LIGO Laboratory / LIGO Scientific Collaboration

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aLIGO HAM-ISI, Pre-integration Test Report, Phase I, LHO Unit #5 (post-assembly, before storage)

E1000314 – V3

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Distribution of this document:
Advanced LIGO Project

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Introduction

HAM-ISI Unit #5 was assembled during April 2012. The testing of this Unit is presented here. It started on May 2nd 2012 and lasted until May 8th 2012 with the testing horizontal GS13s.

These Horizontal GS13s featured non-consistent behavior after reception at LHO. Investigation has been performed at LLO for instruments featuring the same symptoms (LLO aLog 2909). It revealed that the screws of some flexures were not correctly torqued anymore and that they needed *lock tight* in order to remain secured during shipping. Hence, the horizontal GS13s initially used for testing were considered as "testing instruments". They were removed from the assembly at the end of the *assembly validation*, to be replaced with production pods. Tests involving GS13s were performed with the new set of production pods between May 21st and May 24th 2012.

Stage-0 L4Cs and their brackets were not installed during tests.

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 #5, the name of this folder will be:

/SeiSVN/seismic/HAM-ISI/X1/Unit_5/

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
12007	11887	NR	NR	~2.057	0.6	~.01	x
11983	11853	NR	NR	~2.057	x	~.01	x
12022	11869	NR	NR	~2.057	x	~.01	x
12006	11901	NR	NR	~2.057	x	~.01	x
12035	11888	NR	NR	2.032mm/0.080"	**-1	*.01	-4.88
12027	11883	NR	NR	2.032mm/0.080"	**-1	*.01	-4.82

*: Not recorded, estimation
**: The sign was not recorded, but probably is in negative volts
NR: Not recorded
Note: The back panel reads 0.508V/0.001"

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

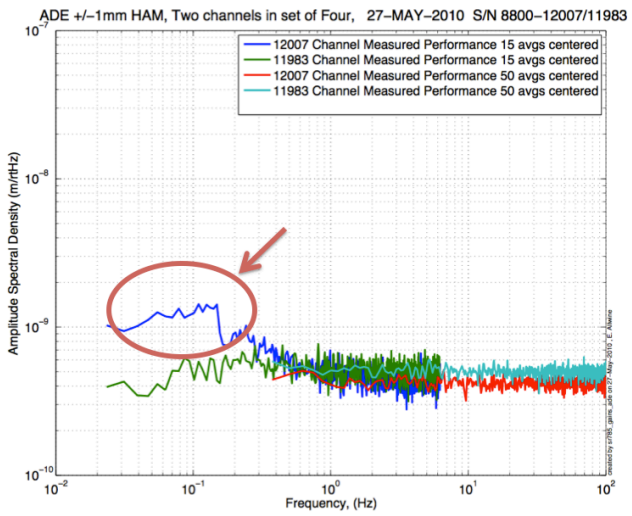


Figure - H1 and V1 sensor noise

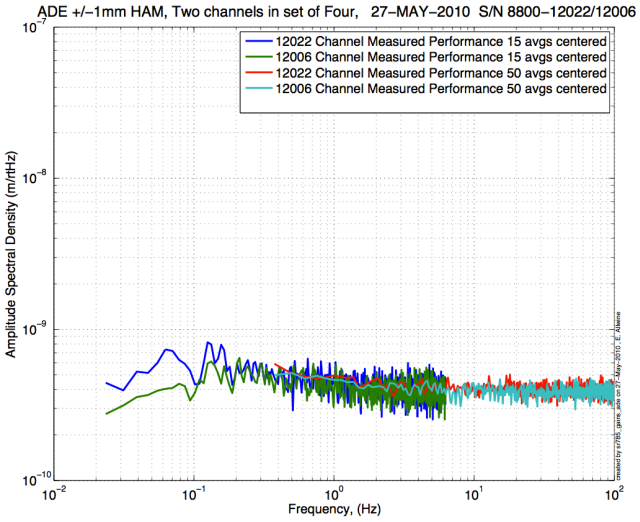


Figure - H2 and V2 sensor noise

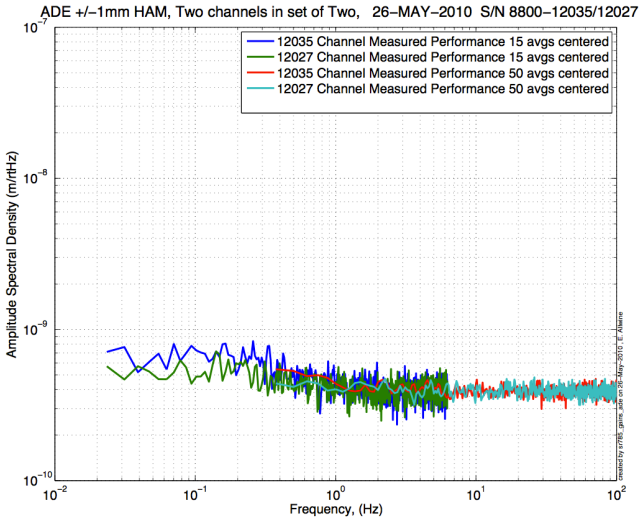


Figure - H3 and V3 sensor noise

Issues/difficulties/comments regarding this test:

- CPS # 12007 (H1) is slightly out of requirements at 0.1 Hz

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__

Note: Failed on H1 at 0.1Hz. Its spectrum is however very close from our requirement.

- ***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
V	Pod	74	72	4
	Instrument	687	733	691
H	Pod	13	38	71
	Instrument	820	829	843

Table- GS13 instrument and Pod S/Ns

- ***Step 2.1 – Horizontal GS-13s***

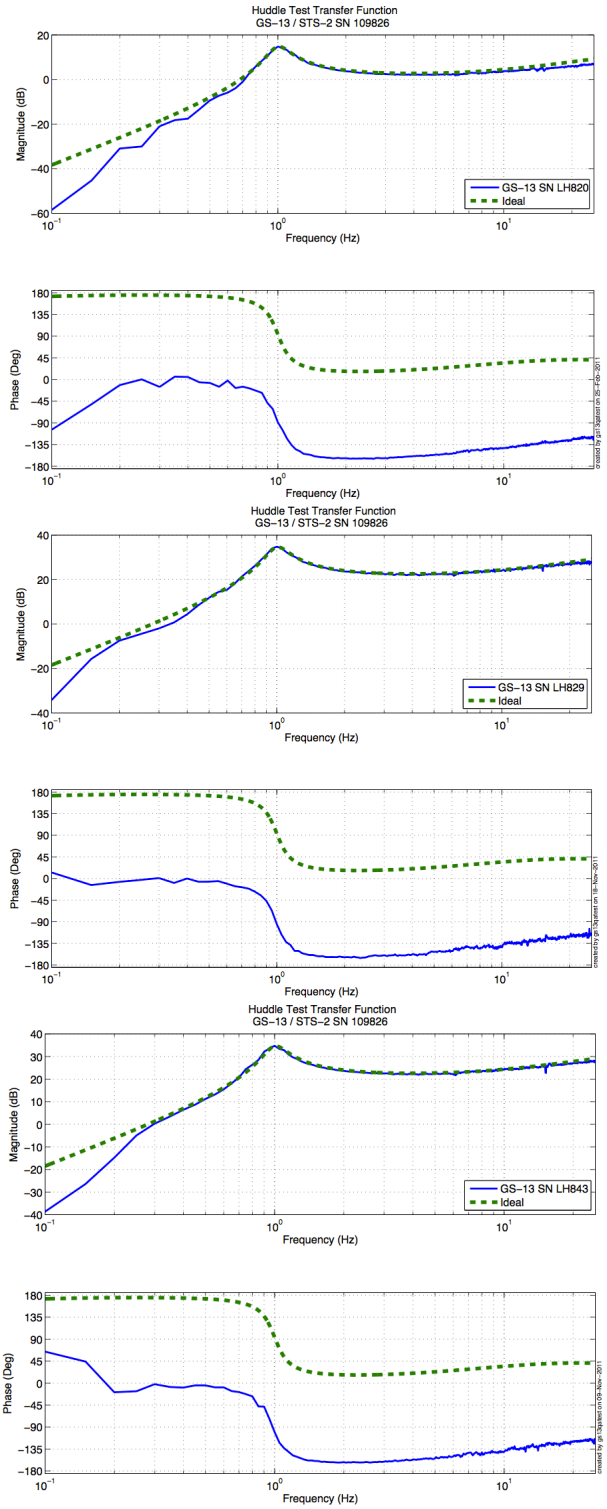


Figure - Huddle testing of Horizontal GS-13 820(H1), 829(H2), and 843(H3) after aLIGO modifications

- ***Step 2.2 – Vertical GS-13s***

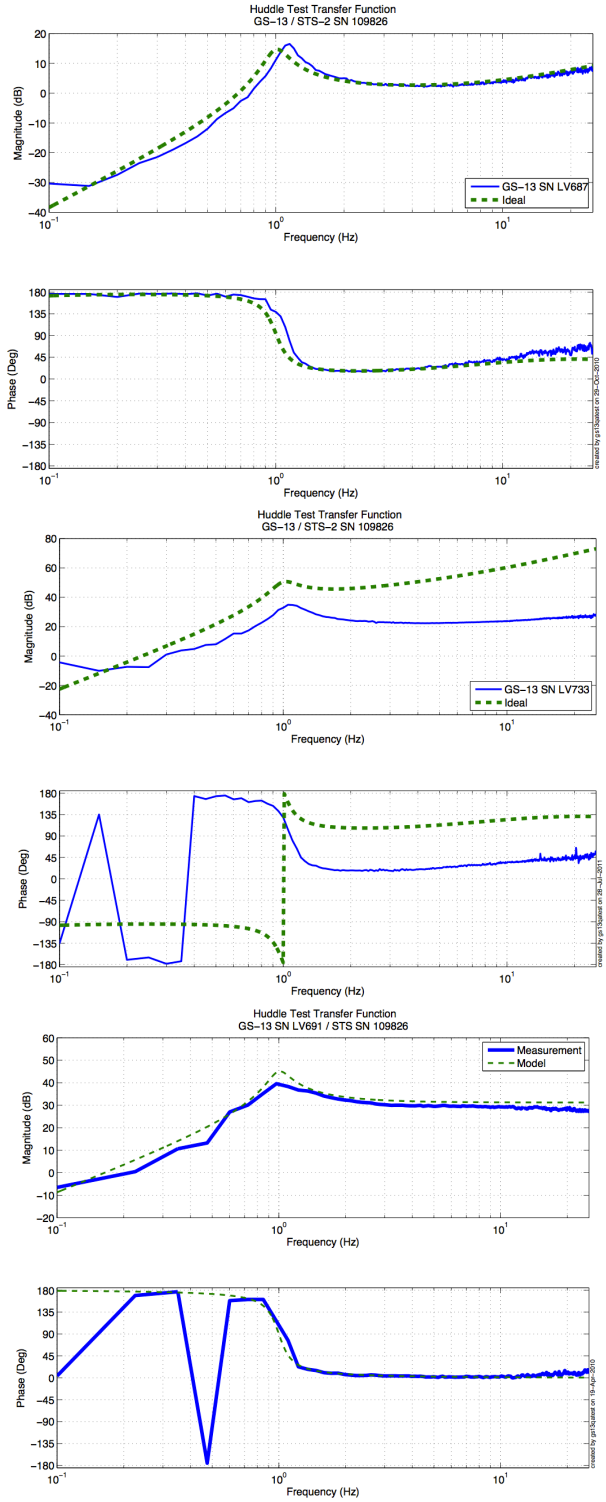


Figure - Huddle testing of Vertical GS-13 687(V1), 733(V2), and 691(V3) after aLIGO modifications

Driven testing

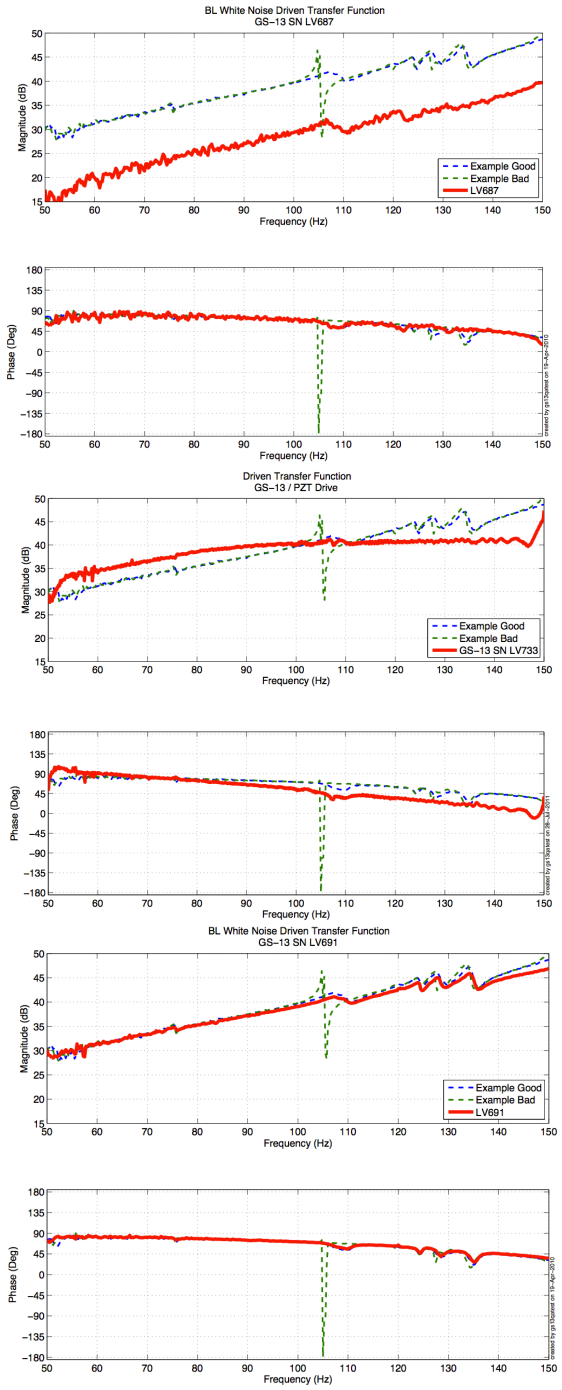


Figure - Driven testing of Vertical GS-13 687(V1), 733(V2), and 691(V3) after aLIGO modifications

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 #: L105 Operator Name: Gordon, Matt Date: 1/30/2010 Time: 11:00 AM Actuator Coil Resistance: 6.42 Ohms, PASS Ambient Temperature: 65.5 F Hi Pot Test Results: 1000 MOhms, PASS X Travel Limit (inches): 0.528 Y Travel Limit (inches): 0.205 Z Travel Limit (inches): 0.501	Actuator Serial #: L023 Operator Name: Smith, Lane Date: 8/12/2009 Time: 9:26 AM Actuator Coil Resistance: 6.42 Ohms, PASS Ambient Temperature: 68.8 F Hi Pot Test Results: 1000 MOhms, PASS X Travel Limit (inches): 0.518 Y Travel Limit (inches): 0.205 Z Travel Limit (inches): 0.478
Actuator Serial #: L098 Operator Name: Gordon, Matt Date: 1/30/2010 Time: 12:14 PM Actuator Coil Resistance: 6.34 Ohms, PASS Ambient Temperature: 65.2 F Hi Pot Test Results: 1000 MOhms, PASS X Travel Limit (inches): 0.534 Y Travel Limit (inches): 0.206 Z Travel Limit (inches): 0.505	Actuator Serial #: L115 Operator Name: Gordon, Matt Date: 1/29/2010 Time: 4:19 PM Actuator Coil Resistance: 6.35 Ohms, PASS Ambient Temperature: 71.3 F Hi Pot Test Results: 1000 MOhms, PASS X Travel Limit (inches): 0.540 Y Travel Limit (inches): 0.205 Z Travel Limit (inches): 0.505
Actuator Serial #: L116 Operator Name: Gordon, Matt Date: 1/29/2010 Time: 3:50 PM Actuator Coil Resistance: 6.35 Ohms, PASS Ambient Temperature: 71.3 F Hi Pot Test Results: 1000 MOhms, PASS X Travel Limit (inches): 0.526 Y Travel Limit (inches): 0.205 Z Travel Limit (inches): 0.506	Actuator Serial #: L117 Operator Name: Gordon, Matt Date: 1/29/2010 Time: 3:32 PM Actuator Coil Resistance: 6.4033 Ohms, PASS Ambient Temperature: 71.3 F Hi Pot Test Results: 1000 MOhms, PASS X Travel Limit (inches): 0.536 Y Travel Limit (inches): 0.206 Z Travel Limit (inches): 0.507

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***

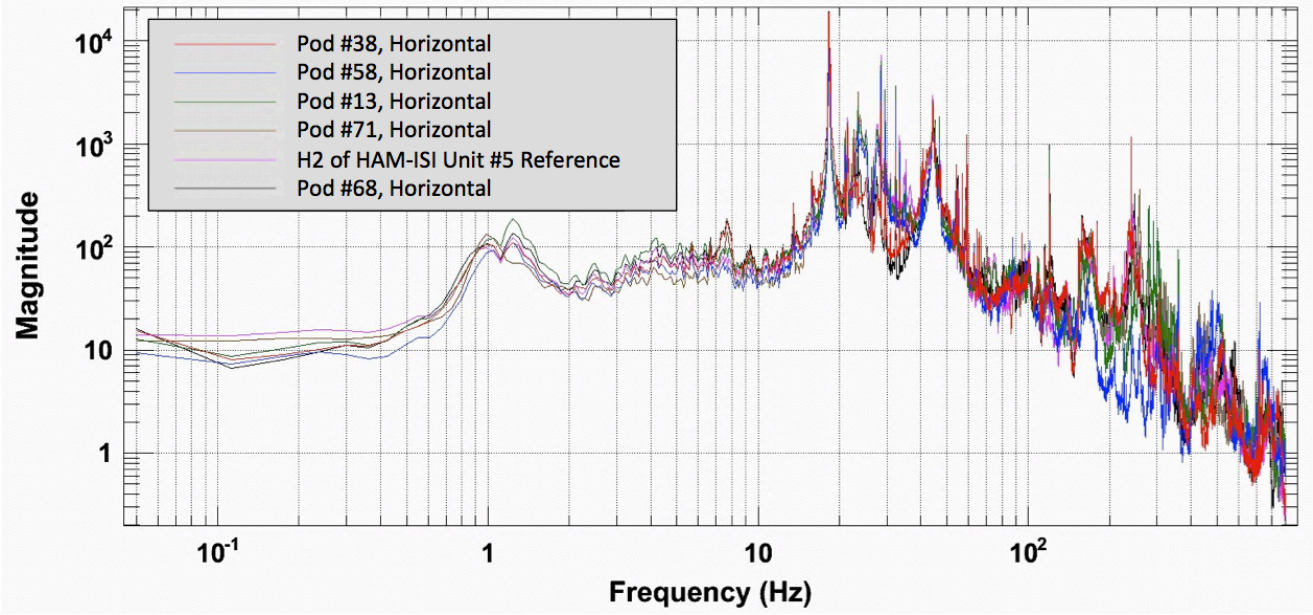


Figure – Horizontal Geophones (H1=13 H2=38, H3=71) inspection after reception at LHO

