LIGO Laboratory / LIGO Scientific Collaboration

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aLIGO HAM-ISI, Pre integration Test report, Phase 1, LHO Unit #2

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Introduction

This document presents the tests performed to characterize and validate the "HAM-ISI LLO Unit #1". This unit is the first unit assembled for aLIGO at LLO.

The procedure document used to perform this test is:

- E1000309 - 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

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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
11999	NR	NR	NR	NR	NR	NR	NR
11987	NR	NR	NR	NR	NR	NR	NR
12041	NR	NR	NR	NR	NR	NR	NR
11998	NR	NR	NR	NR	NR	NR	NR
11990	NR	NR	NR	NR	NR	NR	NR
12048	NR	NR	NR	NR	NR	NR	NR

NR: not recorded

Will be measured for the next units.

Sensors noise spectra measured before baking:

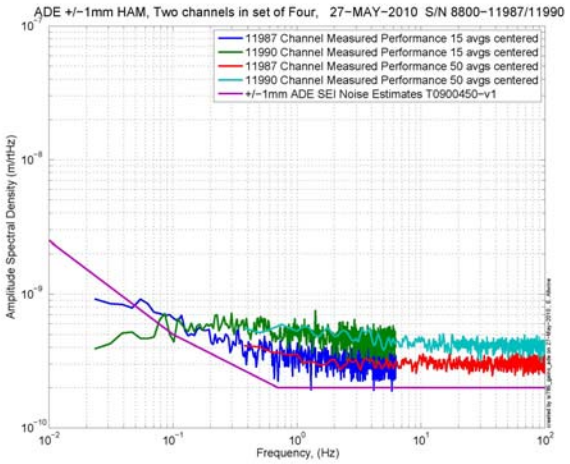

Figure - H1 and V1 sensor noise

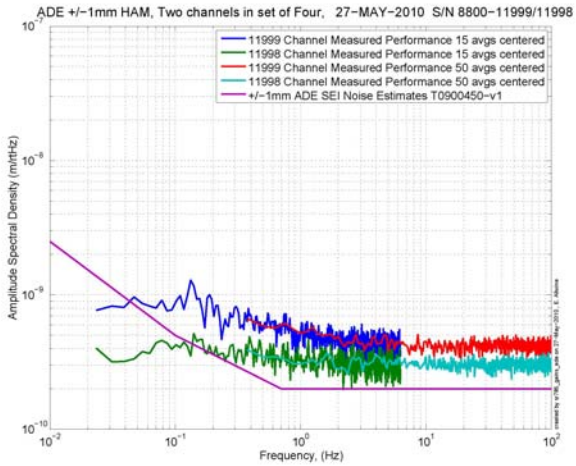

Figure - H2 and V2 sensor noise

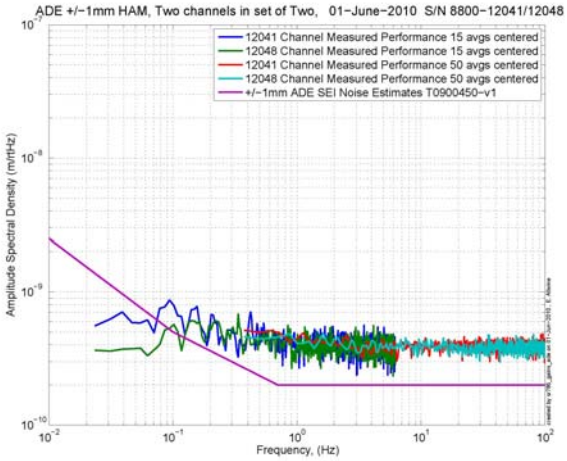

Figure - H3 and V3 sensor noise

Acceptance Criteria: To be defined.

Issues/difficulties/comments regarding this test: Values of sensor gaps and zeroing were nor recorded. Waived for this unit.

Test result: **Passed: ___** **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: To be defined.

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

- ***Step 3: Actuators***

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

Acceptance Criteria: To be defined.

Test result: **Passed: ___** **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 (")	Middle (")	Tip(")	Flatness (mils)
1	0.376		0.371	0.005
2	0.391		0.372	0.019
3	0.38		0.373	0.007

Table 1 - Blade profile

Acceptance Criteria

- Blades must be flat within 0.020" inches. To be approved

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)
313.40	173.93	89.65	576.97

Table - Masses distribution

The total weight is 577Kg.

