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**aLIGO HAM-ISI, Pre integration Test report, Phase 1,
LHO Unit #3**

E1000312 – V1

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Introduction

This document presents the tests performed to characterize and validate the “HAM-ISI LHO Unit #3”.

In the first section, *Pre-Assembly Testing*, we summarize the measurements done on the capacitive position sensors, GS13 seismometers and actuators prior the beginning of the assembly.

In the second section, we present the results of the *Tests to be performed during assembly*. It includes subassemblies flatness check, the blade spring profile, the leveling of stage 0 and the lockers adjustments.

In the third section we present the *Tests to be performed after assembly*. These tests allow to check step by step the overall assembly. Transfer functions are measured and damping loops are implemented

Section four summarizes major issues during testing.

The procedure document used to perform this test is:

- E1000309 –V4 - 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

Problems encountered during transfer function measurements have not been investigated due to the possible disassembly of HAM-ISI LHO Unit #3.

I. Pre-Assembly Testing

▪ Step 1: Position Sensors

Note: The back panel reads 0.508V/0.001"

S/N sensor	S/N board	ADE Gap Standoff(mm)	Location on the Jig	Gap Standoff on Jig(mm/in)	Voltage before zeroing	Voltage after zeroing. Prebake	Voltage after zeroing. Post bake
11988	11846	NR	1	2.007mm/0.079"	-1	0.02	-4.9
12004	11836	NR	1	2.007mm/0.079"	NR	0.01	-5
11989	11842	NR	1	2.007mm/0.079"	-1	0.01	-4.7
11997	11829	NR	1	2.007mm/0.079"	-1	0.01	-4.9
12036	11867	NR	1	2.057mm/0.081"	NR	0.01	-4.7
12030	11893	NR	1	2.057mm/0.081"	NR	0.01	-5.2

NR: not recorded

Sensors noise spectra measured before baking:

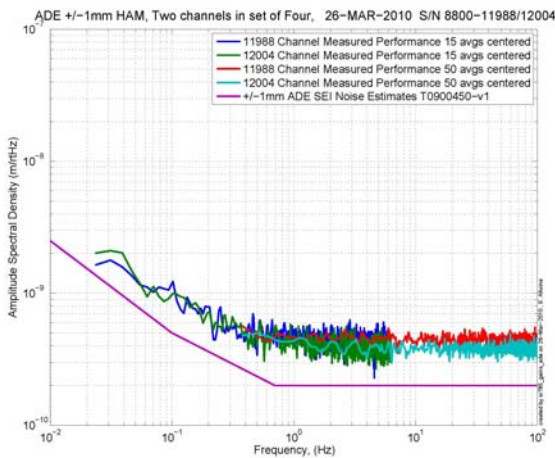


Figure - H1 and V1 sensor noise

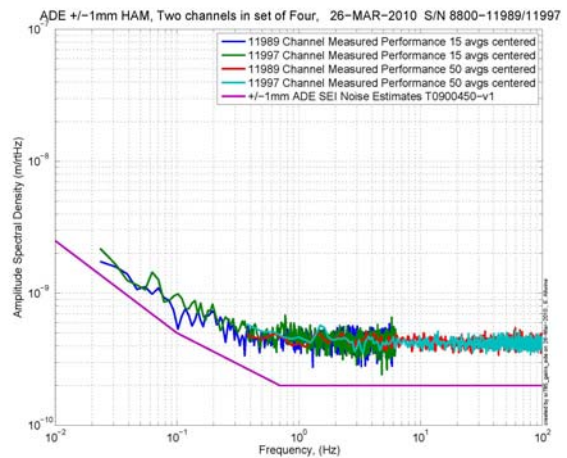


Figure - H2 and V2 sensor noise

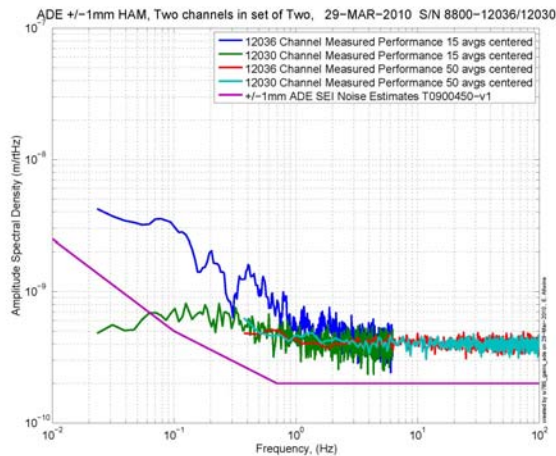


Figure - H3 and V3 sensor noise

Acceptance Criteria:

- Power spectrum magnitudes must be lower than:
 - o 9.e-9 m/ $\sqrt{\text{Hz}}$ at 0.1Hz
 - o 6.e-9 m/ $\sqrt{\text{Hz}}$ at 1Hz

Issues/difficulties/comments regarding this test: Values of sensor gaps and zeroing were not recorded. Waived for this unit.

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

- **Step 2: GS13**

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

Acceptance Criteria:

- GS13 should have been already tested. GS-13 Inspection/Pod Assembly (D047810). Checklist is defined in F090070-v6

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

- **Step 3: Actuators**

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

Acceptance Criteria:

- Actuators were previously tested and results are reported in T900564.

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

II. Tests to be performed during assembly

- *Step 1: 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 2: Check gaps under Support Posts*

Acceptance Criteria:

- The test is passed if: 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 3: Pitchfork/Boxwork flatness before Optical Table install*

Acceptance Criteria:

- Shim inserted won't pass between parts.

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

- *Step 4: Blade spring profile*

Blade #	Base (")	Tip (")	Flatness (mils)
1	0.378	0.375	0.003
2	0.383	0.384	0.001
3	0.38	0.376	0.004

Table 1 - Blade profile

Acceptance Criteria

- Blades must be flat within 0.020" inches.

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

- *Step 5: Gap checks on actuators*

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 6: Check level of Stage 0*

Acceptance Criteria To be defined.

Test result: Passed: X Failed: ___

- *Step 7: Mass budget*

Optical Mass (Kg)	Wall Mass (Kg)	Keel Mass (Kg)	Total Mass (Kg)
305.00	173.58	89.65	568.23

Table - Masses distribution

The total weight is 568.23Kg.