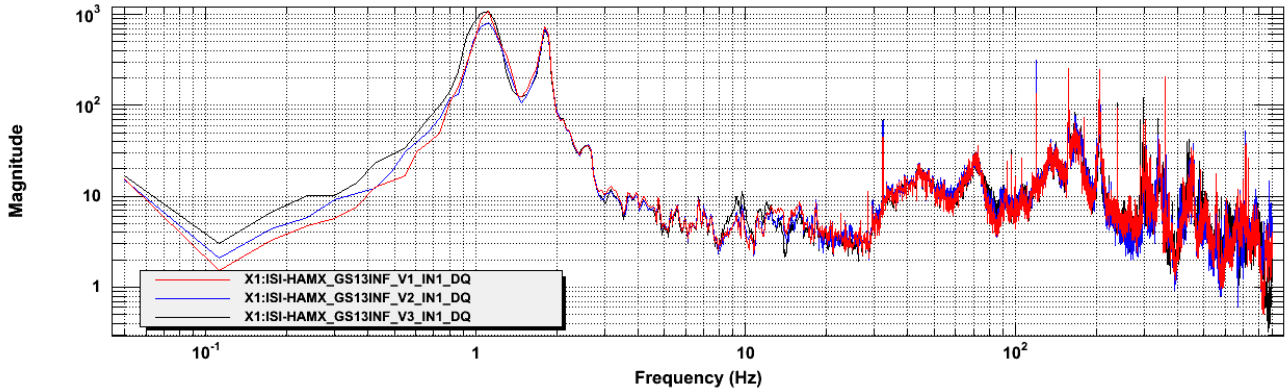


Figure – Vertical Geophones inspection after reception at LHO

Results saved under the SVN at:
/SeiSVN/seismic/Common/Data/aLIGO_GS13_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 *locktight* 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	10		
D071051	Stage 1 base	NA	12		
D071050	Optical table	NA	11		
D071002	Spring Post	NA	2	3	8
D071100	Spring	NA	38	13	29
D071102	Flexure	NA	2	4	14
ADE	Position sensor	Horizontal	12007 Master 0	12022 S1ave 180	12035 Slave 0
		Vertical	11983 Slave 180	12006 Slave 0	12027 Slave 180
D047812	GS-13 pod	Horizontal	13	38	71
		Vertical	74	72	4
D047823	L4C pod	Horizontal	NA	NA	NA
		Vertical	NA	NA	NA
D0902749	Actuator	Horizontal	23	115	117
		Vertical	105	98	116

Table – Parts inventory

Cable Connects		Cable S/N		
Part Name	Configuration	Corner 1	Corner 2	Corner 3
GS13	Horizontal	S1106664	S1106659	S1104712
	Vertical			
L4C	Horizontal	NA	NA	NA
	Vertical	NA	NA	NA
Actuator	Horizontal	S1104492	S1104756	S1106678
	Vertical	S1106679	S1104490	S1105207

Table – Cables inventory

NA: Not applicable

- ***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***

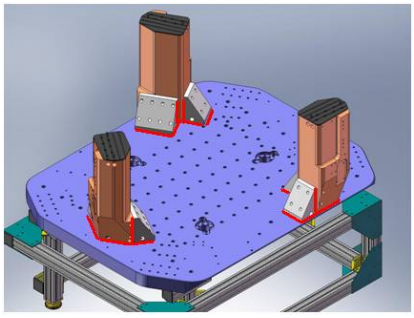


Figure - Showing edges that need checked on support posts and gussets

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***

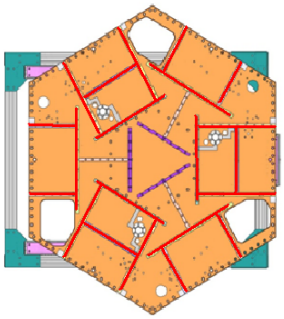


Figure – Showing what needs to be checked on Boxworks and Pitchforks

Acceptance Criteria:

- Shim inserted won't pass between parts.

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

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

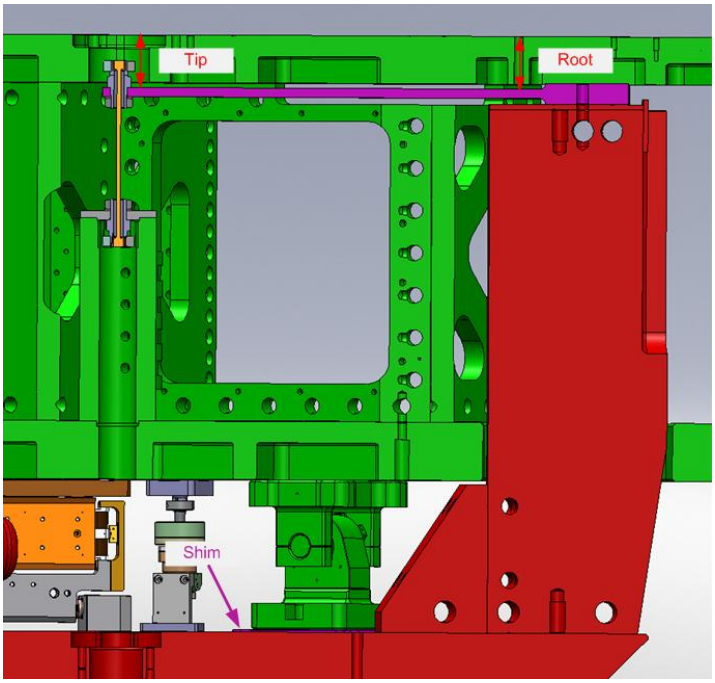


figure – Blade spring profile measurement points

Blade #	Root (Mils)	Tip(Mils)	Flatness (mils)
1	611.5	624	12.5
2	608.5	620	11.5
3	612	622	10

Table - Blade profile

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***

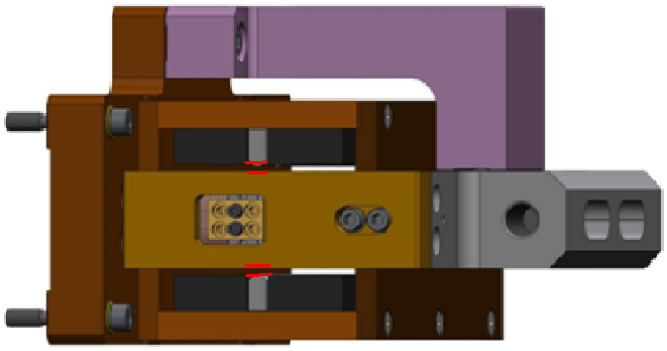


Figure - Showing gaps that need to be checked on actuators.

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***

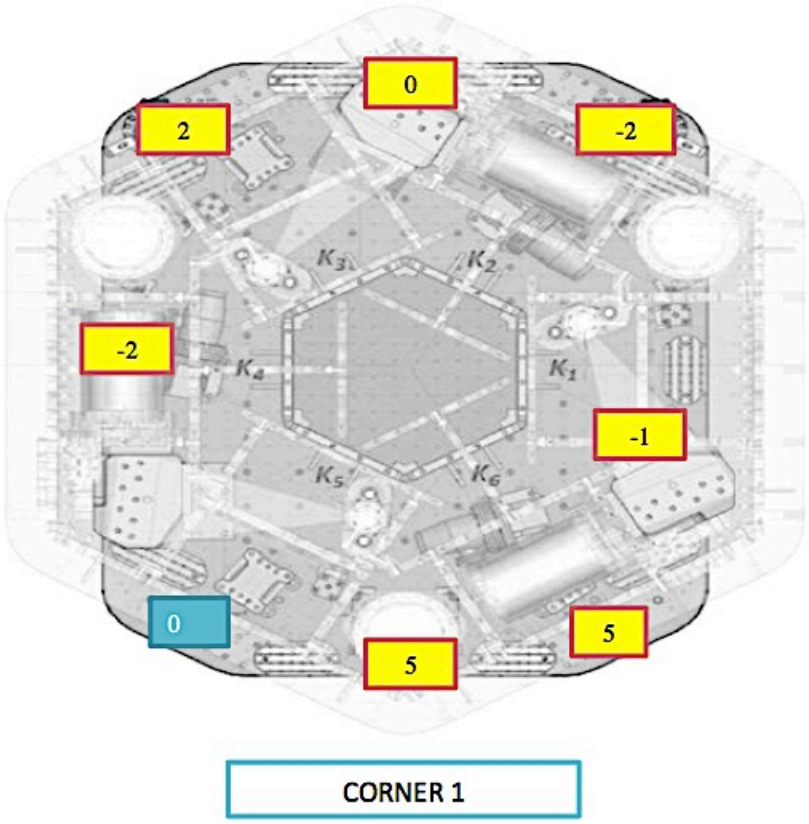


Figure – Level measured on Stage 0

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=0.007/72 (± 0.001/72) = 97.2 (±13.8) µrad

Acceptance Criteria

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

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

Note:
This test is borderline to our stringent requirement, however this leveling value is sufficient for all the tests being performed.

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

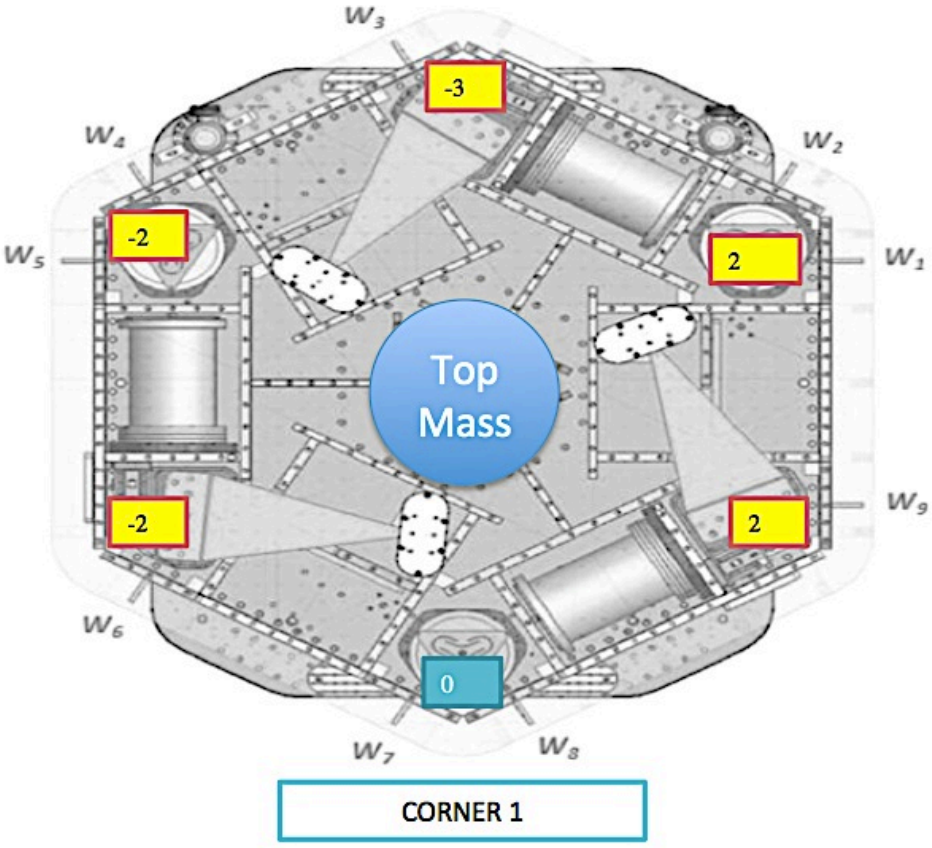


Figure – Level measured on Stage 1

Issues/difficulties/comments regarding this test:
The 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 = 0.004/86 (± 0.001/86) = 47.5 (± 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						2.8	1.27
W1				1			1	31.7	14.38
W2			1	1			1	33.9	15.38
W3	2	2						3.4	1.54
W4		1					1	28.3	12.84
W5				1			1	31.7	14.38
W6	1							0.6	0.27
W7				2			1	36.2	16.42
W8	1						1	27.8	12.61
Side Masses Total	5	5	1	5	0	0	6	196.4	89.09

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

	Mass (kg)
t1	40.00
t2	280.79
t3	35.00
t4	30.00
Total	385.79

Table – Optic table masses distribution

	Side	Keel	Top	Total
Weigh (kg)	89.09	90.22	385.79	565.10

Table – Mass budget sum up

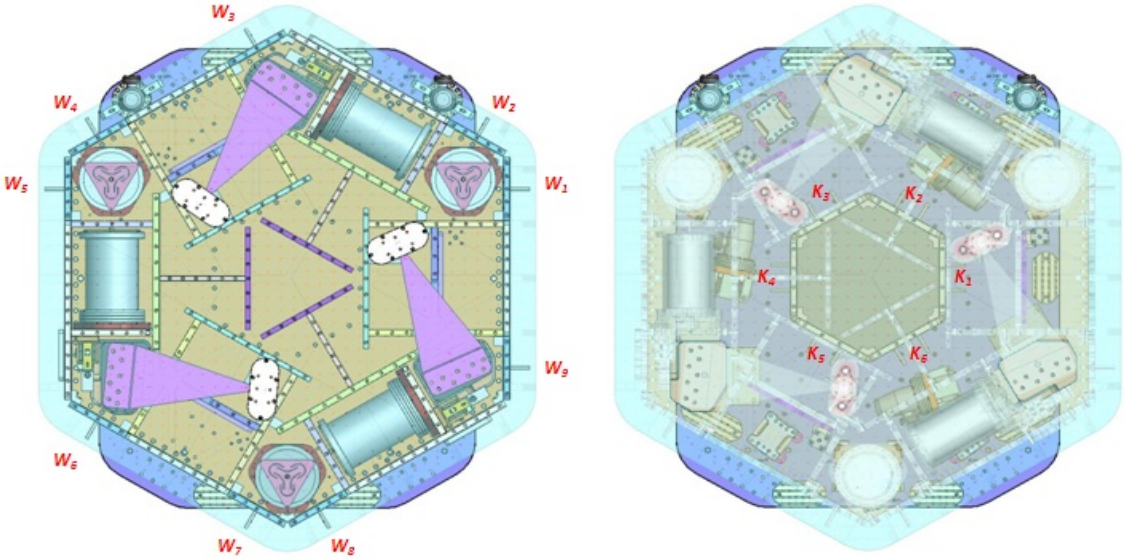
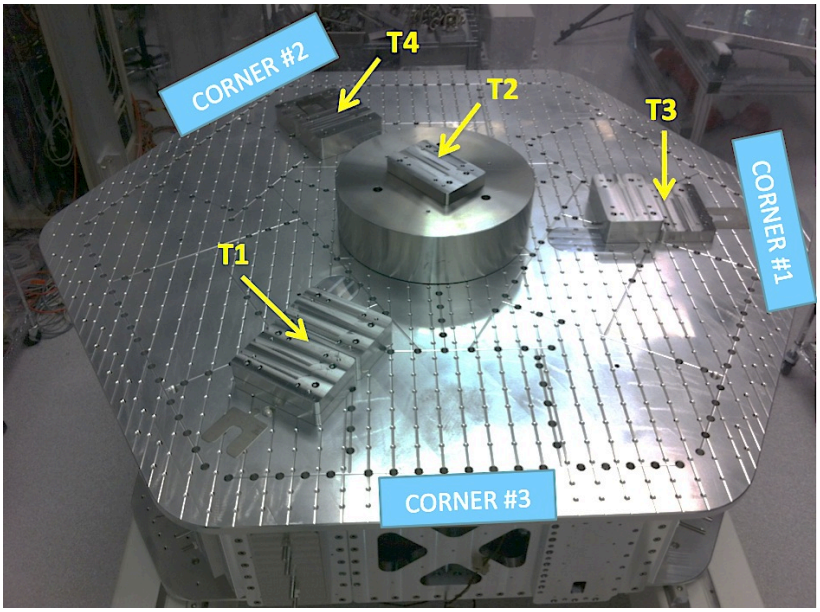


Figure – Wall Masses (W) and Keel masses (K) location. ***South of picture = corner 1***



Picture – Optic table masses distribution

Issues/difficulties/comments regarding this test:

- T2's big mass evaluated at nominal value: 270.79lbs. 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	120
B	120
C	121
D	122

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	1	0
B	0.8	-0.6
C	0.5	0.2
D	1.2	0

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

Acceptance Criteria

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

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

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	-349.90	6.69
H2	10.84	6.49
H3	360.82	6.95
V1	-221.90	7.10
V2	-822.97	8.87
V3	-539.05	11.92

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: ____** **Failed: __X__**

Note: Failed because of standard deviation. However, a CPS was set on a test-jig and featured 4.3 counts of standard deviation, which is within specs. Hence, the high standard deviation observed is correlated to the 10Hz-100Hz peaks observed on the locked/unlocked GS13 and CPS ASDs. As shown in *SEI Logbook entry #15*, these peaks are caused by ground motion. Hence, high standard deviations should not be associated with sensor noise.
Note: Vertical CPSs are out of requirement when the ISI is unlocked. This little issue will be solved when the balancing was perfected for the next steps of testing.