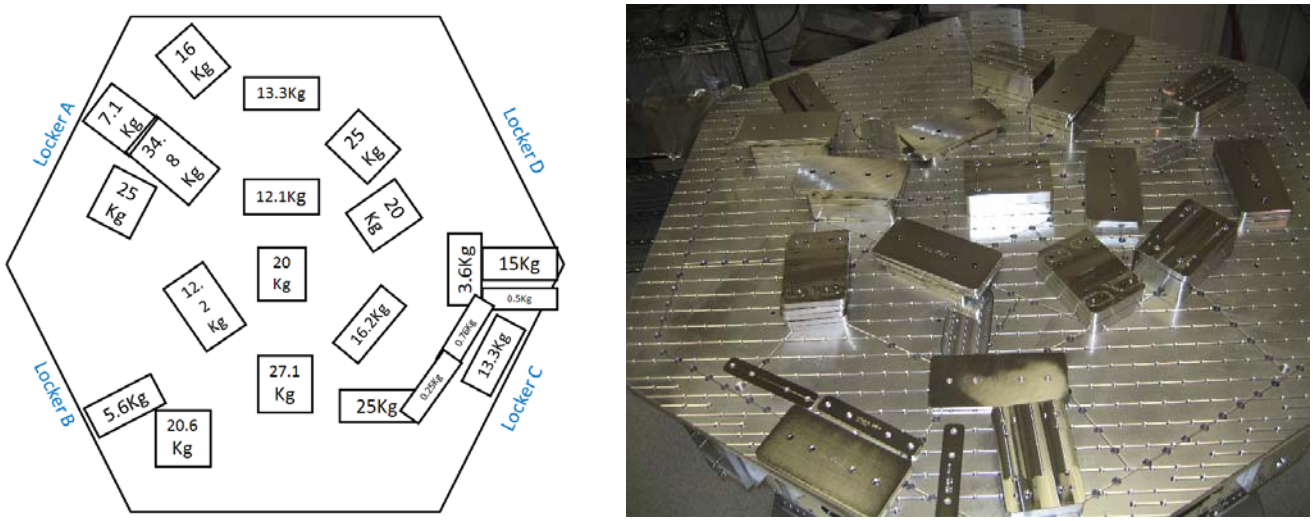

Figure - Masses distribution

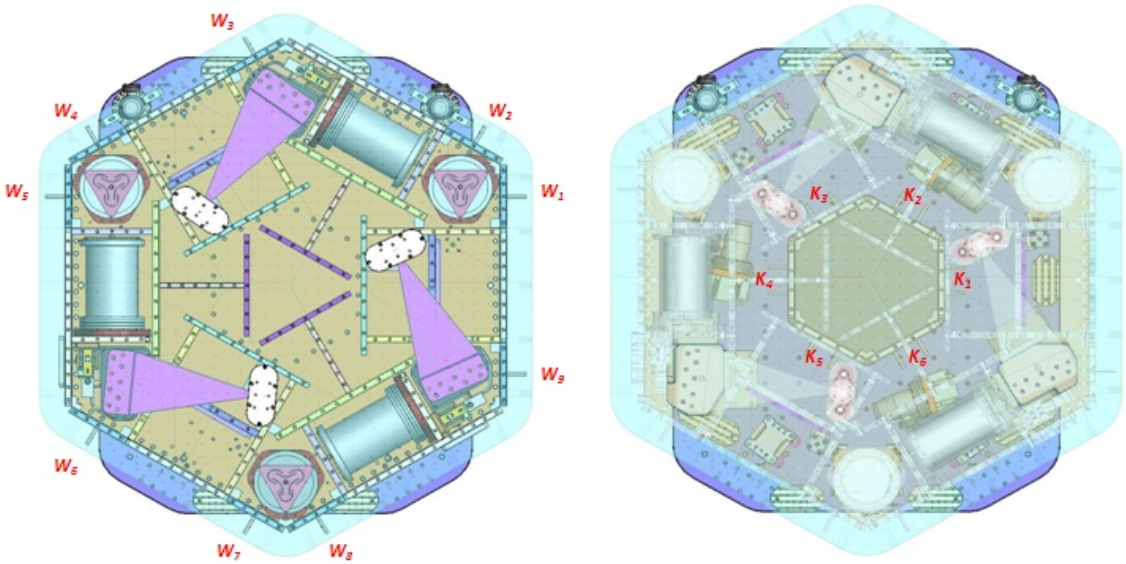

Figure – Keel Masses and Wall masses location

		Mass							
	Type	00	01	02	03	04	05	06	
	Weight	0.246	0.512	0.992	2.052	3.558	7.028	12.268	Kg
Location	w1						1	1	19.3
	w2						1	1	19.3
	w3					2		1	19.4
	w4						1	1	19.3
	w5						1	1	19.3
	w6					2		1	19.4
	w7						1	1	19.3
	w8						1	1	19.3
	w9					2		1	19.4
		0	0	0	0	4	6	9	**173.9**
Location	k1					1		1	15.8
	k2						2		14.1
	k3					1		1	15.8
	k4						2		14.1
	k5					1		1	15.8
	k6						2		14.1
		0	0	0	0	3	6	3	**89.6**

Table – Wall masses and Keel masses distribution

Locker shim thickness indicated in mils.

Lockers	Shim thickness (mil)
A	128
B	127
C	120
D	121

Table – Shims Thickness

Acceptance Criteria

- The total weight must be Kg +/- Kg

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

- ***Step 8: Lockers adjustment***

D.I at Lockers	Dial indicators V	Dial indicators H
A	0	-0.5
B	0	0.5
C	-1	-0.5
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	26
H2	12
H3	1
V1	16-L038
V2	20-L040
V3	14-L058

Table - Actuators' inventory

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

Acceptance Criteria: all S/N must be recorded.

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

- ***Step 2 - Sensors Inventory***

Sensor	CPS S/N	Mount S/N	ADE board serial #
H1	11999		
H2	11987		
H3	12041		
V1	11998		
V2	11990		
V3	12048		

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***

	10 Kg masses at each corners		No mass		No mass	
Table locked	**ADE boxes on**		**ADE boxes on**		**ADE boxes on/off**	
Sensors	**Offset (Mean)**	**Std deviation**	**Offset (Mean)**	**Std deviation**	**Offset (Mean)**	**Std deviation**
H1	-455	1.0	100	0.8	102	0.8
H2	-80	0.9	-107	0.7	-110	0.8
H3	293	1.0	-36	1.0		
V1	-144	0.6	28	1.1	30	1.4
V2	-248	1.2	-27	1.6	-27	1.6
V3	537	1.0	449	1.8		

Table - Set-up sensors gap

Issues/difficulties/comments regarding this test: HAM-ISI – LHO unit#2 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: X** **Failed: ___**

- ***Step 5 - Measure the Sensor gap***

Sensors	Gap measured on the Jig	Gap measured on the table	% of change	Offset sensors (counts)
H1	NR	0.080"		100
H2	NR	0.080"		-107
H3	NR	0.080"		-36
V1	NR	0.080"		28
V2	NR	0.080"		-27
V3	NR	0.080"		449

Table - Sensors gap

Issues/difficulties/comments regarding this test: No information of gaps measured on the Jig. Difficult to measure without scratching the target.

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***

	Table locked		Table unlocked	
Sensors	**Offset (Mean)**	**Std deviation**	**Offset (Mean)**	**Diff**
H1	100	0.8	-511	-611
H2	-107	0.7	-1215	-1108
H3	-36	1.0	-1367	-1331
V1	28	1.1	866	838
V2	-27	1.6	369	396
V3	449	1.8	60	-389

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:
  - 1600 cts for horizontal sensors (~0.002")
  - 1600 cts for vertical sensors (~0.002")
- Considering the acceptance criteria of step 4, all mean values must be lower than
  - 2000 cts for horizontal sensors (~0.0025")
  - 2000 cts for vertical sensors (~0.0025")

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

- ***Step 7 - Check range of motion (hand pushing)***
  - ***Step 7.1 – Test Nº1***

	CPS read out		Calculated after calibration	
Sensors	**UP (Counts)**	**Down (Counts)**	**UP (mil)**	**Down (mil)**
V1	20600	-19900	24.7	-23.9
V2	18900	-19990	22.7	-24.0
V3	20280	-18500	24.3	-22.2