To do
Figure - Masses distribution

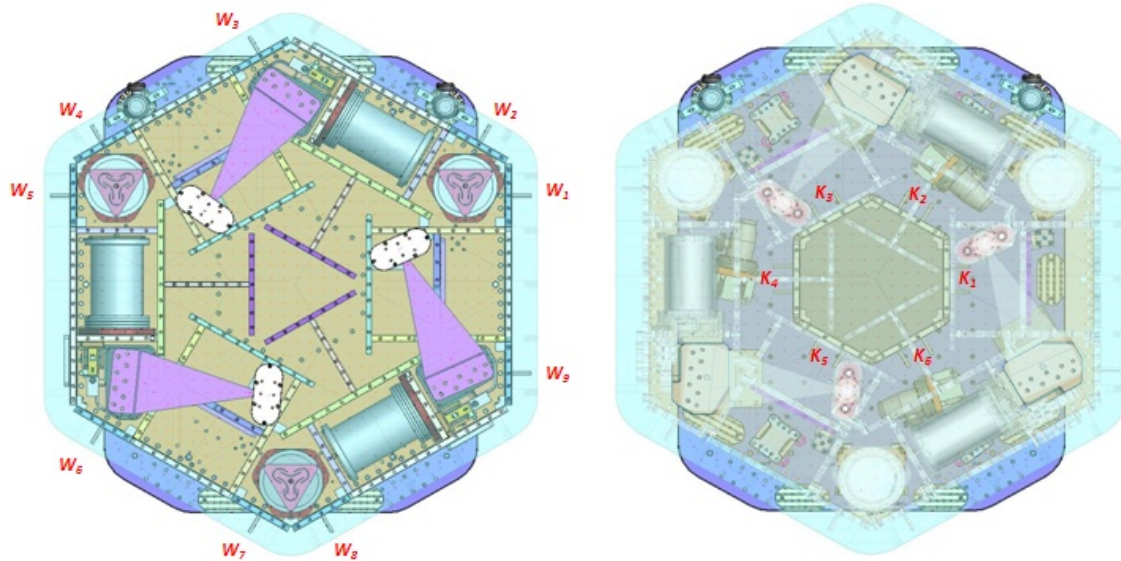


Figure – Keel Masses and Wall masses location

		Mass							
		00	01	02	03	04	05	06	
Location	Type	00	01	02	03	04	05	06	
	Weight	0.246	0.512	0.992	2.052	3.558	7.028	12.268	Kg
	w1		1		1		1	1	21.9
	w2	1			1	1		1	18.1
	w3				1	1		1	17.9
	w4		1		1		1	1	21.9
	w5	1			1	1		1	18.1
	w6				1	1		1	17.9
	w7		1		1		1	1	21.9
	w8	1			1	1		1	18.1
w9				1	1		1	17.9	
		3	3	0	8	6	3	9	173.6
Location	k1						2		14.1
	k2					1		1	15.8
	k3						2		14.1
	k4					1		1	15.8
	k5						2		14.1
	k6					1		1	15.8
			0	0	0	0	3	6	3

Table – Wall masses and Keel masses distribution

Shims Thickness

Lockers	Shim thickness (mil)
A	130
B	128
C	120
D	122

Table – Shims Thickness

Acceptance Criteria

The Mass budget must be
 - 596.7Kg +/-25Kg (4%)

Test result: Passed: Failed:

▪ *Step 8: Lockers adjustment*

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

Table – Dial indicators read-out

Issues/difficulties encountered during this test :

Acceptance Criteria

- Vertical and horizontal displacement near the lockers must be lower than 2 mils

Test result: Passed: X Failed:

III. Tests to be performed after assembly

- *Step 1 - Actuators Inventory*

Actuator	Actuator S/N
H1	42-L042
H2	61-L053
H3	63-L057
V1	60-L039
V2	44-L036
V3	59-L033

Table - Actuators' inventory

Issues/difficulties/comments regarding this test: Horizontal actuators S/N missing

Test result:

Passed: X

Failed: __

- *Step 2 - Sensors Inventory*

Sensor	CPS S/N	Mount S/N	ADE board serial #
H1	11988	10	11846
H2	11989	58	11842
H3	12036	80	11867
V1	12004	55	11836
V2	11997	73	11829
V3	12030	81	11893

Table - Capacitive position sensors' inventory

Geophones GS13	Serial Number	POD	Adaptor
H1	799	58	32
H2	803	13	42
H3	805	68	33
V1	701	40	40
V2	695	49	41
V3	705	59	37

Table - Geophones' inventory

Issues/difficulties/comments regarding this test:

Test result:

Passed: X

Failed: __

▪ **Step 3 - Electronics Inventory**

Write down serial number of coil driver, Anti aliasing chassis, Anti image chassis and interface chassis used for this test are listed below:

Hardware	Ligo reference	S/N
Coil driver	D0902744	S1000266
		S1000269
Anti Image filter	D070081	S1000250
Anti aliasing filter	D1000269	S1000247
		S1000246
Interface chassis	D1000067	S1000270
		S1000271
		S1000272

Table - Inventory electronics

Issues/difficulties/comments regarding this test:

Test result: Passed: X Failed: ___

▪ **Step 4 - Set up sensors gap**

Table locked	10 Kg masses at each corners		No mass	
	ADE boxes on		ADE boxes on	
Sensors	Offset (Mean)	Std deviation	Offset (Mean)	Std deviation
H1	-764.2	0.9	-606.8	1.0
H2	-703.6	0.8	-516.2	0.8
H3	580.4	1.0	479.0	0.9
V1	307.1	0.7	415.7	0.7
V2	143.2	1.1	279.7	1.1
V3	123.3	1.3	317.6	0.8

Table - Set-up sensors gap

Issues/difficulties/comments regarding this test: HAM-ISI – LHO unit#3 uses synchronized satellite boxes

Acceptance criteria:

- All mean values must be lower than 400 cts (a bit less than .0005”).
- All standard deviations below 5 counts.

Test result: Passed: ___ Failed: ___

▪ *Step 5 - Measure the Sensor gap*

Sensors	Gap measured on the Jig	Gap measured on the table	% of change	Offset sensors (counts)
H1	80	80	0	-606.8
H2	80	80	0	-516.2
H3	80	80	0	479.0
V1	80	80	0	415.7
V2	80	80	0	279.7
V3	80	80	0	317.6

Table - Sensors gap

Issues/difficulties/comments regarding this test: No information of gaps measured on the Jig.

Acceptance criteria:

- Change of gaps lower than 2% (reference is the gap measured on the Jig)

Test result:

Passed: X Failed:

▪ *Step 6 - Check Sensor gaps after the platform release*

Sensors	Table locked		Table unlocked		Diff
	Offset (Mean)	Std deviation	Offset (Mean)	STD	
H1	-558.0	1.3	98.0	3.8	656.0
H2	-575.9	1.2	-31.5	3.2	544.4
H3	501.4	1.3	427.6	4.0	-73.8
V1	422.2	0.9	-179.7	3.3	-602.0
V2	327.3	1.8	1008.9	8.4	681.6
V3	262.9	1.9	-314.5	5.8	-577.5

Table – Sensor gaps after platform release

Issues/difficulties/comments regarding this test:

Acceptance criteria:

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

Test result:

Passed: X Failed:

- **Step 7 - Check range of motion (hand pushing)**
 - **Step 7.1 – Test N°1 – Push up and down**

Sensors	CPS read out		Calculated after calibration	
	UP (Counts)	Down (Counts)	UP (mil)	Down (mil)
V1	20450	-19000	24.5	-22.8
V2	20500	-18250	24.6	-21.9
V3	20500	-20500	24.6	-24.6

Sensors	CPS read out		Calculated after calibration	
	CW(-RZ)	CCW (+RZ)	CW (mil)	CCW (mil)
H1	20100	-21500	24.1	-25.8
H2	21500	-21500	25.8	-25.8
H3	23000	-21500	27.5	-25.8

Table - Optic table range of motion

Issues/difficulties/comments regarding this test: the results indicate that all displacement sensor signals have the same sign all the way through the read chain.

- **Step 7.2 – Test N°2 – Push “sideways”**

Displacement sensors and actuator gap check:

	Push in positive direction	Push in negative direction	Railing	Actuator Gap Check
H1	22600	-23550		X
H2	23000	-25300		X
H3	25700	-25000		X
V1	21100	-19900		X
V2	32768	-32680	X	X
V3	22500	-24000		X

Table - Sensor and Actuator gap check

Acceptance criteria:

- The vertical sensor readout be positive when the optic table is pushed in the +Z direction
- The horizontal sensor readout be negative when the optic table is pushed in the +RZ direction
- **Step 7.1**
 - Absolute value of all estimated motions must be higher than 16000counts (~0.020")
- **Step 7.2**
 - 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 8 - Capacitive position sensor Power Spectrum**

Data files in SVN at:

/opt/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_3/ Powerspectrum_Undamped

- Power_spectrum_table_locked_ADE_Sync_10_10_08.xml
- Power_spectrum_table_unlocked_ADE_Sync_10_10_08.xml
- Power_spectrum_table_locked_ADE_Sync_10_10_07.txt
- Power_spectrum_table_unlocked_ADE_Sync_10_10_07.txt

Scripts files for processing and plotting in SVN at:

/opt/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_3/ Powerspectrum_Undamped

- PSD_CPS_GS13_lock_unlock_HAM_ISI_LHO_unit_3_2010_10_07.m

Figures in SVN at:

/opt/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_3/Figures/Powerspectrum_GS13_CPS

- Calibrated_CPS_Powerspectrum_Locked_Unlocked.fig

CPS calibration:

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

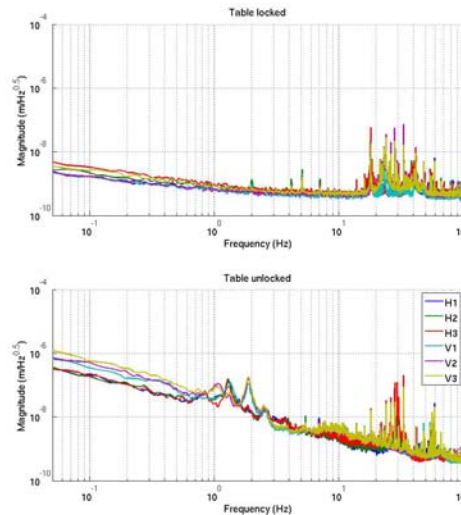


Figure - Calibrated CPS power spectrum

Acceptance criteria:

- No cross talk (peaks at low frequencies + harmonics on measurements)
- Magnitude of power spectrums must be lower than

	Locked		Unlocked	
	at 0.1Hz	at 1Hz	at 0.1Hz	at 1Hz
Horizontal	1.00E-07	2.00E-08	5.00E-07	8.00E-08
Vertical	4.00E-07	5.00E-08	8.00E-07	4.00E-07

Test result:

Passed: X

Failed:

- **Step 9 - GS13 power spectrums**
 - **Step 9.1 – Table locked and unlocked (free)**

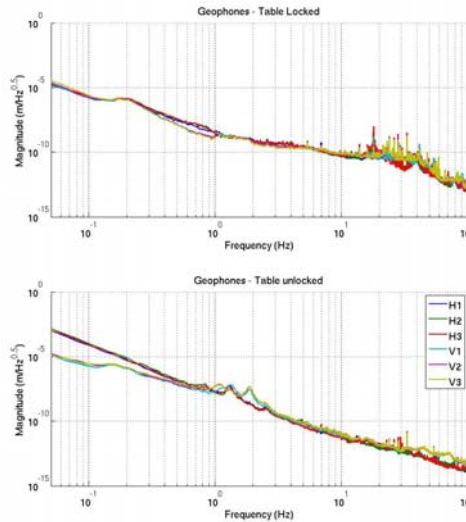


Figure – Power spectrum Calibrated GS13

- **Step 9.2 – Table tilted**

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

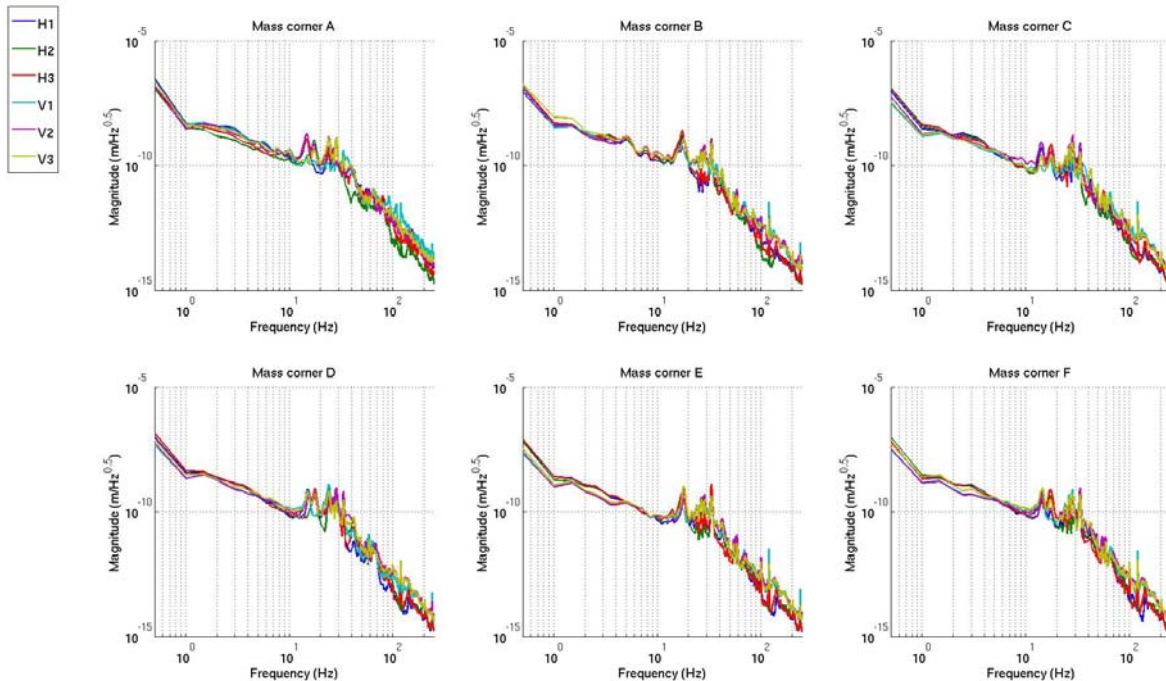


Figure – Power spectrum Calibrated GS13 with mass at corner

Data files in SVN at:

- opt//svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_3/ Powerspectrum_Undamped
- Power_spectrum_table_locked_ADE_Sync_10_10_08.xml
 - Power_spectrum_table_unlocked_ADE_Sync_10_10_08.xml
 - Power_spectrum_table_locked_ADE_Sync_10_10_07.txt
 - Power_spectrum_table_unlocked_ADE_Sync_10_10_07.txt
 - Power_spectrum_table_unlocked_Mass_corner_A_ADE_Sync_10_10_07_V2.xml
 - Power_spectrum_table_unlocked_Mass_corner_B_ADE_Sync_10_10_07_V2.xml
 - Power_spectrum_table_unlocked_Mass_corner_C_ADE_Sync_10_10_07_V2.xml
 - Power_spectrum_table_unlocked_Mass_corner_D_ADE_Sync_10_10_07_V2.xml
 - Power_spectrum_table_unlocked_Mass_corner_E_ADE_Sync_10_10_07_V2.xml
 - Power_spectrum_table_unlocked_Mass_corner_F_ADE_Sync_10_10_07_V2.xml
 - Power_spectrum_table_unlocked_Mass_corner_A_ADE_Sync_10_10_07_V2.txt
 - Power_spectrum_table_unlocked_Mass_corner_B_ADE_Sync_10_10_07_V2.txt
 - Power_spectrum_table_unlocked_Mass_corner_C_ADE_Sync_10_10_07_V2.txt
 - Power_spectrum_table_unlocked_Mass_corner_D_ADE_Sync_10_10_07_V2.txt
 - Power_spectrum_table_unlocked_Mass_corner_E_ADE_Sync_10_10_07_V2.txt
 - Power_spectrum_table_unlocked_Mass_corner_F_ADE_Sync_10_10_07_V2.txt

Scripts files for processing and plotting in SVN at:

- opt//svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_3/ Powerspectrum_Undamped
- PSD_CPS_GS13_Lock_Unlock_HAM_ISI_LHO_Unit_3_2010_10_07.m

Figures in SVN at:

- opt//svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_3/Figures/Powerspectrum_GS13_CPS
- Calibrated_Geophones_Powerspectrum_Locked_Unlocked.fig
 - Calibrated_Geophones_Powerspectrum_with_20Kg_Mass_at_one corner.fig

Acceptance criteria:

- With table locked, magnitudes of power spectra must be lower than:

	Table locked		
	at 0.1Hz	at 1Hz	at 10Hz
H & V Geophones	8.E-05	3.E-08	2.E-10

- With table unlocked, magnitudes of power spectra must be lower than:

	Table unlocked		
	at 0.1Hz	at 1Hz	at 10Hz
Horizontal Geophones	3.E-04	1.E-07	1.E-11
Vertical Geophones	5.E-05	1.E-07	1.E-11

- With table unlocked and tilted, magnitudes of power spectra must be lower than:

	Table unlocked (tilted with masses)		
	at 0.1Hz	at 1Hz	at 10Hz
H & V Geophones	8.E-05	3.E-08	2.E-10

Test result:

Passed: X

Failed: __

▪ *Step 10 - Coil Driver, cabling and resistance check*

Actuator	V1		H1		V2	
Coil driver	S1000266 - Coarse 1 OUT		S1000266 - Fine 1 OUT		S1000266 - Fine 2 OUT	
Cable #	25		26		27	
Resistance (Ohm)	P1 - P2	P2 - P3	P1 - P2	P2 - P3	P1 - P2	P2 - P3
	6.5	O.L (infinity)	6.5	O.L (infinity)	6.5	O.L (infinity)
MEDM offset (1000 counts)	Measurement P2 (-) ; P1&P3 (+)		Measurement P2 (-) ; P1&P3 (+)		Measurement P2 (-) ; P1&P3 (+)	
	0.303 V		0.306 V		0.305 V	

Actuator	H2		V3		H3	
Coil driver	S1000266 - Coarse 2 OUT		S1000267 - Coarse 1 OUT		S1000267 - Fine 1 OUT	
Cable #	28		29		30	
Resistance (Ohm)	P1 - P2	P2 - P3	P1 - P2	P2 - P3	P1 - P2	P2 - P3
	6.5	O.L (infinity)	6.5	O.L (infinity)	6.5	O.L (infinity)
MEDM offset (1000 counts)	Measurement P2 (-) ; P1&P3 (+)		Measurement P2 (-) ; P1&P3 (+)		Measurement P2 (-) ; P1&P3 (+)	
	0.307 V		0.298 V		0.301 V	

Table - Actuators resistance check

Issues/difficulties/comments regarding this test:

Acceptance criteria:

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

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

▪ *Step 11 - Actuators Sign and range of motion (Local drive)*

○ *Step 11.1 - Actuators sign*

Acceptance criteria: 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 11.2 - Range of motion - Local drive*

	Negative push	Positive push
H1	-24207	23825
H2	-25031	23209
H3	-24216	25252
V1	-19040	27519
V2	-25095	22519
V3	-22470	21292

Table - Range of motion - Local drive

Issues/difficulties/comments regarding this test:

Acceptance criteria:

- Main couplings read out must be at least +/-16000 counts (~0.002")
- Signs of actuators drive and sensors read out have to be the same

Test result:

Passed: X

Failed:

▪ *Step 12 - 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	-19	0	19	
B	-19	0	19	
C	-19	0	19	
D	-19.5	0	19	
Average	-19.125	0	19	38.1

Sensors	Counts	Counts	Counts	Difference (Counts)
V1	-15405	687.4	16464	31869
V2	-14575	1244.5	17432	32007
V3	-16268	-304.9	15351	31619
			Average	31832

Table - Calibration of capacitive position sensors

Vertical sensitivity: $31832/38.1 = 834.9$ count/mil

or 834.9 count/mil * $1/1638$ V/count = 0.510 V/mil

or 25400 nm/mil * $1/834.9$ mil/count = 30.42 nm/count

Difference with Nominal sensitivity = $(834.9-840)/840=-0.60\%$

Issues/difficulties/comments regarding this test:

Acceptance criteria: Deviation from nominal value < 2%. Nominal value is 840 count/mil.

Test result:

Passed: X

Failed:

▪ **Step 13 - Vertical Spring Constant**

Sensors	Mean diff counts	Mean diff m	K (N/m)
V1	8436	2.55E-04	7.85E+04
V2	8007	2.42E-04	8.27E+04
V3	7837	2.37E-04	8.45E+04
Average (N/m)			2.46E+05

Table - Vertical spring constant

The measured vertical stiffness is 2.46e5N/m. The nominal vertical spring constant is 2.428e5N/m. The measured error on the vertical stiffness is 1.24%.

Issues/difficulties/comments regarding this test:

Acceptance criteria:

- Spring constant is within +/- 10/-1% of 2.428e5 N/m (HPD FEA Results).

Test result: Passed: X Failed:

▪ **Step 14 - Static Testing (Tests in the local basis)**

		Sensors (counts)					
		H1	H2	H3	V1	V2	V3
Actuators (1000 counts)	H1	2081	1289	1301	5	-3	6
	H2	1286	2049	1291	-9	-1	4
	H3	1306	1291	2078	17	-8	12
	V1	194	184	-380	1467	-26	-613
	V2	-376	192	195	-626	1479	-25
	V3	206	-368	199	-11	-634	1465

Main coupling
 Important cross coupling

Table - Main and cross coupling

Issues/difficulties/comments regarding this test:

Acceptance criteria:

- **Vertical**
For a +1000 count offset drive on vertical actuators
 - o Collocated sensors must be 1400 counts +/- 10%
- **Horizontal**
For a +1000 count offset drive on horizontal actuators
 - o Collocated sensors must be 2000 counts +/- 10%
 - o Non-collocated horizontal sensors must be 1250 counts +/-10%

Test result: Passed: X Failed:

▪ *Step 15 - Linearity test*

	Slope	Offset	Average slope	Variation from average(%)
H1	2.081	108	2.0860	-0.25
H2	2.079	-35		-0.32
H3	2.098	437		0.57
V1	1.478	-151	1.4674	0.71
V2	1.473	1003		0.40
V3	1.451	-280		-1.11

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

Data files in SVN at:

/opt/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_3/Linearity_test

- Linearity_test_2010_10_07.mat
- Slope_Offset_Linearity_test_2010_10_07.mat

Scripts files for processing and plotting in SVN at:

/opt/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_3/Linearity_test

- Plot_linearity_test_2010_10_07.m

Figures in SVN at:

/opt/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_3/Figures/Linearity_test

- Linearity_test.fig

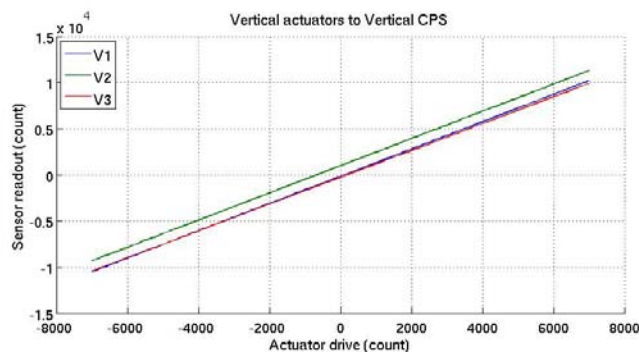
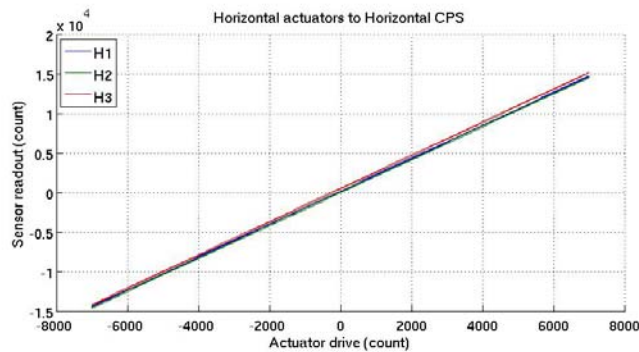


Figure - Horizontal and vertical actuators x HAM-ISI x sensors

Issues/difficulties/comments regarding this test:

Acceptance criteria:

- Horizontal and vertical slopes of the triplet actuators x HAM-ISI x sensors: Average slope +/- 3%.