- ***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	-250.23	8.98	-130.32	24.21	119.91
H2	100.34	7.15	144.23	18.61	43.89
H3	135.28	7.49	-425.38	30.98	560.66
V1	-125.67	9.33	439.86	22.21	565.53
V2	-777.05	17.66	151.37	23.91	928.42
V3	-279.89	13.21	-395.83	26.57	115.94

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	20600	-19200	24.8	-23.1	39800
V2	17400	-19600	20.9	-23.6	37000
V3	19800	-21030	23.8	-25.3	40830

Pushing RZ, -RZ	CPS read out		Calculated after calibration		ROM
Sensors	CCW (+RZ)	CW(-RZ)	CW (mil)	CCW (mil)	
H1	-22000	22000	-26.4	26.4	44000
H2	-19000	20000	-22.8	24.0	39000
H3	-22000	23000	-26.4	27.6	45000

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	-23000	22300		X	45300
H2	-22400	21700		X	44100
H3	-21900	23300		X	45200
V1	20300	-20100		X	40400
V2	32000	-32000	X	X	64000
V3	25000	-26000		X	51000

Table - Optic table range of motion

Issues/difficulties encountered during this test:

- Contact points are difficult to check on vertical actuators.
- V2 was railing when pushing locally on V3.
- Horixontal motion (Rz) was computed in mils from the vertical CPS calibration.

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.

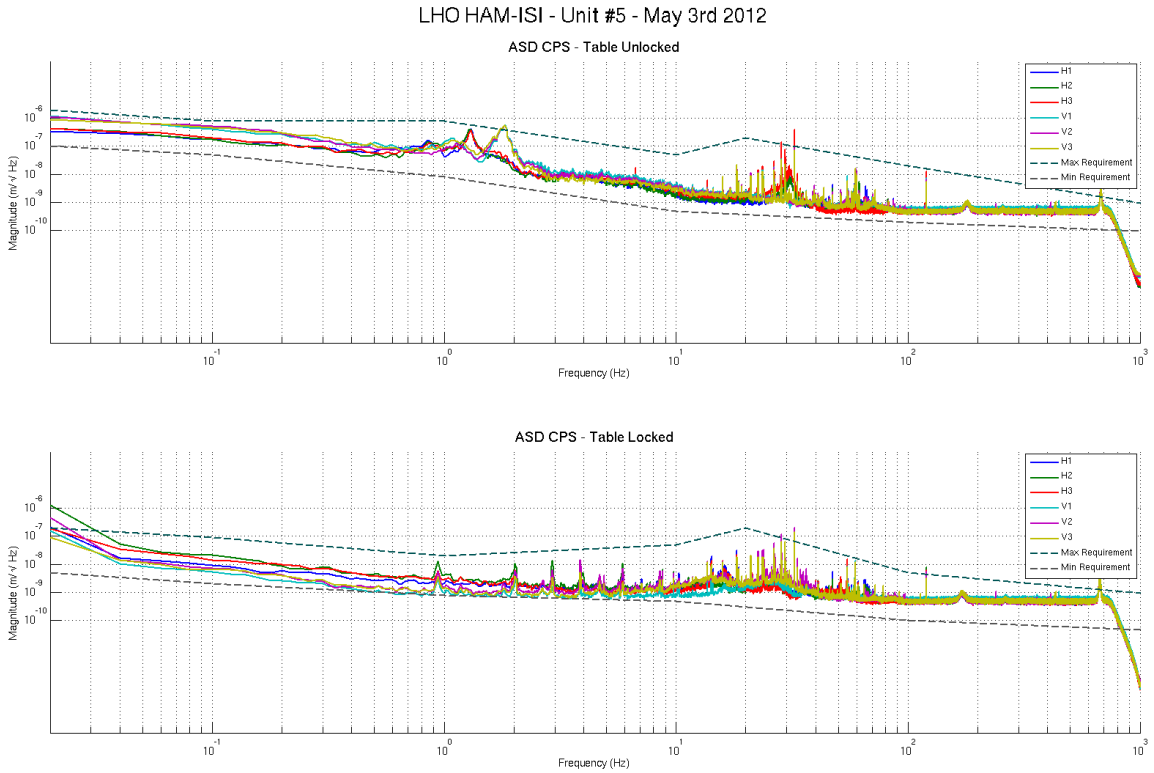


Figure - Calibrated CPS power spectra

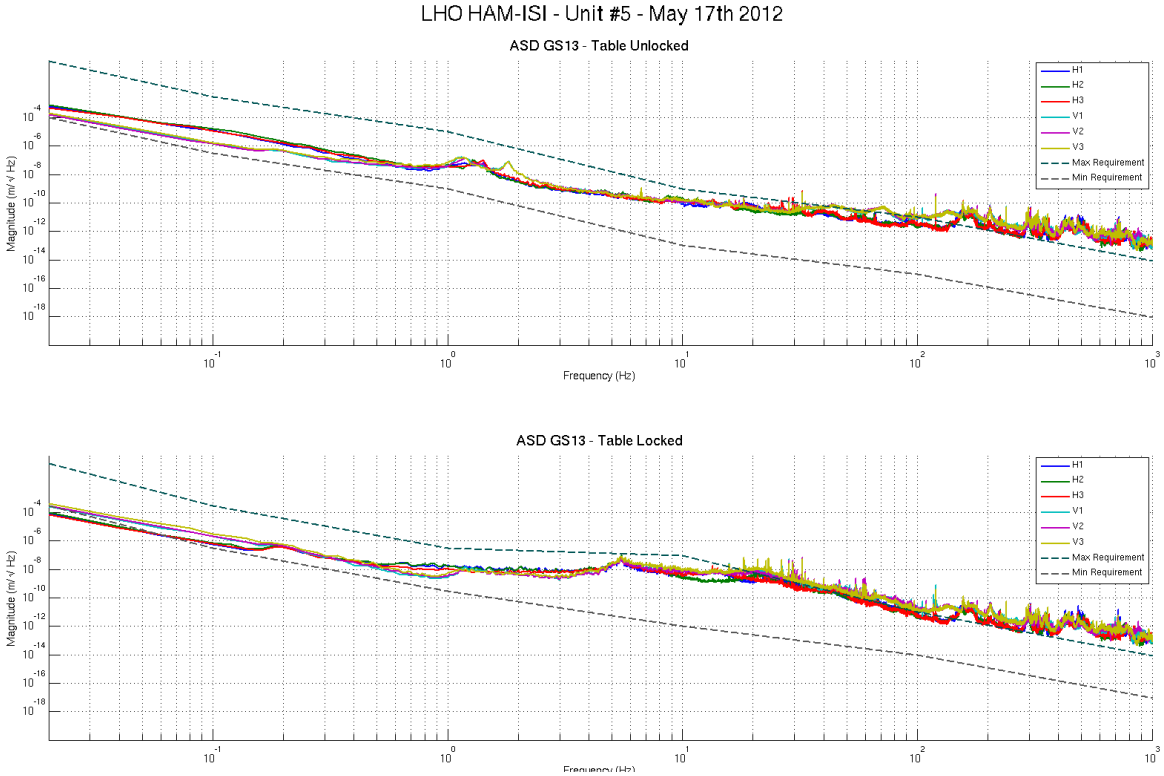


Figure – Calibrated GS13 Power spectra

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_5_ASD_m_CPS_T240_L4C_GS13_Locked_vs_Unlocked_2012_05_17.mat

Figures in SVN at:
/SeiSVN/seismic/HAM-ISI/X1/HAMX/Data/Figures/Spectra/Undamped
- LHO_ISI_UNIT_5_PSD_m_GS13_Locked_vs_Unlocked_2012_05_17.fig
- LHO_ISI_UNIT_5_PSD_m_CPS_ Locked_vs_Unlocked_2012_05_17.fig

Issues/difficulties/comments regarding this test:
- 10Hz-100Hz peaks 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.

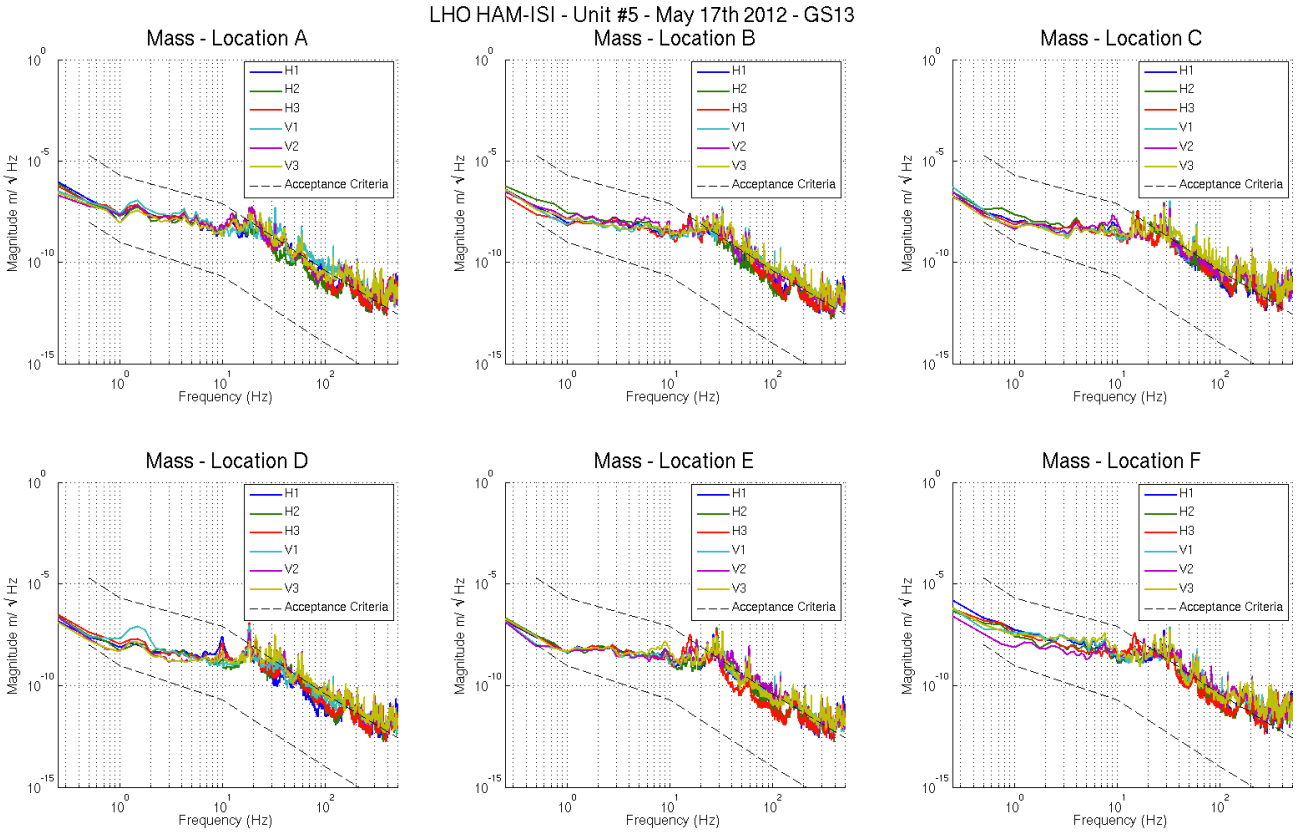


Figure – Power spectrum Calibrated GS13 with mass at corners A to F

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_5_ASD_m_GS13_Stage_Tilted_2012_05_17.mat

Figures in SVN at:
SeiSVN/seismic/HAM-ISI/X1/HAMX/Data/Figures/Spectra/Undamped
- LHO_ISI_UNIT_5_m_PSD_GS13_Tilted_2012_05_17.fig

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***

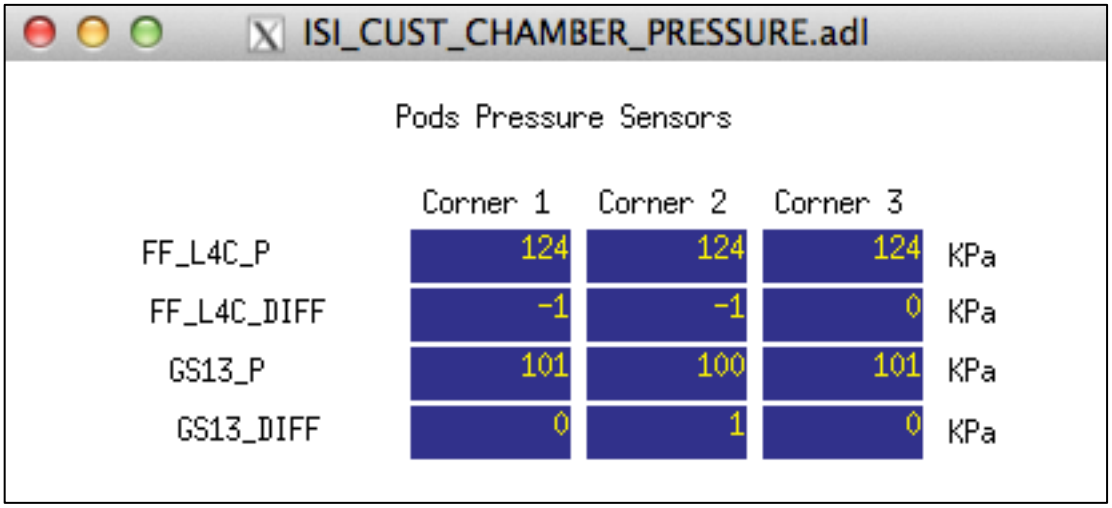


Figure – Pressure Readouts

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: There is no L4C on this Unit. The values read on the FF_L4C_P channels are suspicious. These channels display 30KPa when GS13 interface-chassis are OFF, and 124KPa when GS13 interface chassis are ON.

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

Actuator	V1		H1		V2	
Coil driver	S1000266 - Coarse 2		S1000266 - Coarse 1		S1000269 - Coarse 2	
Cable #	S1106679		S1104492		S1104490	
Resistance (Ohm)	P1 - P2	P2 - P3	P1 - P2	P2 - P3	P1 - P2	P2 - P3
	O.L (infinity)	6.5	O.L (infinity)	6.5	O.L (infinity)	6.5
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 #	S1104756		S1105207		S1106678	
Resistance (Ohm)	P1 - P2	P2 - P3	P1 - P2	P2 - P3	P1 - P2	P2 - P3
	O.L (infinity)	6.5	O.L (infinity)	6.5	O.L (infinity)	6.5
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)	-24394	-147	23977	48371
H2 readout (count)	-24102	124	23981	48083
H3 readout (count)	-24270	-424	25092	49362
V1 readout (count)	-19143	462	20146	39289
V2 readout (count)	-26064	184	26109	52173
V3 readout (count)	-23320	-360	20977	44297

Table - Range of motion - Local drive

Issues/difficulties/comments regarding this test:

- 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	-18.90	0.00	19.50
B	-19.10	0.00	19.10
C	-18.90	0.00	19.10
D	-18.50	0.00	19.00
Average	-18.85	0.00	19.18

Sensors	Counts	Counts	Counts	Difference
V1	-14971.00	362.81	16410.00	31381.00
V2	-15149.00	770.03	16463.00	31612.00
V3	-15919.00	-117.31	15999.00	31918.00

Vertical Sensibility	
832.01	Count/mil
0.51	V/mil
30.53	nm/count
-0.95	% from ref (840count/mil)

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	-8323	-2.541E-04	78805	-2.65%
V2	-8039	-2.454E-04	81592	0.79%
V3	-7954	-2.428E-04	82457	1.86%
		Average (N/m)	242854	
			-1.69	% variation from nominal

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

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

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

	Sensors (counts)					
	H1	H2	H3	V1	V2	V3
H1	2099	1309	1296	-23	-17	14
H2	1292	2064	1293	17	-24	-16
H3	1260	1261	2001	5	-25	-11
V1	196	190	-392	1506	-55	-630
V2	-378	186	187	-648	1453	-33
V3	193	-381	201	-71	-648	1451

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	2.1037	-193.1119	2.06	2.04
H2	2.0597	93.2935		-0.09
H3	2.0215	-461.5963		-1.95
V1	1.5042	492.2323	1.47	2.08
V2	1.4634	218.1938		-0.69
V3	1.453	-322.766		-1.39

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

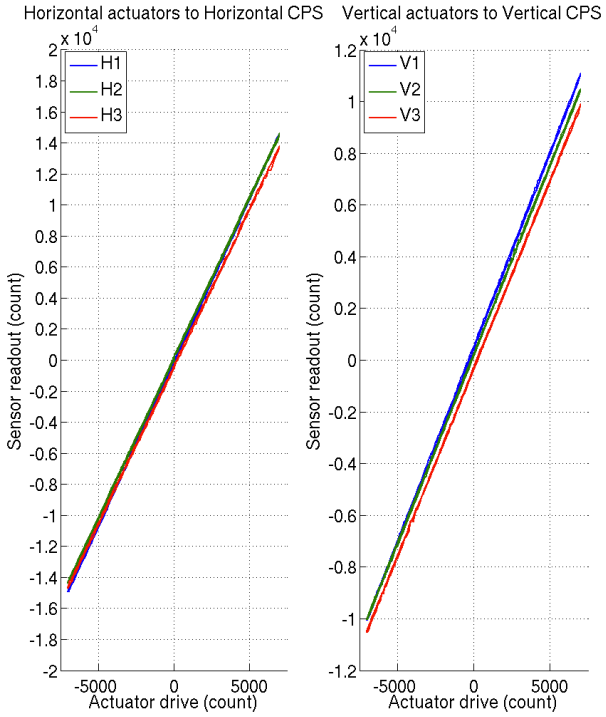


Figure - Linearity test on the triplet 'actuators - HAM-ISI – sensors' in both Horizontal and vertical directions

Issues/difficulties encountered during this test:

- H1, H3 and V1 do not meet our requirements.
- 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.