	CPS read out		Calculated after calibration	
Sensors	**CW(-RZ)**	**CCW (+RZ)**	**CW (mil)**	**CCW (mil)**
H1	22350	-23600	26.8	-28.3
H2	19200	-21400	23.1	-25.7
H3	23350	-19600	28.0	-23.5

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 Nº2***

Displacement sensors and actuator gap check:

	Push in positive direction	Push in negative direction	Railing	Actuator Gap Check
H1	25177	-24906		**X**
H2	24179	-26046		**X**
H3	26335	-28076		**X**
V1	20883	-19813		**X**
V2	32767	-32768	**X**	**X**
V3	25209	-25426		**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**
  - Absolutes 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_2/DTT_Powerspectrum_Undamped
- Power_spectrum_table_locked_ADE_Sync_082410.xml
- Power_spectrum_table_unlocked_ADE_Sync_082410.xml
- Power_spectrum_table_locked_ADE_Sync_082410.txt
- Power_spectrum_table_unlocked_ADE_Sync_082410.txt

Scripts files for processing and plotting in SVN at:
/opt/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_2/DTT_Powerspectrum_Undamped
- PSD_CPS_GS13_lock_unlock_HAM_ISI_LHO_unit_2_2010_08_24.m

Figures in SVN at:
/opt/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_2/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.

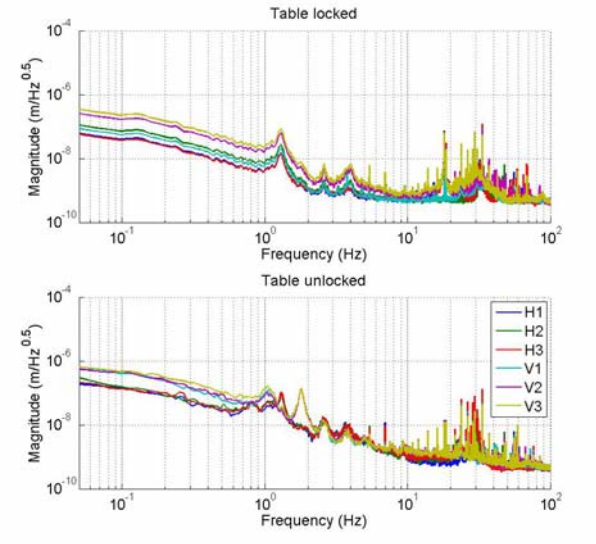

Figure - Calibrated CPS power spectrum

Acceptance criteria:
- No cross talk (peaks at low frequencies + harmonics on measurements)
- Magnitude of power spectrums must be
  - Less than 5e-10m/√Hz at 0.1Hz
  - Less than 5e-10m/√Hz at 1Hz
  - Less than 5e-10m/√Hz at 10Hz

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

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

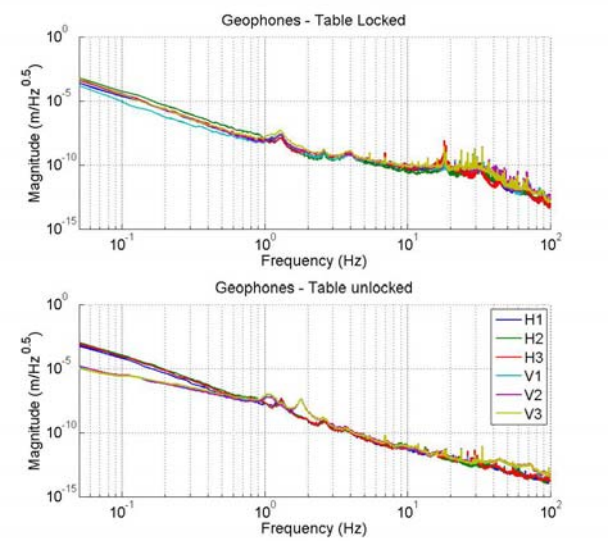

Figure – Power spectrum Calibrated GS13

  - ***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.

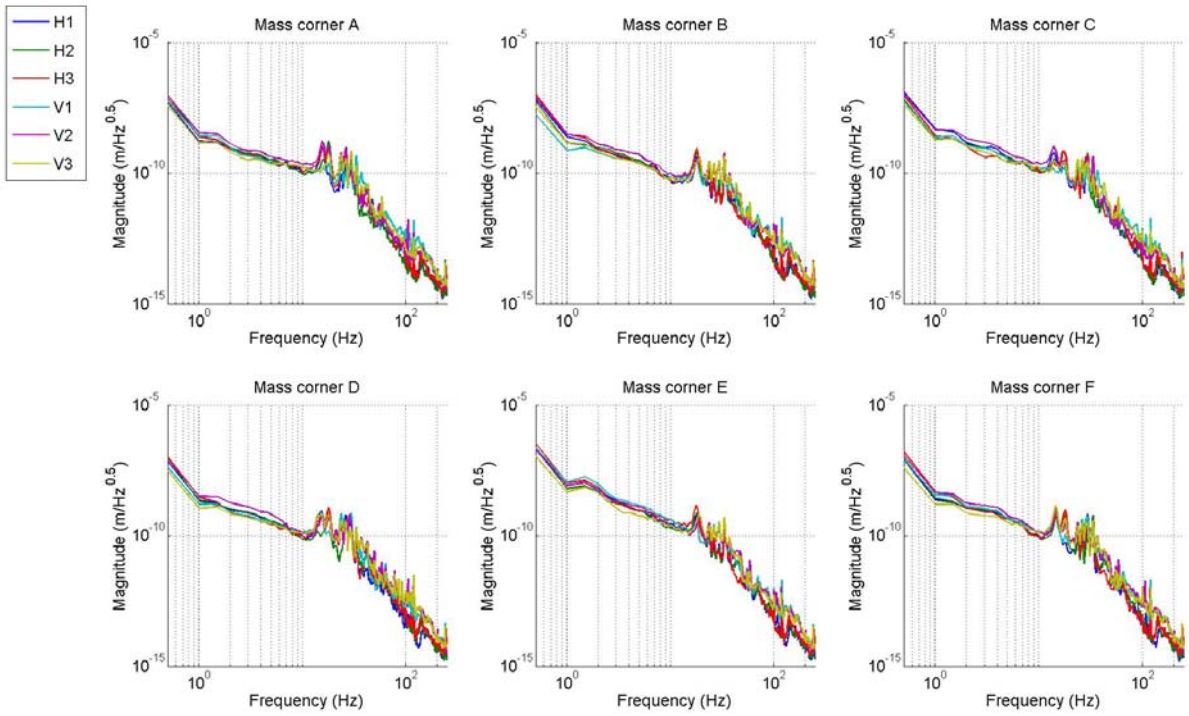

Figure – Power spectrum Calibrated GS13 with mass at corner

Data files in SVN at:
opt//svncommon/seisvn/seismic/HAM-ISI/X2/Data/Unit_1/DTT_Powerspectrum_Undamped

