LIGO Laboratory / LIGO Scientific Collaboration

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aLIGO LHO BSC 6 BSC-ISI (Unit # 2),

Phase I (post-assembly, before storage)

E1100295 – V3

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Distribution of this document:
Advanced LIGO Project

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Table of contents:

Introduction

The BSC-ISI testing is performed in three phases:
1) BSC-ISI, Pre-integration Testing, Phase I (post-assembly)
2) BSC-ISI, Pre-integration Testing, Phase II: Tests done after Transport (and possible storage), during mating phase with Suspensions, before insertion.
3) BSC-ISI, Integration Phase Testing: Procedure and results related to the commissioning in the chamber.

This document presents the series of tests (Phase I) performed on the ISI-BSC6 (ETMY) in the Staging building before its move to the End Station (Teststand). Tests started on August 5. Due to lots of issues with cabling and sensors, tests were stopped and finished on October 27, 2011. The testing procedure document E1000486-v3 was used. Some tests have been waived.

The ISI-BSC6 was moved from the Staging building to EY on October 31, 2011. The ISI left the staging building in a working state.

All results are posted on the SVN at:
https://svn.ligo.caltech.edu/svn/seismic/BSC-ISI/X1/Data/BSC6/

The following type of document can be found in the SVN:
- Excel spreadsheet (.xls)
- Data location
- Figures location
- Masses distribution scheme (ppt)

I. Pre-Assembly Testing

- ***Step 1 - CPS Test and calibration – E1100369***

CPS sensors are tested (calibration and noise test) at MIT before being cleaned and baked at LHO. During testing, the initial set of CPSs (12) was changed due to flux issue.

The list of installed sensors used for testing (phase I) are reported in step II.3.

All data related to the CPS testing can be found in the SVN at
/svn/seismic/ Common\Data\aLIGO_BSC_ISI_CPS\

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

- ***Step 2 - GS13 – Inspection/Assembly – E1000058 – E1100740***

GS13 are tested and podded at LLO before being shipped to LHO. The first set of GS13s was replaced due to wrong screws (length) installed on the electrical feedthroughs.
All the data related to GS-13 post podding testing can be found in the **SVN at :**
/svn/seismic/Common/Data/aLIGO_GS13_TestData/GeoTech_TestResults_PDFs/

The list of installed sensors used for testing (phase I) are reported in step II.3.

E1000058 spreadsheet provides the status of each individual GS-13 at LLO site for HAM-ISI and BSC-ISI. E1100740 shows the installation location of the geophones.

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

- ***Step 3 - L4C – Inspection/Assembly – E1000136 – E1100740***

L4C are tested and podded at LLO before being shipped to LHO. During testing, two pods were replaced (1 non-working pressure sensor and 1 pod non vacuum compatible)

The list of installed sensors used for testing (phase I) are reported in step II.3.

All the data related to L4C post podding testing can be found in the **SVN at :**
svn/seismic/Common/Data/aLIGO_L4C_TestData/TestResults_PDFs/

E1000136 spreadsheet provides the status of each individual GS-13 at LLO site for HAM-ISI and BSC-ISI. E1100740 shows the installation location of the geophones.

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

- ***Step 4 - T240 – Inspection/Assembly - E1100326 – E1100740***

T240 are tested and podded at LLO before being shipped to LHO.
All T240s were replaced during testing to be fixed and retrofitted. On the initial set, two of the three pressure sensors were not working.
Before retrofitting the T240 pods, if the seismometer were unplugged when the interface chassis was not turned off, the surge created by the inductance of the cable could damaged the pressure sensors. Surge protectors are now added on the seismometer pressure sensors.

The list of installed sensors used for testing (phase I) are reported in step II.3.

All the data related to T240 post podding testing can be found in the **SVN at :**
seismic/Common/Data/aLIGO_T240_TestData/AsReceived_TestResults_PDFs.

E1100326 spreadsheet provides the status of each individual T240 at LLO site for BSC-ISI. E1100740 shows the installation location of the geophones.

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

- ***Step 5 - Actuators - T0900564 - T1100234 – E1100741***

The list of installed sensors used for testing (phase I) are reported in step II.2

Large actuator data can be found at: T0900564. Actuator inventory is made at Section II – Step 2.
Small actuator data can be found at: T1100234. Actuator inventory is made at Section II – Step 2.

Details of the actuators testing are given in the table below.

	Stage 0-1		Stage 1-2	
Corner	H	V	H	V
1	Actuator Serial #: L051 Operator Name: Gordon, Matt Date: 9/24/2009 Time: 8:35 AM Actuator Coil Resistance: 6.38 Ohms, PASS Ambient Temperature: 68.8 F Hi Pot Test Results: 1000 MOhms, PASS X Travel Limit (inches): 0.520 Y Travel Limit (inches): 0.205 Z Travel Limit (inches): 0.506	Actuator Serial #: L034 Operator Name: Hartmann Donna Date: 9/23/2009 Time: 10:57 AM Actuator Coil Resistance: 6.43 Ohms, PASS Ambient Temperature: 72.9 F Hi Pot Test Results: 1000 MOhms, PASS X Travel Limit (inches): 0.527 Y Travel Limit (inches): 0.205 Z Travel Limit (inches): 0.505	Actuator Serial #: S054 Operator Name: Gordon, Matt Date: 9/15/2010 Time: 1:27 PM Actuator Coil Resistance: 10.36 Ohms, PASS Ambient Temperature: 78.8 F Hi Pot Test Results: 1000 MOhms, PASS X Travel Limit (inches): 0.657 Y Travel Limit (inches): 0.205 Z Travel Limit (inches): 0.515	Actuator Serial #: S050 Operator Name: Gordon, Matt Date: 9/15/2010 Time: 10:06 AM Actuator Coil Resistance: 10.29 Ohms, PASS Ambient Temperature: 78.8 F Hi Pot Test Results: 1000 MOhms, PASS X Travel Limit (inches): 0.674 Y Travel Limit (inches): 0.205 Z Travel Limit (inches): 0.512

2	Actuator Serial #: L047 Operator Name: Gordon, Matt Date: 9/24/2009 Time: 3:34 PM Actuator Coil Resistance: 6.34 Ohms, PASS Ambient Temperature: 75.4 F Hi Pot Test Results: 1000 MOhms, PASS X Travel Limit (inches): 0.523 Y Travel Limit (inches): 0.204 Z Travel Limit (inches): 0.504	Actuator Serial #: L048 Operator Name: Gordon, Matt Date: 9/24/2009 Time: 3:52 PM Actuator Coil Resistance: 6.32 Ohms, PASS Ambient Temperature: 75.1 F Hi Pot Test Results: 1000 MOhms, PASS X Travel Limit (inches): 0.526 Y Travel Limit (inches): 0.205 Z Travel Limit (inches): 0.504	Actuator Serial #: S053 Operator Name: Gordon, Matt Date: 9/15/2010 Time: 11:43 AM Actuator Coil Resistance: 10.23 Ohms, PASS Ambient Temperature: 78.8 F Hi Pot Test Results: 1000 MOhms, PASS X Travel Limit (inches): 0.679 Y Travel Limit (inches): 0.205 Z Travel Limit (inches): 0.516	Actuator Serial #: S056 Operator Name: Gordon, Matt Date: 9/15/2010 Time: 2:00 PM Actuator Coil Resistance: 10.35 Ohms, PASS Ambient Temperature: 78.8 F Hi Pot Test Results: 1000 MOhms, PASS X Travel Limit (inches): 0.676 Y Travel Limit (inches): 0.205 Z Travel Limit (inches): 0.515
3	Actuator Serial #: L053 Operator Name: Gordon, Matt Date: 9/24/2009 Time: 4:23 PM Actuator Coil Resistance: 6.36 Ohms, PASS Ambient Temperature: 76.0 F Hi Pot Test Results: 1000 MOhms, PASS X Travel Limit (inches): 0.527 Y Travel Limit (inches): 0.205 Z Travel Limit (inches): 0.501	Actuator Serial #: L046 Operator Name: Gordon, Matt Date: 9/23/2009 Time: 3:31 PM Actuator Coil Resistance: 6.375 Ohms, PASS Ambient Temperature: 74.0 F Hi Pot Test Results: 1000 MOhms, PASS X Travel Limit (inches): 0.526 Y Travel Limit (inches): 0.206 Z Travel Limit (inches): 0.505	Actuator Serial #: S055 Operator Name: Gordon, Matt Date: 9/15/2010 Time: 1:44 PM Actuator Coil Resistance: 10.33 Ohms, PASS Ambient Temperature: 78.8 F Hi Pot Test Results: 1000 MOhms, PASS X Travel Limit (inches): 0.663 Y Travel Limit (inches): 0.206 Z Travel Limit (inches): 0.516	Actuator Serial #: S051 Operator Name: Gordon, Matt Date: 9/15/2010 Time: 11:11 AM Actuator Coil Resistance: 10.18 Ohms, PASS Ambient Temperature: 78.8 F Hi Pot Test Results: 1000 MOhms, PASS X Travel Limit (inches): 0.657 Y Travel Limit (inches): 0.205 Z Travel Limit (inches): 0.513

Table 1 - Actuator Testing results

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

II. Tests to be performed during assembly

- ***Step 1 - Test stand level***

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

- ***Step 2 - Actuators Inventory***

The actuators S/N are reported in the table below. Further information can be found in T0900564 and T1100234.

Stage 1		Stage 2	
Actuator	**Actuator S/N**	**Actuator**	**Actuator S/N**
H1	51	**H1**	54
H2	47	**H2**	53
H3	53	**H3**	55
V1	34	**V1**	50
V2	48	**V2**	56
V3	46	**V3**	51

Table 2 - Actuators' inventory

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

- ***Step 3 - Sensors Inventory***

A first set of capacitive position sensors, initially installed was removed, due to questionable flux inside the sensor heads. The S/N of sensors and electronic boards of the final configuration are reported in the tables below.

CPS Stage 1	CPS S/N	ADE board serial #
H1	13576	15881
H2	13583	15854
H3	13180	13066
V1	13572	12831
V2	13620	13062
V3	13577	15860

Table 3 - Capacitive position sensors' inventory – Stage 1

CPS Stage 2	CPS S/N	ADE board serial #
H1	13415	15874
H2	13575	15864
H3	12901	12427
V1	13573	15865
V2	13465	15867
V3	13578	15863

Table 4 - Capacitive position sensors' inventory – Stage 2

A first set of GS13 installed in the ISI was replaced due to a wrong screw (length) installed in the feedthroughs. The S/N sensors of the final configuration are reported in the table below.

Location GS13	Serial Number	POD
H1	711	95
H2	839	101
H3	846	83
V1	746	100
V2	734	75
V3	743	102

Table 5 - GS13 Inventory

The S/N sensors of the final configuration are reported in the table below. During testing, two pods were replaced (non-working pressure sensor – non vacuum compatible)

Location L4C	Serial Number	POD
H1	1105	76
H2	970	30
H3	819	129
V1	1085	37
V2	1089	127
V3	929	17

Table 6 - L4C inventory

All T240s were replaced during testing to be fixed and retrofitted. On the initial set, two of the three pressure sensors were not working.

Note: Before retrofitting the T240 pods, if the seismometer were unplugged when the interface chassis was not turned off, the surge created by the inductance of the cable could damaged the pressure sensors. Surge protectors are now added on the seismometer pressure sensors.

The S/N sensors of the final configuration are reported in the table below:

Geophones T240	Serial Number	POD
1	131	41
2	110	22
3	127	18

Table 7 - T240 Geophones

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

- ***Step 4 - Electronics Inventory***

Write down in the table below all serial numbers all the electronic equipment:

Hardware	Ligo reference	S/N
Interface Chassis - Corner 1	D1002432	S1102223
Interface Chassis - Corner 2		S1102224
Interface Chassis - Corner 3		S1102218
Anti-Alliasing Chassis - Corner 1	D1002693	S1102693
Anti-Alliasing Chassis - Corner 2		S1102694
Anti-Alliasing Chassis - Corner 3		S1102679
Anti-image Chassis	D070081	S1000250
Binary Input Chassis	D1001726	S1101309
Binary Input Chassis		S1101300
Binary Output Chassis	D1001728	S1101347
T240 Interface - Corner 1	D1002694	S1101840
T240 Interface - Corner 2		S1101838
T240 Interface - Corner 3		S1101839
I/O Chassis	n/a	DTSFE0
Coil driver Pod 1	D0902744	S1000266
Coil driver Pod 2		S1000269
Coil driver Pod 3		S1102692

Table 8 - Electronic equipment

Note: During testing 2 geophone interface chassis (D1002432) were fixed (defect of operational amplifiers). The power regulator of one anti-aliasing chassis (D1002693) overheated. The location of the anti-aliasing chassis is modified to cool them down. We also took the lid off. The anti image chassis (D070081) was fixed twice. The coil drivers were retrofitted (new logic of the binary output).