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	285.10	272.52	-463.91	-17.34	-30.18	-22.76	506.38
Y Drive	-461.20	418.89	-15.08	6.68	-32.85	-18.13	525.64
Z Drive	-5.47	-6.26	-1.06	272.07	256.14	242.21	266.38
Rx Drive	-452.02	447.27	12.34	-485.66	1673.81	-1216.00	2584.48
Ry Drive	-279.17	-271.21	549.72	-1724.15	399.50	1241.35	2631.81
Rz Drive	-1998.09	-2000.19	-1995.12	-3.80	-34.73	-31.69	2524.51

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	506.38	0.63	2.17	3.61	9.78	-40.31	506.38
Y Drive	-6.97	525.64	1.05	6.06	14.93	15.09	525.64
Z Drive	-0.45	2.12	266.38	36.92	-15.86	-2.81	266.38
Rx Drive	12.63	2.26	3.78	2584.48	4.73	-1.47	2584.48
Ry Drive	-1.83	7.32	-5.54	30.44	2631.81	-4.58	2631.81
Rz Drive	1.48	11.88	3.36	2.66	-8.44	2524.51	2524.51

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
- 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_5_Data_TF_L2L_10mHz_100mHz_20120522-011123.mat
- LHO_ISI_HAM_Unit_5_Data_TF_L2L_100mHz_500mHz_20120521-222957.mat
- LHO_ISI_HAM_Unit_5_Data_TF_L2L_500mHz_5Hz_20120521-184031.mat
- LHO_ISI_HAM_Unit_5_Data_TF_L2L_5Hz_200Hz_20120521-174707.mat
- LHO_ISI_HAM_Unit_5_Data_TF_L2L_200Hz_1000Hz_20120521-162943.mat

Scripts files for processing and plotting in SVN at:
/SeiSVN/seismic/HAM-ISI/X1/HAMX/Scripts/Control_Scripts/
- 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_05_22.fig
- X1_ISI_HAMX_TF_L2L_Raw_from_ACT_to_GS13_2012_05_22.fig

Storage of measured transfer functions in the SVN at:
/SeiSVN/seismic/HAM-ISI/X1/HAMX/Data/Transfer_functions/ Simulations/Undamped/
- LHO_ISI_Unit_5_TF_L2L_Raw_2012_05_22.mat

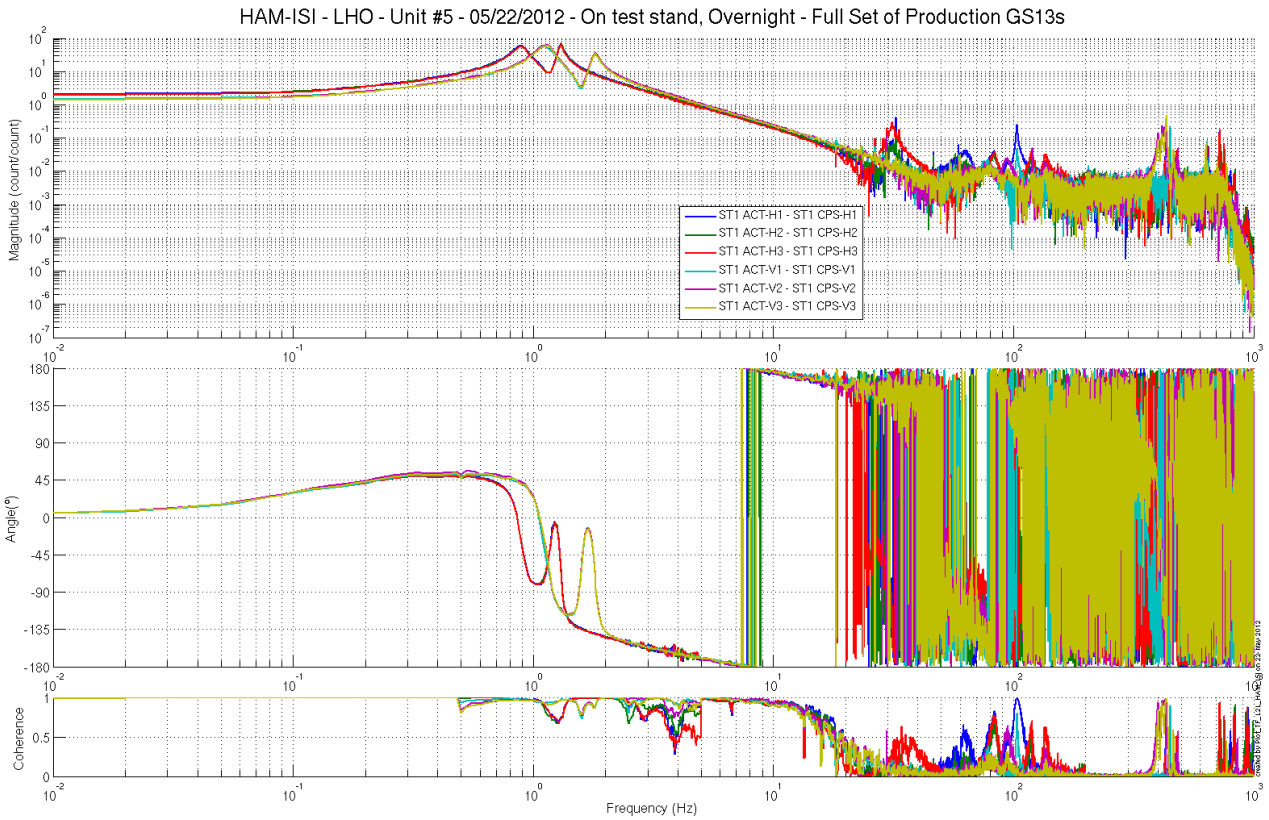


Figure - local-to-Local Measurements – Capacitive sensors

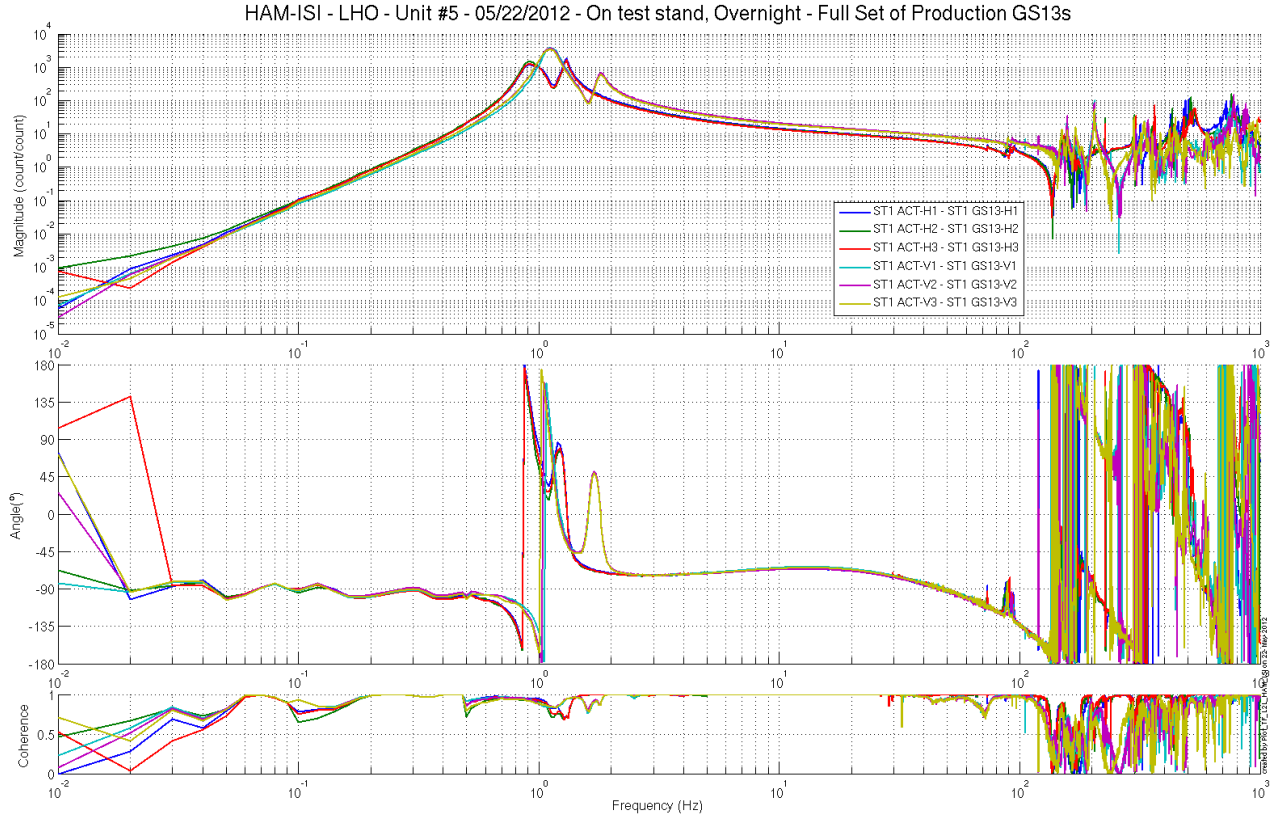
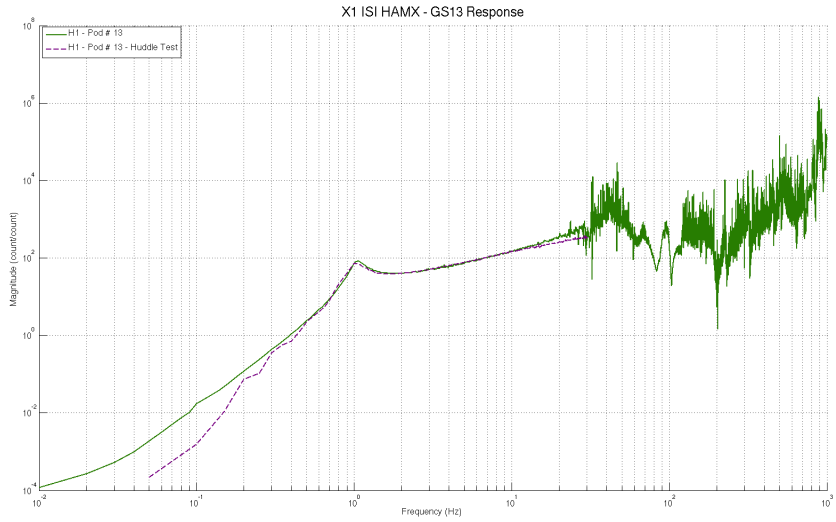


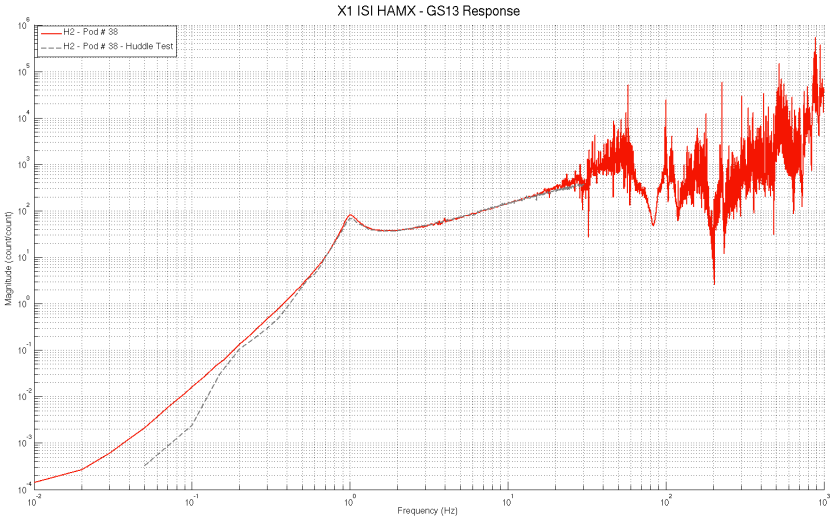
Figure - local-to-Local Measurements – Inertial sensors

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

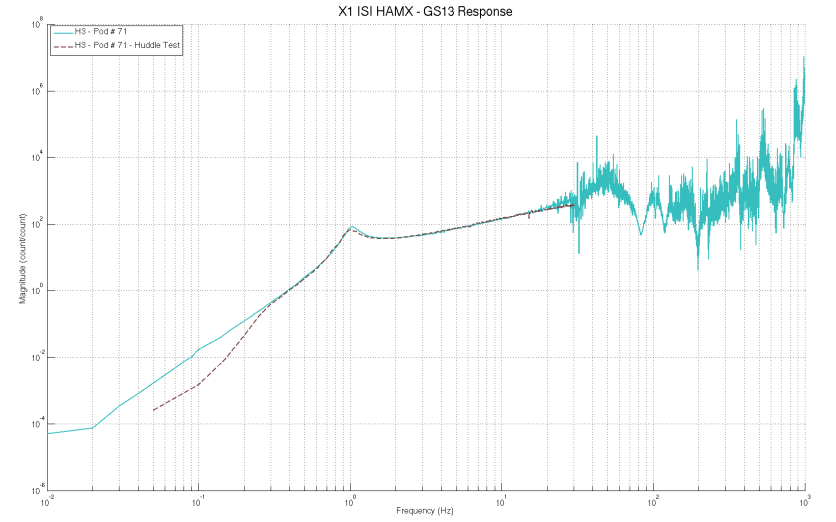
Plots for the extracted responses are presented below.



