing_Functions_HAM_ISI/
- Step_1_TF_Loc_to_Loc_X1_ISI_HAMX

Local to local comparison figures in SVN at:
/SeiSVN/seismic/ HAM-ISI/X1/HAMX/Data/
Figures/Transfer_Functions/Measurements/Comparisons/L2L/
- X1_ISI_HAMX_TF_L2L_Raw_from_ACT_H_to_CPS_H_vs_UNIT_1_2012_02_02_With_3_Washers_Under_Top_Mass.fig
- X1_ISI_HAMX_TF_L2L_Raw_from_ACT_H_to_CPS_H_vs_UNIT_1_2012_02_02_With_3_Washers_Under_Top_Mass.pdf
- X1_ISI_HAMX_TF_L2L_Raw_from_ACT_H_to_GS13_H_vs_UNIT_1_2012_02_02_With_3_Washers_Under_Top_Mass.fig
- X1_ISI_HAMX_TF_L2L_Raw_from_ACT_H_to_GS13_H_vs_UNIT_1_2012_02_02_With_3_Washers_Under_Top_Mass.pdf
- X1_ISI_HAMX_TF_L2L_Raw_from_ACT_V_to_CPS_V_vs_UNIT_1_2012_02_02_With_3_Washers_Under_Top_Mass.fig

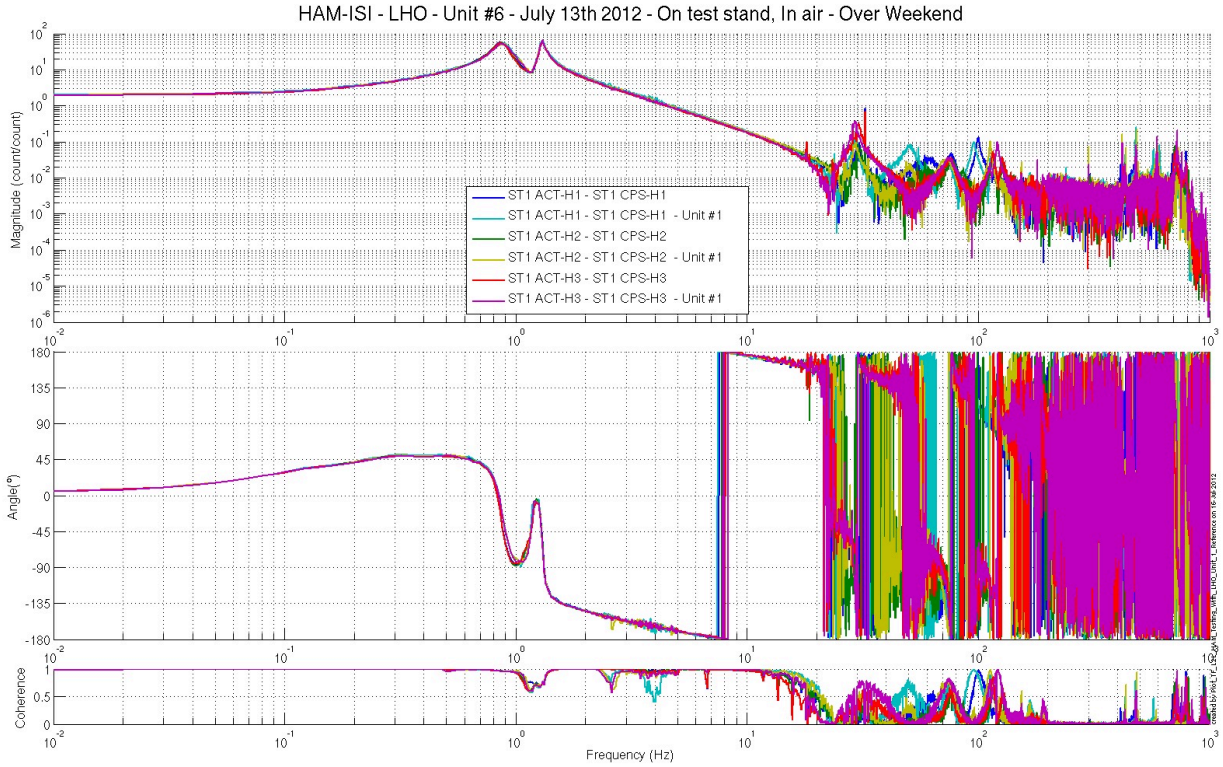


Figure – local-to-Local measurements, comparison with Unit #1 reference
Capacitive Position Sensors - Horizontal motion

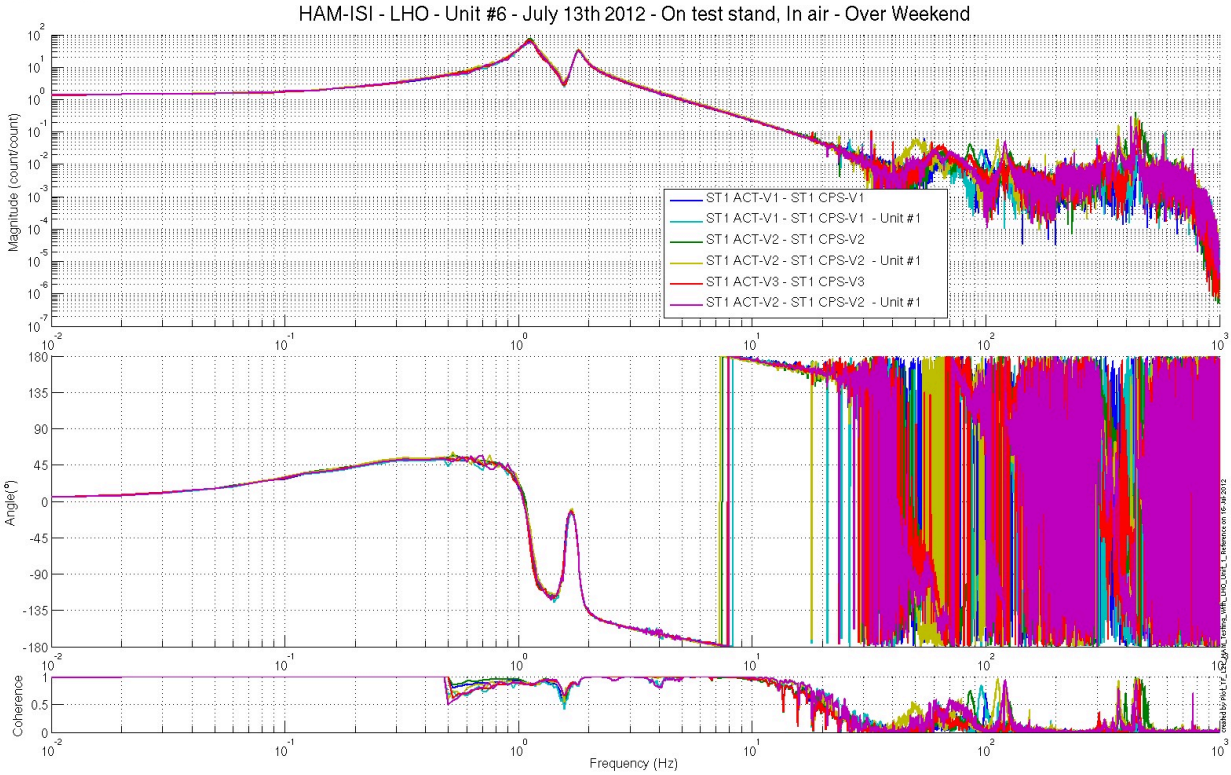


Figure – local-to-Local measurements, comparison with Unit #1 reference
Capacitive Position Sensors - Vertical motion