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

- ***Step 5 - Check level of Stage 0 after top-bottom plate assembly***

Note : This test has not been performed

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

- ***Step 6 - Check gaps under the blade posts***

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

- ***Step 7 - Blade post shim thickness***

This table shows the shims thickness installed under the lockers.

Stage 1		Stage 2	
Lockers	**Shim thickness (mil)**	**Lockers**	**Shim thickness (mil)**
A	0,128	**A**	0,123
B	0,121	**B**	0,129
C	0,129	**C**	0,124

Table 9 - Shims thickness

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

- ***Step 8 - Blade 0-1 post launch angle***

Note : This test was not performed.

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

- ***Step 9 - Gap checks on actuators***

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

- ***Step 10 - Mass budget***

The mass budget is reported in the tables below. Locations of stage 1 masses are presented in the figure below.

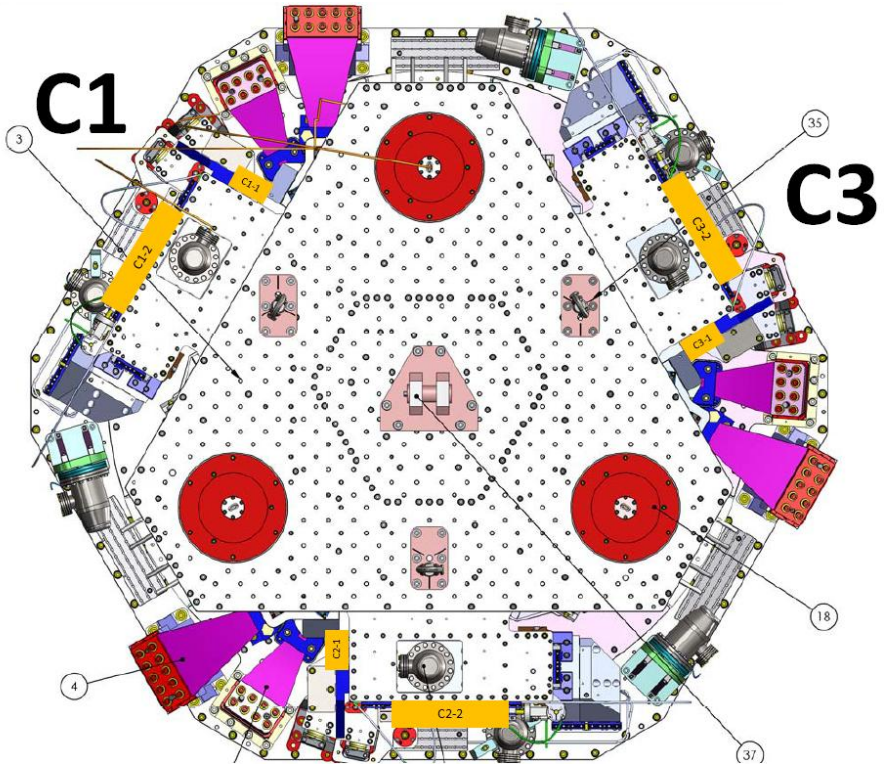

Figure 1 - Mass location legend

Stage 1:

Stage 1		
Location	**Weight (lb)**	**Weight (Kg)**
C1-1	22	10
C1-2	28	12.7
C2-1	18	8.2
C2-2	28	12.7
C3-1	18	8.2
C3-2	15	6.8
Total	129	58.6

Table 10 - Payload - Stage 1

Nominal payload: 109Kg – 240lb
Added masses are 50Kg – 23lb lighter than expected.
Nominal mass of stage 1=912Kg - 2010lb
Difference with the nominal mass: -5.4%

Stage 2:

Quantity	Weight (Kg)	Total Weight(Kg)
3	276.7	830.1
2	105.7	211.4
2	5.0	10.0
2	2.0	4.0
2	1.0	2.0
4	0.5	2.0
	Total :	**1059.5**

Table 11 - Payload - Stage 2

Nominal payload: 1185Kg – 2612lb
The added masses is 125Kg lighter than expected.

Total mass of Stage 2: 2830Kg – 6239lb
Error on the nominal overall mass of stage 2: 125/2830=-4%

Acceptance Criteria

The Mass budget must be:
- Nominal payload on stage 1: 109Kg – 240lb (-5% +/- 2% due to blade softness)
- Nominal payload on stage 2: 1185Kg – 2612lb (-5% +/- 2% due to blade softness)

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

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

	Stage 1		Stage 2	
D.I at Lockers	Dial indicators V	Dial indicators H	Dial indicators V	Dial indicators H
A	-2	0	-0,5	0
B	-2	0	-2	0
C	0	0	-0,5	-1

Table 12 - Dial indicators read-out (stage locked-unlocked independently)

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

- ***Step 12 - Cables inventory – E1100822***

Initial testing was realized with a hybrid set of the HAM-ISI and BSC-ISI cables. After serializing and recleaning the cables, final testing was performed.

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

- ***Step 13 - Cable routing – E1101027***

Cable routing is defined in E1101027.

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

III. Tests to perform after assembly

- ***Step 1- Geophones pressure readout***

During the first series of tests, we noticed 2 non working T240 and 1 non working L4C pressure sensors. After replacement of 3 T240s and 1 L4C, the pressure was measured on the input channels of the IOP.

	Raw pressure (count)		
Sensors	**Corner 1**	**Corner 2**	**Corner 3**
ST1-L4C-D	-457	-813	-818
ST1-L4C-P	24622	24701	24702
ST1-GS13-D	716	-72	-87
ST1-GS13-D	24502	24501	24503
ST1-T240-P	13531	13140	13142

Table 13 - Geophones pressure readout

Acceptance criteria:

- The absolute pressure on the L4Cs and the GS13s must be 24700 +/- 600 counts (100+/- 2 KPA)
- The differential pressure on the L4Cs and the GS13s must be <2400 counts (2 KPa)
- The absolute pressure on the T240 must be 14300 +/-300 counts (100 +/- 2 KPA)

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

- ***Step 2- Set up sensors gap – Locked vs unlocked position***

During this step, sensors gap are adjusted. This step considers that the lockers have been finely set up during assembly.
Measurements for this test are in the SVN at:
svn/seismic/BSC-ISI/X1/Data/BSC6/Static_Tests/:

- LHO_ISI_BSC6_Locked_2011_10_27.mat
- LHO_ISI_BSC6_Unlocked_2011_10_27.mat

	ISI locked		ISI unlocked		Difference locked - unlocked	
Sensors	**Offset (Mean)**	**Std deviation**	**Offset (Mean)**	**Std deviation**	**Offset (Mean)**	**mil**
ST1 - H1	-175.7	18.4	-210.9	40.3	35	0.04
ST1 - H2	-14.6	12.7	-106.3	26.0	92	0.11
ST1 - H3	-130.1	11.5	-191.2	19.7	61	0.07
ST1 - V1	319.9	20.0	545.5	23.8	-226	-0.27
ST1 - V2	599.0	12.9	684.1	16.2	-85	-0.10
ST1 - V3	-398.8	21.4	394.2	30.9	-793	-0.94
ST2 - H1	470.3	55.1	407.4	16.2	63	0.02
ST2 - H2	1003.1	40.1	826.9	42.4	176	0.05
ST2 - H3	608.3	53.8	982.5	35.4	-374	-0.11
ST2 - V1	-478.3	46.3	-37.9	62.0	-440	-0.13
ST2 - V2	-466.2	52.1	-323.8	40.7	-142	-0.04
ST2 - V3	452.8	76.1	1289.1	71.0	-836	-0.25

Table 14 - Capacitive position sensors readout after gap set-up

Note:
On BSC8 in a "locked position", we noticed large shifts in the CPS offsets after changing the type of payload (Masses on top of stage 2 vs QUAD). Unfortunately, we didn't keep track of these shifts. During the preparation of the BSC6 move to the end station, we recorded the CPS offsets when the ISI was locked with two different payloads. We measured these CPS offsets before and after removing the masses on top of stage 2 (~1000Kg). After removing the payload, the ISI went up (up to 7 mils at the CPS locations on stage 2) without twist. Note that the CPSs are from the lockers and the clearance of the lockers in a "locked position" is 2mils.
Measurements for this test are in the SVN at svn/seismic/BSC-ISI/X1/Data/BSC6/Static_Tests/:

- LHO_ISI_BSC6_Locked_Unloaded_2011_10_27.mat

	ISI locked - loaded	ISI locked unloaded	Difference locked - loaded vs unloaded	
Sensors	Offset (Mean)	Offset (Mean)	Offset (Mean)	mil
ST1 - H1	-175.7	837.1	-1013	-1.21
ST1 - H2	-14.6	1130.6	-1145	-1.36
ST1 - H3	-130.1	1375.3	-1505	-1.79
ST1 - V1	319.9	3406.6	-3087	-3.67
ST1 - V2	599.0	3509.3	-2910	-3.46
ST1 - V3	-398.8	2235.1	-2634	-3.14
ST2 - H1	470.3	2227.3	-1757	-0.52
ST2 - H2	1003.1	3300.7	-2298	-0.68
ST2 - H3	608.3	1870.8	-1262	-0.38
ST2 - V1	-478.3	20380.2	-20859	-6.21
ST2 - V2	-466.2	23272.6	-23739	-7.07
ST2 - V3	452.8	19366.8	-18914	-5.63

Table 15 - CPS Offset - Locked - Loaded vs Unloaded

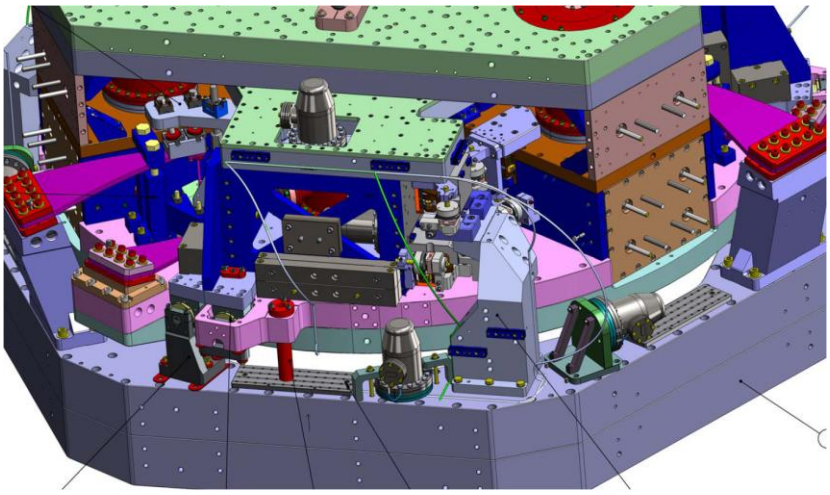

Figure 2 - BSC-ISI overview

Acceptance criteria:

- In the locked position, all mean values must be lower than 400 counts for stage 1 CPS and 1600 counts for stage 2 CPS on Dataviewer (a bit less than .0005").
- In the locked position, all standard deviations below 5 counts for stage 1, 20 counts for stage 2
- Absolute values of the difference between the unlocked and the locked table must be below:
  Stage 1
    - 1600 cts for horizontal sensors (~0.002")
    - 1600 cts for vertical sensors (~0.002")
  Stage 2
    - 6500 cts for horizontal sensors (~0.002")
    - 6500 cts for vertical sensors (~0.002")
- Considering the acceptance criteria of step 2, all mean values must be lower than
  Stage 1
    - 2000 cts for horizontal sensors (~0.0025")
    - 2000 cts for vertical sensors (~0.0025")
  Stage 2
    - 8000 cts for horizontal sensors (~0.0025")
    - 8000 cts for vertical sensors (~0.0025")

Note: The locker offset is set to +2 mils in step I.11.

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

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

This test was not performed. The sensors were checked at LASTI. Measuring the sensor gap using a Teflon shim may increase the risk of scratching the target.

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

- ***Step 4- Performance of the limiters***
  - ***Step 4.1 - Test Nº1 - Push "in the general coordinates Z/RZ"***

This test was not performed because it is redundant with the test in the local basis.