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

▪ **Step 16 – Static tests in the general coordinate basis**

Sensors readout (count)	1000 counts Drive	X Drive	Y Drive	Z Drive	Rx Drive	Ry Drive	Rz Drive
	H1	260	-460	2	-460	-269	-2002
	H2	251	436	7	450	-257	-2008
	H3	-522	3	-1	5	541	-2013
	V1	9	-9	280	-488	-1692	5
	V2	-20	6	262	1695	423	-12
	V3	5	18	252	-1177	1237	-2
	Direction read out	516	517	265	2572	2593	2542

Table - Tests in the general coordinate basis

Issues/difficulties/comments regarding this test:

Acceptance criteria:

For a positive drive in the Cartesian basis:

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

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

▪ **Step 17 - Frequency response**

Compensation filters of the new GS13 interface chassis are located in the geophone pre-filters bank. Powerspectra were measured with masses on the optic table not bolted.

○ **Step 17.1 - Local to local measurements**

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

Data collection script files:

opt/svncommon/seisvn/seismic/HAM-ISI/X1/Scripts/Data_Collection

- Run_L2L_50mHz_500mHz.m
- Run_L2L_500mHz_5Hz.m
- Run_L2L_5mHz_200Hz.m
- Run_L2L_200Hz_800Hz.m

Data files in SVN at:

/opt/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_3/Transfer_functions/Local_to_local

- Data_L2L_50mHz_500mHz_20100916-105204.mat
- Data_L2L_500mHz_5Hz_20101014-121533.mat
- Data_L2L_5_200Hz_20101014-104200.mat
- Data_L2L_200_800Hz_20101014-090827.mat

Scripts files for processing and plotting in SVN at:

opt/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_3/Transfer_functions/Local_to_local

- Plot_TF_Local_to_Local_2010_10_14.m

Figures in SVN at:

opt/svncommon/seisvn/seismic/HAM-ISI/X2/Data/Unit_3/Figures/Transfer_functions/Local_to_Local

- TF_Horizontal_CPS.fig
- TF_Vertical_CPS.fig
- TF_Horizontal_Geophone.fig
- TF_Vertical_Geophone.fig

Storage of measured transfer functions in the SVN at:

opt/svncommon/seisvn/seismic/HAM-ISI/X2/Data/Unit_1/Transfer_functions/Local_to_local

- Local_2_Local_LHO_HAM-ISI-Unit_3_2010_10_14.mat

The local to local transfer functions are presented below.

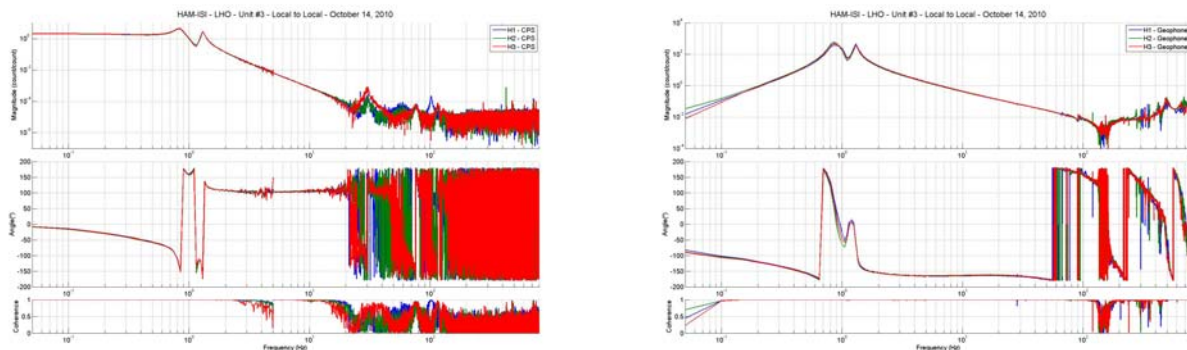


Figure - Local to Local Measurements – Horizontal sensors

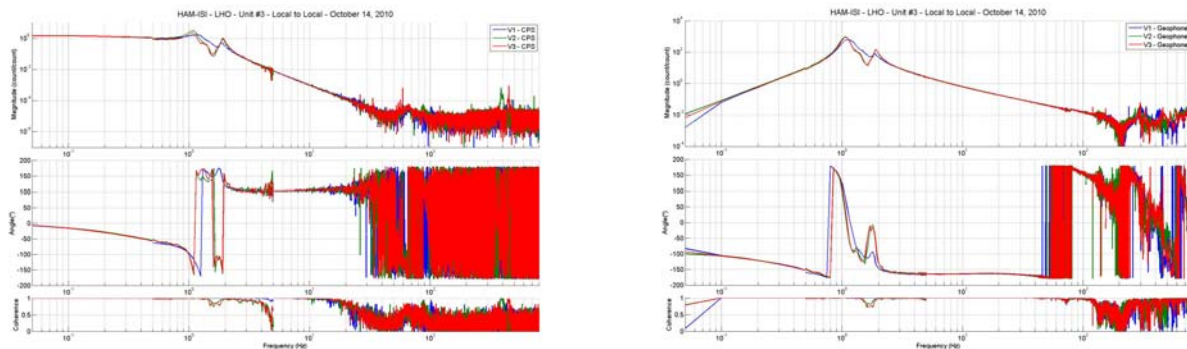


Figure - Local to Local Measurements – Vertical sensors

Issues/difficulties/comments regarding this test: Vertical transfer functions shows an extra resonance between 1Hz and 2Hz

○ *Step 17.2 - Cartesian to Cartesian measurements*

Cartesian to Cartesian transfer functions have been measured with 90 repetitions.

Data files in SVN at:

opt/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_3/Transfer_functions/Cartesian_to_cartesian

- Data_Cart2Cart_50mHz_500mHz_20101022-182142.mat
- Data_Cart2Cart_500mHz_5Hz_20101022-151609.mat
- Data_Cart2Cart_5_200Hz_20101022-134236.mat
- Data_Cart2Cart_200_800Hz_20101022-120902.mat

Scripts files for processing and plotting in SVN at:

opt/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_3/Transfer_functions/Cartesian_to_cartesian

- Plot_TF_Cartesian_to_Cartesian_2010_10_23.m

Figures in SVN at:

opt/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_3/Figures/Transfer_functions/

Cartesian_to_cartesian

- TF_X_Y_RZ_CPS.fig
- TF_X_Y_RZ_Geophone.fig
- TF_Z_RX_RY_CPS.fig
- TF_Z_RX_RY_Geophone.fig

Storage of measured transfer functions in the SVN at:

/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_3/Transfer_functions/Cartesian_to_Cartesian