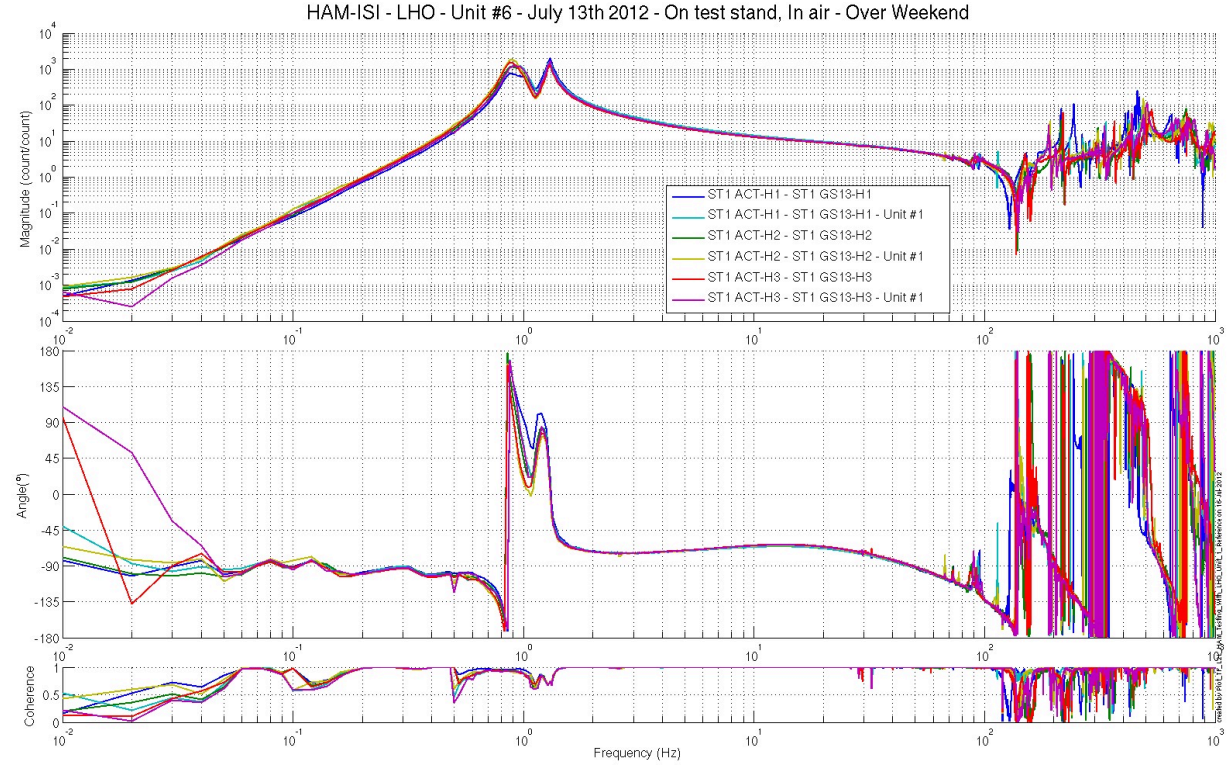


Figure – local-to-Local measurements, comparison with Unit #1 reference
Inertial Sensors - Horizontal motion

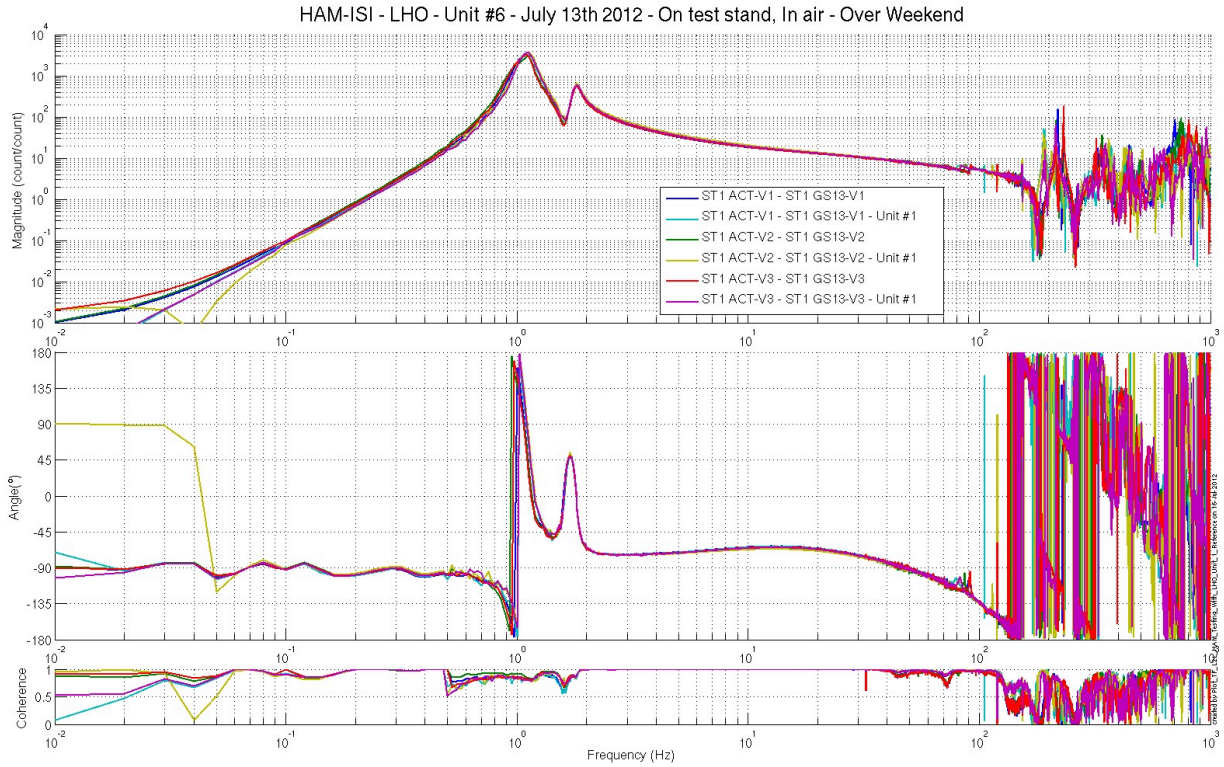


Figure – local-to-Local measurements, comparison with Unit #1 reference
Inertial Sensors - Vertical motion

Acceptance criteria:
No difference with the reference transfer functions (Unit #1)

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

Scripts files for processing and plotting in SVN at:
/SeiSVN/seismic/HAM-ISI/X1/HAMX/Scripts/Control_Scripts/
- Step_3_TF_Cart_to_Cart_M1_ISI_HAMX.m

/SeiSVN/seismic/HAM-ISI/Common/Testing_Functions_HAM_ISI/
- Plot_TF_C2C_HAM_Testing_With_LHO_Unit_1_Reference.m

Cartesian to Cartesian figures in SVN at:
/SeiSVN/seismic/ HAM-ISI/X1/HAMX/Data/
Figures/Transfer_Functions/Measurements/Comparisons/C2C/
- X1_ISI_HAMX_TF_C2C_Raw_from_ACT_H_to_CPS_H_Symmetrized_vs_Unit_1_2012_07_13.fig
  X1_ISI_HAMX_TF_C2C_Raw_from_ACT_V_to_CPS_V_Symmetrized_vs_Unit_1_2012_07_13.fig
- X1_ISI_HAMX_TF_C2C_Raw_from_ACT_H_to_GS13_H_Symmetrized_vs_Unit_1_2012_07_13.fig
  X1_ISI_HAMX_TF_C2C_Raw_from_ACT_V_to_GS13_V_Symmetrized_vs_Unit_1_2012_07_13.fig