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

  - ***Step 4.2 - Test Nº2 – Push "locally"***

Sensors	Push in positive direction	Push in negative direction	Mil (positive)	Mil (negative)	Railing	Actuator Gap Check
ST1 - H1	19152	-18114	23	-22		
ST1 - H2	15689	-17055	19	-20		
ST1 - H3	15151	-18768	18	-22		
ST1 - V1	24745	-27300	29	-33		
ST1 - V2	21456	20367	26	24		
ST1 - V3	26439	-25550	31	-30		
ST2 - H1	32767	-32767	X	X	Rail	
ST2 - H2	32767	-32768	X	X	Rail	
ST2 - H3	32767	-32768	X	X	Rail	
ST2 - V1	32767	-32768	X	X	Rail	
ST2 - V2	32767	-32768	X	X	Rail	
ST2 - V3	32767	-32768	X	X	Rail	

Table 16 - Stages range of motion – "Push locally"

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 4.2**
  - Absolutes value of all estimated motions must be higher than 15000counts for stage 1 (~0.018")
  - Absolutes value of all estimated motions must be higher than 32000counts for stage 2 (~0.010")

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

- ***Step 5 - Sensors Powerspectra***

All position sensors powerspectra have been measured can be found on the SVN:

/seismic/BSC-ISI/X1/Data/BSC6/Figures/Powerspectra/Undamped/
- LHO_ISI_BSC6_Powerspectra_m_ST1_Locked_ST2_Locked_2011_10_24.fig
- LHO_ISI_BSC6_Powerspectra_m_ST1_Unlocked_ST2_Unlocked_2011_10_24.fig
- LHO_ISI_BSC6_Tilted_Powerspectra_CT_ST1_L4C_2011_10_25.fig
- LHO_ISI_BSC6_Tilted_Powerspectra_CT_ST2_GS13_2011_10_25.fig

/seismic/BSC-ISI/X1/Data/BSC6/Powerspectra/Undamped/
- LHO_ISI_BSC6_Calibrated_PSD_CPS_T240_L4C_GS13_Unlocked_Locked_2011_10_24.mat
- LHO_ISI_BSC6_Calibrated_PSD_L4C_GS13_Stage_Tilted_2011_10_25.mat

Note :
The powerspectra presented hereinafter were measured with the last set of instruments.

Acceptance criteria:
- No cross talk on CPS (peaks at low frequencies + harmonics on measurements)
- All spectra must be similar per instrument type.
- Magnitudes of power spectra must be lower than the reference powerspectra above (not presented in the following plots)