- Power_spectrum_table_locked_ADE_Sync_082410.xml
- Power_spectrum_table_unlocked_ADE_Sync_082410.xml
- Power_spectrum_table_locked_ADE_Sync_082410.txt
- Power_spectrum_table_unlocked_ADE_Sync_082410.txt
- Power_spectrum_table_unlocked_Mass_corner_A_ADE_Sync_082410.xml
- Power_spectrum_table_unlocked_Mass_corner_B_ADE_Sync_082410.xml
- Power_spectrum_table_unlocked_Mass_corner_C_ADE_Sync_082410.xml
- Power_spectrum_table_unlocked_Mass_corner_D_ADE_Sync_082410.xml
- Power_spectrum_table_unlocked_Mass_corner_E_ADE_Sync_082410.xml
- Power_spectrum_table_unlocked_Mass_corner_F_ADE_Sync_082410.xml
- Power_spectrum_table_unlocked_Mass_corner_A_ADE_Sync_082410.txt
- Power_spectrum_table_unlocked_Mass_corner_B_ADE_Sync_082410.txt
- Power_spectrum_table_unlocked_Mass_corner_C_ADE_Sync_082410.txt
- Power_spectrum_table_unlocked_Mass_corner_D_ADE_Sync_082410.txt
- Power_spectrum_table_unlocked_Mass_corner_E_ADE_Sync_082410.txt
- Power_spectrum_table_unlocked_Mass_corner_F_ADE_Sync_082410.txt

Scripts files for processing and plotting in SVN at:
opt/svncommon/seisvn/seismic/HAM-ISI/X2/Data/Unit_1/DTT_Powerspectrum_Undamped

- PSD_CPS_GS13_Lock_Unlock_HAM_ISI_LHO_Unit_2_2010_08_24.m

Figures in SVN at:
opt/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_2/Figures/Powerspectrum_GS13_CPS

- Calibrated_Geophones_Powerspectrum_Locked_Unlocked.fig
- Calibrated_Geophones_Powerspectrum_with_20Kg_Mass_at_one corner.fig

Note: Powerspr

Acceptance criteria:

- Table locked
  - Less than xx at 0.1Hz
  - Less than xx at 1Hz
  - Less than xx at 10Hz
- Table unlocked (no tilt)
  - Less than xx at 0.1Hz
  - Less than xx at 1Hz
  - Less than xx at 10Hz
- Table unlocked (tilt Rx & Ry)
  - Less than xx at 0.1Hz
  - Less than xx at 1Hz
  - Less than xx at 10Hz

Test result: **Passed: ___** **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*

	Positive and negative offset Drive(+/-30000 counts)					
	V1	**V2**	**V3**	**H1**	**H2**	**H3**
V1 readout (counts)	20088	-1989	-8540	X	X	X
	-19439	-353	8685			
V2 readout (counts)	-6256	26420	-8118	X	X	X
	4818	-24717	7165			
V3 readout (counts)	6022	-15782	21595	X	X	X
	-6601	15201	-22703			
H1 readout (counts)	X	X	X	23863	15560	16362
				-24419	-17650	-17558
H2 readout (counts)	X	X	X	17716	23311	17221
				-16627	-24489	-16864
H3 readout (counts)	X	X	X	13668	13626	25018
				-13163	-13296	-25206

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	-18	0	21	
B	-18.5	0	20	
C	-18	0	19.5	
D	-18	0	19.5	
Average	-18.125	0	20	**38.1**

Sensors	Counts	Counts	Counts	Difference (Counts)
V1	-15697	16	15807	31504
V2	-15577	-6	15782	31359
V3	-16502	-328	15895	32397
			Average	**31753**

Table - Calibration of capacitive position sensors

Vertical sensitivity: 31753/38.1 = 832.9 count/mil

or 832.9 count/mil * 1/1638 V/count = 0.508V/mil

or 25400nm/mil * 1/832.9 mil/count = 30.5 nm/count

Difference with Nominal sensitivity = (832.9-840)/840=-0.85%

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	7981	2.41E-04	8.30E+04
V2	8017	2.42E-04	8.26E+04
V3	7955	2.40E-04	8.33E+04
		Average (N/m)	2.49E+05

Table - Vertical spring constant

The measured vertical stiffness is 2.489e5N/m. The nominal vertical spring constant is 2.428e5N/m. The measured error on the vertical stiffness is 2.53%.

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**	2057	1297	1295	2	15	-3
	H2	1285	2071	1294	-4	13	-11
	H3	1296	1304	2082	-5	11	5
	V1	184	193	-372	1408	-34	-620
	V2	-372	198	190	-630	1470	-47
	V3	179	-391	183	-44	-629	1477

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
  - 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 15 - Linearity test***

	Sensors (counts)					
	V1/V1	**V2/V2**	**V3/V3**	**H1/H1**	**H2/H2**	**H3/H3**
-7000	-14747	-15424	-15560	-10245	-10622	-11190
-3000	-6536	-7160	-7265	-4628	-4832	-5280
-1000	-2474	-3031	-3125	-1821	-1914	-2330
-300	-1002	-1594	-1670	-835	-907	-1280
0	-395	-985	-1050	-416	-475	-830
300	223	-364	-436	4	-35	-382
1000	1662	1090	1018	995	974	632
3000	5771	5217	5173	3794	3864	3588
7000	13977	13463	13481	9431	9674	9470

Table - Linearity test of the triplet Actuators – HAM-ISI – Sensors

	Slope	**Offset**	**Average slope**	**Variation from average (%)**
H1	1.4052	-413.44	1.4437	-2.66
H2	1.4496	-474.78		0.41
H3	1.4762	-844.67		2.25
V1	2.0519	-391.22	2.0631	-0.54
V2	2.0632	-976.44		0.01
V3	2.0741	-1048.2		0.53