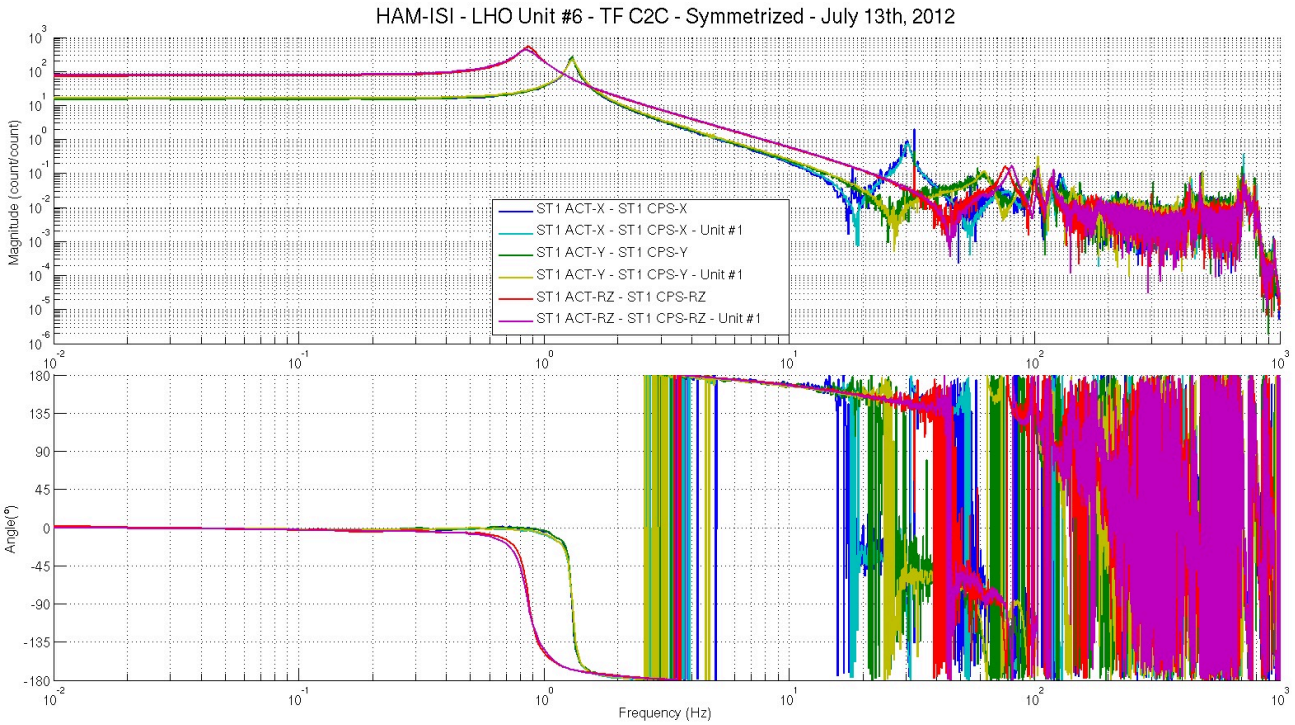


Figure – Cartesian to Cartesian measurements, comparison with Unit #1 reference
Capacitive Position Sensors - Horizontal motion

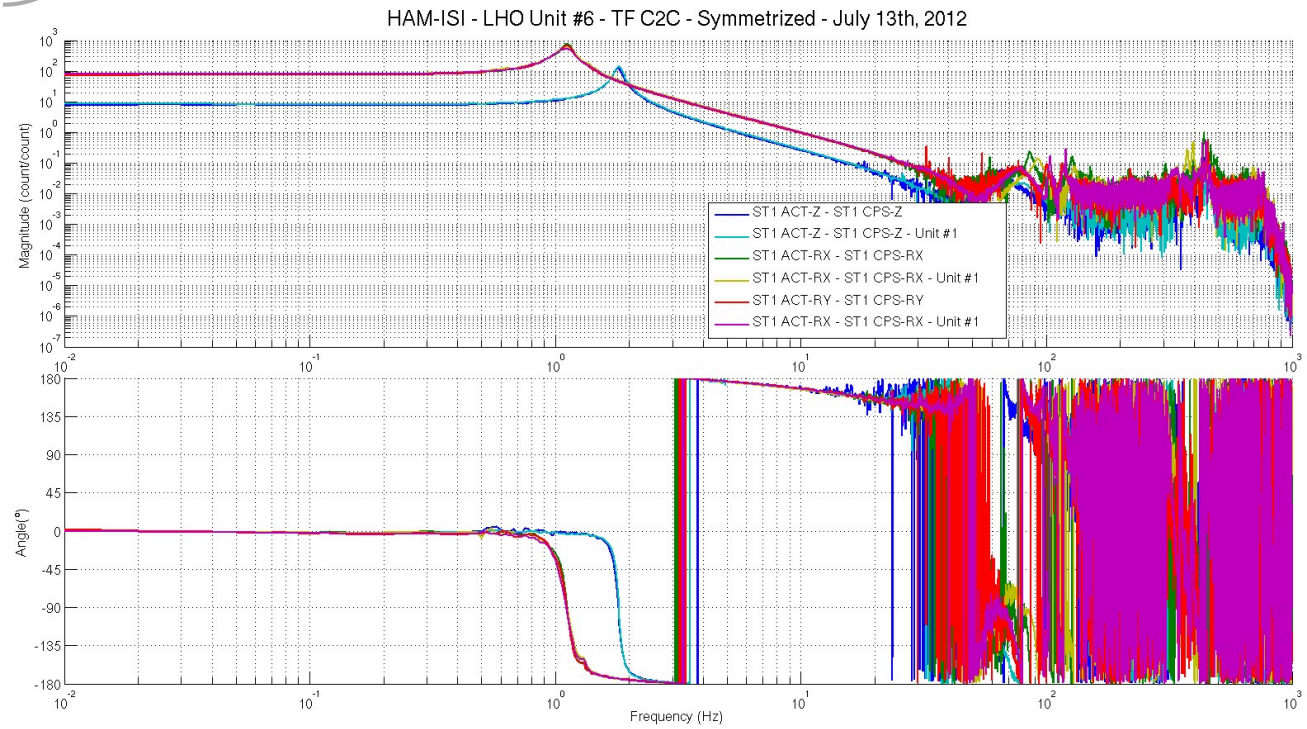


Figure – Cartesian to Cartesian measurements, comparison with Unit #1 reference
Capacitive Position Sensors - Vertical motion

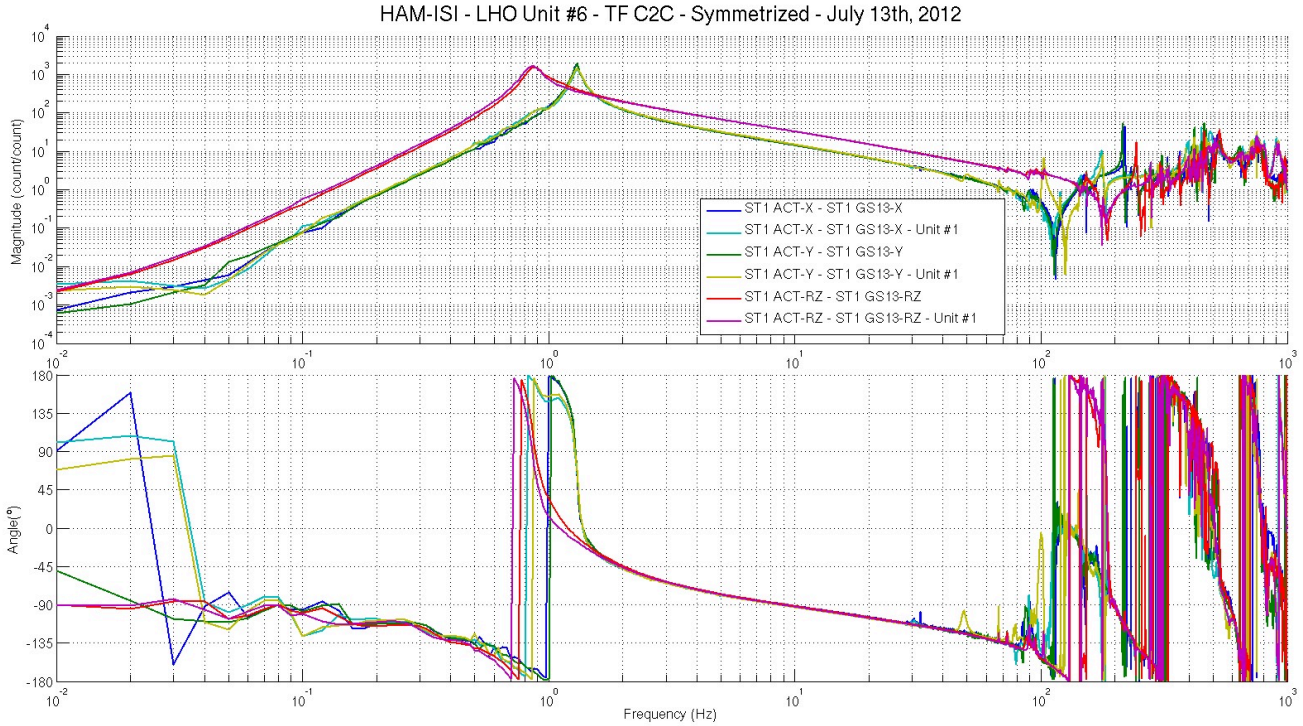


Figure – Cartesian to Cartesian measurements, comparison with Unit #1 reference – Inertial Sensors
Horizontal motion