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

Stage locked – unlocked

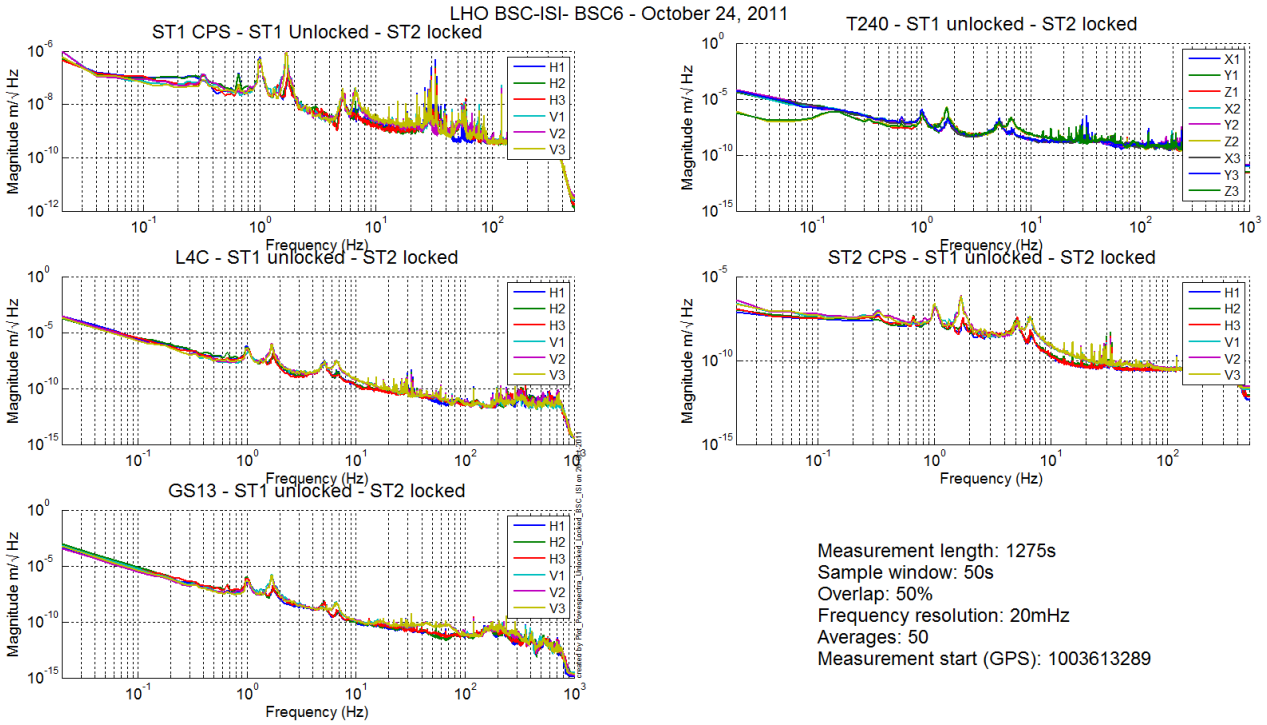

Figure 3 – ST1 & ST2 Locked

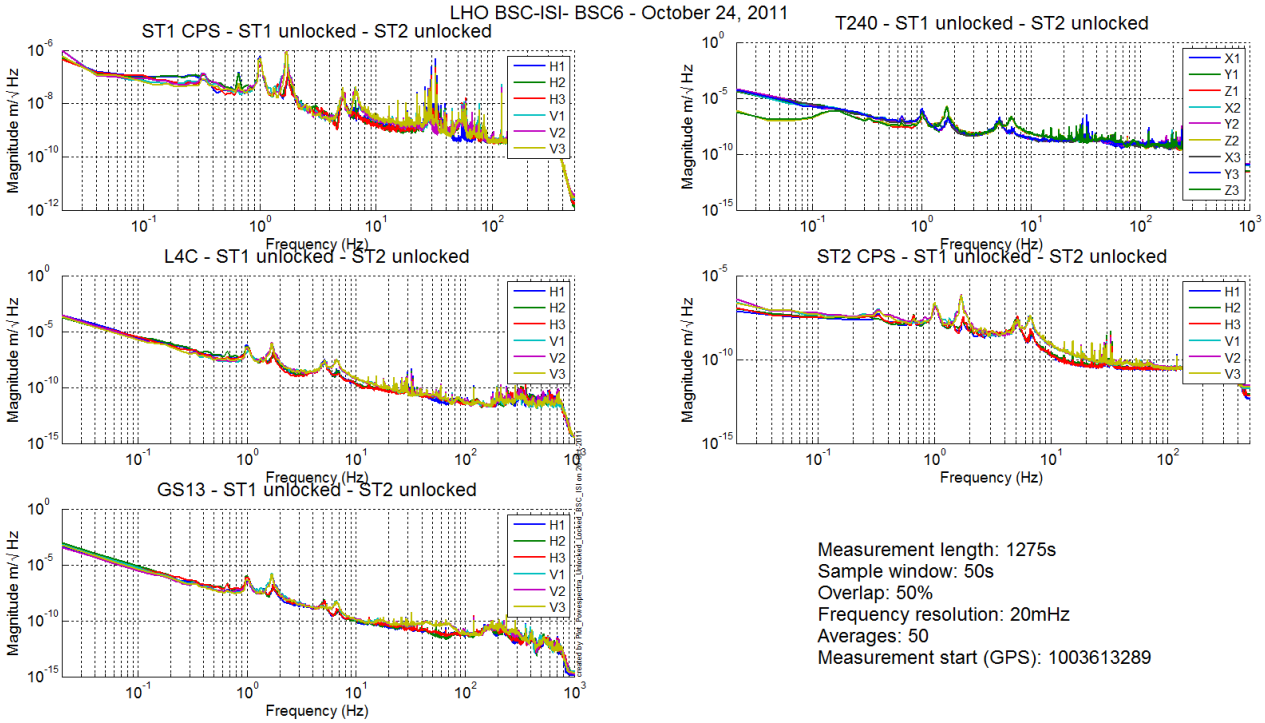

Figure 4 - ST1 & ST2 Unlocked

Stage Tilted

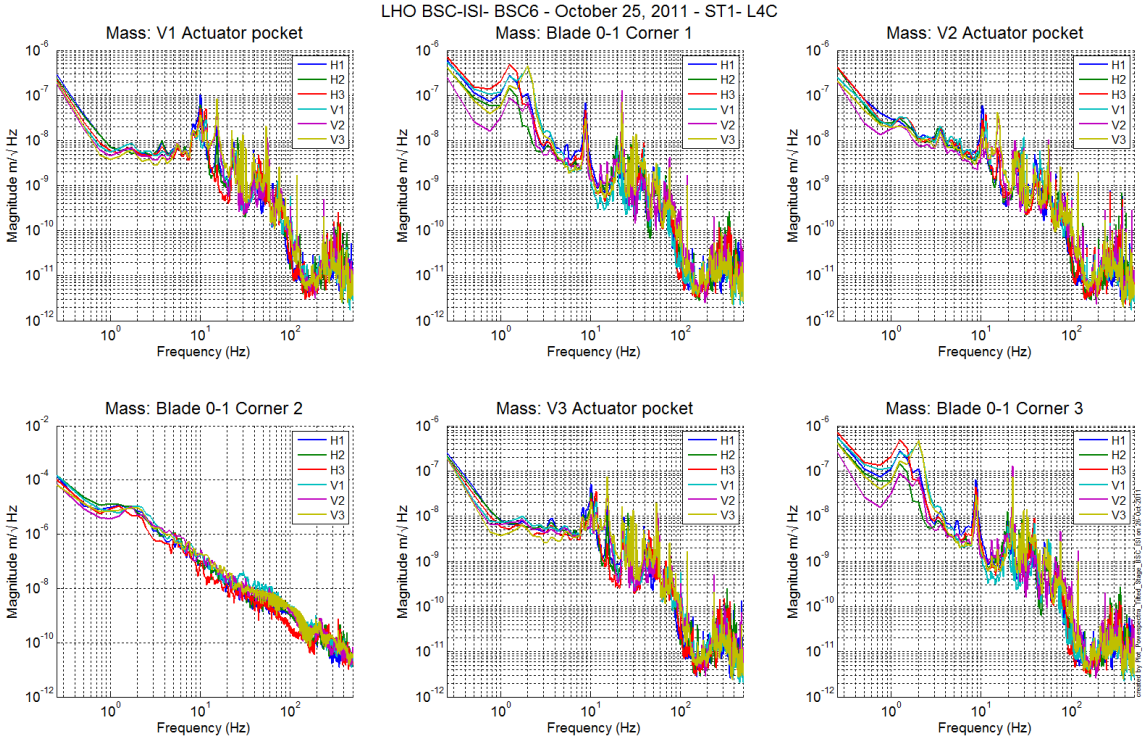

Figure 5 - ST1 L4C – Tilted

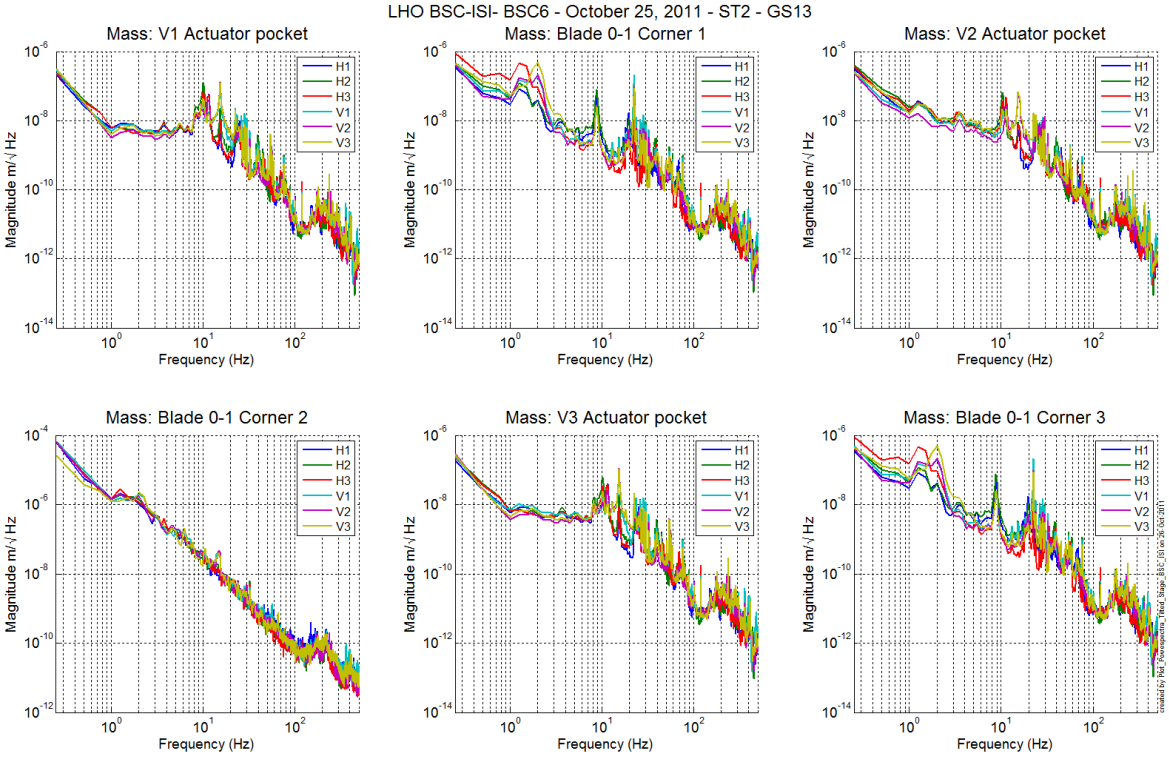

Figure 6 - ST1 GS13 – Tilted

- ***Step 6 - Coil Driver, cabling and resistance check***

The resistance of the actuator + power cables are reported in the table below:

Actuator	Coil driver name	Resistance (Ω)
ST1 H1	Coil1 Coarse 1	6.8
ST2 H1	Coil 1 Fine 1	10.7
ST2 V1	Coil 1 Fine 2	10.8
ST1 V1	Coil 1 Coarse 2	6.8
ST1 H2	Coil 2 Coarse 2	6.9
ST2 H2	Coil 2 Fine 1	10.7
ST2 V2	Coil 2 Fine 2	10.7
ST1 V2	Coil 2 Coarse 2	7
ST1 H3	Coil 3 Coarse 1	7
ST2 H3	Coil 3 Fine 1	10.7
ST2 V3	Coil 3 Fine 2	10.6
ST1 V3	Coil 3 Coarse 2	7

Acceptance criteria:

- For the actuators of stage 1, the measured resistance between the middle pin and one side pin must be 6.3 +/-0.5 ohms
- For the actuators of stage 2, the measured resistance between the middle pin and one side pin must be 10.3 +/-0.5 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 the binary input bit must be in the upper state.

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

- ***Step 7- Actuators Sign and range of motion (Local drive)***
  - ***Step 7.1 - 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 7.2 - Range of motion - Local drive***

In this step, range of motion of the two stages is checked when applying a local drive on actuators.

Sensor readout (counts)	Negative drive	no drive	Positive drive	Amplitude count	mil
ST1 - H1	-15290	250	16742	31956	38
ST1 - H2	-15809	-232	16818	32596	39
ST1 - H3	-17450	-2162	15166	32596	39
ST1 - V1	-17349	-2538	12273	29645	35
ST1 - V2	-13821	667	15166	29078	35
ST1 - V3	-16626	-2209	12080	28596	34
ST2 - H1	-8849.4	1252	11227	20155	6
ST2 - H2	-6770.2	3067	12951	19970	6
ST2 - H3	-9649.6	333	10313	19970	6
ST2 - V1	-9051.7	3449	15996	24973	7
ST2 - V2	-13136	-787	11423	24696	7
ST2 - V3	-10954	1231	13426	24338	7

Table 17 - Range of motion - Local drive

Acceptance criteria:

- Amplitude must be at least 32000 counts (+/-0.02”) for Stage 1 CPS
- Amplitude must be at least 32000 counts (+/-0.003”) for Stage 2 CPS
- Signs of actuators drive and sensors read out have to be the same

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

- ***Step 8 - Vertical Sensor Calibration***

This test was not performed because sensors are tested at LASTI.

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

- ***Step 9 - Vertical Spring Constant***

The stiffness measurements of the spring are reported in the tables below. The nominal blade stiffness are:

- Stage 1: 1241lb/in
- Stage 2: 1465lb/in

	Unloaded				Loaded 3x5kg			
Stage1	**Meas 1**	**Meas 2**	**Meas 3**	**Average**	**Meas 1**	**Meas 2**	**Meas 3**	**Average**
V1	4014,1	4015,1	4014,6	-22524	-22751	-22685	-22637	4014,1
V2	561,94	-560,94	-561,44	-24389	-26052	-26762	-25220	-561,94
V3	1962,8	1963,8	1963,3	-23471	-24027	-24769	-23749	1962,8

Load 3x10kg						
Meas 1	**Meas 2**	**Meas 3**	**Average**	**Diff 1**	**Diff 2**	
-16906	-17008	-17025	-16980	-7624	-14504	
-14835	-14808	-14807	-14817	-7572	-15569	
-15681	-15686	-15691	-15686	-7793	-13897	
				-7663	-14657	count
				-9,12	-17,45	mil
				-1207	-1262	lb/in
				Average :	-1235	
					-0,50	%

The blades from stage 0 to stage 1 are too soft by 0.50%.

Note:
The stage 1 payload is too light by 5% which is not consistent with the measured blade stiffness. The blade stiffness is a tricky measurement. Some errors and approximation may have been done during these measurements. However, we can consider that the unit passed the test.

Acceptance criteria:
- Spring constant of stage 0-1 blades must be 229KN/m (T0900569) +/- 2%

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

	No load			Load			
Stage 2	**Meas 1**	**Meas 2**	**Average**	**Meas 1**	**Meas 2**	**Meas 3**	**Average**
V1	4014,1	4015,1	4014,6	-22524	-22751	-22685	-22637,5
V2	-561,94	-560,94	-561,44	-24389	-26052	-26762	-25220,5
V3	1962,8	1963,8	1963,3	-23471	-24027	-24769	-23749,0

Diff
-26652,1
-24659,06
-25712,3

-25674	count
-7,64	mil
-1429	lb/in
-2,48	%

The blades from stage 0 to stage 1 are too soft by 2.48%.

Note:
The stage 2 payload is too light by 4% which is not consistent with the measured blade stiffness. The blade stiffness is a tricky measurement. Some errors and approximation may have been done during these measurements.

Acceptance criteria:
- Spring constant of stage 1-2 blades must be 257KN/m (T0900569) +/- 2%

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

- ***Step 10 - Static Testing (Tests in the local basis)***

The table below shows the main and the cross-coupling when the actuators are driven in the local basis:

		Sensors					
		ST1 - H1	**ST1 - H2**	**ST1 - H3**	**ST1 - V1**	**ST1 - V2**	**ST1 - V3**
Actuators	**ST1 - H1**	4333	1716	1756	-15	-7	14
	ST1 - H2	1715	4224	1705	-10	-15	6
	ST1 - H3	1745	1716	4246	2	1	30
	ST1 - V1	38	-164	101	3481	-665	-588
	ST1 - V2	132	87	-135	-609	3385	-615
	ST1 - V3	-102	128	76	-591	-570	3347

Table 18 - Static test - Local to local - Stage 1

		Sensors					
		ST2 - H1	**ST2 - H2**	**ST2 - H3**	**ST2 - V1**	**ST2 - V2**	**ST2 - V3**
Actuators	**ST2 - H1**	2316	351	337	8	-4	11
	ST2 - H2	324	2338	349	7	3	-12
	ST2 - H3	311	375	2332	3	27	-11
	ST2 - V1	65	122	-220	2942	331	-28
	ST2 - V2	-244	101	94	-12	2901	297
	ST2 - V3	86	-167	41	349	-31	2846

Table 19 - Static test - Local to local - Stage 2

The static tests results are reported in the SVN at :
/seismic/BSC-ISI/X1/Data/BSC6/Static_Tests/

- LHO_ISI_BSC6_Offset_Local_Drive_20110805.mat

Acceptance criteria:

- Main couplings readout must be positive
- Comparison with the reference table:
  - Main coupling differences mustn't exceed 200 counts
  - Cross coupling differences mustn't exceed 50 counts

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

- ***Step 11- Static Testing - In the general coordinate basis (Static test - CPS)***
  - ***Step 11.1 – Base change matrices from Cartesian to Local***

The table below shows the main and the cross-coupling when the actuators are driven in the local basis:

		Sensors					
		ST1 - H1	**ST1 - H2**	**ST1 - H3**	**ST1 - V1**	**ST1 - V2**	**ST1 - V3**
Actuators	**ST1 - X**	1752	-839	-812	-26	0	-8
	ST1 - Y	-32	1493	-1469	6	-5	-14
	ST1 - Z	-33	-14	3	753	709	711
	ST1 - RX	40	189	-137	-2877	2408	422
	ST1 - RY	-162	77	86	-1119	-1871	2959
	ST1 - RZ	3162	3124	3166	-13	-23	-5

		Sensors					
		ST2 - H1	**ST2 - H2**	**ST2 - H3**	**ST2 - V1**	**ST2 - V2**	**ST2 - V3**
Actuators	**ST2 - X**	670	-1312	653	-25	-79	-42
	ST2 - Y	1144	-20	-1162	-33	-136	-62
	ST2 - Z	17	-9	-33	1059	939	993
	ST2 - RX	-312	-3	270	-2572	2352	-125
	ST2 - RY	151	-303	116	-1558	-1486	2792
	ST2 - RZ	1738	1715	1728	-69	-122	-64

Table 20 - Static test cartesian drive – Cartesian to local

The static tests results are reported in the SVN at :
/seismic/BSC-ISI/X1/Data/BSC6/Static_Tests/

- LHO_ISI_BSC6_Offset_Local_Drive_20110805.mat

○ *Step 11.2 – Base change matrices from Cartesian to Cartesian*

The static tests results are reported in the SVN at :
/seismic/BSC-ISI/X1/Data/BSC6/Static_Tests/

- LHO_ISI_BSC6_Offset_Cartesian_Drive_20110811.mat

		Sensors					
		ST1 - X	**ST1 - Y**	**ST1 - Z**	**ST1 – RX**	**ST1 - RY**	**ST1 - RZ**
Actuators	**ST1 - X**	1715	9	6	6	1	39
	ST1 - Y	-2	1720	-3	-10	3	-4
	ST1 - Z	-15	17	729	-25	-9	-14
	ST1 - RX	9	380	-25	2985	-6	29
	ST1 - RY	-342	16	-6	-5	2901	6
	ST1 - RZ	24	-4	-21	-6	20	3276

		Sensors					
		ST2 - X	**ST2 - Y**	**ST2 - Z**	**ST2 – RX**	**ST2 - RY**	**ST2 - RZ**
Actuators	**ST2 - X**	1317	25	-31	-22	21	24
	ST2 - Y	13	1331	-36	-53	55	-13
	ST2 - Z	-6	-1	1030	-91	28	-9
	ST2 - RX	-5	-22	-98	4223	58	-14
	ST2 - RY	-8	30	-44	15	4247	-3
	ST2 - RZ	21	6	-42	-35	52	2509

Table 21 - Static Test - Cartesian to Cartesian

Acceptance criteria:

- Main couplings readout must be positive
- Comparison with the reference table:
  - Main coupling differences mustn't exceed 200 counts
  - Cross coupling differences mustn't exceed 50 counts

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

▪ *Step 12 - Linearity test*

The linearity test results are reported in the SVN at:
/seismic/BSC-ISI/X1/Data/BSC6/Linearity_Test/

- LHO_ISI_BSC6_Linearity_test_20111025.mat

The linearity test figure are reported in the SVN at:
/seismic/BSC-ISI/X1/Data/BSC6/Figures/Linearity_Test/