Huddle Test Adjustment Gain: 1.3319



Huddle Test Adjustment Gain: 0.12459



Huddle Test Adjustment Gain: 0.1279

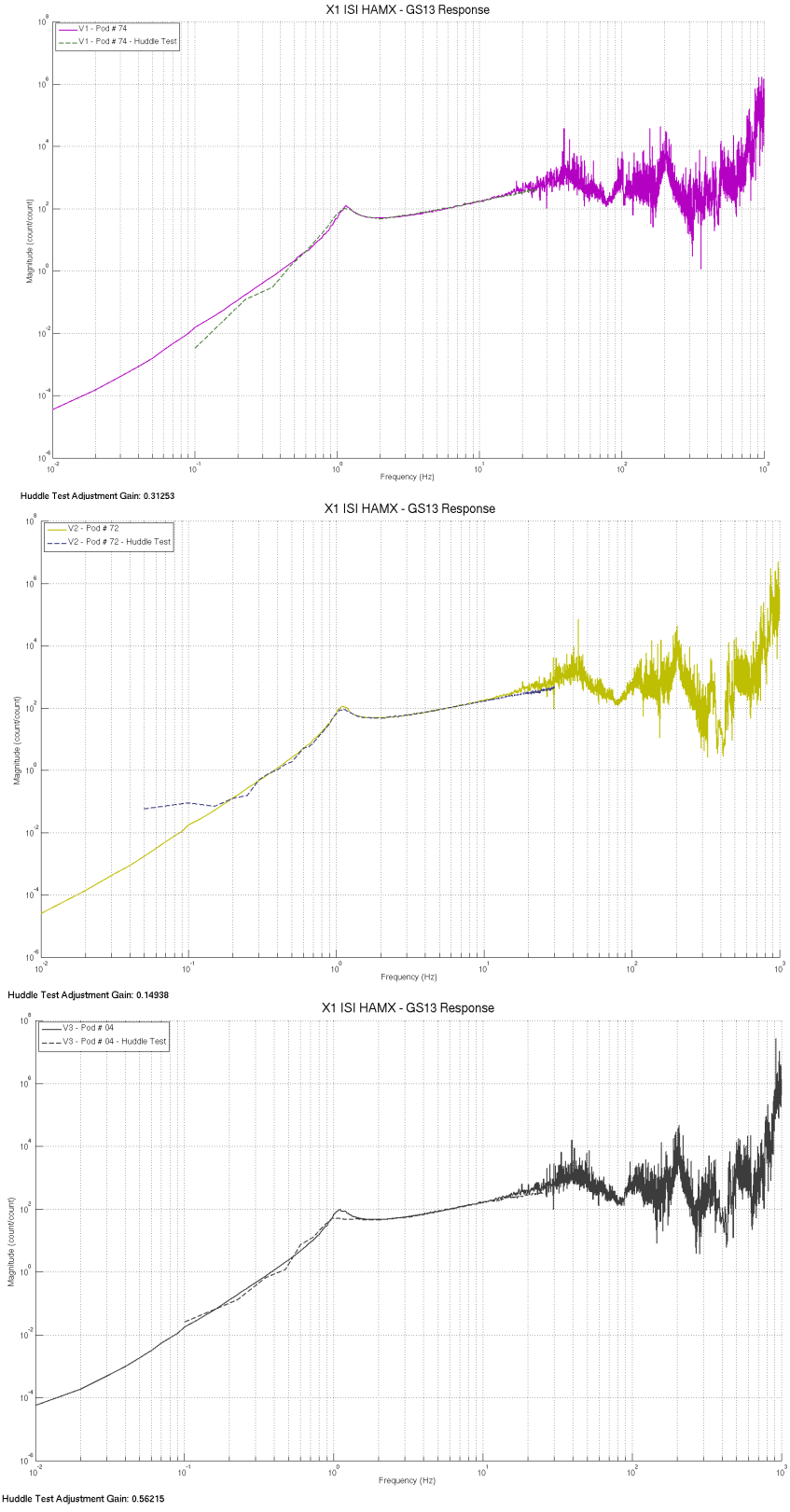


figure – GS13 extracted responses VS Huddle test responses

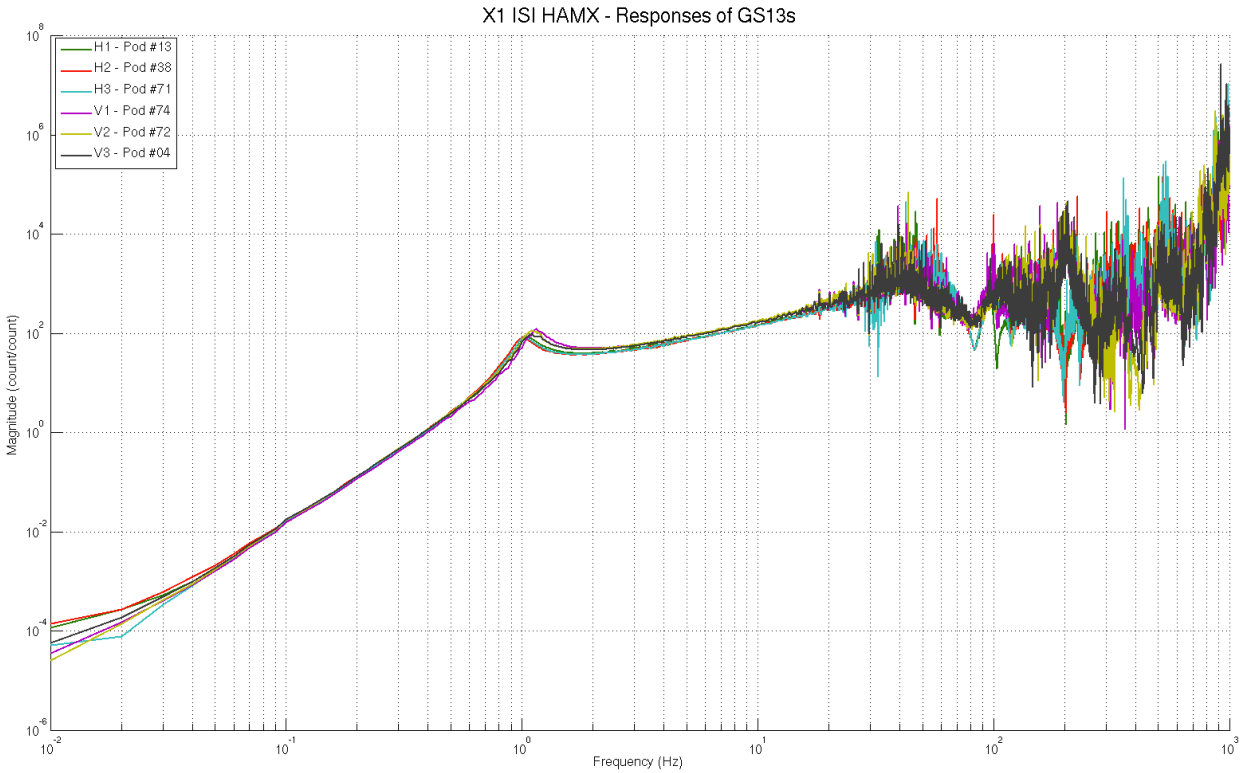


figure – Extracted GS13 responses comparison

Issues/difficulties encountered during this test:

- 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_13_Extracted_Response_VS_Huddle.fig
- X1_ISI_HAMX_GS13_H2_Pod_38_Extracted_Response_VS_Huddle.fig
- X1_ISI_HAMX_GS13_H3_Pod_71_Extracted_Response_VS_Huddle.fig
- X1_ISI_HAMX_GS13_V1_Pod_74_Extracted_Response_VS_Huddle.fig
- X1_ISI_HAMX_GS13_V2_Pod_72_Extracted_Response_VS_Huddle.fig
- X1_ISI_HAMX_GS13_V3_Pod_04_Extracted_Response_VS_Huddle.fig

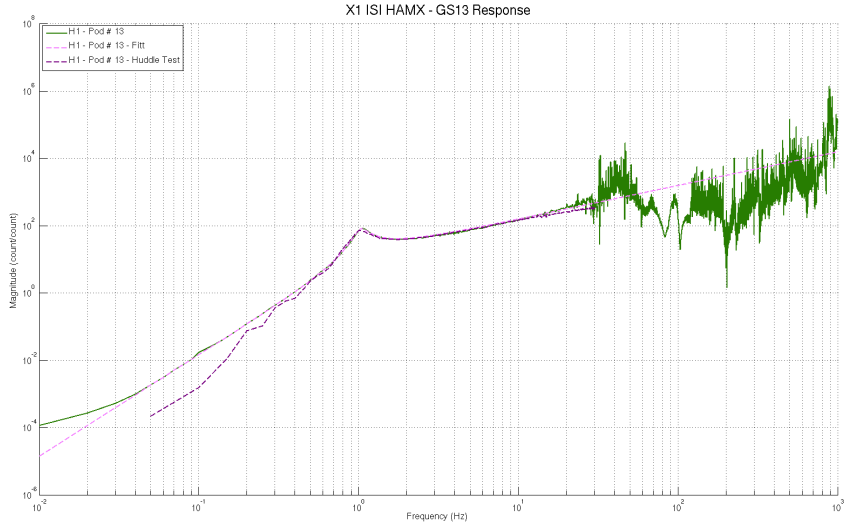
Acceptance criteria:

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

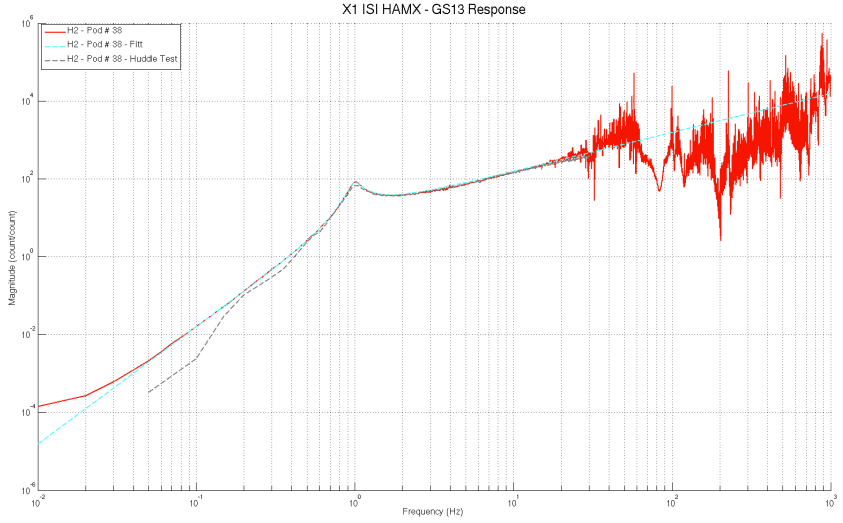
Test result: **Passed: X** **Failed: ____**

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

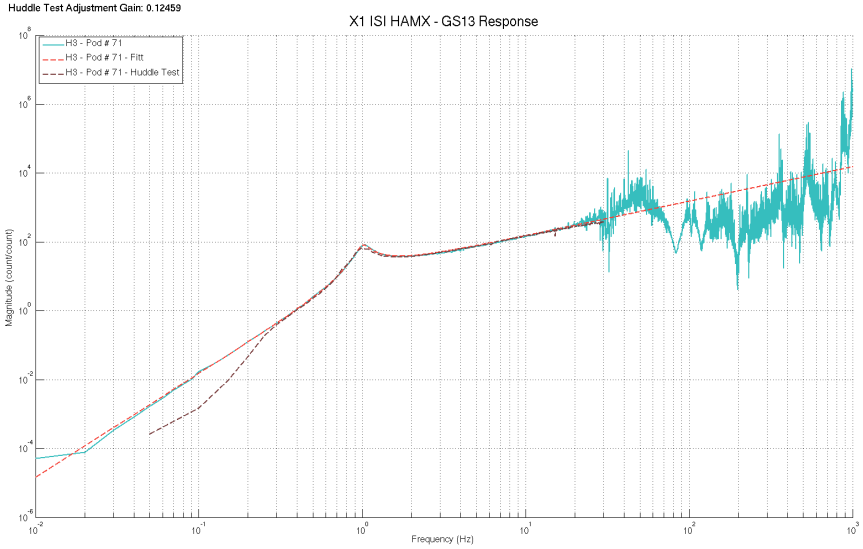
Fitted responses for the GS13s are presented below.



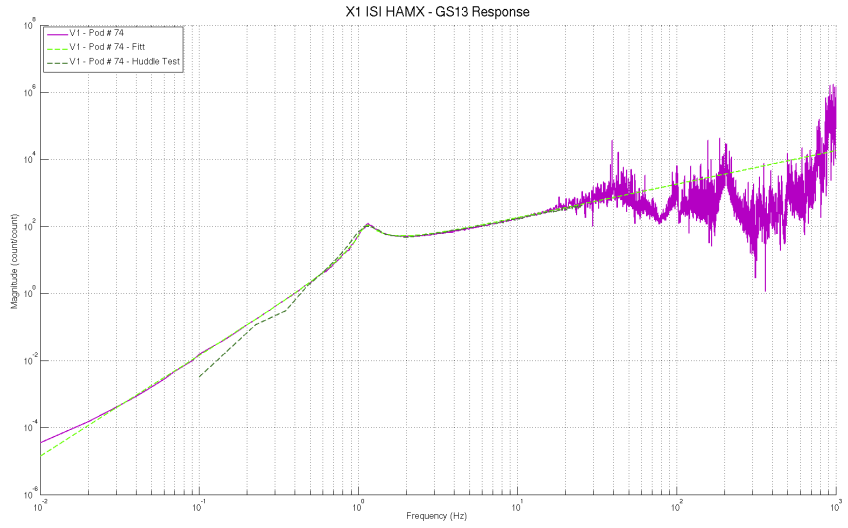
Huddle Test Adjustment Gain: 1.3319



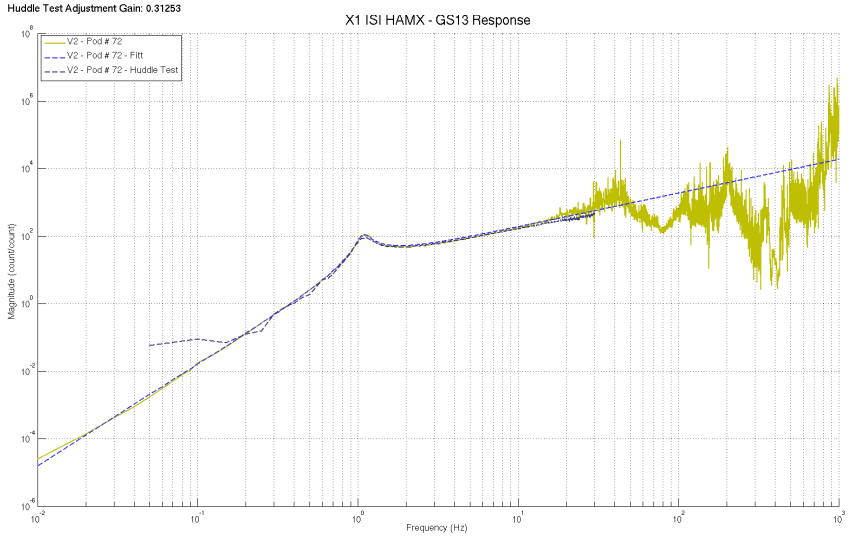
Huddle Test Adjustment Gain: 0.12459



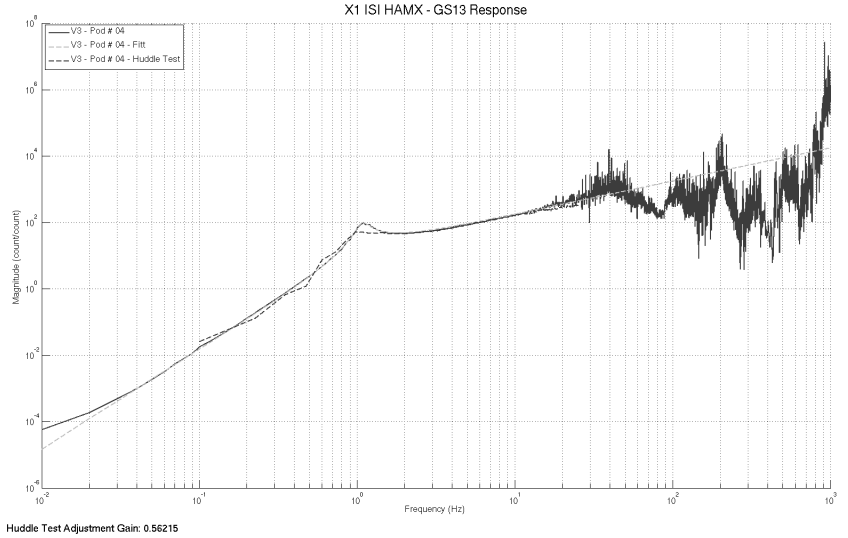
Huddle Test Adjustment Gain: 0.1279



Huddle Test Adjustment Gain: 0.31253



Huddle Test Adjustment Gain: 0.14938



Huddle Test Adjustment Gain: 0.56215

figure – Fitted responses of the GS13s

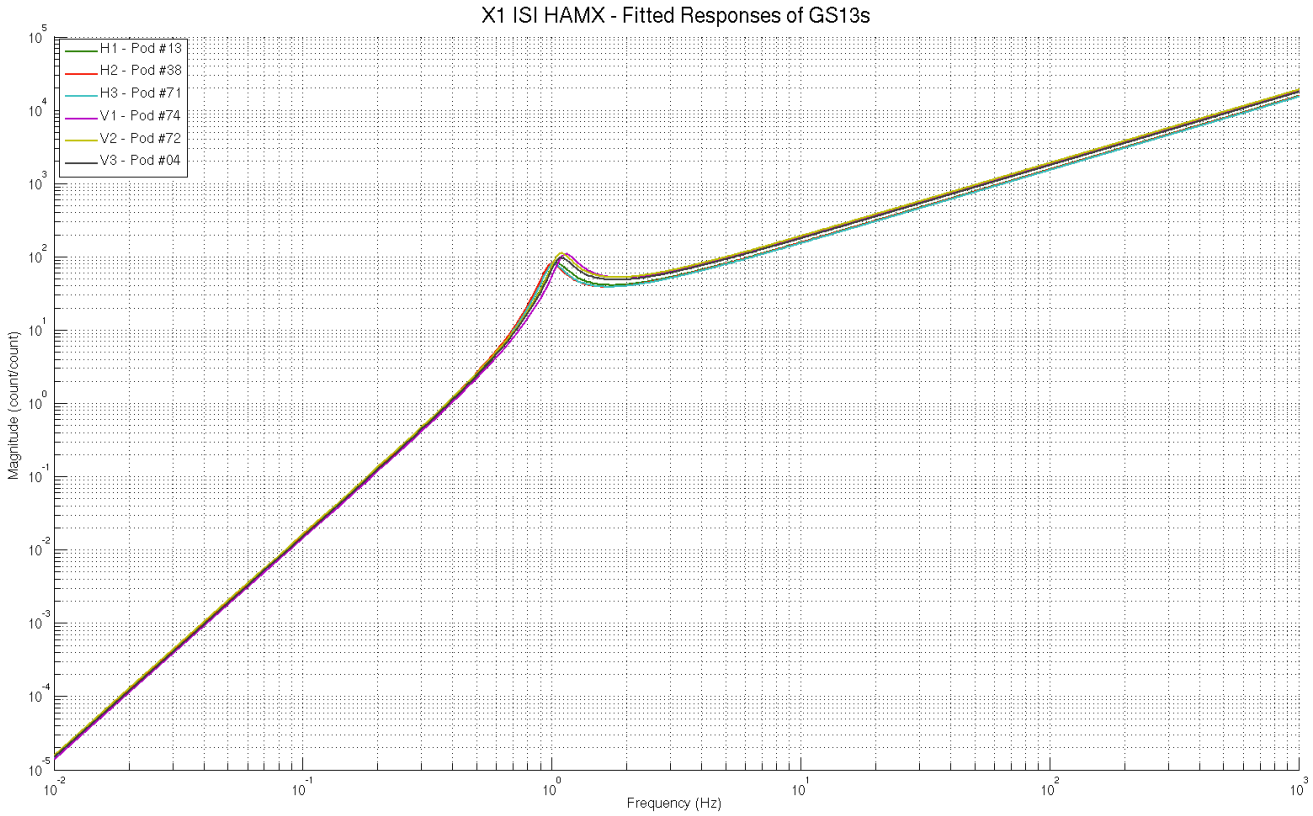


figure – Comparison of the fitted responses for the GS13s

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_84_Extracted_Response_VS_Fitt_VS_Huddle.fig
- X1_ISI_HAMX_GS13_H2_Pod_20_Extracted_Response_VS_Fitt_VS_Huddle.fig
- X1_ISI_HAMX_GS13_H3_Pod_37_Extracted_Response_VS_Fitt_VS_Huddle.fig
- X1_ISI_HAMX_GS13_V1_Pod_74_Extracted_Response_VS_Fitt_VS_Huddle.fig
- X1_ISI_HAMX_GS13_V2_Pod_72_Extracted_Response_VS_Fitt_VS_Huddle.fig
- X1_ISI_HAMX_GS13_V3_Pod_04_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.