- Cartesian_2_Cartesian_LHO_HAM-ISI-Unit_3_2010_10_23.mat

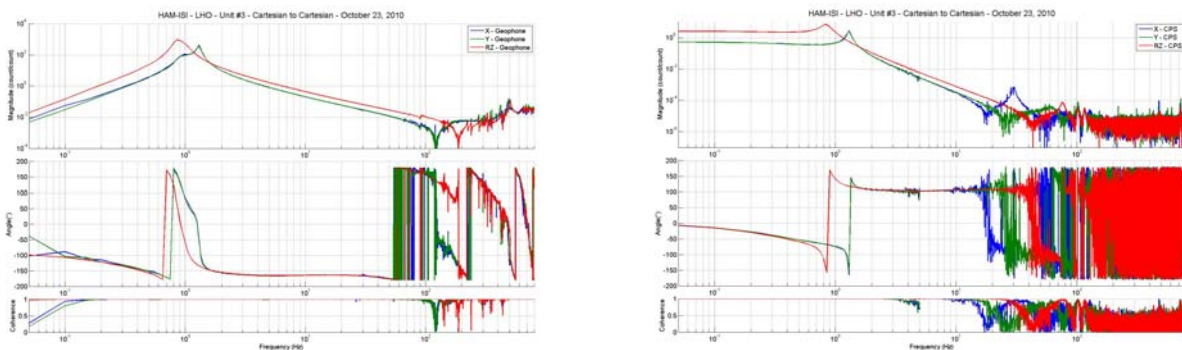


Figure - Cartesian to Cartesian measurements – X, Y, RZ directions

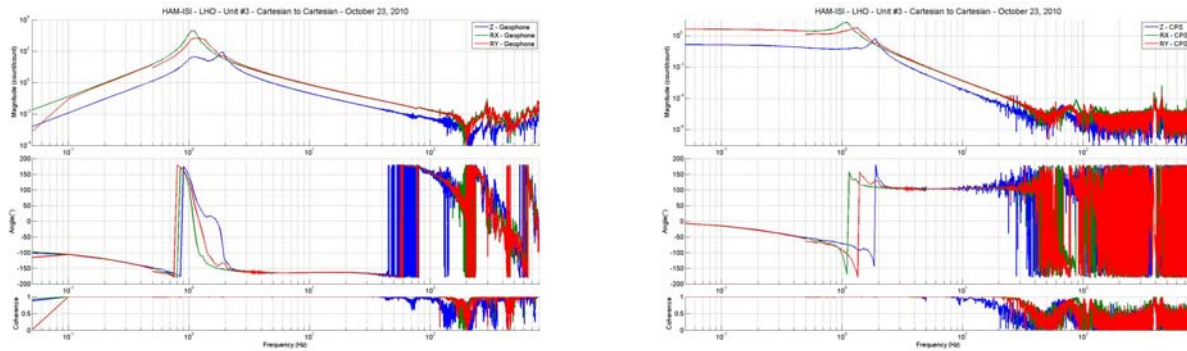


Figure - Cartesian to Cartesian measurements – Z, RX, RY directions

Issues/difficulties/comments regarding this test:

Acceptance criteria:

- Local to local measurement
 - o On CPS, the phase must be 0° at DC
 - o On Geophones, the phase must be -90° at DC
 - o Modal to modal measurement
 - o On CPS, the phase must be 0° at DC
 - o On Geophones, the phase must be -90° at DC

Test result:

Passed:

Failed: X

- *Step 18 - Transfer function comparison*
 - o *Step 18.1 - Local to local - Comparison with HAM6*

Scripts files for processing and plotting in SVN at:

opt/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_3/Transfer_functions/Local_to_local
 - Plot_TF_Local_to_Local_2010_10_14.m

Local to local figures in SVN at:

/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_3/Figures/Transfer_functions/Local_to_Local

- TF_Horizontal_CPS_vs_HAM6.fig
- TF_Vertical_CPS_vs_HAM6.fig
- TF_Horizontal_Geophone_vs_HAM6.fig
- TF_Vertical_Geophone_vs_HAM6.fig

GS13, Local to local measurement

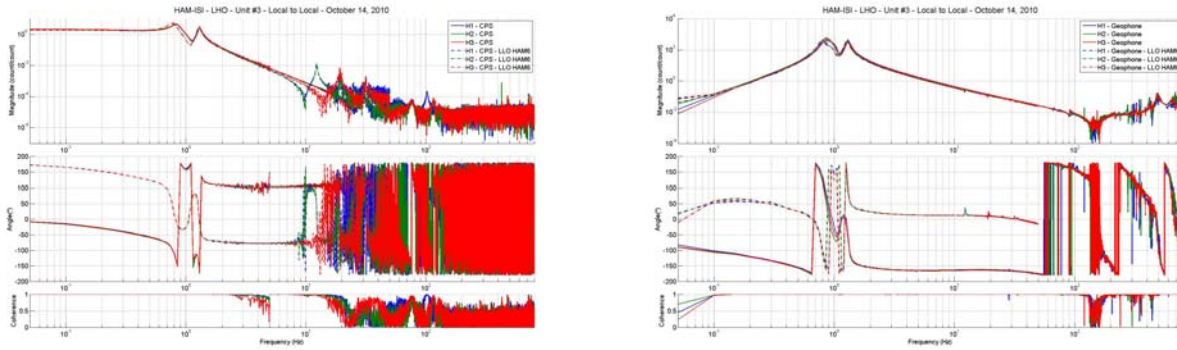


Figure - Local to local measurements comparison with HAM6 – GS13

CPS, Local to local measurement, Undamped

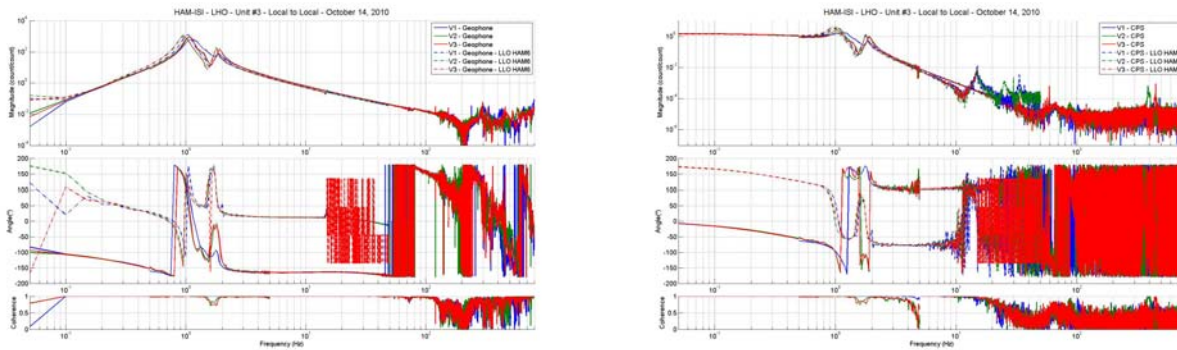


Figure - Local to local measurements comparison – Position sensors

Difference with HAM6:

- Sign difference on CPS and Geophones.
- Transfer functions don't have the same shape

o *Step 18.2 - Cartesian to Cartesian - Comparison with HAM6*

Scripts files for processing and plotting in SVN at:

opt/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_3/Transfer_functions/Cartesian_to_cartesian
 - Plot_TF_Cartesian_to_Cartesian_2010_10_23.m

Cartesian to Cartesian figures in SVN at :

/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_3/Transfer_functions/Cartesian_to_Cartesian

- TF_X_Y_RZ_CPS_vs_HAM6.fig
- TF_Z_RX_RY_CPS_vs_HAM6.fig
- TF_X_Y_RZ_Geophone_vs_HAM6.fig
- TF_Z_RX_RY_Geophone_vs_HAM6.fig