- LHO_ISI_BSC6_Linearity_test_20111025.fig

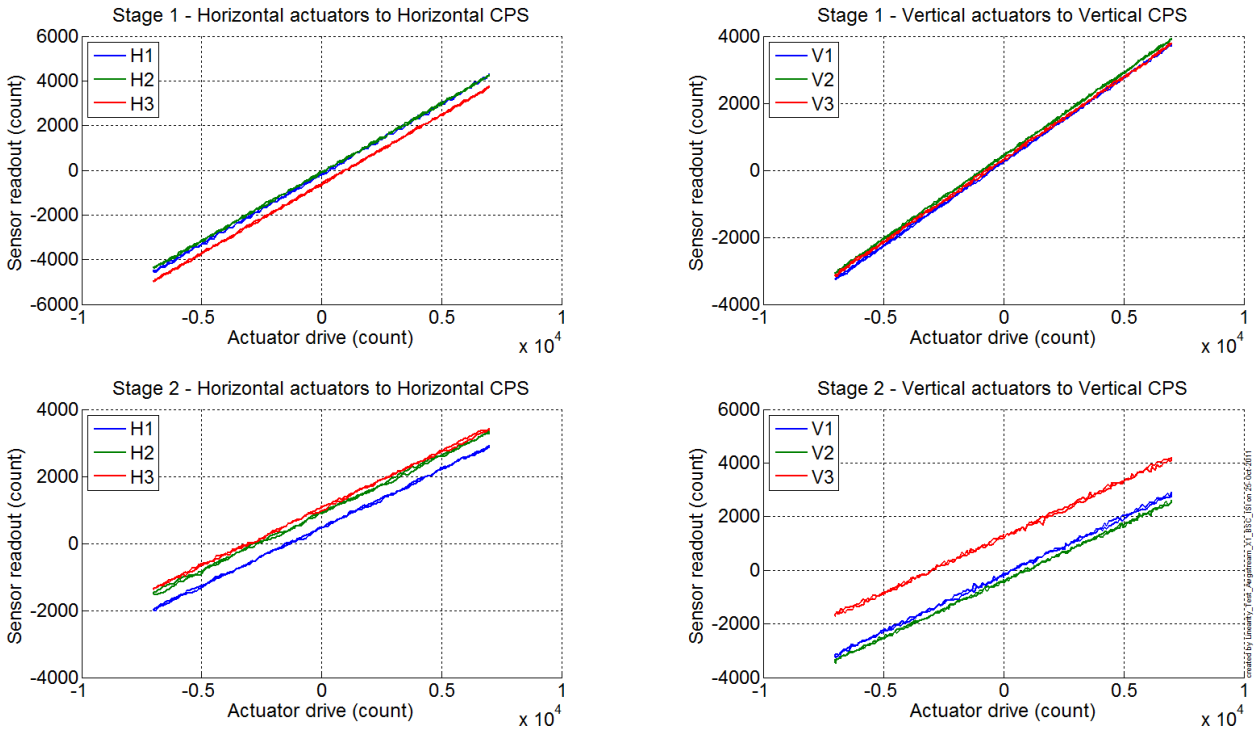

Figure 7 - Linearity Test

The slopes and the slopes are reported in the table below:

		Slope	Offset	Average slope	Variation from average(%)
Stage 1	ST1 - H1	0.628	-170	0.6214	1.06
	ST1 - H2	0.616	-85		-0.89
	ST1 - H3	0.620	-618		-0.17
	ST1 - V1	0.501	252	0.4972	0.86
	ST1 - V2	0.498	433		0.11
	ST1 - V3	0.492	320		-0.98
Stage 2	ST2 - H1	0.347	466	0.3439	0.96
	ST2 - H2	0.344	903		-0.04
	ST2 - H3	0.341	1039		-0.91
	ST2 - V1	0.428	-166	0.4225	1.30
	ST2 - V2	0.422	-403		-0.09
	ST2 - V3	0.417	1248		-1.21

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

Acceptance criteria:
- Horizontal and vertical slopes of the triplet actuators x BSC-ISI x sensors: Average slope +/- 3%

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

- ***Step 13 – Transfer functions – Local to Local***

Data files measurement of local to local transfer functions in SVN at:
/svncommon/seisvn/seismic/BSC-ISI/X1//Data/BSC6/Transfer_Functions/Measurements/Undamped

- LHO_ISI_BSC6_Data_L2L_10mHz_100mHz_ST1_ST2_20111025-185345.mat
- LHO_ISI_BSC6_Data_L2L_100mHz_700mHz_ST1_ST2_20111026-033627.mat
- LHO_ISI_BSC6_Data_L2L_700mHz_10Hz_ST1_ST2_20111025-203718.mat
- LHO_ISI_BSC6_Data_L2L_10Hz_100Hz_ST1_ST2_20111025-034700.mat
- LHO_ISI_BSC6_Data_L2L_100Hz_500Hz_ST1_ST2_20111024-174439.mat
- LHO_ISI_BSC6_Data_L2L_500Hz_1000Hz_ST1_ST2_20111025-105701.mat

Script file for processing and plotting local to local transfer functions in SVN at:
/seisvn/seismic/BSC-ISI/X1/Data/BSC6/Transfer_Functions/Measurements/Undamped

- Plot_ TF_L2L_10mHz_1000Hz_LHO_BSC6.m

Figures of local to local transfer functions (Main couplings) in SVN at:
seisvn/seismic/BSCISI/X1/Data/BSC6/Figures/Transfer_Functions/Measurements/Undamped

- LHO_BSC6_TF_L2L_Raw_from_ST1_ACT_to_ST1_CPS_2011_10_24.fig
- LHO_BSC6_TF_L2L_Raw_from_ST1_ACT_to_ST1_CPS_2011_10_24.fig
- LHO_BSC6_TF_L2L_Raw_from_ST2_ACT_to_ST2_CPS_2011_10_24.fig
- LHO_BSC6_TF_L2L_Raw_from_ST2_ACT_to_ST2_GS13_2011_10_24.fig

Measured of local to local transfer functions in the SVN at:
/svncommon/seisvn/seismic/BSC-ISI/X1//Data/BSC6/Transfer_Functions/Measurements/Undamped

- LHO_BSC6_TF_L2L_Raw_10mHz_1000Hz_2011_10_25.mat

Note 1: The transfer functions are measured from the Output filter bank (excitation variable) to the input (IN1) of the input filter bank. The transfer functions presented below are raw transfer functions without any electronic compensation of the sensor electronic. The actuator and the coil driver electronic compensation are introduced in these transfer functions.

Note 2: The L4Cs are out of phase (should be -90 before 1Hz). A minus sign is added in the calibration filters that convert count to nm/s.

Note 3: The resonance observed at 33Hz is the resonance of the teststand. When the transfer functions will be measured in the LVEA, this resonance will be observed at lower frequency (19Hz). The staging building teststand has short feet in comparison with the LVEA teststand (some comparison plots will be presented the testing report – phase II).

Note 4: The first high frequency resonance observed on stage 1 by the L4C is at 196Hz. The next resonance is observed at 248Hz. The first mode of the blade has been measured at ~250Hz at LASTI.

Note 5: There is a poor coherence on the GS13 transfer functions. It can be explained by the weak drive of the fine actuators. Moreover, the stage 2 of the ISI is strongly excited by the fans of the clean rooms. These two factors strongly affect the quality of the measurements.

Note 6: On the ST2-ACT to ST2-GS13 transfer functions, the first high frequency resonances are observed at 150Hz and 185Hz.