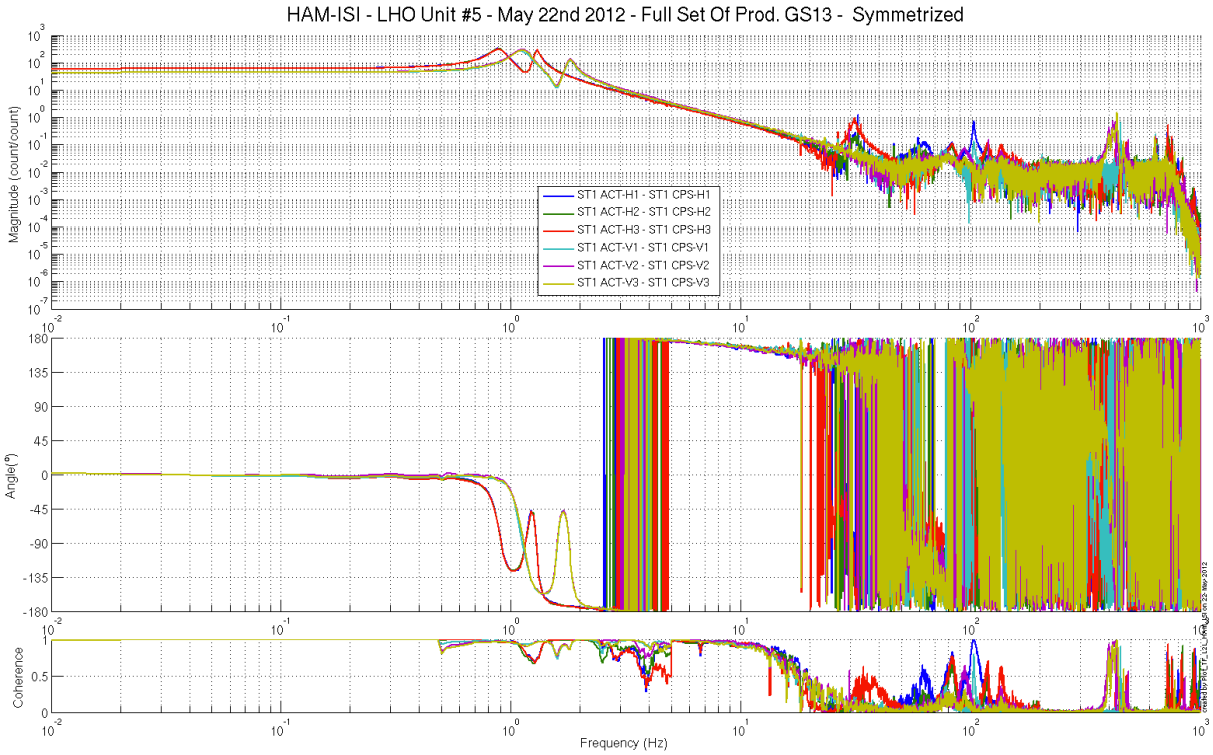


figure – Symmetrized L2L – Computed TFs – Capacitive sensors

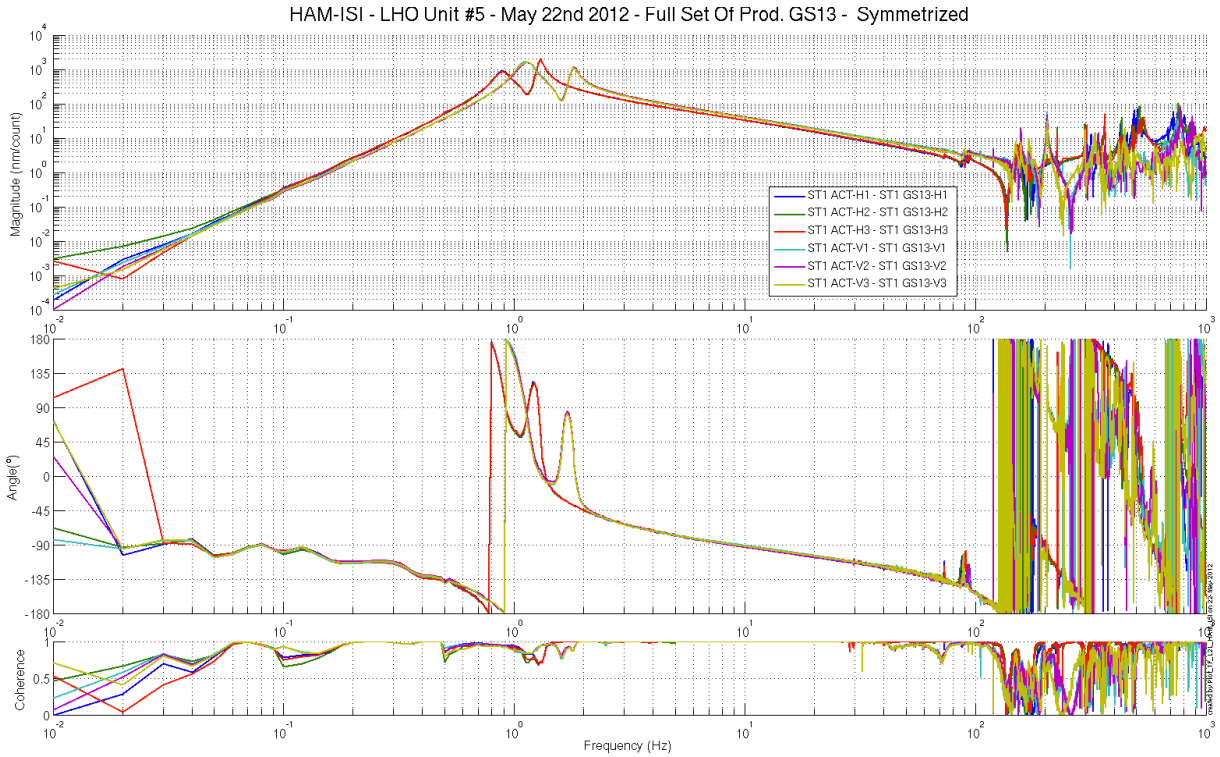


figure – Symmetrized L2L – Computed TFs – Innertial sensors

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

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

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

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_05_22.fig
- X1_ISI_HAMX_TF_C2C_Symmetrized_from_ACT_to_GS13_2012_05_22.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_05_22.mat
-

The Cartesian to Cartesian transfer functions are presented below:

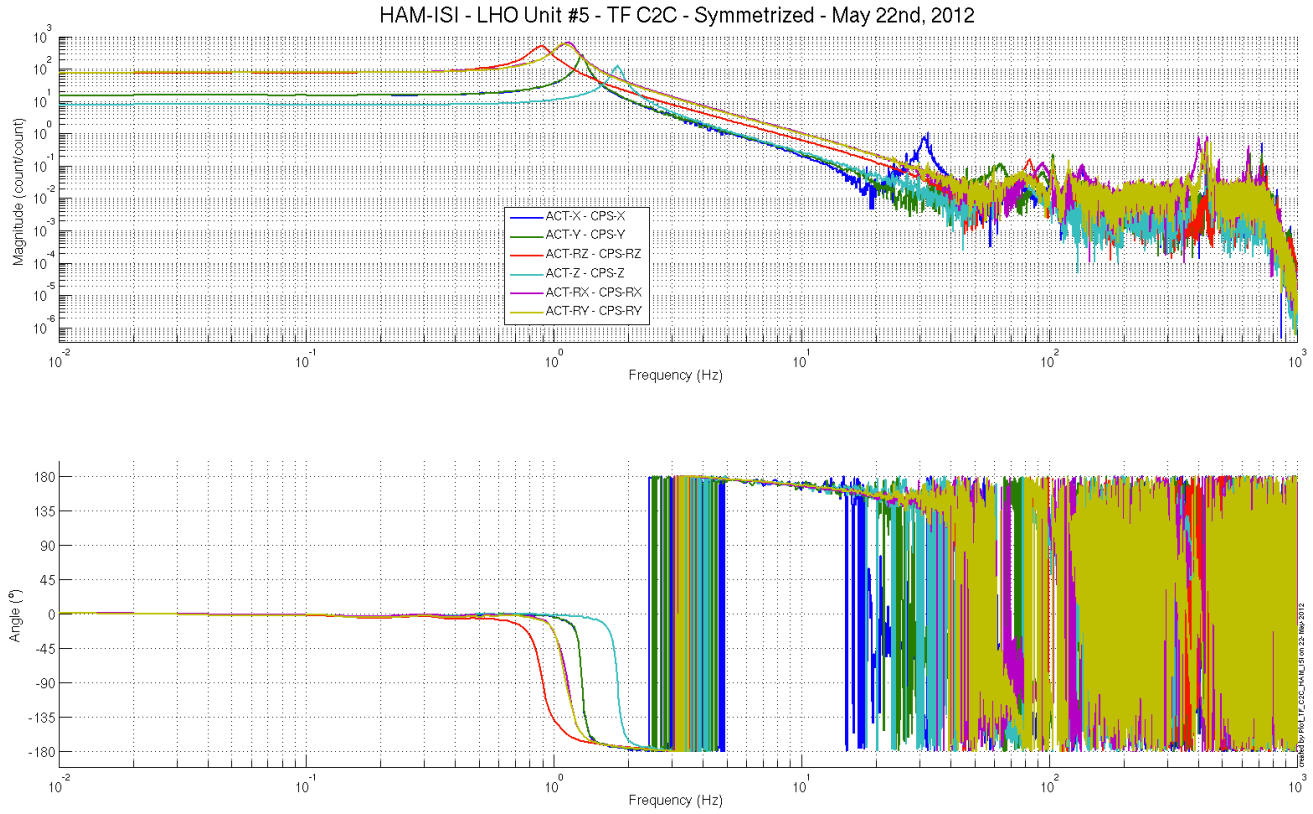


Figure – Cartesian to Cartesian – computed - Capacitive sensors

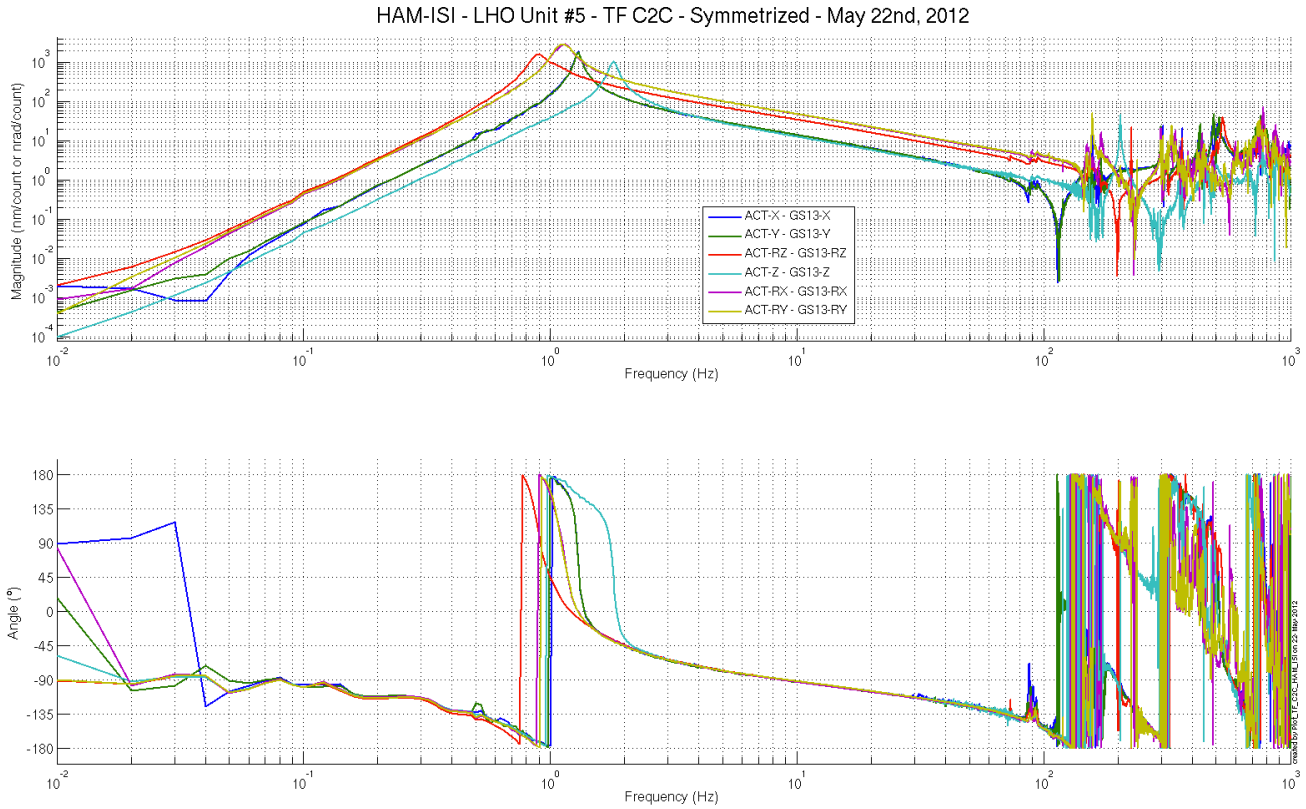


Figure – Cartesian to Cartesian - computed - Inertial sensors

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
- 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

