LIGO Laboratory / LIGO Scientific Collaboration

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aLIGO BSC-ISI, Pre-integration Testing report, Phase II (before cartridge install)

E1100845 – V3

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Advanced LIGO Project

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Introduction

The BSC-ISI testing is performed in three phases:
1) BSC-ISI, Pre-integration Testing, Phase I (post-assembly, in the staging building)
2) BSC-ISI, Pre-integration Testing, Phase II: Final tests done before insertion in the chamber
3) BSC-ISI, Integration Phase Testing: Procedure and results related to the commissioning in the chamber.

The ISI-BSC8 was moved from the Staging building to the LVEA test stand on June 30, 2011.

This document presents the series of tests (Phase II) performed on the ISI-BSC8 (ITMY) in the LVEA. Some tests were done with and without the QUAD and the folding miror. Tests started on July 8, 2011. Damping loops were closed for the first time on July 22, 2011 and Isolation loops on August 4, 2011.

All results are posted on the SVN at:
https://svn.ligo.caltech.edu/svn/seismic/BSC-ISI/H2/ITMY/

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

The dome of the chamber was put on February 2, 2012.

1. Hardware changes

1. CPS – E1100369

Due to flux issues on capacitive position sensors during the production process, six out of twelve installed sensors have been removed. The table below presents the list of the sensors installed during phase II. These sensors have been changed on August 17, 2011.

This table is the final configuration of the table installed on ISI-BSC8 (after August 17, 2011).

Status	Location	Invoice	Gauge	S/N	Probe	S/N	Master/Slave	Phase	Coarse/Fine
Installed on Unit 1	ST1-H1	101612	8800	12504	2822-V	12949	Slave	180	Coarse
Installed on Unit 1	ST1-H2	101406	8800	12305	2822-V	12864	Slave	180	Coarse
Installed on Unit 1	ST1-H3	101612	8800	12512	2822-V	12952	Slave	180	Coarse
Installed on Unit 1	ST1-V1	101406	8800	12312	2822-V	12860	Master	0	Coarse
Installed on Unit 1	ST2-V2	101406	8800	12307	2822-V	12863	Slave	0	Coarse
Installed on Unit 1	ST2-V3	101406	8800	12337	2822-V	12865	Slave	0	Coarse
Installed on Unit 1	ST2-H1	101406	8800	12380	2822-V	12867	Slave	180	Fine
Installed on Unit 1	ST2-H2	101612	8800	12378	2822-V	12940	Slave	180	Fine
Installed on Unit 1	ST2-H3	101612	8800	12423	2822-V	12938	Slave	180	Fine
Installed on Unit 1	ST2-V1	101612	8800	12413	2822-V	12939	Slave	0	Fine
Installed on Unit 1	ST2-V2	101612	8800	12381	2822-V	12950	Slave	0	Fine
Installed on Unit 1	ST2-V3	101406	8800	12373	2822-V	12868	Slave	0	Fine

Table 1 - CPS sensors location after removal of the questionable ones

2. GS13 – E1100740

All GS13 were changed during phase II testing. One GS13 on was opened during phase I testing and the 5 other GS13s initially installed were mounted with the wrong screws on the electrical feedthroughs.

The final installation locations are reported in the table below:

location GS13	Serial Number	POD	Cleaning status	Comments
H1	Not noted at LLO	33	Class A	Initially installed - POD 68 - S/N 822 - Replacement on September 30, 2011
H2	801	31	Class A	Initially installed - POD 85 - S/N 842 - Replacement on September 30, 2011
H3	783	16	Class A	Initially installed - POD 89 - S/N 841 - Replacement on September 30, 2011
V1	740	79	Class A	Initially installed - POD 76 - S/N 728 - Replacement on September 30, 2011
V2	739	94	Class A	Initially installed - POD 84 - S/N703 - Replacement on September 30, 2011
V3	677	26	Class A	Initially installed - POD 98 - S/N 719 - Replacement by the 26 on August 11, 2011

Table 2 - GS13 Location

Note: Control work was realized with the set of geophones with the following serial numbers: 822, 842 841 728, 703 and 719.