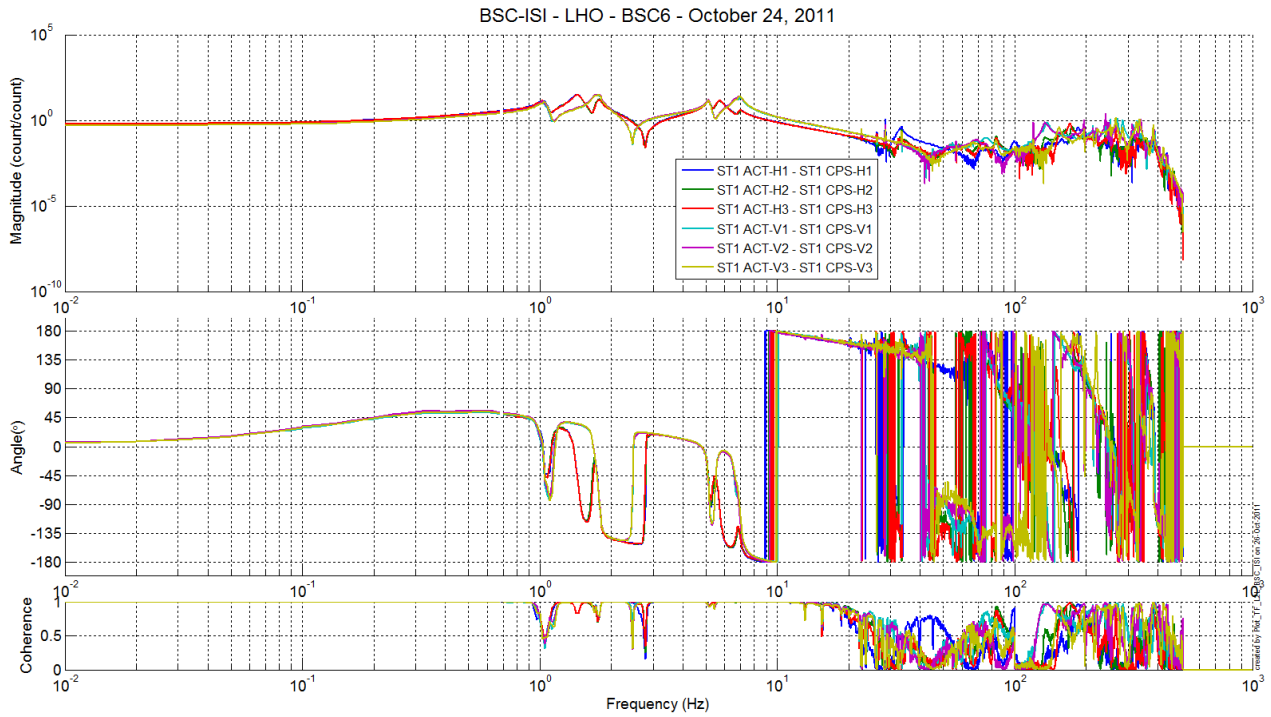

Table 22 - TF L2L Raw - ST1 Act to ST1 CPS

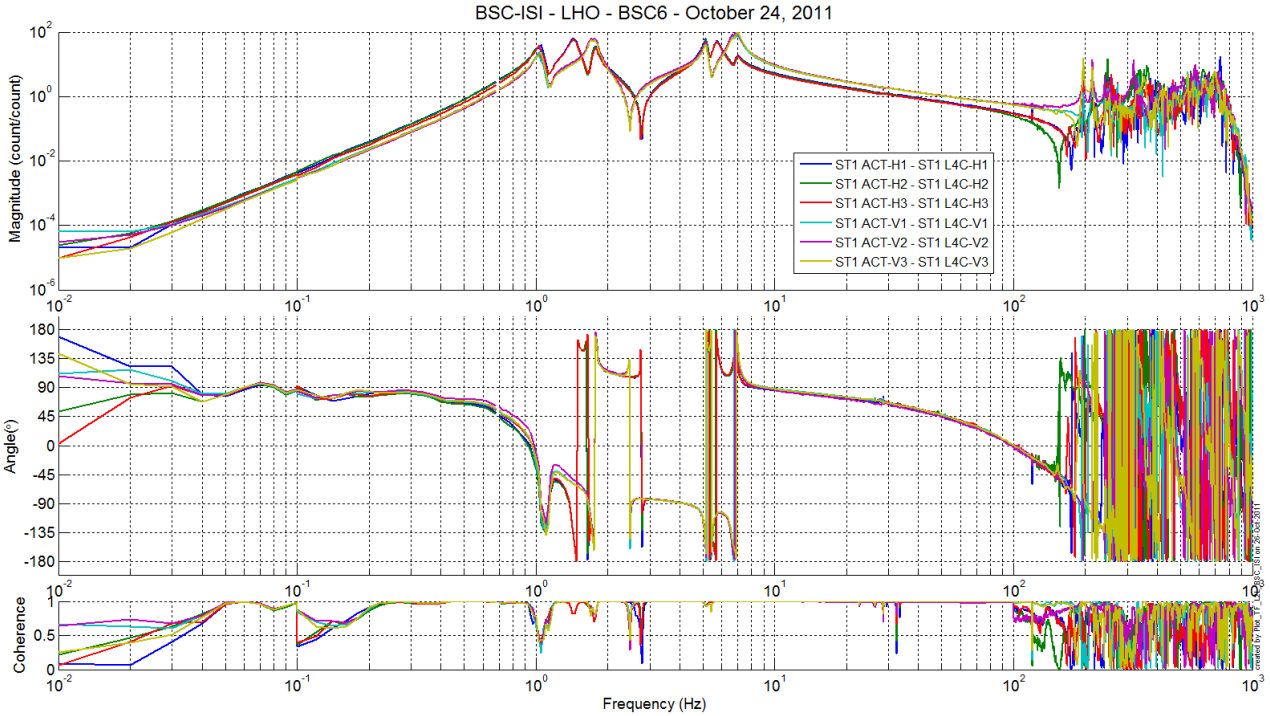

Table 23 - TF L2L Raw - ST1 Act to ST1 L4C

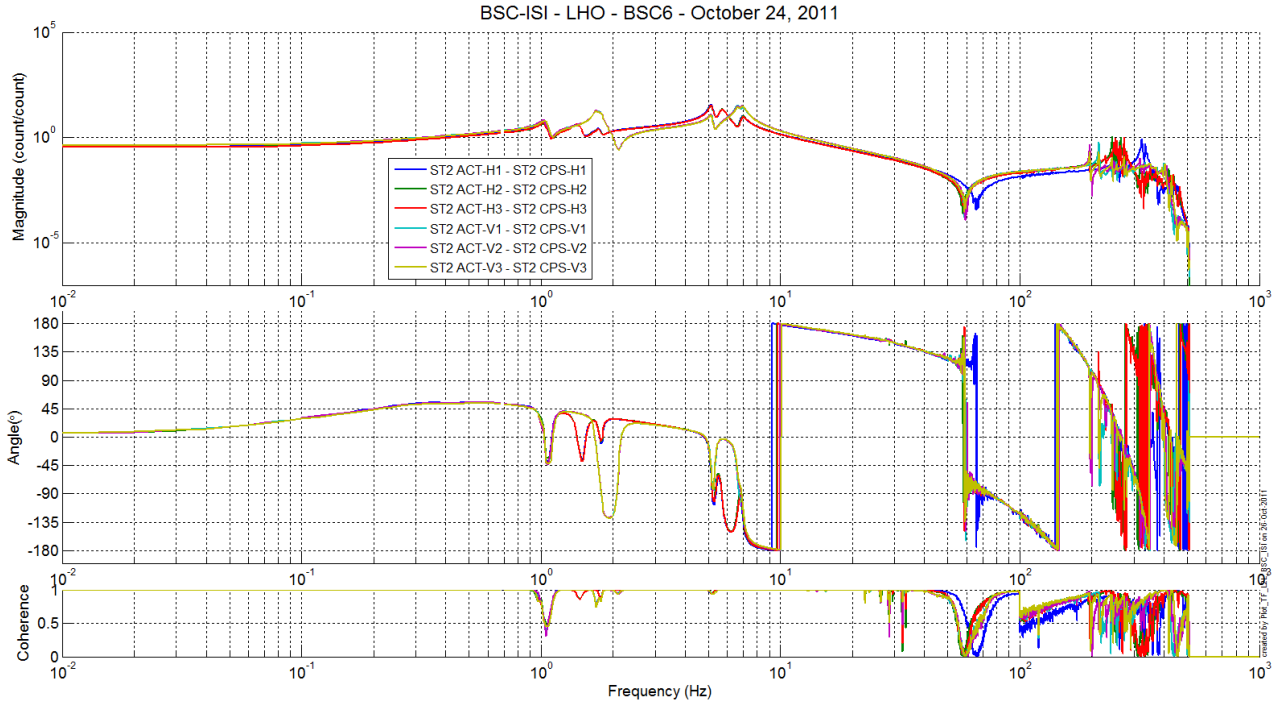

Table 24 - TF L2L Raw - ST2 Act to ST2 CPS

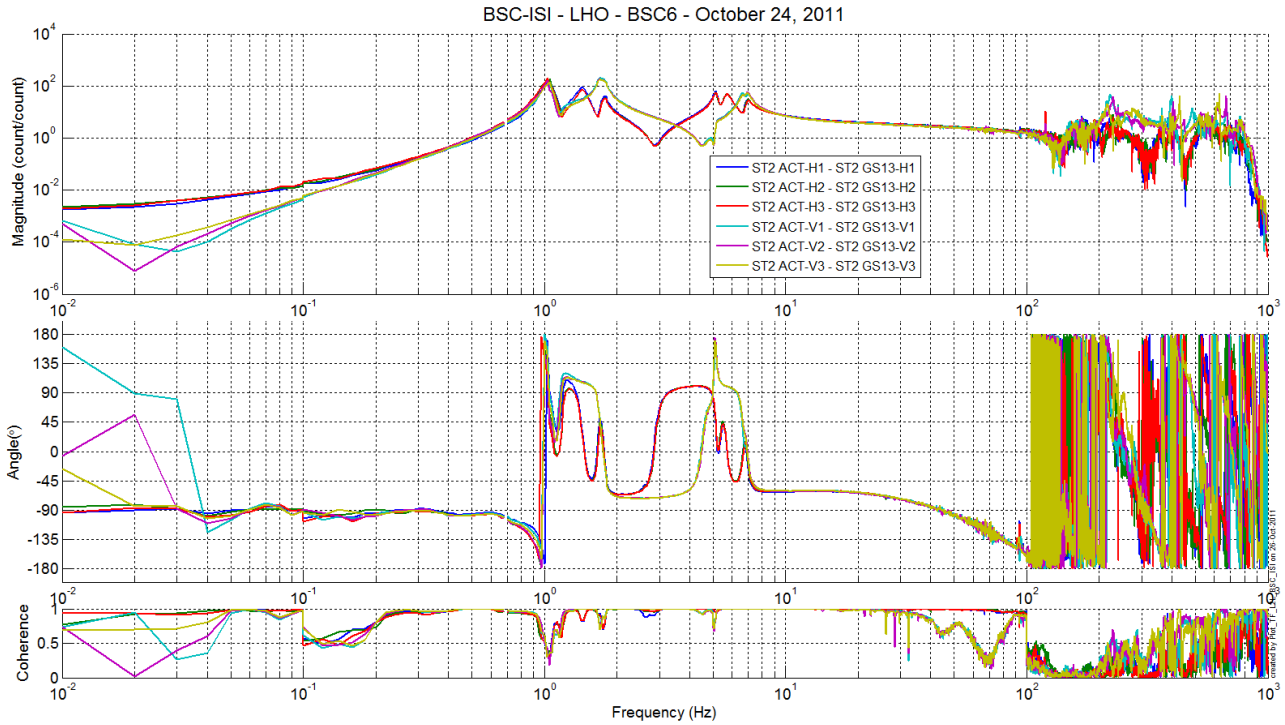

Table 25 - TF L2L Raw - ST2 Act to ST2 GS13

Note: The structural resonance frequency of stage 1 are pretty low in comparison with BSC8.

Comparison BSC6 vs BSC8 in the staging building

The figures that show the comparisons between the BSC6 and the BSC8 transfer functions can be found in the SVN at:
seismic/BSC-ISI/X1/Comparison/BSC6_vs_BSC8/

- LHO_ISI_BSC6_vs_BSC8_Comparison_ST1_ACT_H_to_ST1_CPS_H_20110622_vs_20111025.fig
- LHO_ISI_BSC6_vs_BSC8_Comparison_ST1_ACT_H_to_ST1_L4C_H_20110622_vs_20111025.fig
- LHO_ISI_BSC6_vs_BSC8_Comparison_ST1_ACT_V_to_ST1_CPS_V_20110622_vs_20111025.fig
- LHO_ISI_BSC6_vs_BSC8_Comparison_ST1_ACT_V_to_ST1_L4C_V_20110622_vs_20111025.fig
- LHO_ISI_BSC6_vs_BSC8_Comparison_ST2_ACT_H_to_ST2_CPS_H_20110622_vs_20111025.fig
- LHO_ISI_BSC6_vs_BSC8_Comparison_ST2_ACT_H_to_ST2_GS13_H_20110622_vs_20111025.fig
- LHO_ISI_BSC6_vs_BSC8_Comparison_ST2_ACT_V_to_ST2_CPS_V_20110622_vs_20111025.fig
- LHO_ISI_BSC6_vs_BSC8_Comparison_ST2_ACT_V_to_ST2_GS13_V_20110622_vs_20111025.fig

List of differences:

- ST1 ACT H to ST1 CPS H: Transfer functions of BSC6 and BSC8 look identical
- ST1 ACT H to ST1 L4C H: The first resonance measured on horizontal L4C is measured at 196Hz on BSC6 and 214Hz on BSC8 (-9% from BSC8 to BSC6)
- ST1 ACT V to ST1 CPS V: The transfer functions are similar up to 100Hz. But the first important resonance is observed at 133Hz on BSC6 whereas this resonance is observed at 154Hz on BSC8 (-15% from BSC8 to BSC6).
- ST1 ACT V to ST1 L4C V: The transfer functions are similar up to 180Hz. The first resonance of stage is observed at 196Hz on BSC6 and 214Hx on BSC8 (-15% from BSC8 to BSC6)
- ST2 ACT H to ST2 CPS H: Transfer functions of BSC6 and BSC8 look identical up to 30Hz. The first zero is observed at 58Hz on BSC6 and 64Hz on BSC8. The high frequency resonances are respectively measured at 255Hz and 322Hz on BSC6 and BSC8.
- ST2 ACT H to ST2 GS13 H: Transfer functions of BSC6 and BSC8 look identical
- ST2 ACT V to ST2 CPS V: These transfer functions shows the resonances of stage 1 when stage 2 is excited by ST2 actuators. These resonances are 196Hz for BSC6 and 214Hz for BSC8.
- ST2 ACT V to ST2 GS13 V: Transfer functions of BSC6 and BSC8 look identical

Differences sum-up:

The suspension resonances are identical on BSC6 and BSC8. However, it seems that BSC6 is softer than BSC8. It is mainly visible on stage 1 (both on CPS and L4C transfer functions) and it is particularly true on the vertical transfer functions where the first structural resonances of BSC6 are observed at frequencies 15% lower than BSC8 resonance frequencies.
Stage 2 of BSC6 and BSC8 seem more similar. A light difference is observed ST2 ACT H to ST2 CPS H transfer functions. Note that the resonances of stage 1 are visible in stage 2 transfer functions (ST2 ACT V to ST2 GS13 V).