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_2/Linearity_test

- Linearity_test_HAM-ISI_LHO_Unit_2_2010_08_26.mat

Scripts files for processing and plotting in SVN at:
/opt/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_2/Linearity_test

- Linearity_test_2010_08_26.m

Figures in SVN at:
/opt/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_2/Figures/Linearity_test

- Linearity_test.fig

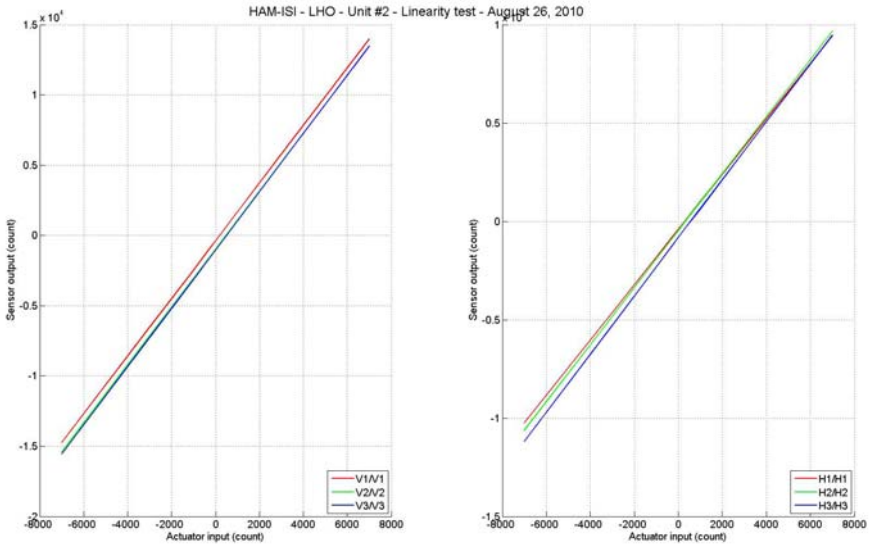

Figure - Horizontal and vertical actuators x HAM-ISI x sensors

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	257	-434	11	-433	-236	-1970
	H2	260	469	15	497	-246	-1971
	H3	-513	13	17	22	543	-1980
	V1	-41	-53	191	-565	-1710	-98
	V2	-39	-25	230	1634	334	-71
	V3	-49	-53	222	-1315	1178	-89
	Direction read out	**514**	**512**	**236**	**2631**	**2518**	**2547**

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 files in SVN at:
opt/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_1/Transfer_functions/Local_to_local

- Data_L2L_50mHz_500mHz_20100828-025758.mat
- Data_L2L_500mHz_5Hz_20100827-235225.mat
- Data_L2L_5_200Hz_20100827-221852.mat
- Data_L2L_200_800Hz_20100827-204519.mat

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

Scripts files for processing and plotting in SVN at:
opt/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_2/Transfer_functions/Local_to_local

- Plot_TF_Local_to_Local_2010_08_27.m

Figures in SVN at:
opt/svncommon/seisvn/seismic/HAMISI/X2/Data/Unit_1/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_2_2010_08_27.mat

The local to local transfer functions are presented below.

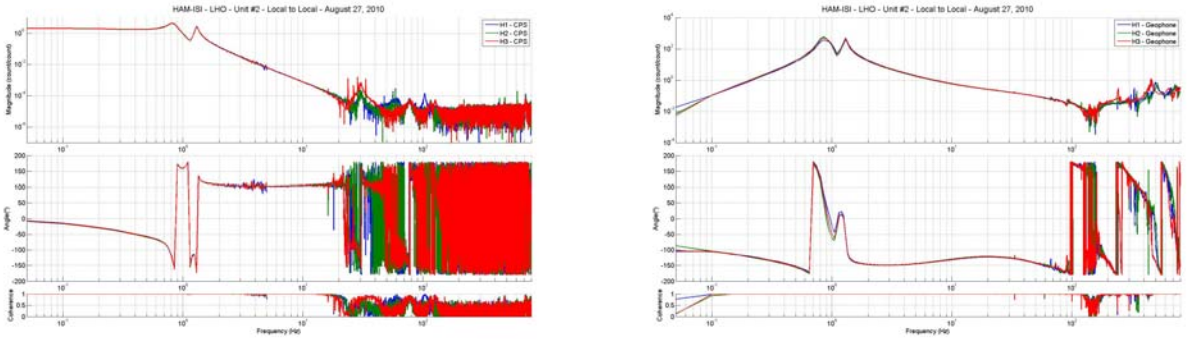

Figure - Local to Local Measurements – Horizontal sensors

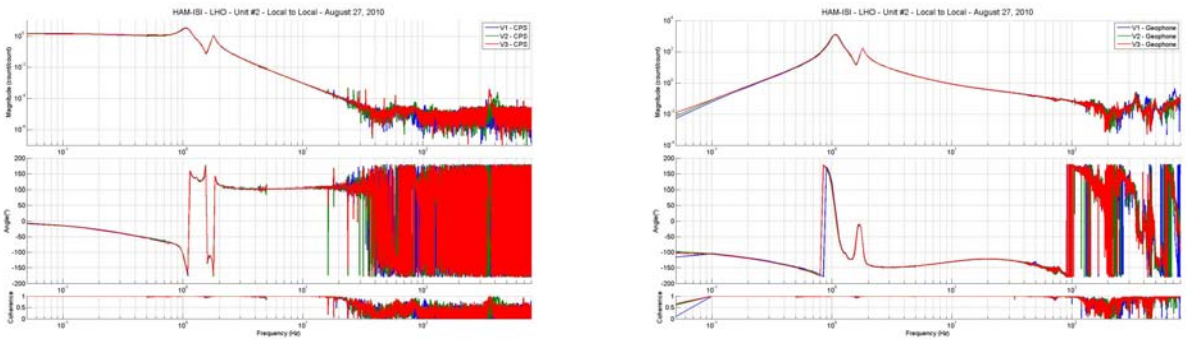

Figure - Local to Local Measurements – Vertical sensors

Issues/difficulties/comments regarding this test: Local to local transfer functions have been measured from the actuator to pre-filter inputs instead of pre-filter outputs. Consequently, we see the GS13 interface chassis response.

o *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_2/Transfer_functions/Cartesian_to_cartesian