GS13, Cartesian to Cartesian measurement, Undamped

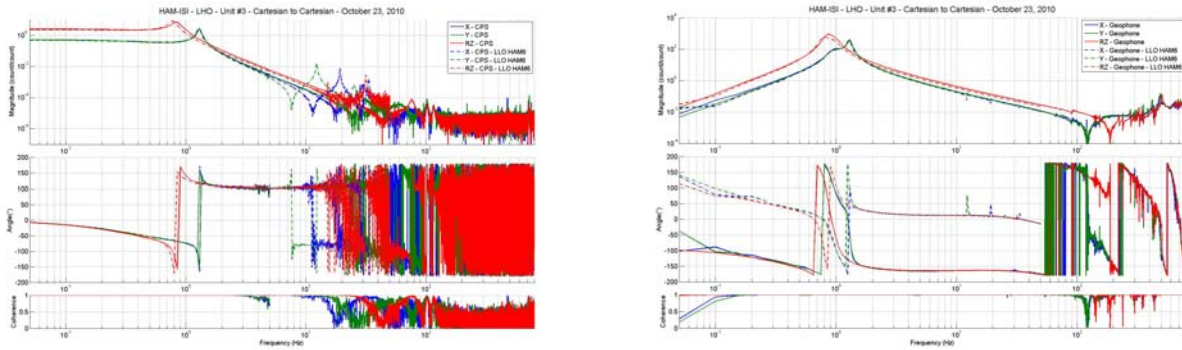


Figure - Cartesian to Cartesian measurements comparison with HAM6 – GS13

CPS, Cartesian to Cartesian measurement, Undamped

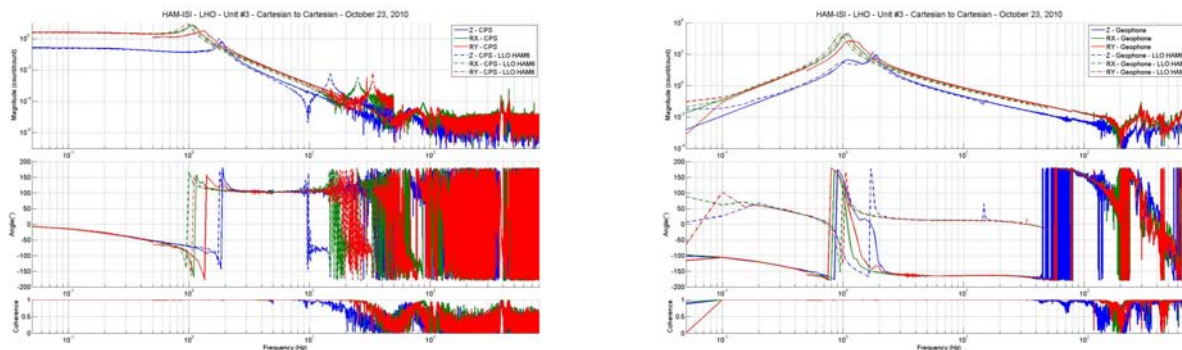


Figure - Cartesian to Cartesian measurements comparison – Position sensors

Difference with HAM6:

- Resonance at 1 Hz is slightly higher than HAM6
- Sign difference on CPS and Geophones
- Transfer function don't have the same shape

Acceptance criteria:

- No difference with the reference transfer functions (SVN)
 - o Phase – less than 10° - In Phase – Out of Phase
 - o Damping (fit by eye with the reference transfer functions)
 - o DC gain
 - o Eigen frequencies shift less than 5%

Test result:

Passed:

Failed: X

▪ **Step 19 - Lower Zero Moment Plane**

Data collection script files:

opt/svncommon/seisvn/seismic/HAM-ISI/X1/Scripts/Data_Collection
 - Run_Cart2Cart_10mHz_100mHz.m

Data files in SVN at:

opt/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_3/Transfer_functions/LZMP
 - Data_LZMP_Cart2Cart_10mHz_100mHz_20101021-014251.mat

Scripts files for processing and plotting in SVN at:

opt/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_3/Transfer_functions/LZMP
 - LZMP_2010_10_21.m

Figures in SVN at:

opt/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_3/Figures/Transfer_functions/LZMP
 - LZMP.fig

X & Y offsets:

X offset (mm)	1.77
Y offset (mm)	0.37

Table – Offset of the Lower Zero Moment Plane

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

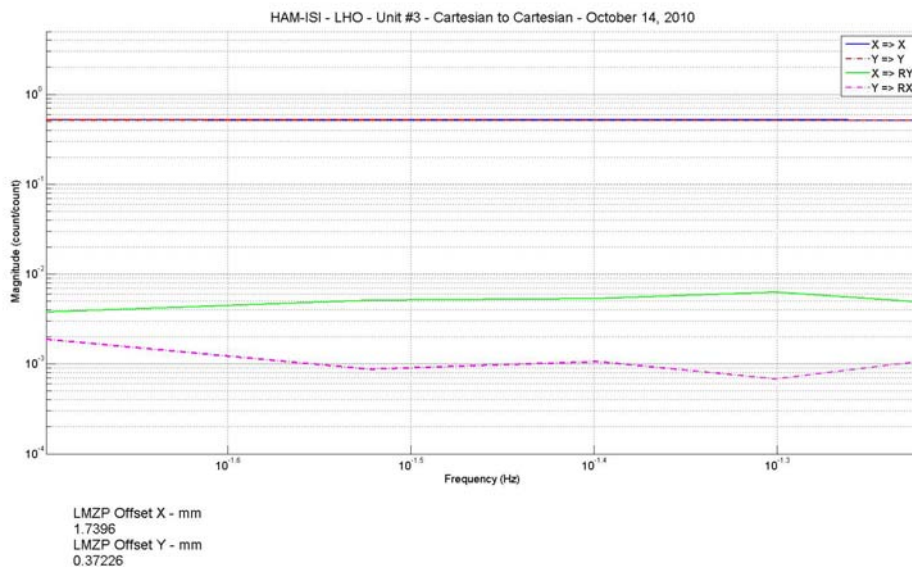


Figure - Lower Zero moment plane – Main and cross couplings at low frequency

Acceptance criteria:

- X offset must be less than 1 mm
- Y offset must be less than 1mm

Test result:

Passed:

Failed: X

▪ **Step 20 - Damping loops**

Filters used by Damping loops in SVN at:

/opt/svncommon/seisvn/seismic/HAM-ISI/X1/FilterDesign/Unit_2/txt_file

- G11SIHAM_Back_up_2010_09_01.txt (digitalized filters copied and rename to G11SIHAM.txt in /opt/rtds/geo/g1/chans)

○ **Step 20.1 - Transfer functions - Simulation**

Scripts files for processing and plotting in SVN at:

/opt/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_3/Damping_Loops/Transfer_functions_simulation

- HAM_ISI_LHO_Unit_3_Damping_TF_2010_10_24.m

Figures in SVN at:

/svncommon/seisvn/seismic/HAM-ISI/X2/Data/Unit_3/Figures/Damping_Loops

- Damping_LOOP_H1_H2_H3.fig
- Damping_LOOP_V1_V2_V3.fig

Results are saved in SVN at:

/opt/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_3/Damping_Loops/Transfer_functions_simulation

- Damping_loop_transfer_functions_HAM-ISI-LHO-unit3_2010_10_24.mat

The following figures present the plant, controller, open loop, closed loop and sensitivity of vertical and horizontal damping loops. H1/V1 are plotted in solid line, H2/V2 are plotted in dash line, H3/V3 are plotted in dash-dot line.