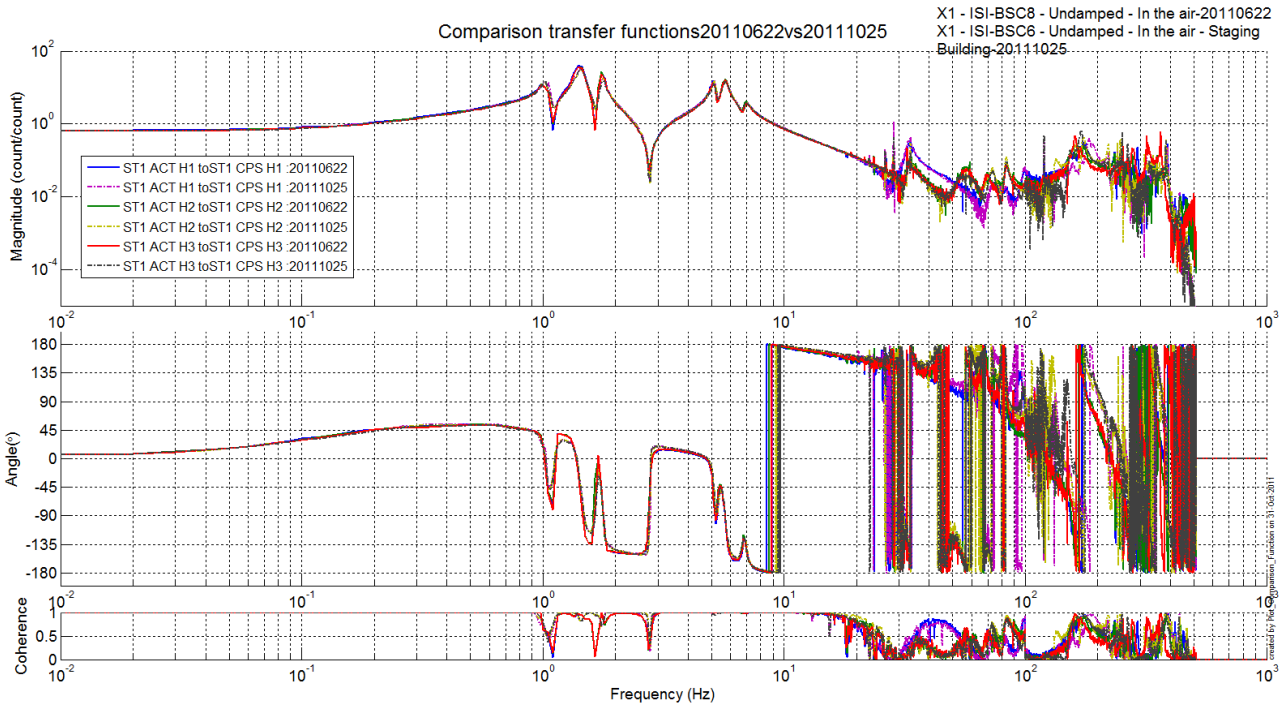

Figure 8 – Comparison BSC6 vs BSC8 - ST1 ACT H to ST1 CPS H

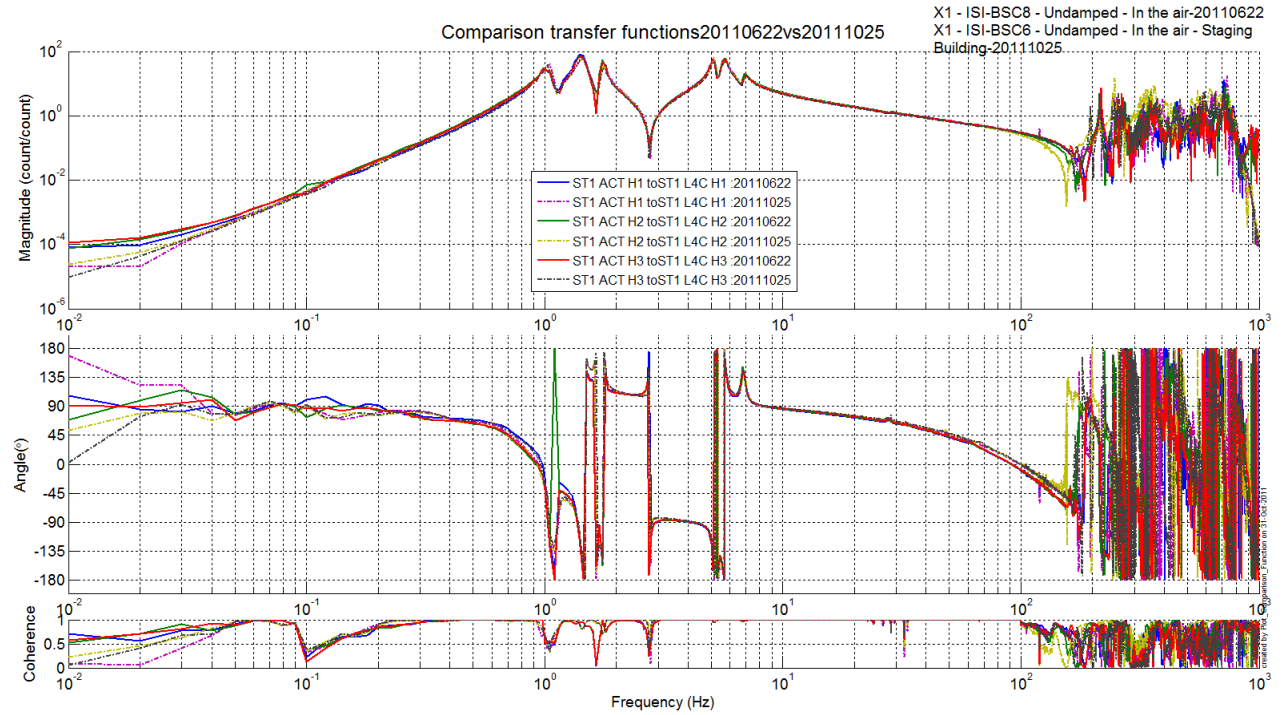

Figure 9 - Comparison BSC6 vs BSC8 - ST1 ACT H to ST1 L4C H

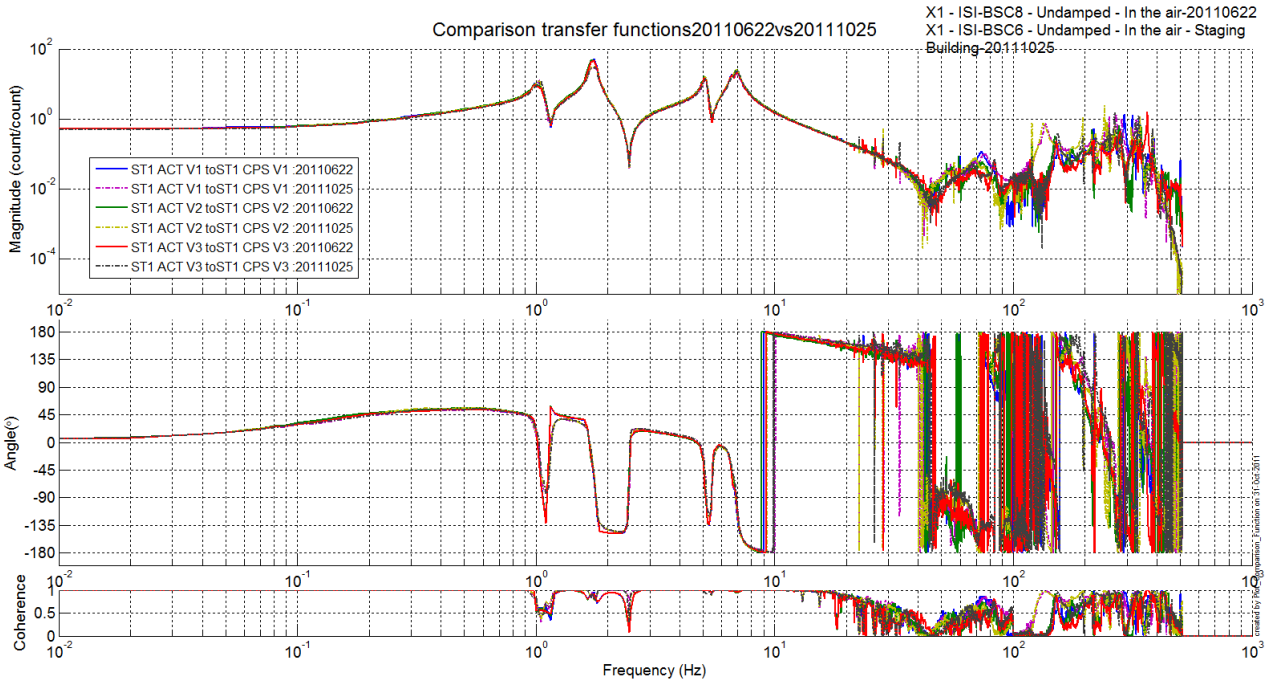

Figure 10 - Comparison BSC6 vs BSC8 - ST1 ACT V to ST1 CPS V

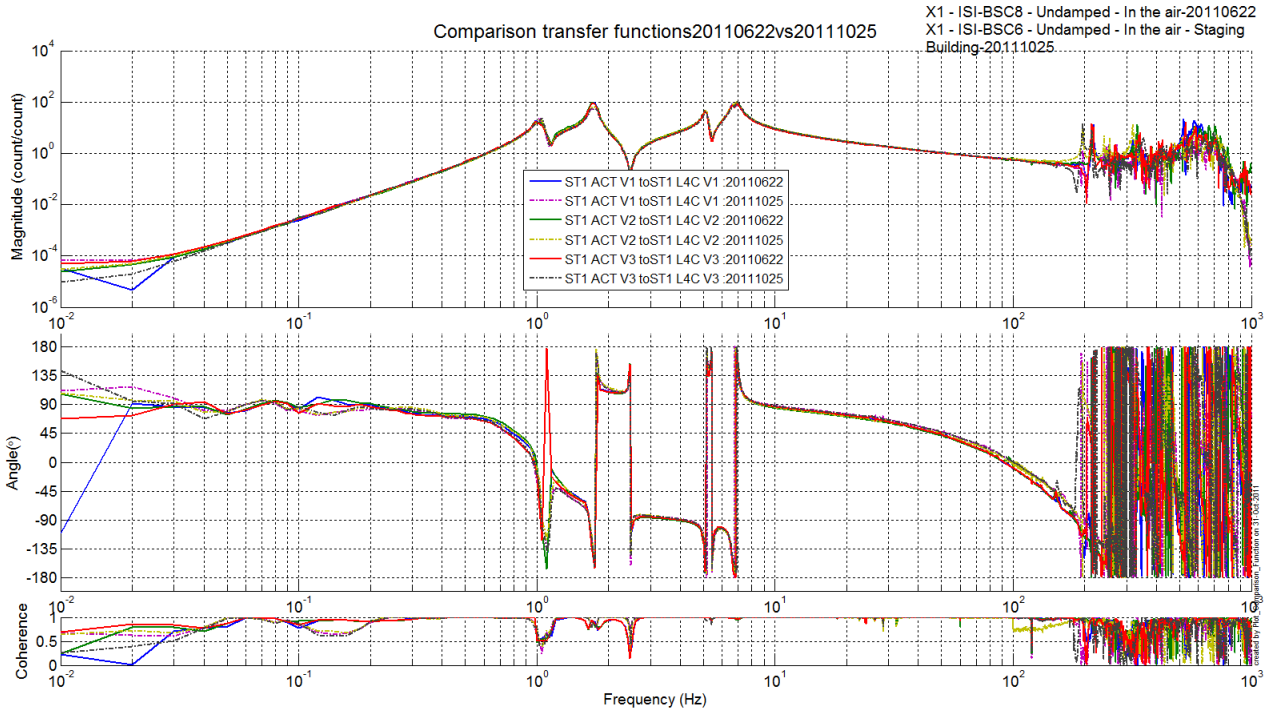

Figure 11 - Comparison BSC6 vs BSC8 - ST1 ACT V to L4C V

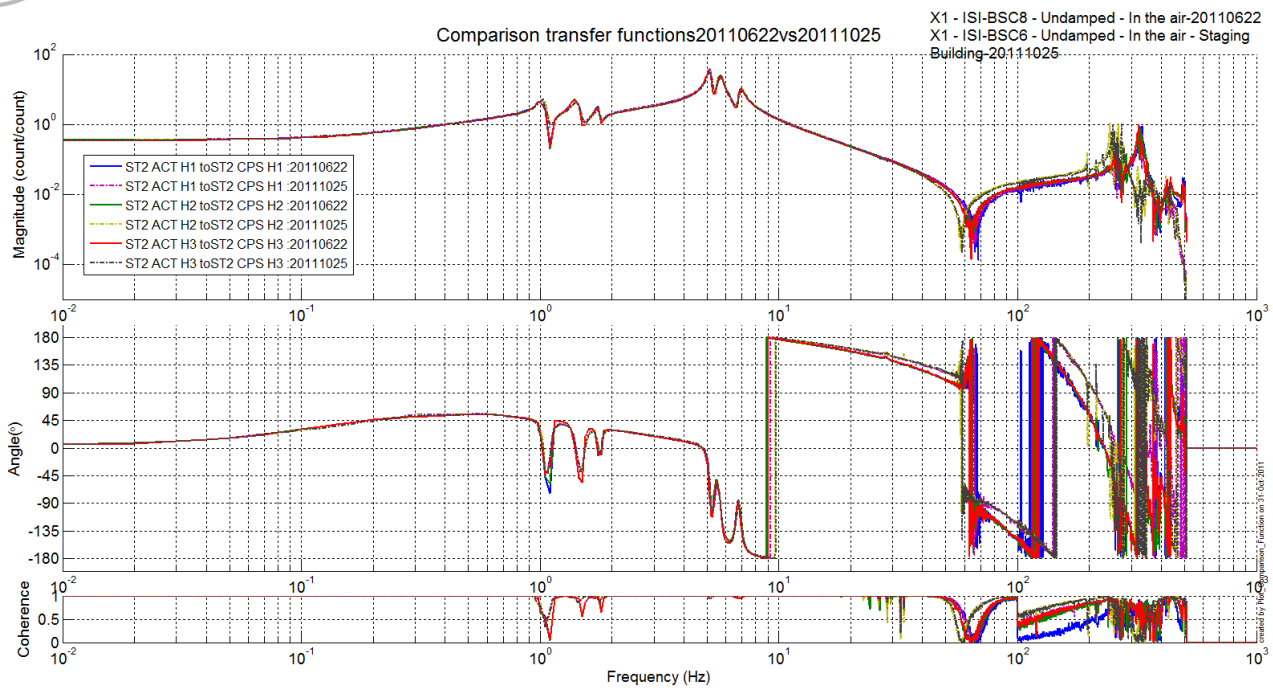

Figure 12 - Comparison BSC6 vs BSC8 - ST2 ACT H to ST2 CPS H

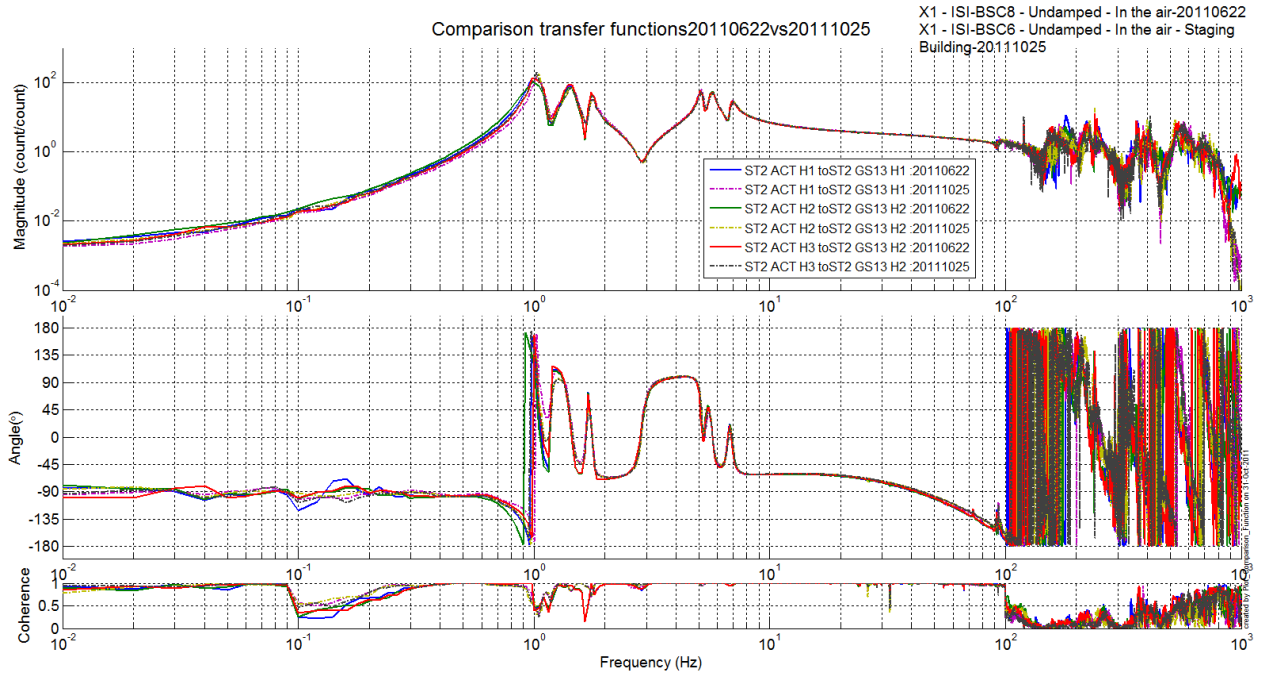

Figure 13 - Comparison BSC6 vs BSC8 - ST2 ACT H to ST2 GS13 H

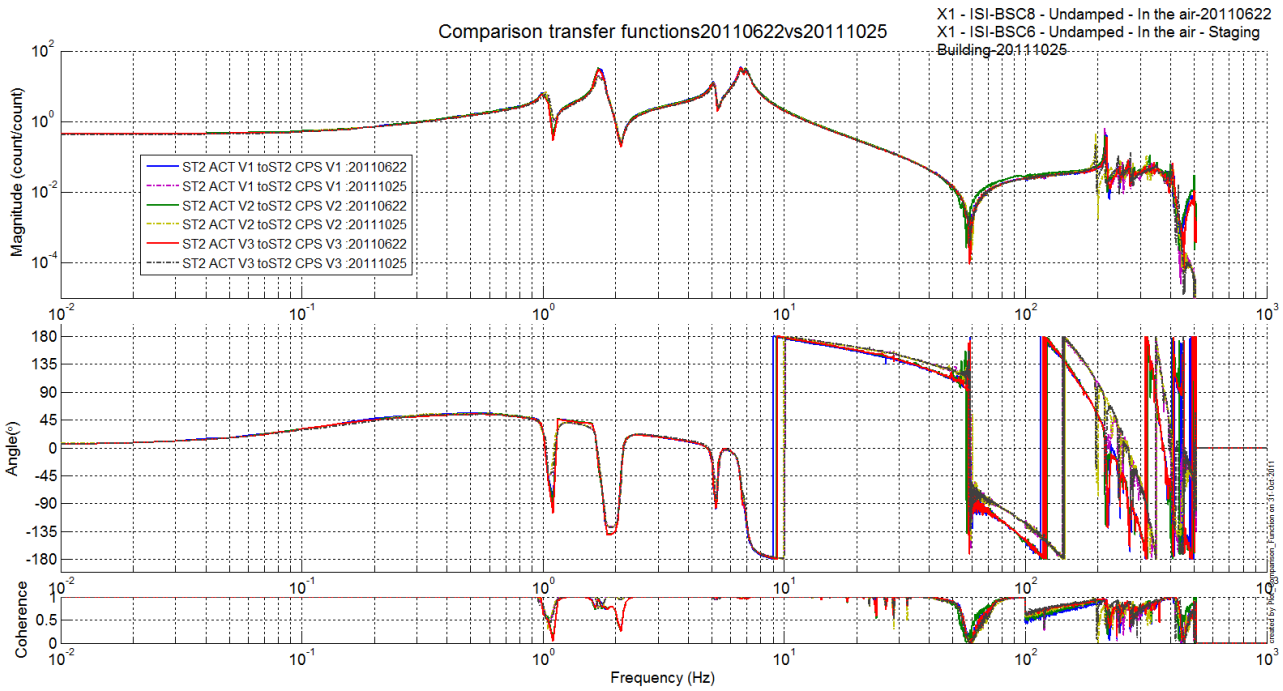

Figure 14 - Comparison BSC6 vs BSC8 - ST2 ACT V to ST2 CPS V

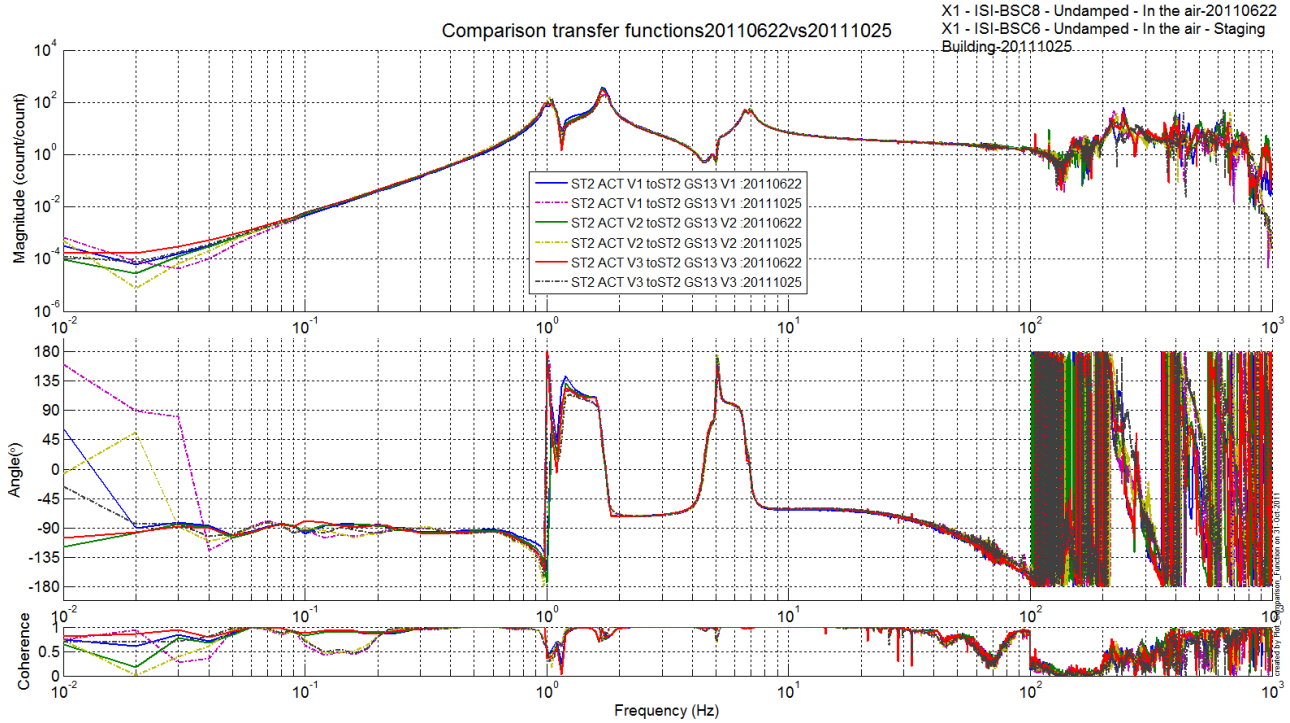

Figure 15 - Comparison BSC6 vs BSC8 - ST2 ACT V to ST2 GS13 V

Acceptance criteria:
- All sensors must be plugged
- First structural resonance of stage 1 must be above 200Hz
- First structural resonance of stage 2 must be above 200Hz

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

- ***Step 14 - Symmetrization – Calibration***

Not performed

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

- ***Step 15 - Basis change – Cartesian to Local - Simulations***

Not performed

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

- ***Step 16- Transfer functions - Cartesian to Cartesian - Measurements***

Not performed

- ***Step 17 - Lower Zero Moment Plan***
  - ***Step 17.1 - Stage 1 - LZMP***

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

  - ***Step 17.2 - Stage 2 - LZMP***

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

- ***Step 18- Damping Loops – Transfer function – Simulations***
  - ***Step 18.1 - Damping Loops – Stage 2***

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

  - ***Step 18.2 - Damping Loops – Stage 1***

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

- ***Step 19- Damping Loops – Powerspectra***

All damping loops were turned on and were stable. No powerspectra was measured.