- Data_Cart2Cart_50mHz_500mHz_20100828-121600.mat
- Data_Cart2Cart_500mHz_5Hz_20100828-091027.mat
- Data_Cart2Cart_5_200Hz_20100828-073654.mat
- Data_Cart2Cart_200_800Hz_20100828-060321.mat

Scripts files for processing and plotting in SVN at:
opt/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_2/Transfer_functions/Cartesian_to_cartesian

- Plot_TF_Cartesian_to_Cartesian_2010_08_28.m

Figures in SVN at:
opt/svncommon/seisvn/seismic/HAMISI/X1/Data/Unit_2/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_2/Transfer_functions/Cartesian_to_Cartesian

- Cartesian_2_Cartesian_LHO_HAM-ISI-Unit_2_2010_08_28.mat

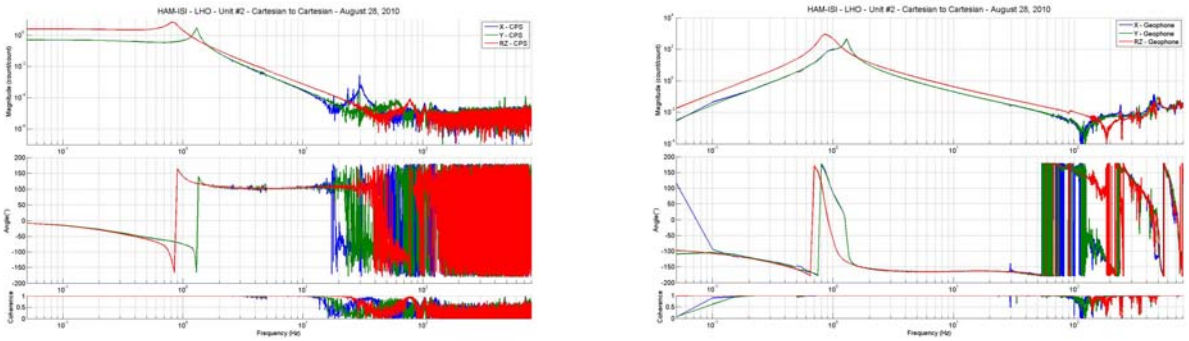

Figure - Cartesian to Cartesian measurements – X, Y, RZ directions

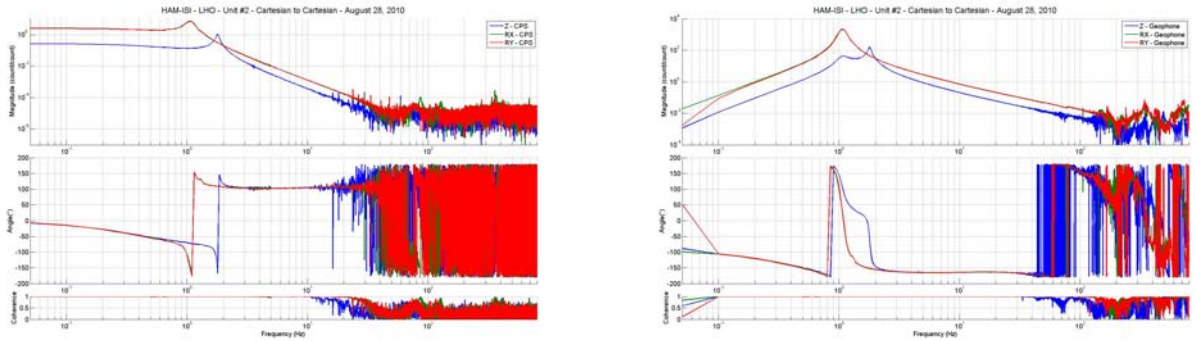

Figure - Cartesian to Cartesian measurements – Z, RX, RY directions

Issues/difficulties/comments regarding this test:

Acceptance criteria:

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

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

- ***Step 18 - Transfer function comparison***
  - ***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_2/Transfer_functions/Local_to_local

- Plot_TF_Local_to_Local_2010_08_27.m

Local to local figures in SVN at:
/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_2/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

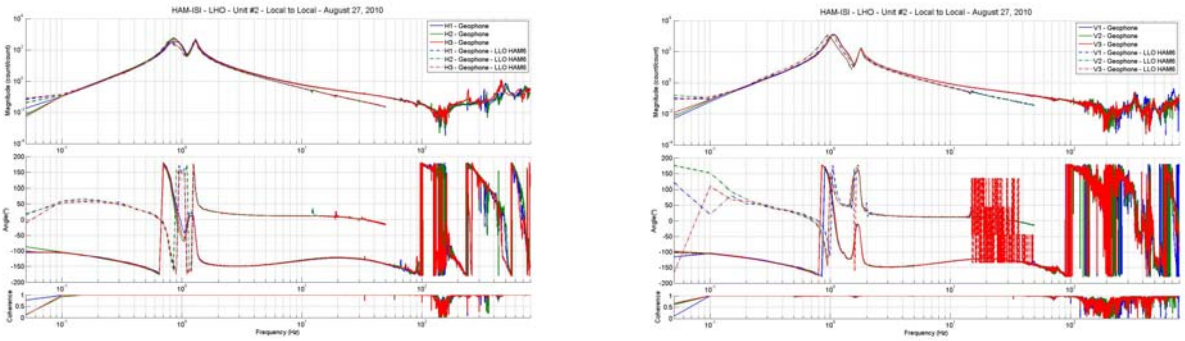

Figure - Local to local measurements comparison with HAM6 – GS13

CPS, Local to local measurement, Undamped

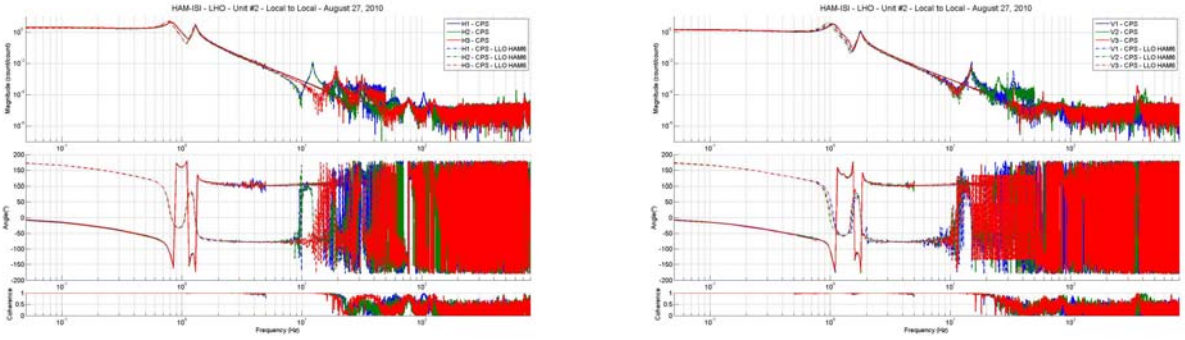

Figure - Local to local measurements comparison – Position sensors

Difference with HAM6:

- Sign difference on CPS and Geophones.