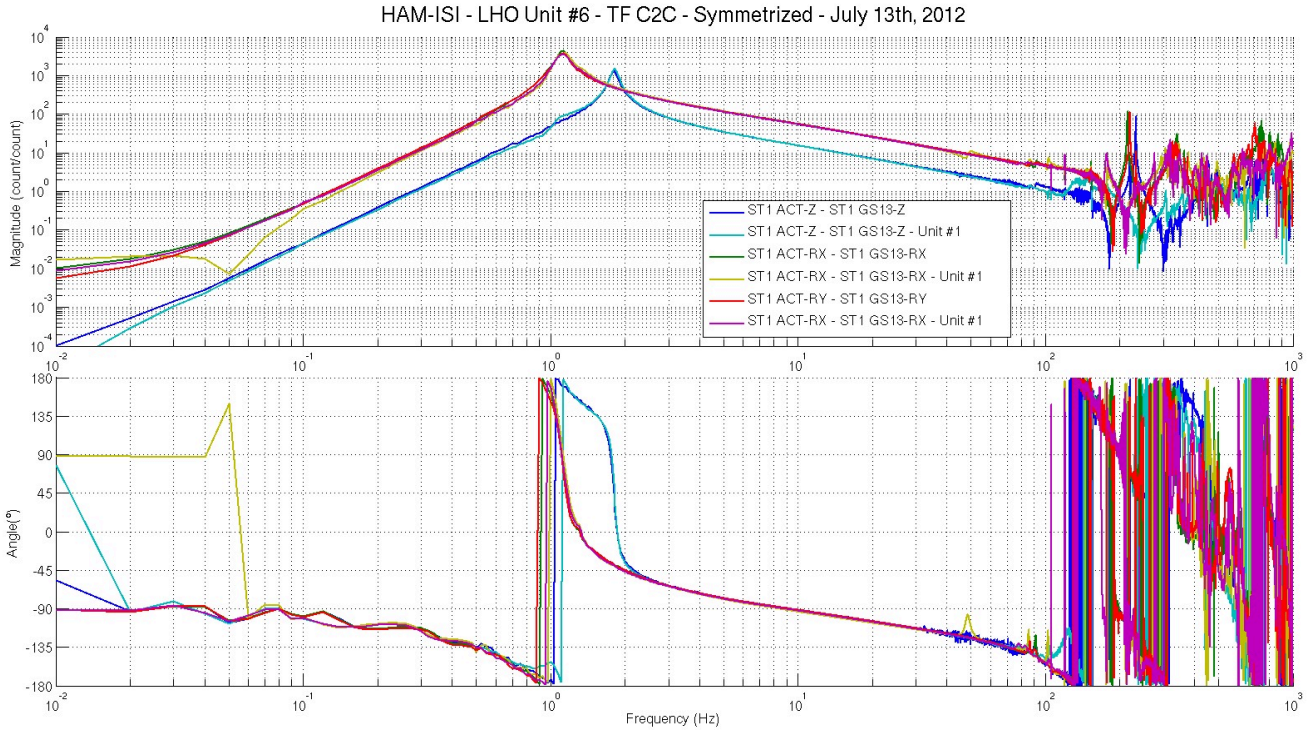


Figure – Cartesian to Cartesian measurements, comparison with Unit #1 reference Inertial Sensors - Vertical motion

Issues/difficulties encountered during this test:
Cartesian-TFs were simulated. Coherence is not available.

Acceptance criteria:

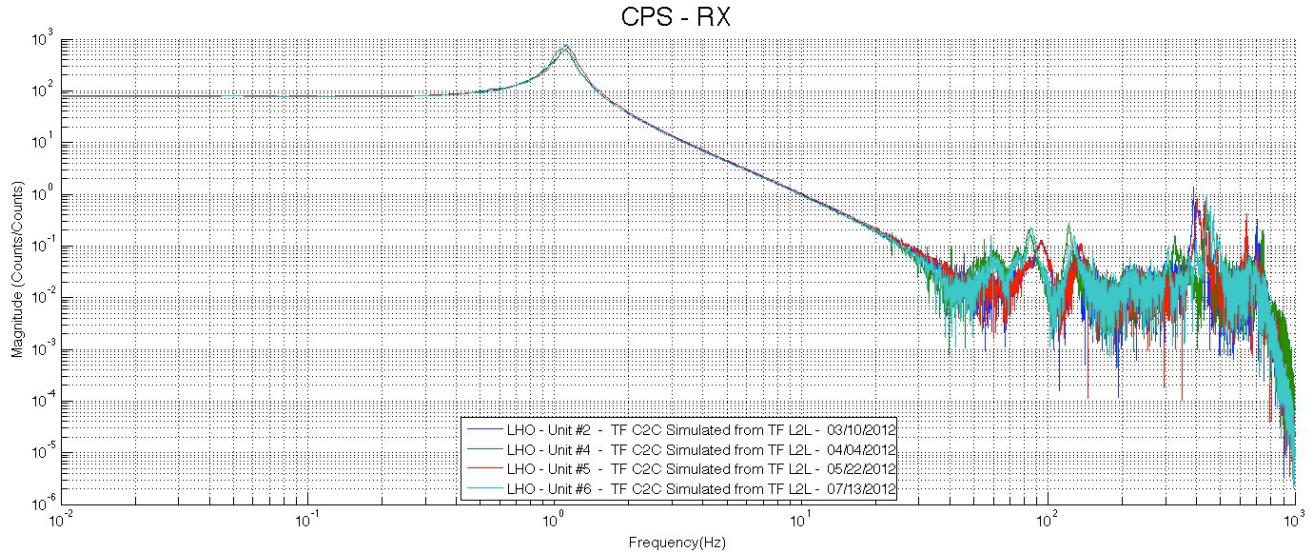
- No difference with the reference transfer functions (SVN)
  - Phase – less than 10º - In Phase – Out of Phase
  - Damping (fit by eye with Reference transfer functions)
  - DC gain
  - Eigen frequencies shift less than 10%

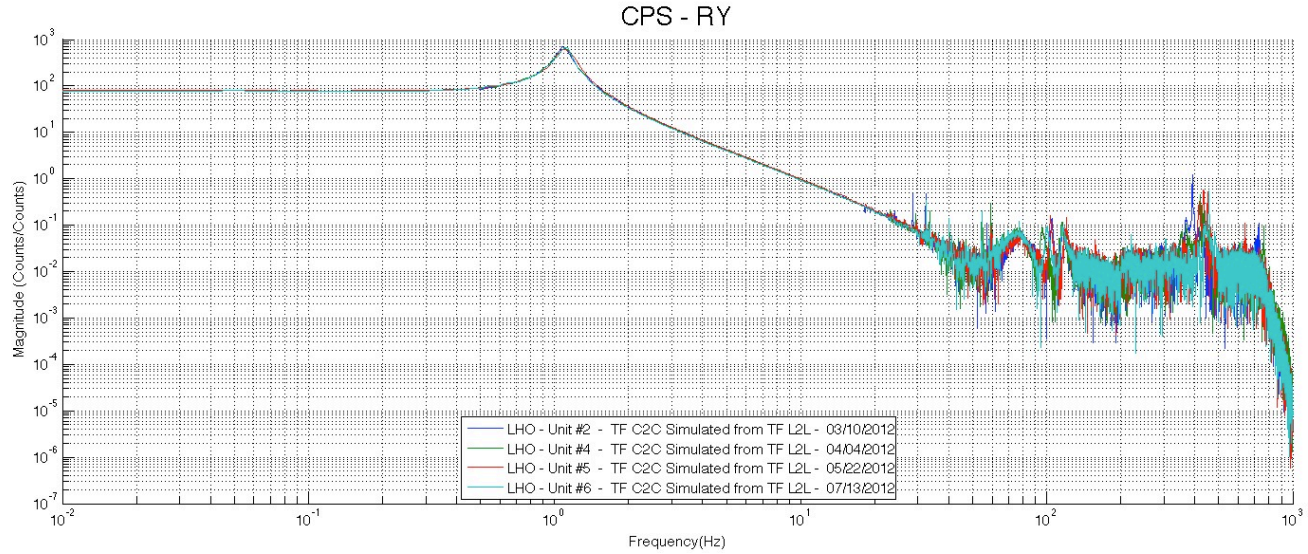
Test result: **Passed: X** **Failed: ___**