- ***Step 20- Isolation Loops – for one unit per site***

This test was performed on unit # 1 (BSC 8).

IV. BSC-ISI testing Summary

This is the second "aLigo BSC-ISI" tested at LHO. The testing procedure document E1000483-v3 was used. Due to lack of time or availability of the BSC-ISI, some tests have been waived.
All results are posted on the SVN at:
https://svn.ligo.caltech.edu/svn/seismic/BSC-ISI/X1/Data/BSC6/

1- List of tests that failed and won't be redone

2- List of tests that failed, that need to be re-done during phase 2
- **Step II.12 –** Cables inventory

3- List of tests skipped that won't be performed because not feasable during phase II (i.e. stage 0 leveling)
- **Step I.5 –** Check level of Stage 0 after top-bottom plate assembly

4- List of tests skipped that we won't do because they are not essential (i.e. redundant with another test)
- **Step II.3 – Measure the Sensor gap -** This test was not performed. The sensor gaps have not been measured. These sensors have already been checked at LASTI. Moreover, risks of scratching the target are so high that we preferred not performing this test. In the future, this test will be removed from the testing procedure.
- **Step II.4.1 – Push "in the general coordinate Z/RZ" -** This test was not performed due to lack of time. This test is redundant with step 4.2.
- **Step II.8 – Vertical sensor calibration**

5- Lists of tests skipped that needs to be done during phase II.
- **Step II.14 – Symmetrization – Calibration**
- **Step II.15 – Change of bases – Cartesian to local - Simulations**
- **Step II.16 – Transfer functions – Cartesian to Cartesian - Simulations**
- **Step II.17 – Lower Zero Moment Plan**
- **Step II.18.1 – Damping Loops – Stage 2**
- **Step II.18.2 – Damping Loops – Stage 1**
- **Step II.19 – Damping loops – Powerspectra**
- **Step II.20 – Isolation loops**

The ISI-BSC6 was moved from the Staging building to the LVEA test stand on October 31, 2011.