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_2/Transfer_functions/Cartesian_to_cartesian

- Plot_TF_Cartesian_to_Cartesian_2010_08_28.m

Cartesian to Cartesian figures in SVN at :
/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_2/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

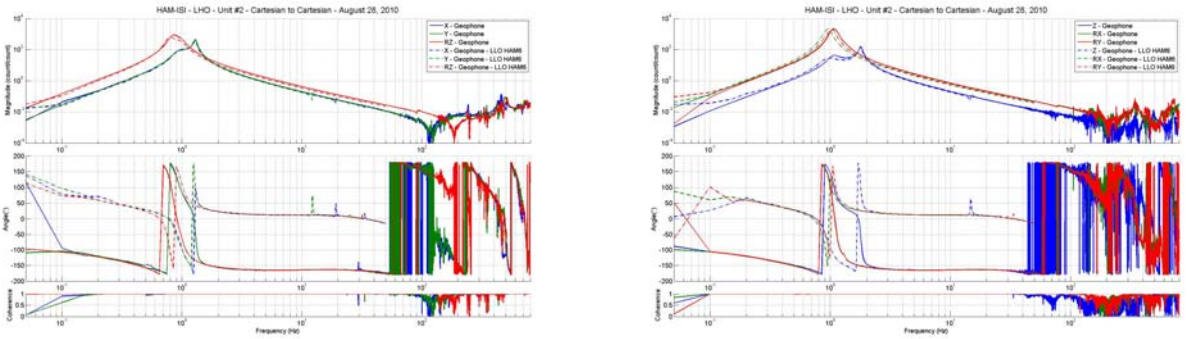

Figure - Cartesian to Cartesian measurements comparison with HAM6 – GS13

CPS, Cartesian to Cartesian measurement, Undamped

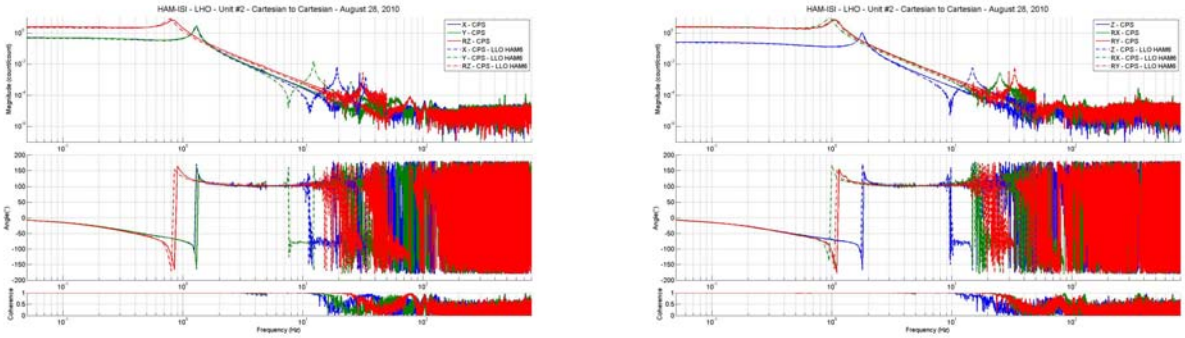

Figure - Cartesian to Cartesian measurements comparison – Position sensors

Difference with HAM6:

- Resonance at 1 Hz is slightly higher than HAM6
- Sign difference on CPS and Geophones

Acceptance criteria:

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

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

- ***Step 19 - Lower Zero Moment Plan***

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_2/Transfer_functions/LZMP
- Data_LZMP_Cart2Cart_10mHz_100mHz_20100829-095746.mat

Scripts files for processing and plotting in SVN at:
opt/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_2/Transfer_functions/LZMP
- LZMP_2010_08_29.m

Figures in SVN at:
opt/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_2/Figures/Transfer_functions/LZMP
- LZMP.fig

X & Y offsets:

X offset (mm)	**0.38**
Y offset (mm)	**0.11**

Table – Offset of the Lower Zero Moment Plane

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

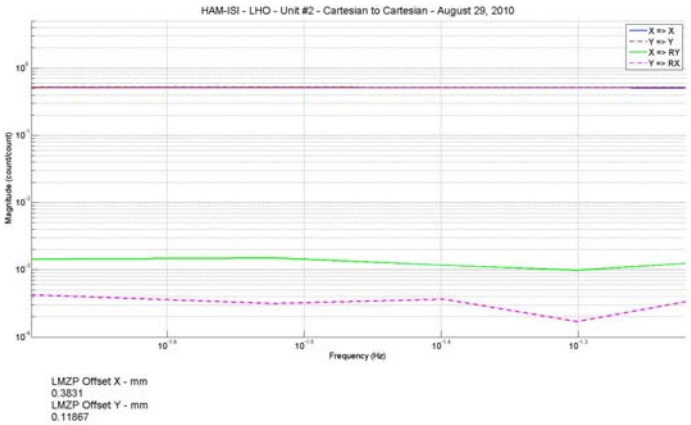

Figure - Lower Zero moment plane – Main and cross coupling at low frequency

Acceptance criteria:

- Vertical offset must be less than mm
- Horizontal offset must be less than mm

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

- ***Step 20 - Damping loops***

Filters used by Damping loops in SVN at:
/opt/svncommon/seisvn/seismic/HAM-ISI/X1/FilterDesign/Unit_2/txt_file

- G1ISIHAM_Back_up_2010_09_01.txt (digitalized filters copied and rename to G1ISIHAM.txt in /opt/rtcds/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_2/Damping_Loops/Transfer_functions_simulation

- HAM_ISI_LHO_unit_2_Damping_TF_2010_08_26.m

Figures in SVN at:
/svncommon/seisvn/seismic/HAM-ISI/X2/Data/Unit_1/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_2/Damping_Loops/Transfer_functions_simulation

- Damping_loop_transfer_functions_HAM-ISI-LHO-unit2_2010_08_26.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.