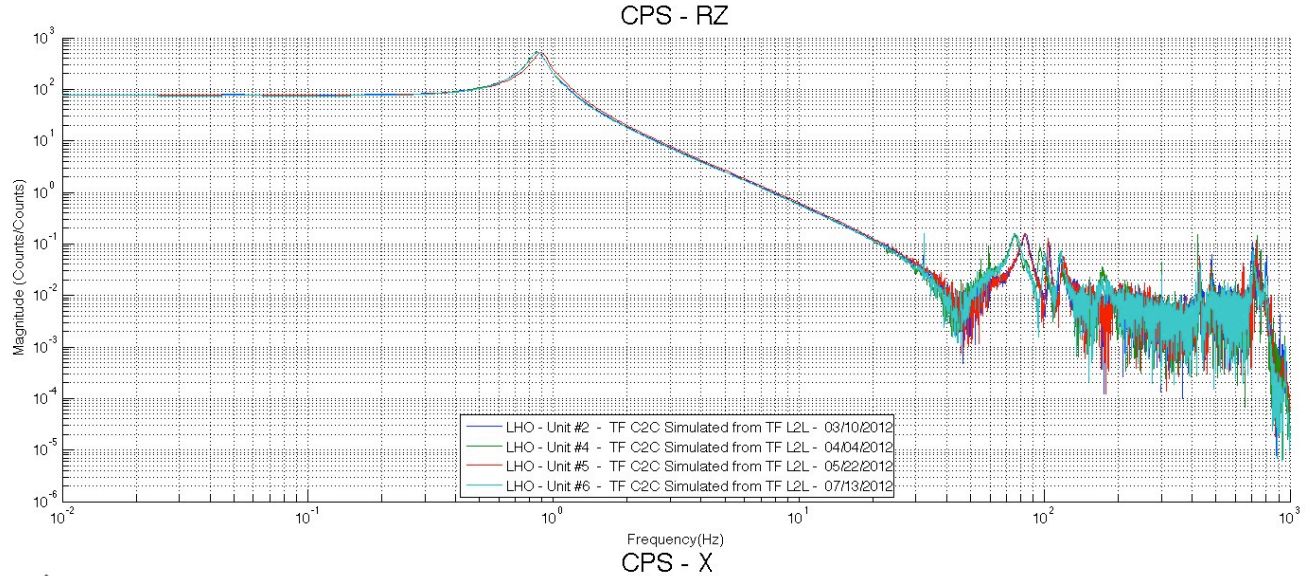
- ***Step 17.3 - Cartesian to Cartesian - Comparison with other Units***

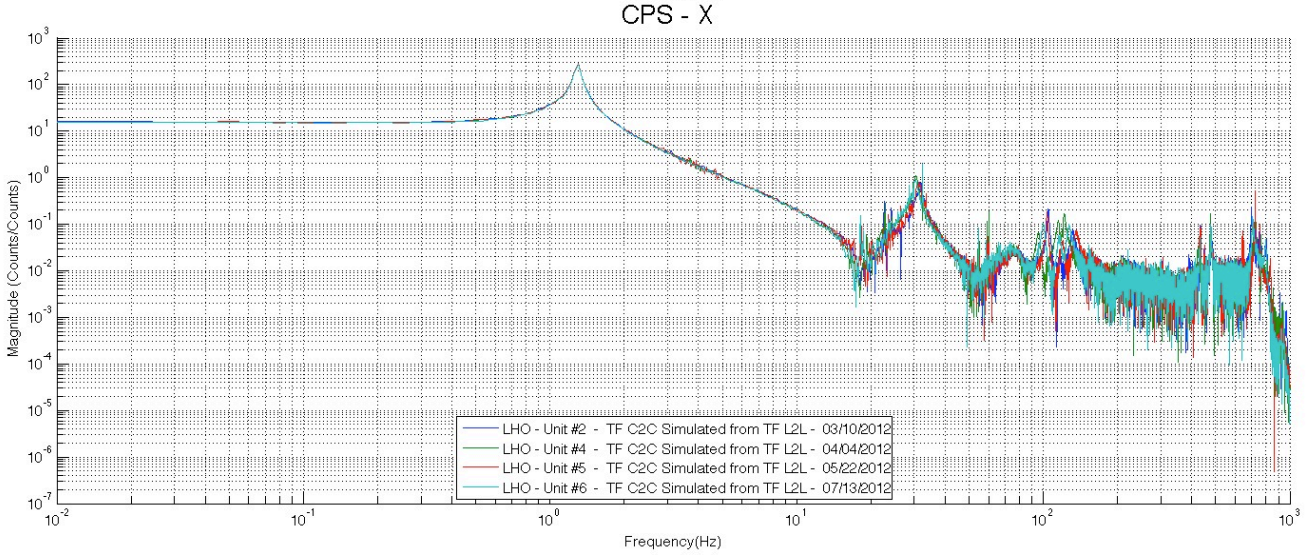
Scripts files for processing and plotting in SVN at:
/SeiSVN/seismic/HAM-ISI/Common/Plot_Functions_HAM_ISI/
- Plot_HAM_ISI___Cartesian_Result_Comparison.m

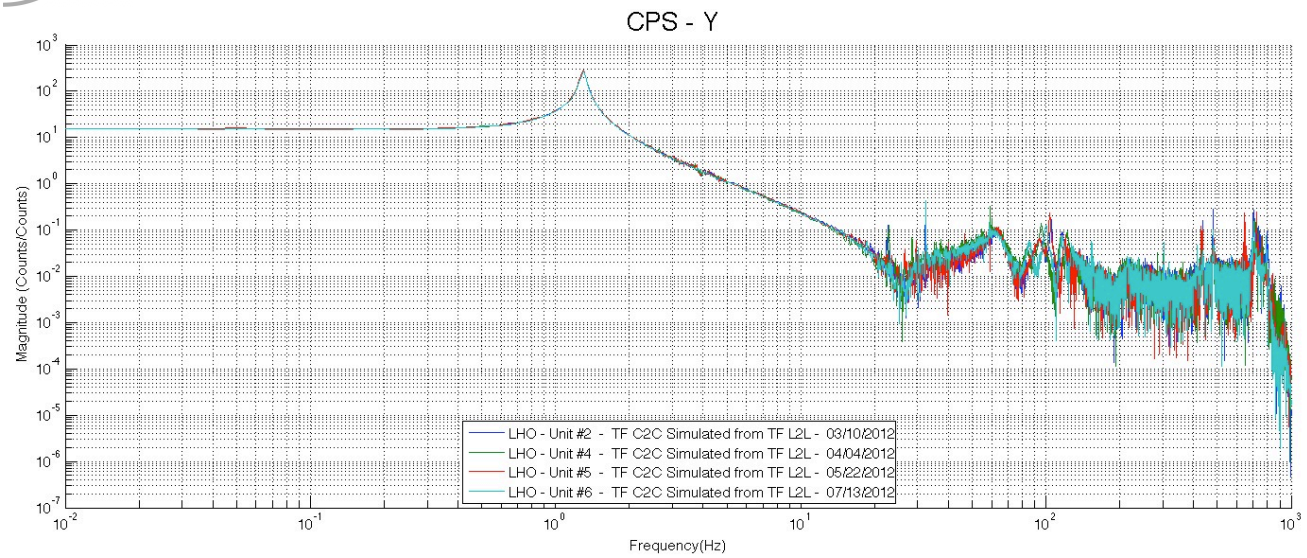
Cartesian to Cartesian figures in SVN at:
/SeiSVN/seismic/ HAM-ISI/X1/ Data/
All_Units_Compared/Transfer_Functions/C2C/
- CPS_X.fig
- CPS_Y.fig
- CPS_Z.fig
- CPS_RX.fig
- CPS_RY.fig
- CPS_RZ.fig
- GS13_X.fig
- GS13_Y.fig
- GS13_Z.fig
- GS13_RX.fig
- GS13_RY.fig
- GS13_RZ.fig