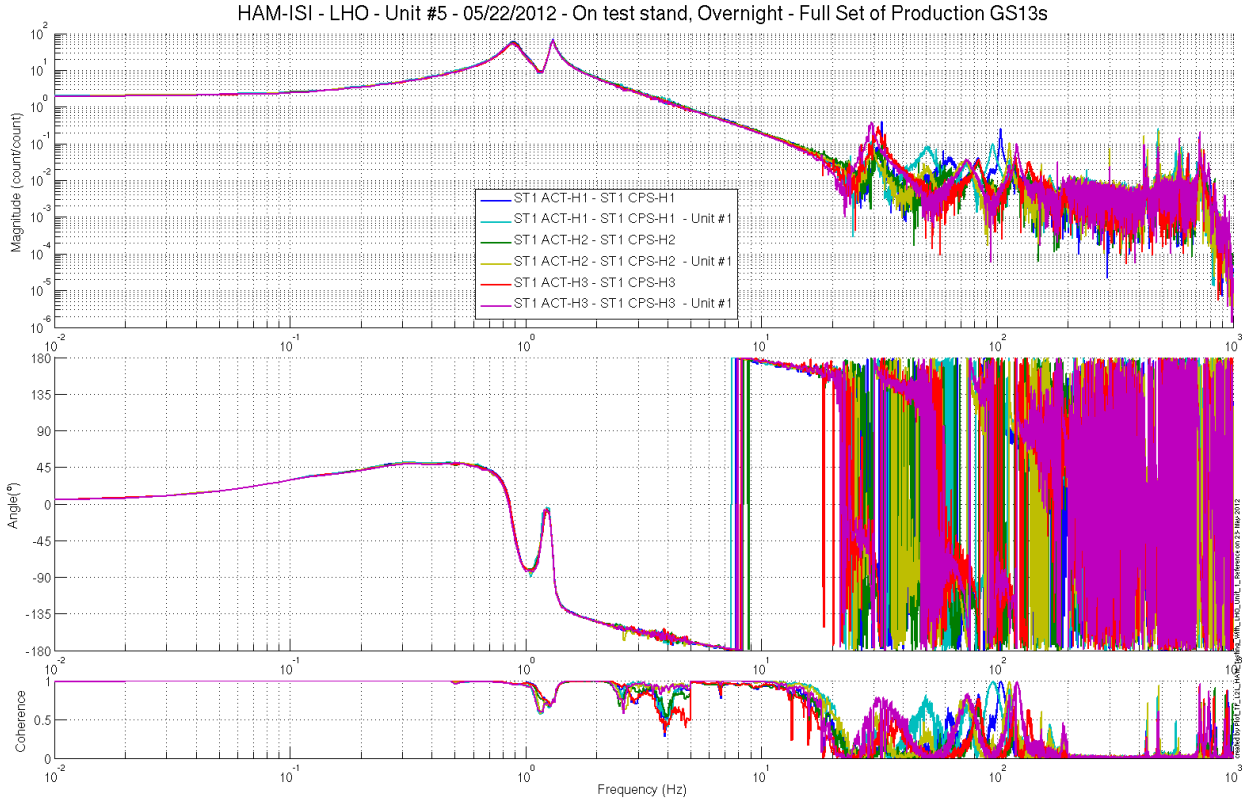


Figure – local-to-Local measurements, comparison with Unit #1 reference

Capacitive Position Sensors - Horizontal motion

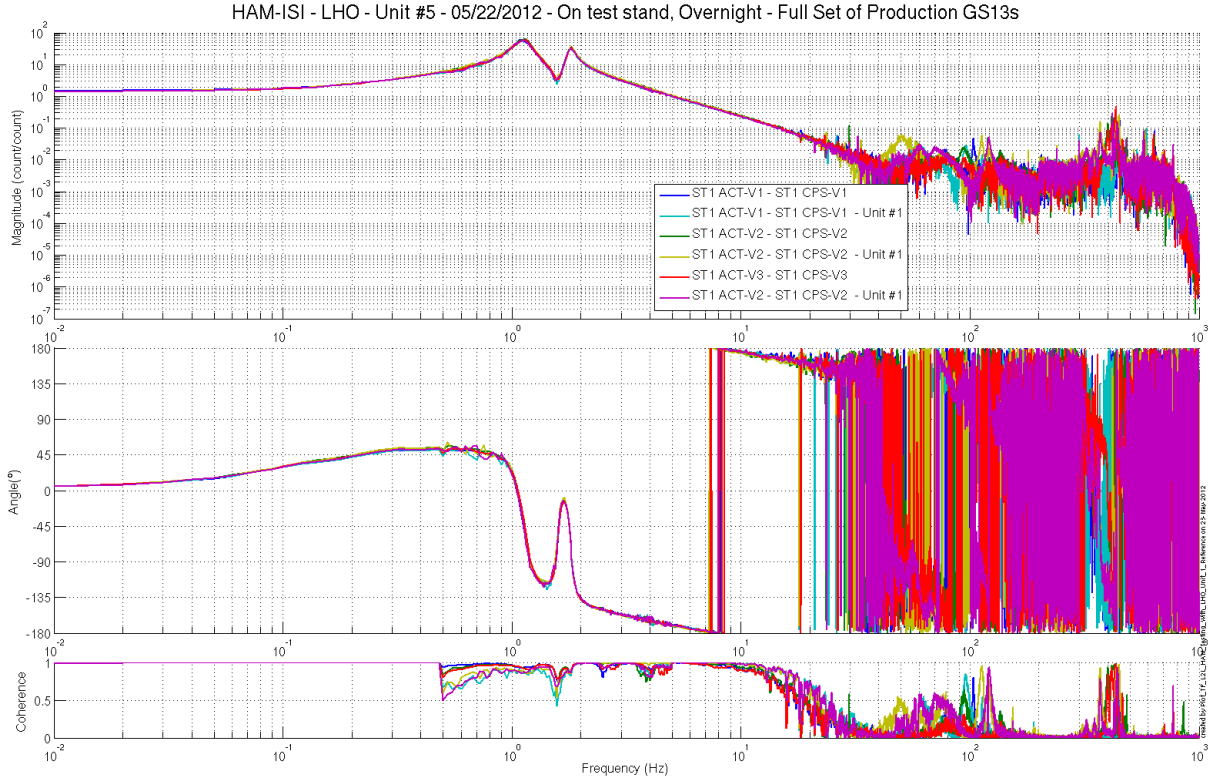


Figure – local-to-Local measurements, comparison with Unit #1 reference

Capacitive Position Sensors - Vertical motion

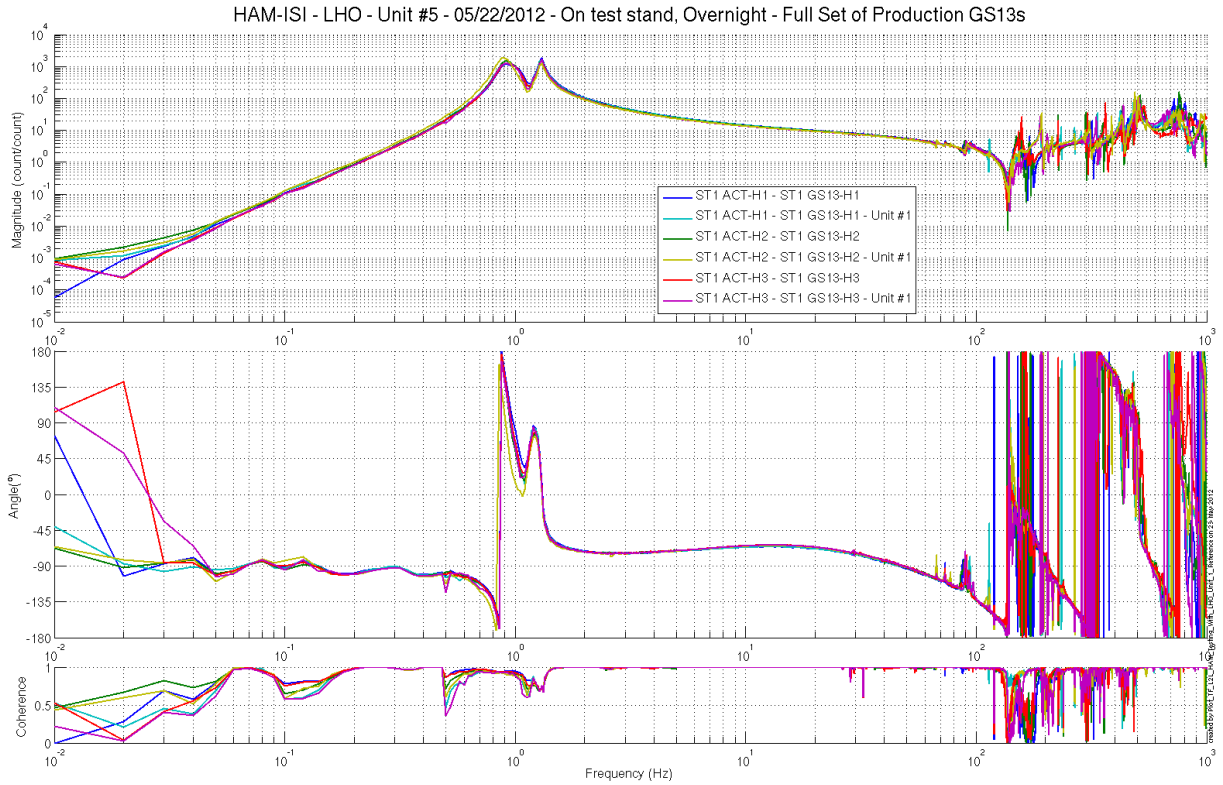


Figure – local-to-Local measurements, comparison with Unit #1 reference

Inertial Sensors - Horizontal motion

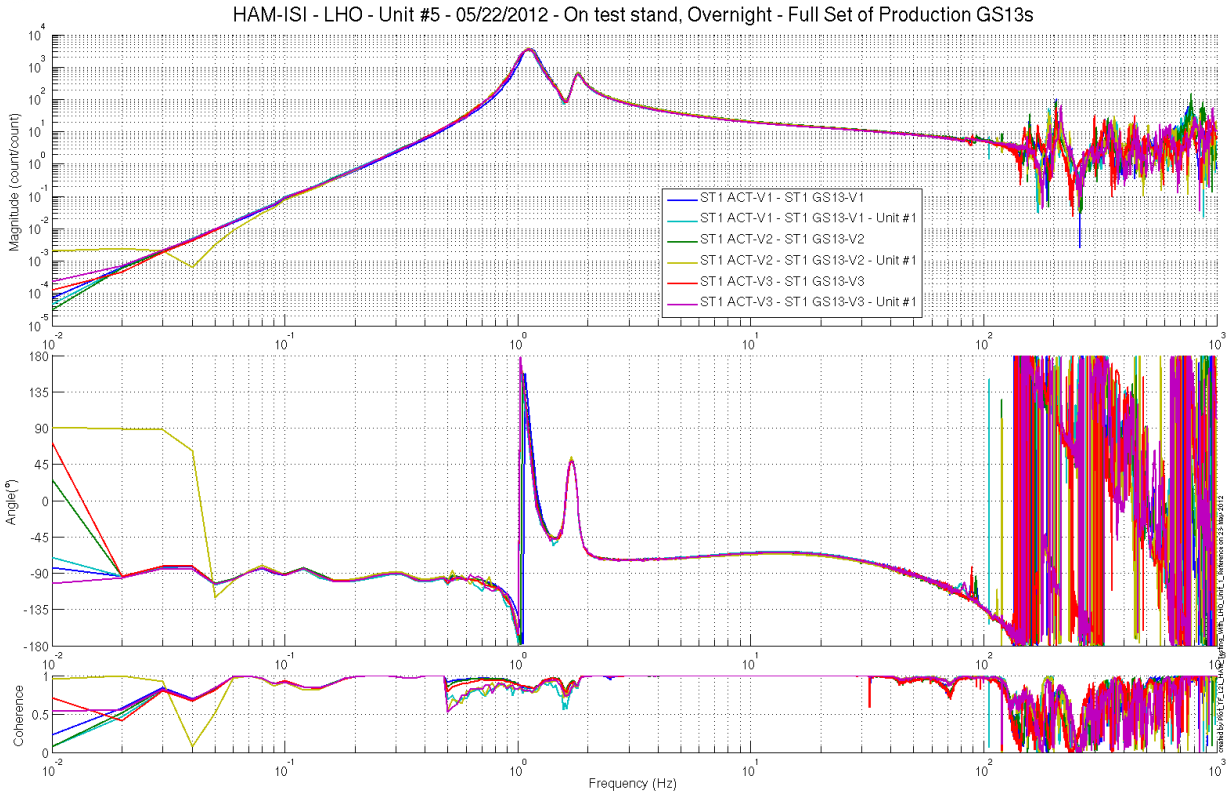


Figure – local-to-Local measurements, comparison with Unit #1 reference
Inertial Sensors - Vertical motion

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_04_04.fig
  X1_ISI_HAMX_TF_C2C_Raw_from_ACT_V_to_CPS_V_Symmetrized_vs_Unit_1_2012_04_04.fig
- X1_ISI_HAMX_TF_C2C_Raw_from_ACT_H_to_GS13_H_Symmetrized_vs_Unit_1_2012_04_04.fig
  X1_ISI_HAMX_TF_C2C_Raw_from_ACT_V_to_GS13_V_Symmetrized_vs_Unit_1_2012_04_04.fig

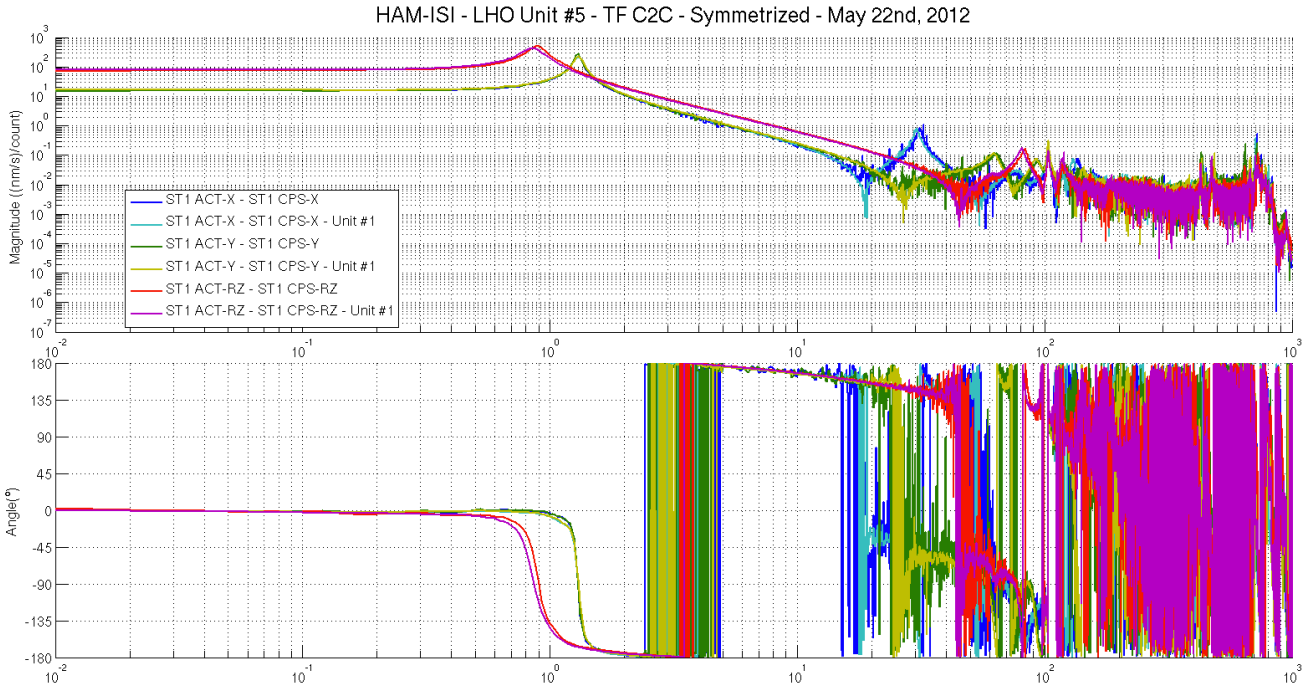


Figure – Cartesian to Cartesian measurements, comparison with Unit #1 reference
Capacitive Position Sensors - Horizontal motion

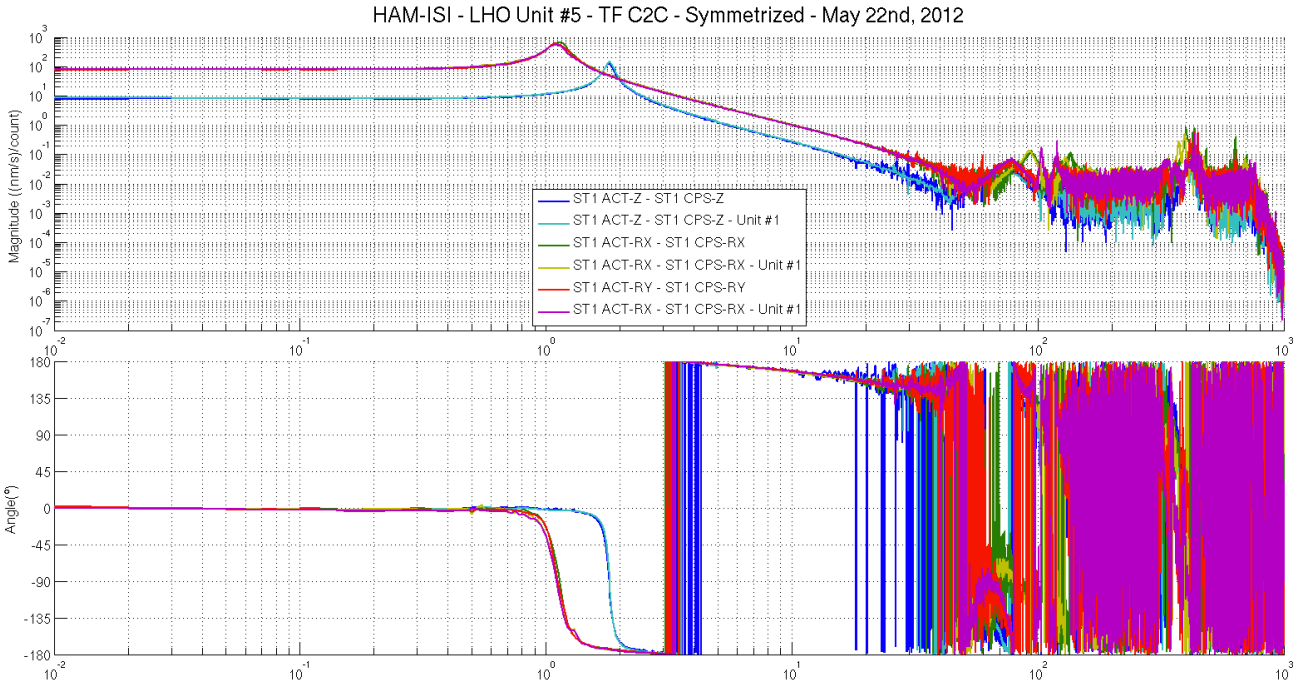


Figure – Cartesian to Cartesian measurements, comparison with Unit #1 reference
Capacitive Position Sensors - Vertical motion

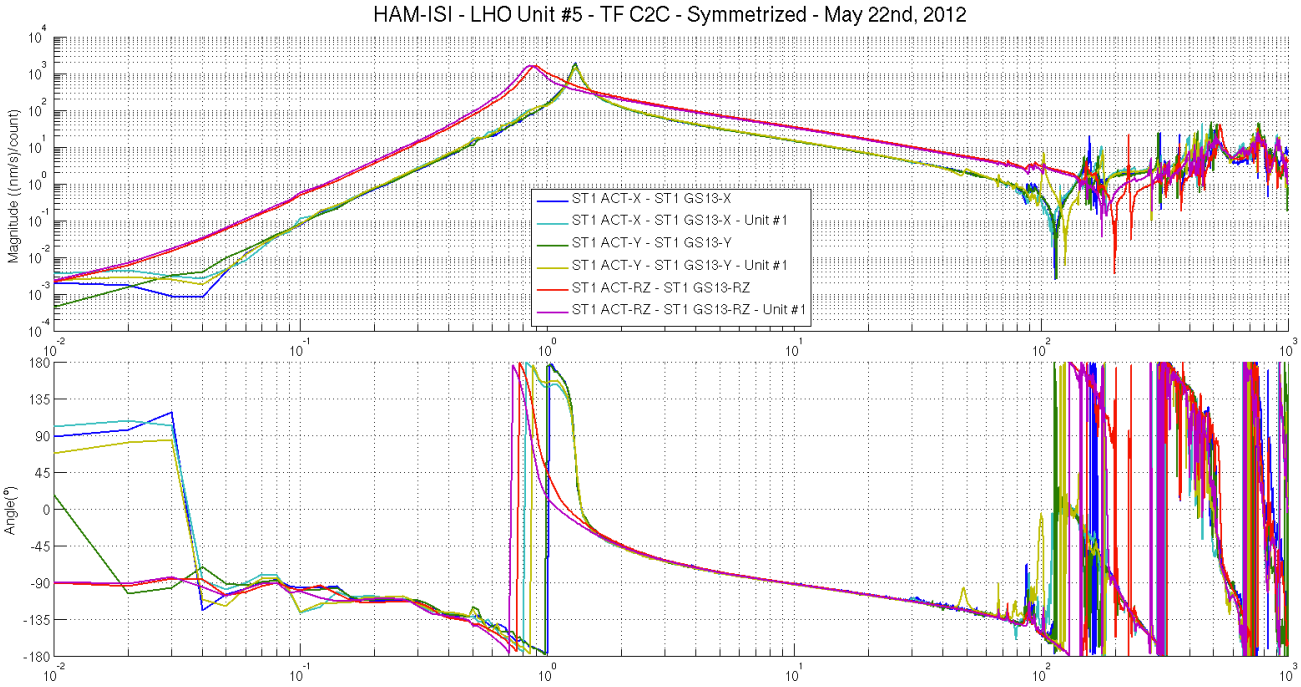


Figure – Cartesian to Cartesian measurements, comparison with Unit #1 reference – Inertial Sensors
Horizontal motion

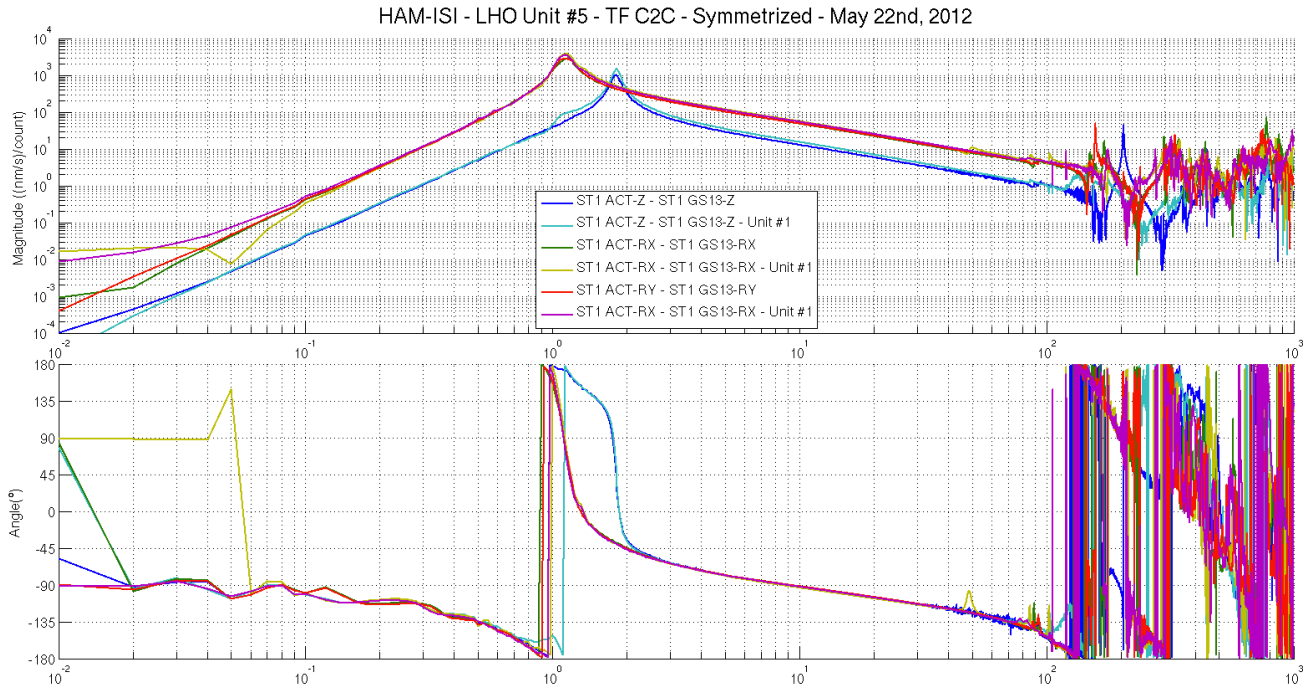


Figure – Cartesian to Cartesian measurements, comparison with Unit #1 reference
Inertial Sensors - Vertical motion

Issues/difficulties encountered during this test:
Unit #5's 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: ___**

Note:
Phase shifts on GS13s, that are not observed on CPSs, can be associated to the difference in response between the GS13s.