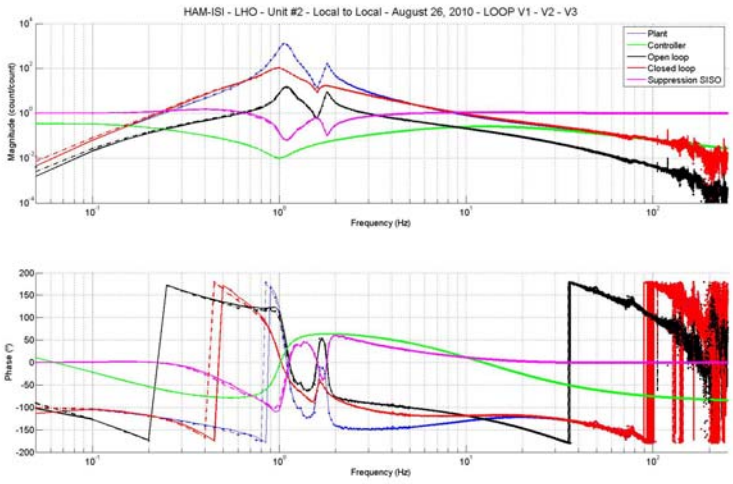

Figure - Vertical damping loops - Simulation

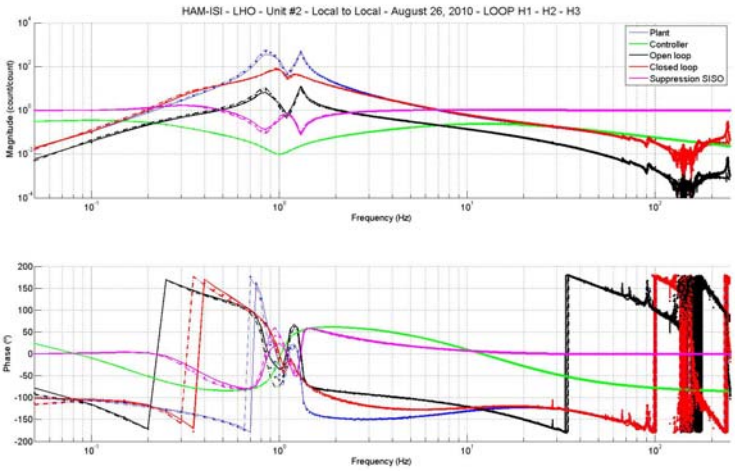

Figure – Horizontal damping loops - Simulation

o *Step 20.2 - Powerspectrum – Experimental*

Data files in SVN at:
/opt/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_2/Damping_Loops/
DTT_Powerspectrum_experimental

- Power_spectrum_table_unlocked_Damping_OFF_082510.xml
- Power_spectrum_table_unlocked_Damping_ON_082510.xml
- Power_spectrum_table_unlocked_Damping_OFF_082510.txt
- Power_spectrum_table_unlocked_Damping_ON_082510.txt

Scripts files for processing and plotting in SVN at:
/opt/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_2/Damping_Loops/
DTT_Powerspectrum_experimental

- HAM_ISI_LHO_unit_2_Damping_Powerspectrum_2010_08_26.m

Figures in SVN at:
/svncommon/seisvn/seismic/HAM-ISI/X1/Data/Unit_2/Figures/Damping_Loops

- Damping_LOOP_GEO_Powerspectrum.fig
- Simulation_vs_experimental_Suppression.fig

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

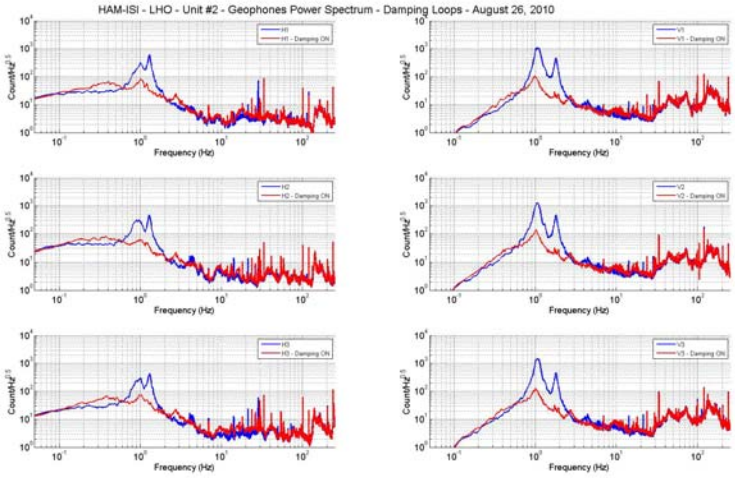

Figure – Horizontal (left) and vertical (right) damping loops - Experimental

Sensitivity:
The figure below compare the sensitivity ('Undamped/'Damped') of LLO HAM (Aug 2008) and LLO Unit 1. 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.

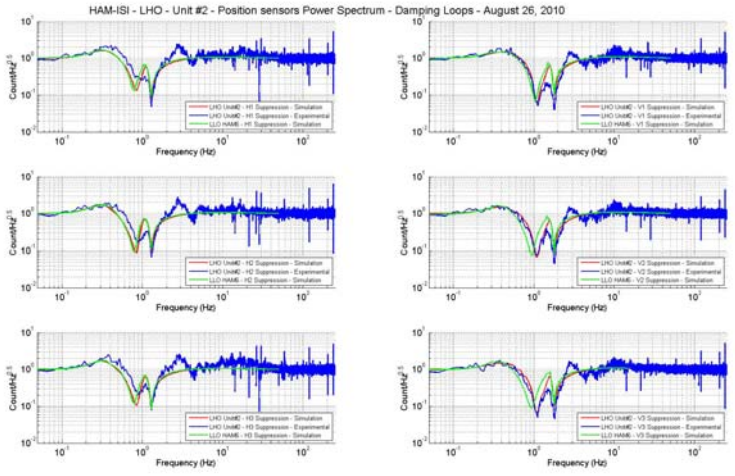

Figure - Damping loop sensitivity

Acceptance criteria:

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

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

IV. Testing Summary