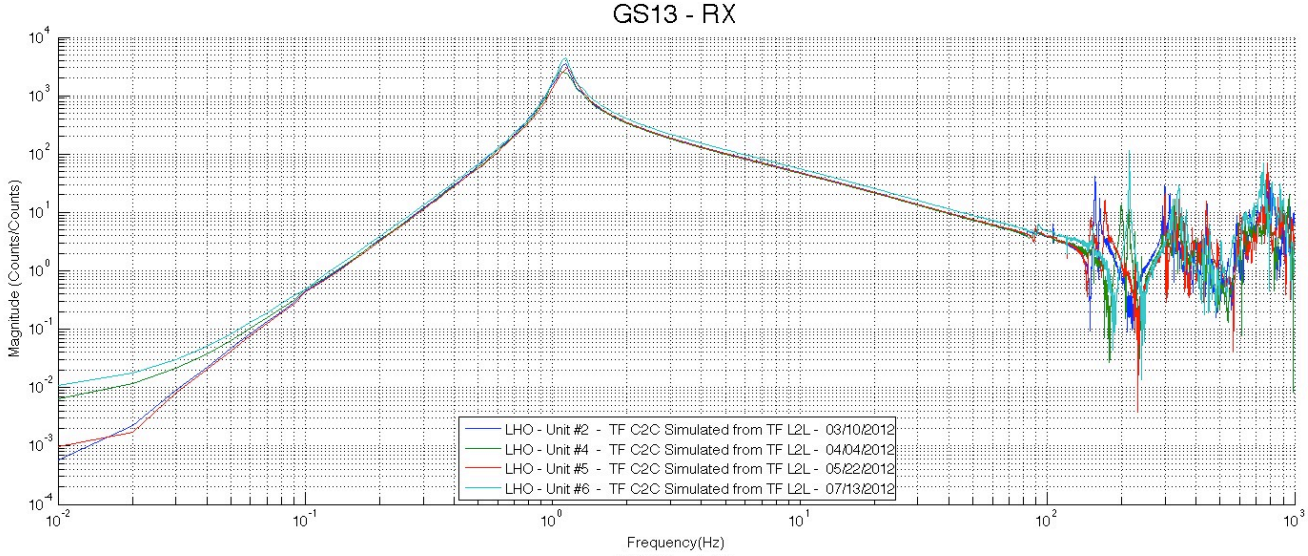


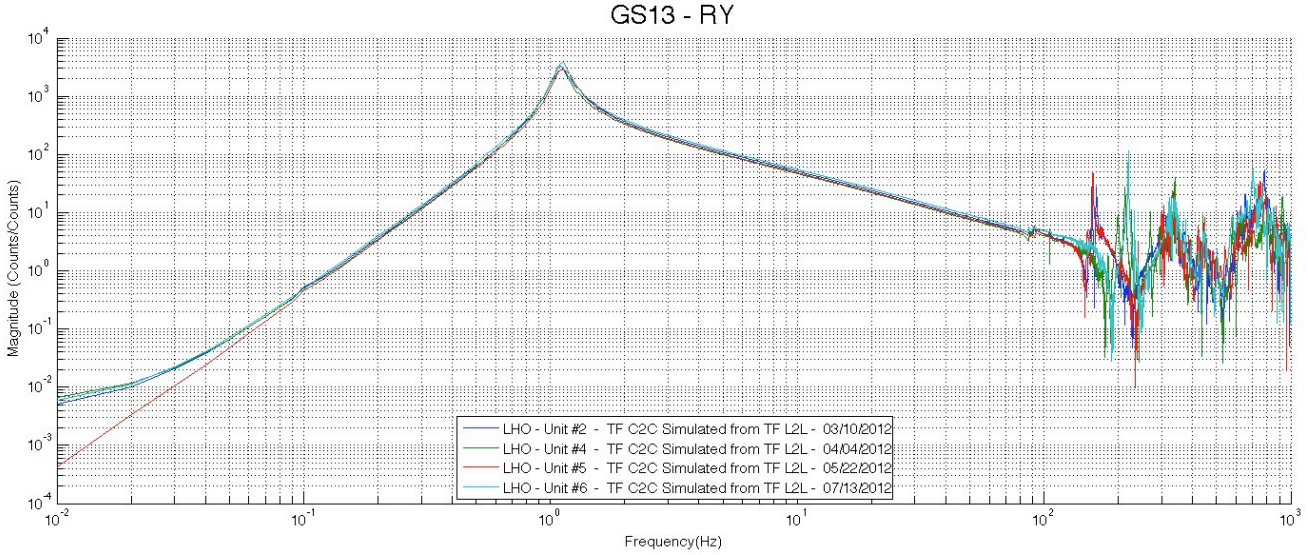

CPS - RY
Magnitude (Counts/Counts)
Frequency(Hz)
LHO - Unit #2 - TF C2C Simulated from TF L2L - 03/10/2012
LHO - Unit #4 - TF C2C Simulated from TF L2L - 04/04/2012
LHO - Unit #5 - TF C2C Simulated from TF L2L - 05/22/2012
LHO - Unit #6 - TF C2C Simulated from TF L2L - 07/13/2012

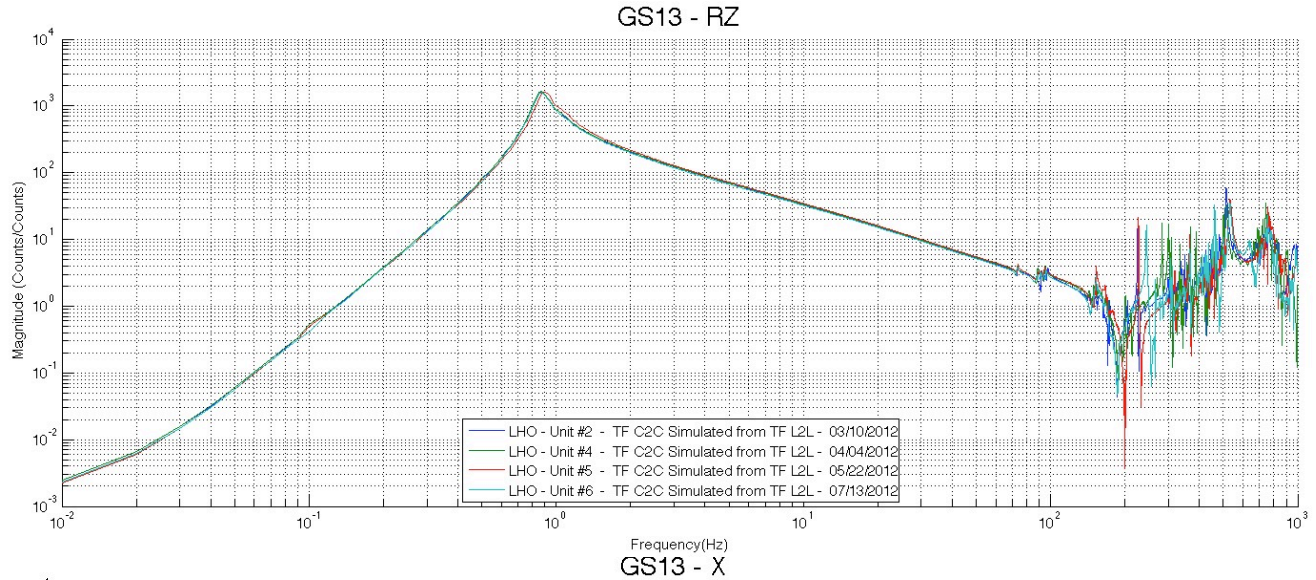

CPS - RZ
Magnitude (Counts/Counts)
Frequency(Hz)
LHO - Unit #2 - TF C2C Simulated from TF L2L - 03/10/2012
LHO - Unit #4 - TF C2C Simulated from TF L2L - 04/04/2012
LHO - Unit #5 - TF C2C Simulated from TF L2L - 05/22/2012
LHO - Unit #6 - TF C2C Simulated from TF L2L - 07/13/2012