3. L4C – E1100740

The L4Cs have not been changed. The X tag on L4C S/N 815 pod 22 raised concerns but the pod has been leaked checked. The L4C S/N 815 pod 22 stays on the assembly.

The final installation locations are reported in the table below:

L4C location	Serial Number	POD	Adaptor	Cleaning status	Comments
H1	815	22		Class A	X tag but fine
H2	1094	152		Class A	
H3	968	150		Class A	
V1	1068	155		Class A	
V2	1070	151		Class A	
V3	811	153		Class A	

Table 3 - L4C location

4. T240 – E1100740

After investigations on the pressure sensors of the T240, it appears that the voltage regulators of the pressure sensors electronic board were failing. The high failure rate on this board is due to the voltage peak (created by the inductance of the cable) when the T240 are unplugged without turning off the interface chassis. Consequently, two of the T240 has been replaced.

The final installation locations are reported in the table below:

location T240	Serial Number	POD	Cleaning status	Comments
Corner 1	112	32	Class A	Initially installed - POD 12 - S/N 138 - Replacement on September 30, 2011
Corner 2	118	20	Class A	Initially installed - POD 26 - S/N 133 - Replacement on September 30, 2011
Corner 3	101	19	Class A	Initially installed - POD 36 - S/N 109 - Replacement on September 30, 2011

Table 4 - T240 Location

Note: Control work was realized with the set of geophones with the following serial numbers: 138, 133 and 109.

5. Electronic Inventory

This table reports the electronic equipment used in the LVEA.

Hardware	Ligo reference	S/N
Interface Chassis Pod 1	D1002432	S1102228
Interface Chassis Pod 2	D1002433	S1102230
Interface Chassis Pod 3	D1002434	S1102229
Anti-alliasing Chassis	D1002693	S1103404
Anti-alliasing Chassis	D1002693	S1103405
Anti-image Chassis	D1002693	S1103402
Binary Input Chassis	D1001726	S1101284
	D1001726	S1101280
Binary Output Chassis	D1001728	S1101319
T240 Interface Pod 1	D1002694	S1103177
T240 Interface Pod 2	D1002694	S1103181
T240 Interface Pod 3	D1002694	S1103180
Anti-image Chassis	D1000305	S1103502
Coil driver Pod 1	D0902744	S1103564
Coil driver Pod 2	D0902744	S1103563
Coil driver Pod 3	D0902744	S1103356

Table 5 - Electronic inventory

The coil drivers have been modified (After modifications, BIO switches are in the upper state when they are working fine – fuse ok – no overheating). The changes were done on September 2, 2011.

6. Models Modifications

The BSC-ISI model has been updated to introduce the SUS watchdogs and fix the BIO inputs after the hardware medication (coil driver). Pressure sensors alarm was added. Channels list used by RCG 2.4 to build the .ini file was also added.

7. Cables – E1100822

The class B cables used for testing have been replaced on October 7, 2011 by the final class A ones as specified in the document E1100770.

8. Mass distribution

The mass distribution evolved a few times during this phase of testing (masses on top of stage 2, cookie cutters, QUAD, FMY)

9. Hardware changes

One locker has been re shimmed around July 14, 2011.

2. Basic functionalities just after installing the BSC-ISI on the teststand (After July 4th, 2011)

1. Pressure sensors

The pressure sensors of 2 T240 (corner 2 and 3) are not working. T240s were later replaced (cf inventory)

2. Offset CPS Unlocked vs locked

The motion of the ISI between the unlocked and the locked position is measured using the CPS. The position of the two stages in the two different configurations is reported in the table below.

NOTE:
It appears that when the system is locked, important variations have been observed in the CPS when the ISI is balanced and when the ISI is not balanced. After transporting the ISI from the staging building to the LVEA, the gap of the capacitive position sensors have been reset. The readout of the CPS in the locked position concerned the assembly team.
By regapping the CPS, the reference position defined in the staging building (with a symmetric payload – masses on top of stage 2) has been lost.
After rebalancing, the level of the optic table has been rechecked.