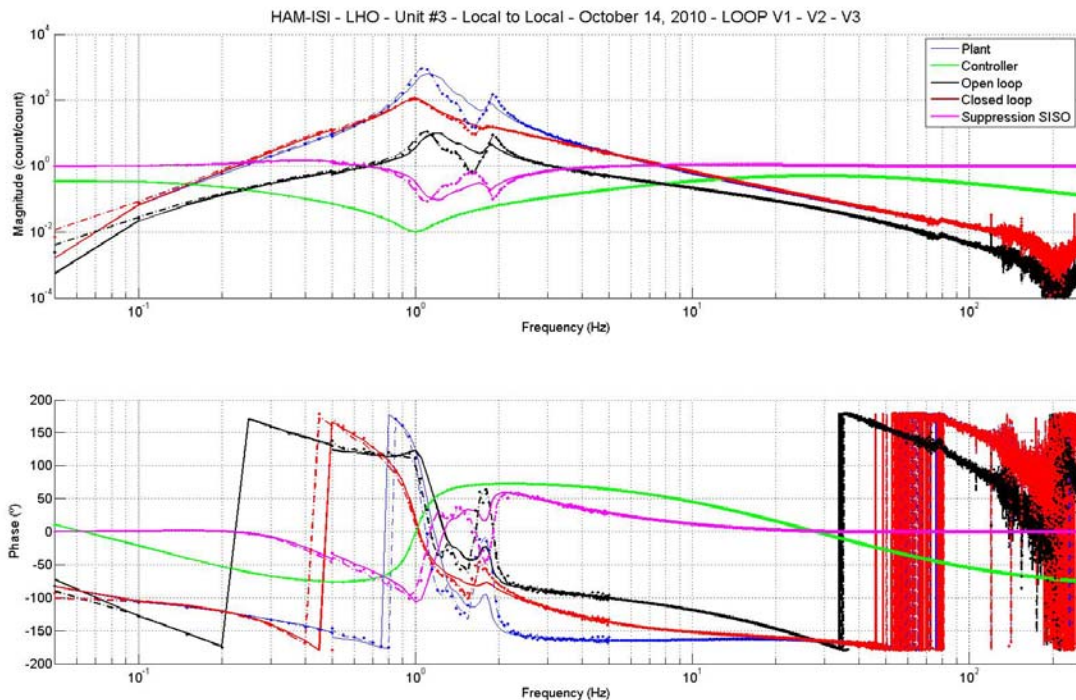


Figure - Vertical damping loops - Simulation

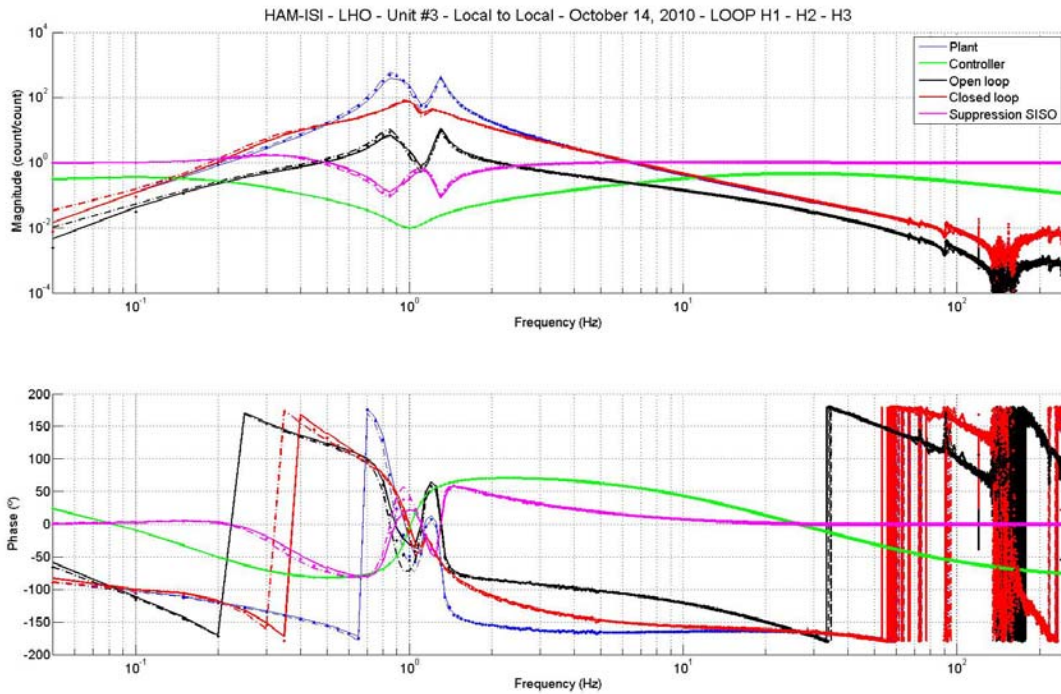


Figure – Horizontal damping loops - Simulation

○ *Step 20.2 - Powerspectrum – Experimental*

Data files in SVN at:

/opt/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_3/Damping_Loops/
Powerspectrum_experimental

- Powerspectrum_experimental_Damping_OFF_10_10_11.xml
- Powerspectrum_experimental_Damping_OFF_10_10_11.txt
- Powerspectrum_experimental_Damping_ON_10_10_11.xml
- Powerspectrum_experimental_Damping_ON_10_10_11.txt

Scripts files for processing and plotting in SVN at:

/opt/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_3/Damping_Loops/
DTT_Powerspectrum_experimental

- HAM_ISI_LHO_Unit_3_Damping_Powerspectrum_2010_10_14.m

Figures in SVN at:

/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_3/Figures/Damping_Loops

- Damping_LOOP_GEO_Powerspectrum.fig
- Simulation_vs_experimental_Suppression.fig

Powerspectrum:

The figure below shows power spectrum of Geophones when there is no damping loop and when all damping loops are engaged.

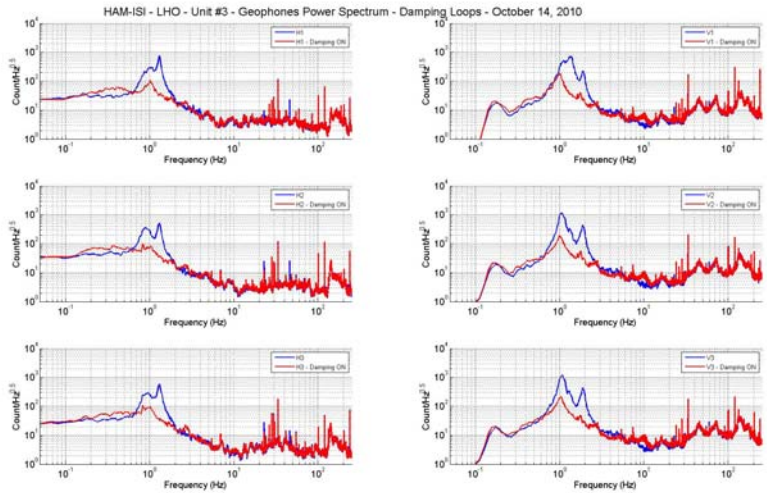


Figure – Horizontal (left) and vertical (right) damping loops - Experimental

Sensitivity:

The figure below compare the sensitivity ('Undamped/Damped') of LLO HAM (Aug 2008) and LHO Unit 2. Performances are very similar, which confirms that we can use the damping loop as they are (modulo electronics change compensation). The plot also shows that the measured performance matches with the prediction.

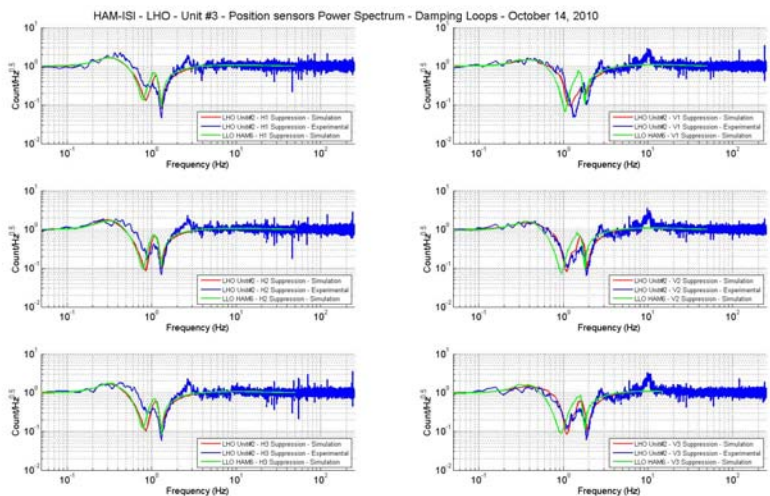


Figure - Damping loop sensitivity

Acceptance criteria:

- Ham 6 damping loop must implemented and stable with
 - o Phase margin must be at least 45°
 - o Gain margin must be at least 20dB

Test result:

Passed: X Failed:

IV. Testing Summary

Problems encountered during transfer function measurements have not been investigated due to the possible disassembly of HAM-ISI LHO Unit #3.