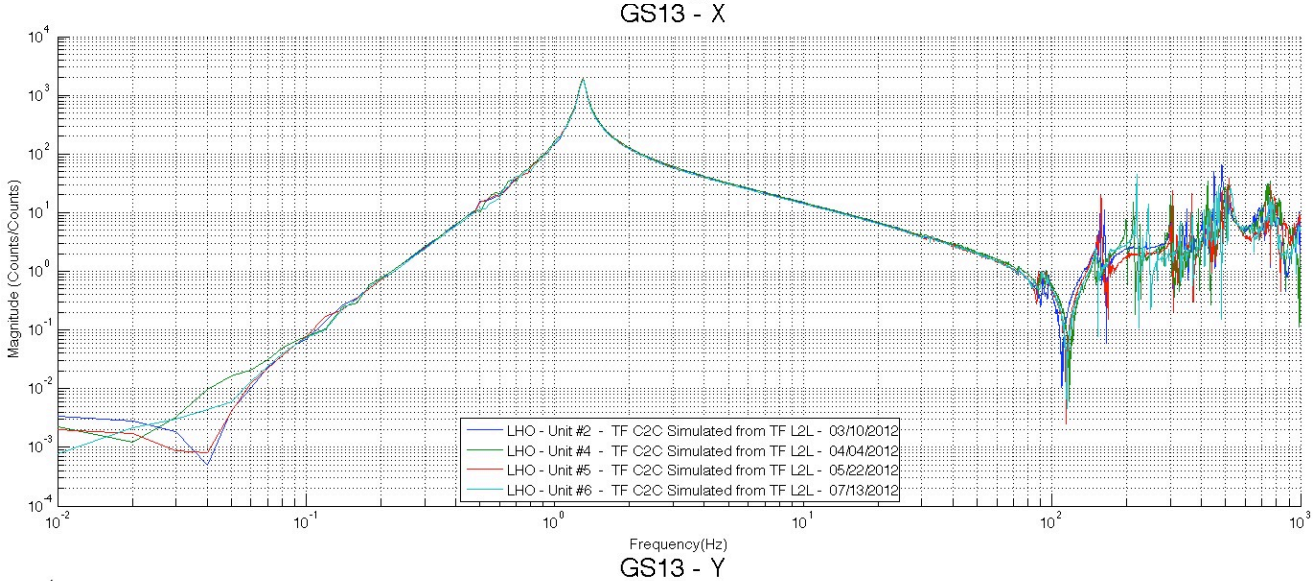

CPS - X
Magnitude (Counts/Counts)
Frequency(Hz)
LHO - Unit #2 - TF C2C Simulated from TF L2L - 03/10/2012
LHO - Unit #4 - TF C2C Simulated from TF L2L - 04/04/2012
LHO - Unit #5 - TF C2C Simulated from TF L2L - 05/22/2012
LHO - Unit #6 - TF C2C Simulated from TF L2L - 07/13/2012

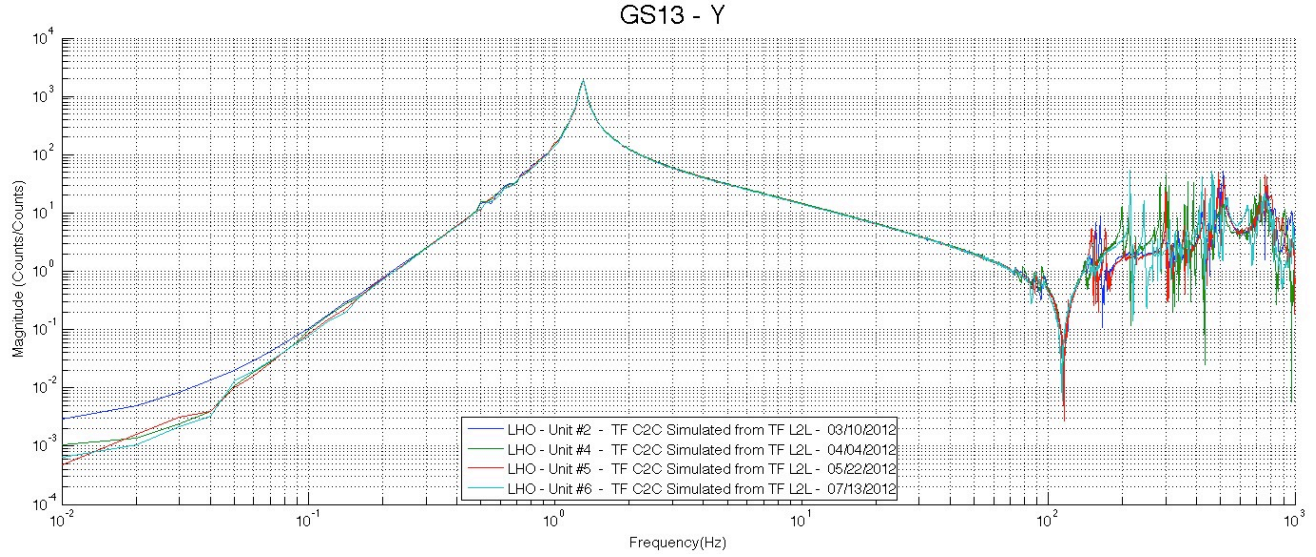

CPS - Y
Magnitude (Counts/Counts)
Frequency(Hz)
LHO - Unit #2 - TF C2C Simulated from TF L2L - 03/10/2012
LHO - Unit #4 - TF C2C Simulated from TF L2L - 04/04/2012
LHO - Unit #5 - TF C2C Simulated from TF L2L - 05/22/2012
LHO - Unit #6 - TF C2C Simulated from TF L2L - 07/13/2012


GS13 - RX
Magnitude (Counts/Counts)
Frequency(Hz)
LHO - Unit #2 - TF C2C Simulated from TF L2L - 03/10/2012
LHO - Unit #4 - TF C2C Simulated from TF L2L - 04/04/2012
LHO - Unit #5 - TF C2C Simulated from TF L2L - 05/22/2012
LHO - Unit #6 - TF C2C Simulated from TF L2L - 07/13/2012


GS13 - RY
Magnitude (Counts/Counts)
Frequency(Hz)
LHO - Unit #2 - TF C2C Simulated from TF L2L - 03/10/2012
LHO - Unit #4 - TF C2C Simulated from TF L2L - 04/04/2012
LHO - Unit #5 - TF C2C Simulated from TF L2L - 05/22/2012
LHO - Unit #6 - TF C2C Simulated from TF L2L - 07/13/2012


GS13 - RZ
Magnitude (Counts/Counts)
Frequency(Hz)
LHO - Unit #2 - TF C2C Simulated from TF L2L - 03/10/2012
LHO - Unit #4 - TF C2C Simulated from TF L2L - 04/04/2012
LHO - Unit #5 - TF C2C Simulated from TF L2L - 05/22/2012
LHO - Unit #6 - TF C2C Simulated from TF L2L - 07/13/2012


GS13 - X
Magnitude (Counts/Counts)
Frequency(Hz)
LHO - Unit #2 - TF C2C Simulated from TF L2L - 03/10/2012
LHO - Unit #4 - TF C2C Simulated from TF L2L - 04/04/2012
LHO - Unit #5 - TF C2C Simulated from TF L2L - 05/22/2012
LHO - Unit #6 - TF C2C Simulated from TF L2L - 07/13/2012


GS13 - Y
Magnitude (Counts/Counts)
Frequency(Hz)
LHO - Unit #2 - TF C2C Simulated from TF L2L - 03/10/2012
LHO - Unit #4 - TF C2C Simulated from TF L2L - 04/04/2012
LHO - Unit #5 - TF C2C Simulated from TF L2L - 05/22/2012
LHO - Unit #6 - TF C2C Simulated from TF L2L - 07/13/2012