- ***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_5_Data_TF_C2C_10mHz_100mHz_LZMP_20120523-163904.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_5_LZMP_20120523.fig

The result of the measurement performed is presented below. Symmetrization filters are engaged. Measurement was performed over 46h (800 averages), during the weekend.

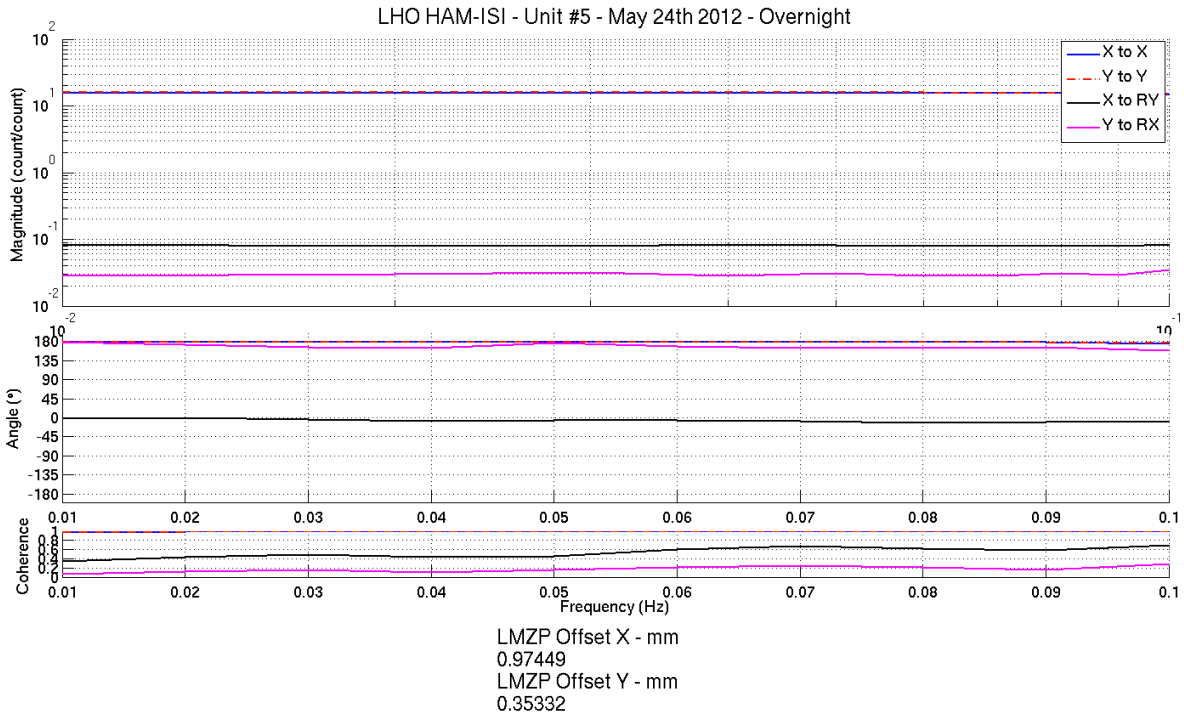


Figure - Lower Zero Moment Plane – Main and cross couplings at low frequency

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

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

- ***Step 19 - Damping loops***

In this step, HAM6 damping loops are implemented. First, damping performances are evaluated in simulation. Second, Damping loops are implemented and performance is experimentally measured.

- ***Step 19.1 – Simulation of damping performance - TF***

Continuous HAM6 filters are located in the SVN at:
/SeiSVN/seismic/HAM-ISI/Common/HAM6_Main_Results/
- HAM6_LLO_Damping_Filters.mat

Scripts files used to evaluate damping loops performance from measurementsare located in SVN at:
/SeiSVN/seismic/HAM-ISI/X1/HAMX/Scripts/Control_Scripts/
- Step_4_Damping_Filters_X1_ISI_HAMX.m

TF Data file is located in the SVN at:
/seismic/HAM-ISI/X2/Data/Unit_2/Transfer_Functions/Simulations/Damping/
- X1_ISI_HAMX_TF_C2C_Damped_2012_05_22.mat

Figures in SVN at:
/SeiSVN/seismic/HAM-ISI/X1/HAMX/Data/Figures/Transfer_Functions/Simulations/Damped/
- X1_ISI_HAMX_Damping_TF_MIMO_ST1_ACT_RX_to_ST1_GS13_RX_2012_05_22.fig
- X1_ISI_HAMX_Damping_TF_MIMO_ST1_ACT_RY_to_ST1_GS13_RY_2012_05_22.fig
- X1_ISI_HAMX_Damping_TF_MIMO_ST1_ACT_RZ_to_ST1_GS13_RZ_2012_05_22.fig
- X1_ISI_HAMX_Damping_TF_MIMO_ST1_ACT_X_to_ST1_GS13_X_2012_05_22.fig
- X1_ISI_HAMX_Damping_TF_MIMO_ST1_ACT_Y_to_ST1_GS13_Y_2012_05_22.fig
- X1_ISI_HAMX_Damping_TF_MIMO_ST1_ACT_Z_to_ST1_GS13_Z_2012_05_22.fig
- X1_ISI_HAMX_TF_Damped_SISO_ACT_RX_to_GS13_RX_2012_05_22.fig
- X1_ISI_HAMX_TF_Damped_SISO_ACT_RY_to_GS13_RY_2012_05_22.fig
- X1_ISI_HAMX_TF_Damped_SISO_ACT_RZ_to_GS13_RZ_2012_05_22.fig
- X1_ISI_HAMX_TF_Damped_SISO_ACT_X_to_GS13_X_2012_05_22.fig
- X1_ISI_HAMX_TF_Damped_SISO_ACT_Y_to_GS13_Y_2012_05_22.fig
- X1_ISI_HAMX_TF_Damped_SISO_ACT_Z_to_GS13_Z_2012_05_22.fig

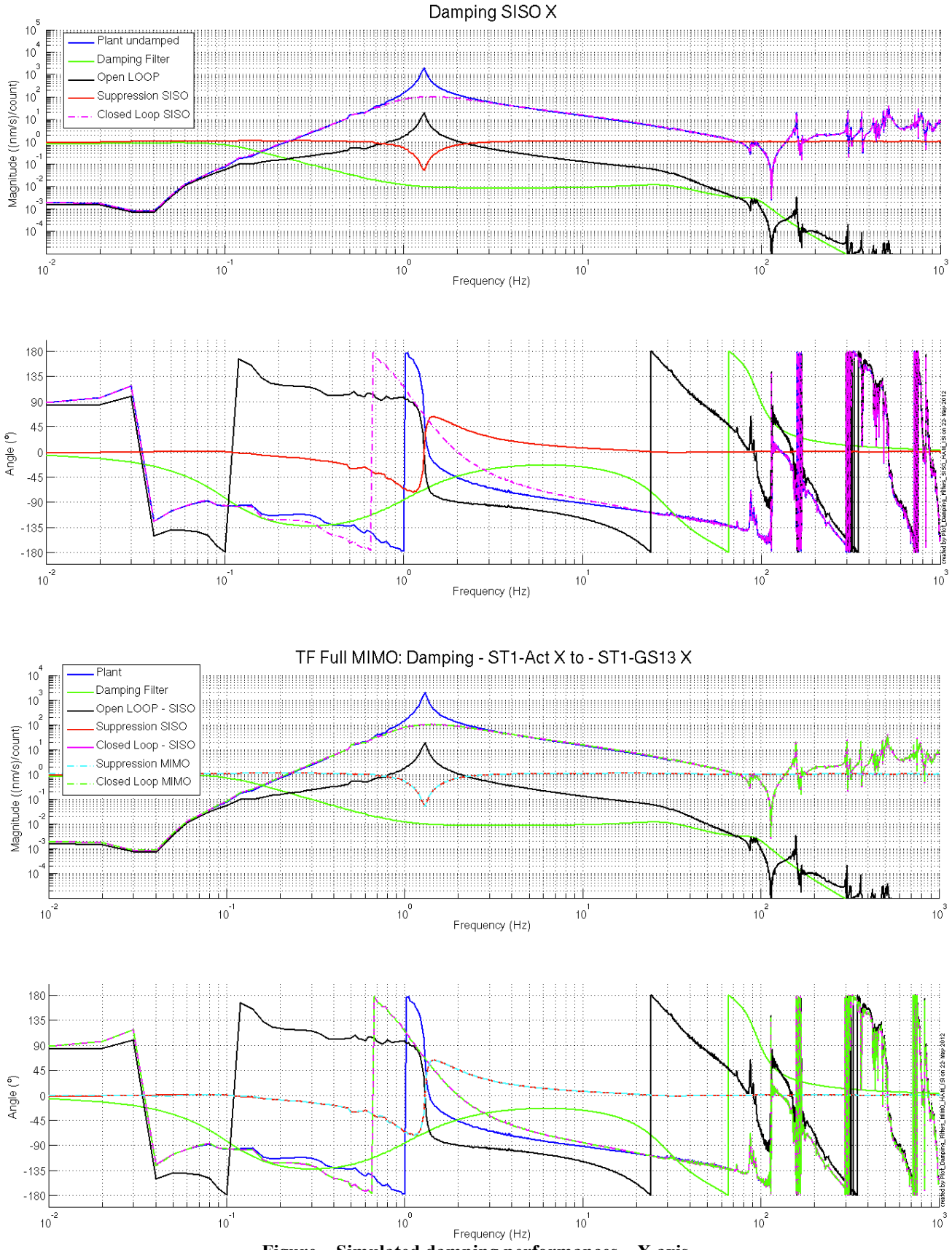


Figure – Simulated damping performances – X axis

Acceptance criteria:

- HAM6 damping loops must implemented and stable with
  - Phase margin must be at least 45º
  - Gain margin must be at least 20dB

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

- ***Step 19.2 – Experiemental evaluation of damping performance - Spectra***

Scripts files for taking data and plotting in SVN at:
/SeiSVN/seismic/HAM-ISI/X1/Scripts/Data_Collection/
- Master_TEST_X1_ISI_Unit_5.m (lines 99 to 114)

Data files in SVN at:
/SeiSVN/seismic/HAM-ISI/X1/HAMX/Data/Spectra/Damped/
- LHO_ISI_UNIT_5_ASD_m_CPS_GS13_Undamped_vs_Damped_ 2012_05_07_103121.mat

Figures in SVN at:
/SeiSVN/seismic/HAM-ISI/X1/HAMX/Data/Figures/Spectra/Damped/
- LHO_ISI_UNIT_5_ASD_CT_CPS_CART_Undamped_vs_Damped 2012_05_22_142540.fig
- LHO_ISI_UNIT_5_ASD_CT_GS13_CART_Undamped_vs_Damped2012_05_22_142540.fig
- LHO_ISI_UNIT_5_ASD_m_CPS_CART_Undamped_vs_Damped2012_05_22_142540.fig
- LHO_ISI_UNIT_5_ASD_m_GS13_CART_Undamped_vs_Damped2012_05_22_142540.fig
- LLO_HAM_ISI_Unit_5_Calibrated_PSD_CPS_Undamped_Damped2012_05_22_142540.fig

Issues/difficulties encountered during this test:
Like for Unit #2 and 4, damping was slightly overestimated along Z-axis.

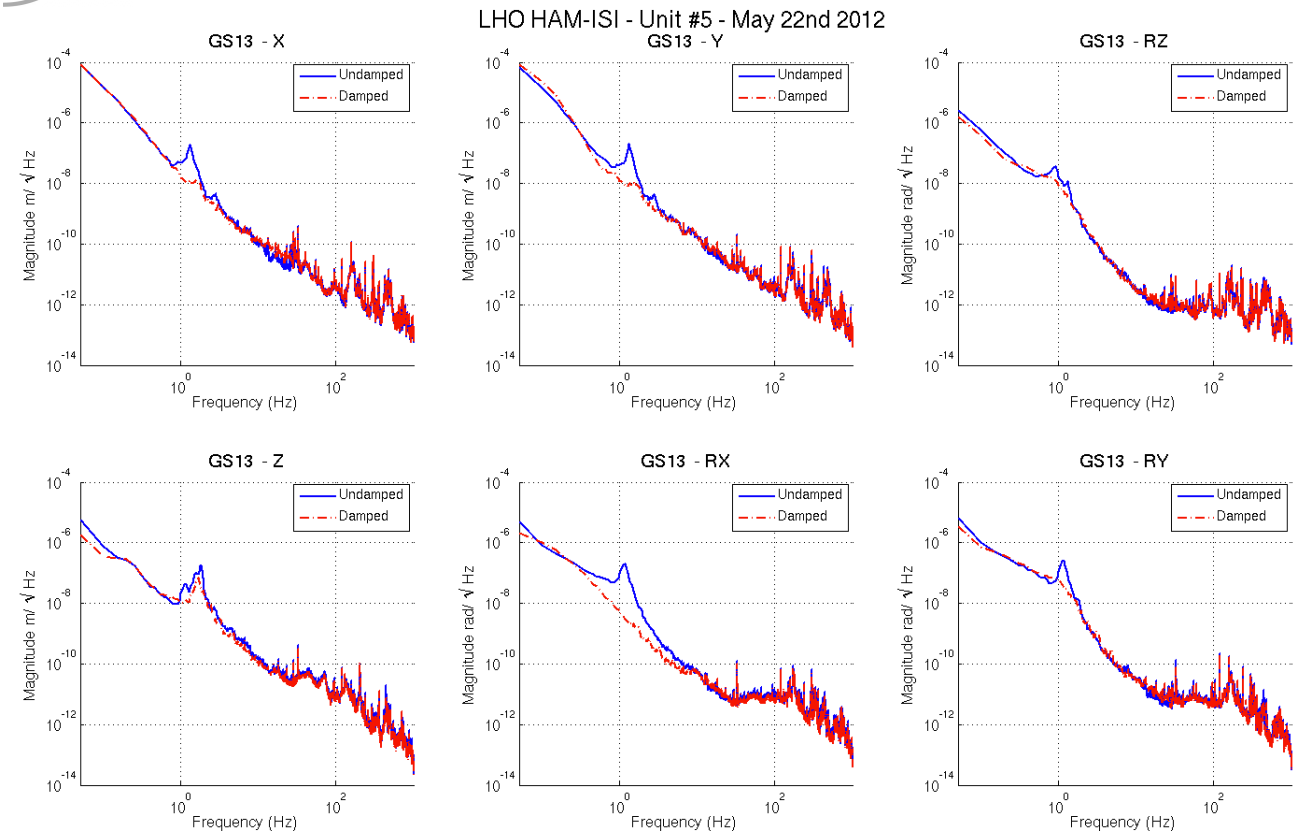


Figure - Damped/Undamped GS-13 Power Spectra comparison

Acceptance criteria:

- HAM6 damping loop must stable when all damping loops are engaged
- Similar damping effect than in simulated plots

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

Generic control scripts were updated after testing was performed. This should only impact the experimental evaluation of damping loops' performances.

IV. HAM-ISI Unit #5 testing summary

HAM-ISI Unit #5 was assembled during April 2012. The testing of this Unit is presented here. It started on May 2nd 2012 and lasted until May 8th 2012 with the testing horizontal GS13s.

These Horizontal GS13s featured non-consistent behavior after reception at LHO. Investigation has been performed at LLO for instruments featuring the same symptoms (LLO aLog 2909). It revealed that the screws of some flexures were not correctly torqued anymore and that they needed *lock tight* in order to remain secured during shipping. Hence, the horizontal GS13s initially used for testing were considered as "testing instruments". They were removed from the assembly at the end of the *assembly validation*, to be replaced with production pods. Tests involving GS13s were performed with the new set of production pods between May 21st and May 24th 2012.

Particularities:
- Full set of production GS13s
- No L4Cs
- No L4C brackets

FAILED AND WAIVED TESTS

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

Step I.1: Failed on CPS-H1 at 0.1Hz. Its spectrum is however very close from our requirement.
Step III.2: Excessive standard deviation on CPSs is associated to ground motion (SEI logbook, entry #15). Sensor noise is acceptable.

- ***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 19.2: The implementation method for the damping loops was updated since testing. Damping loops' experimental performance need to be re-evaluated. However, this test is not mandatory for the assembly validation and is just performed as a preparation for further commissioning.

- ***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.