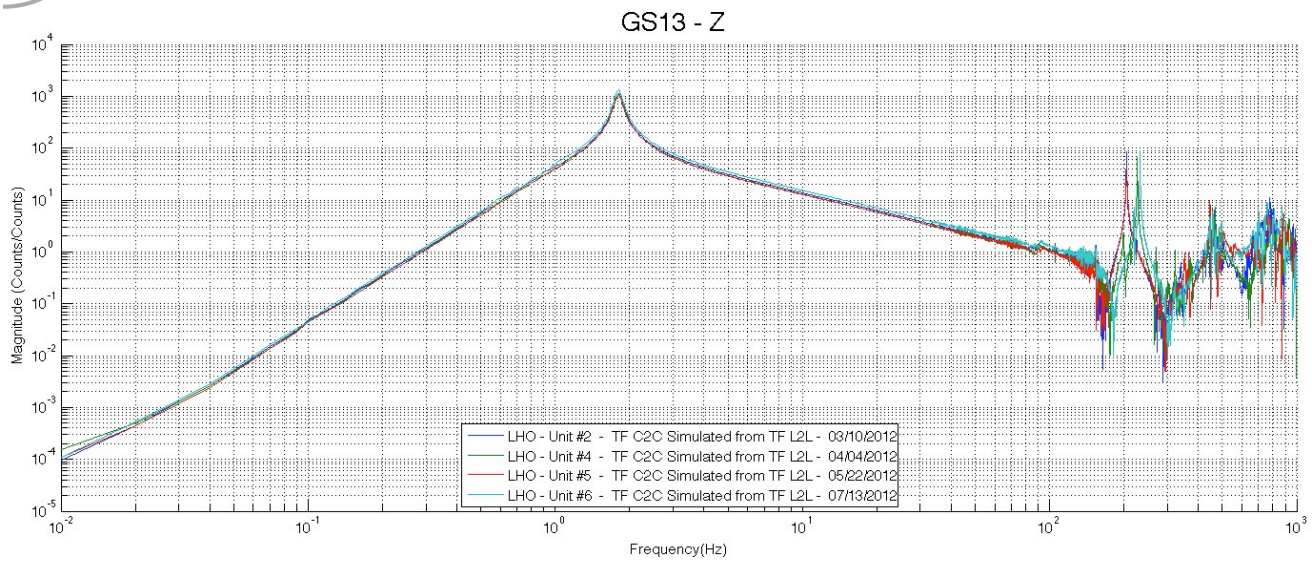


Figure – Cartesian to Cartesian TF, comparison with other Units

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

Data collection script files:
/SeiSVN/seismic/HAM-ISI/Common/Transfer_Function_Scripts/
- Run_TF_C2C_10mHz_100mHz_LZMP_HAM_ISI.m

Data files in SVN at:
/SeiSVN/seismic/HAM-ISI/X1/HAMX/Data/Transfer_Functions/Measurements/Undamped/
- LHO_ISI_HAM_Unit_6_Data_TF_C2C_10mHz_100mHz_LZMP_20120714-042748.mat

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

Figures in SVN at:
/SeiSVN/seismic/HAM-ISI/X1/HAMX/Data/ Figures/Transfer_Functions/Measurements/Undamped/
- LHO_ISI_UNIT_6_LZMP_20120714.fig

The result of the measurement performed is presented below. Symmetrization filters are not engaged. Measurement was performed over 200 averages, during the weekend.

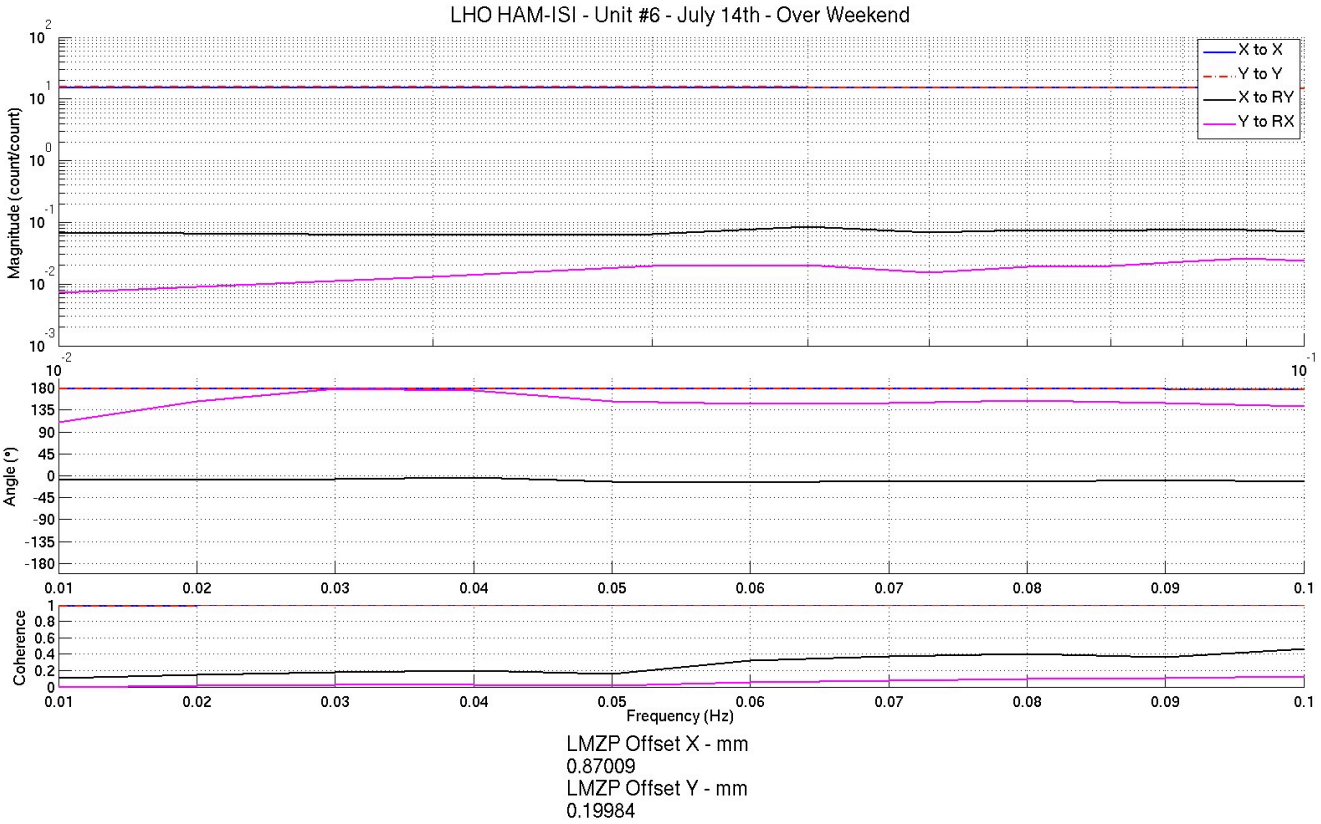


Figure - Lower Zero Moment Plane – Main and cross couplings at low frequency

Issues/difficulties encountered during this test:

- Test performed BEFORE the dramatic temperature changes that caused Stage-1 to be lowered.
- Coherence is low.

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 #6 testing summary

HAM-ISI Unit #6 was assembled during June 2012. The testing of this Unit is presented here. It started on June 18th and lasted until July 14th.

Testing was delayed due to omissions in assembly, instrument failure and strong temperature changes.

Complementary Investigation:

- The ISI went down of -0.09mm (appox. 3000cts down) when the temperature dramatically rose on site (30 degrees Fahrenheit). Strong temperature changes caused the blades to sag. The matter was investigated and reported in LHO aLog # 3370, and comments.
- Data loggers (temperature/humidity) were set in the staging building, in order to assess future strong temperature changes (LHO aLog #3431).

Particularities:

- CPS & lockers were set before strong temperature changes caused the blades to sag.
- Full set of production GS13s
- L4Cs and brackets installed

FAILED AND WAIVED TESTS

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

Step I.1: Initial testing data missing/obsolete on CPSs. CPSs spectra were validate with up to date measurements anyway (step 6)

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

Step III.14: Actuators appear to be linear on measurements. However, deviation from average slope is out of spec. It seems to correlate with cable+actuator resistance measurements. Make sure that linearity test results correlate with the final field cables.
This scale factor, which varies from an actuation point to another, could be corrected with an adjustment gain applied on the excitation signal sent to the actuators.
Step 19: The simulation, and implementation, of the damping loops represent a "bonus test" and was not performed because of delays caused by omissions in assembly, instrument failure and temperature changes.

- ***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.