Measurement realized on July 13, 2011

The results of this test can be found in the SVN at:
\seisvn\seismic\BSC-ISI\H2\ITMY\Data\Static_Tests

- LHO_ISI_BSC_Unlocked_Final_Tuning_2011_07_13.mat
- LHO_ISI_BSC_Locked_Final_Tuning_2011_07_13.mat

	Table locked		Table unlocked		Difference locked - unlocked	
Sensors	Offset (Mean)	Std deviation	Offset (Mean)	Std deviation	Offset (Mean)	mil
ST1 - H1	-220.1	7.0	-128.2	16.5	-92	-0.11
ST1 - H2	-61.5	4.7	378.5	18.4	-440	-0.52
ST1 - H3	0.2	4.0	592.7	18.1	-593	-0.71
ST1 - V1	-32.6	4.3	893.2	42.7	-926	-1.10
ST1 - V2	354.9	3.8	759.7	58.4	-405	-0.48
ST1 - V3	-465.1	4.1	129.5	50.6	-595	-0.71
ST2 - H1	-1015.2	14.7	357.2	42.1	-1372	-0.41
ST2 - H2	-583.3	33.2	-193.1	39.7	-390	-0.12
ST2 - H3	1622.7	28.2	3772.0	47.3	-2149	-0.64
ST2 - V1	6.3	25.3	-1988.9	97.6	1995	0.59
ST2 - V2	-818.2	107.1	823.0	144.2	-1641	-0.49
ST2 - V3	220.8	163.8	-1238.7	122.4	1459	0.43

Table 6 - Locked vs Unlocked Position

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

3. Range of motion

The range of motion of the table is measured by pushing on the table in a direction collinear to the CPS. The Static tests results can be found on the SVN at:
\seisvn\seismic\BSC-ISI\H2\ITMY\Data\Static_Tests

- LHO_ISI_BSC8_Range_Of_Motion_20110714.mat

Sensors	Push in positive direction	Push in negative direction	Mil (positive)	Amplitude (count)	Mill
ST1 - H1	-8199	-137	8089	16288	19.4
ST1 - H2	-7783	371	8239	16022	19.1
ST1 - H3	-7605	591	8080	15685	18.7
ST1 - V1	-12246	932	14126	26372	31.4
ST1 - V2	-12278	831	13964	26242	31.2
ST1 - V3	-12808	236	13264	26072	31.0
ST2 - H1	-9015	349	9715	18730	5.6
ST2 - H2	-9571	-203	9177	18747	5.6
ST2 - H3	-5351	3810	12972	18323	5.5
ST2 - V1	-13391	-1850	9688	23079	6.9
ST2 - V2	-10428	994	12389	22817	6.8
ST2 - V3	-12497	-925	10641	23138	6.9

Table 7 - Range of motion - Actuator drive in the LVEA

Note 1: Due to temporary cables in-air cables (3 extensions), the readout of ST1 horizontal CPS has a gain of 0.5. We realized that he CPS extension cable had pin1 connected to the shield (Warning: Grounded when plugged on the interface chassis but not grounded when plugged to a breakout board. The 2 sockets of a breakout board are not connected). The range of motion measured by the ST1 horizontal CPS has to be multiplied by 2.

Note 2 : Due to longer in-air cables (Test-stand to the flanges) in the LVEA than in the staging building, the voltage drop creates a fall of the actuators output force for a same output voltage on the DAC (-15% on stage 1 actuators and – 9% on stage 2actuators). These changes can also be seen in the linearity test.

Note 3: The results are similar to those measured in the staging building.

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

4. Linearity test

The test was performed on July 19, 2011 after replacing the bad extension cables used for the CPS.
The data of the linearity test can be found on the SVN at:
seismic/BSC-ISI/H2/ITMY/Data/Linearity_Test/

- LHO_ISI_BSC8_Linearity_test_20110719.mat

The figures of the linearity test can be found on the SVN at:
seismic\BSC-ISI\H2\ITMY\Data\Figures\Linearity_Test\

- LHO_ISI_BSC8_Linearity_test_20110719.fig

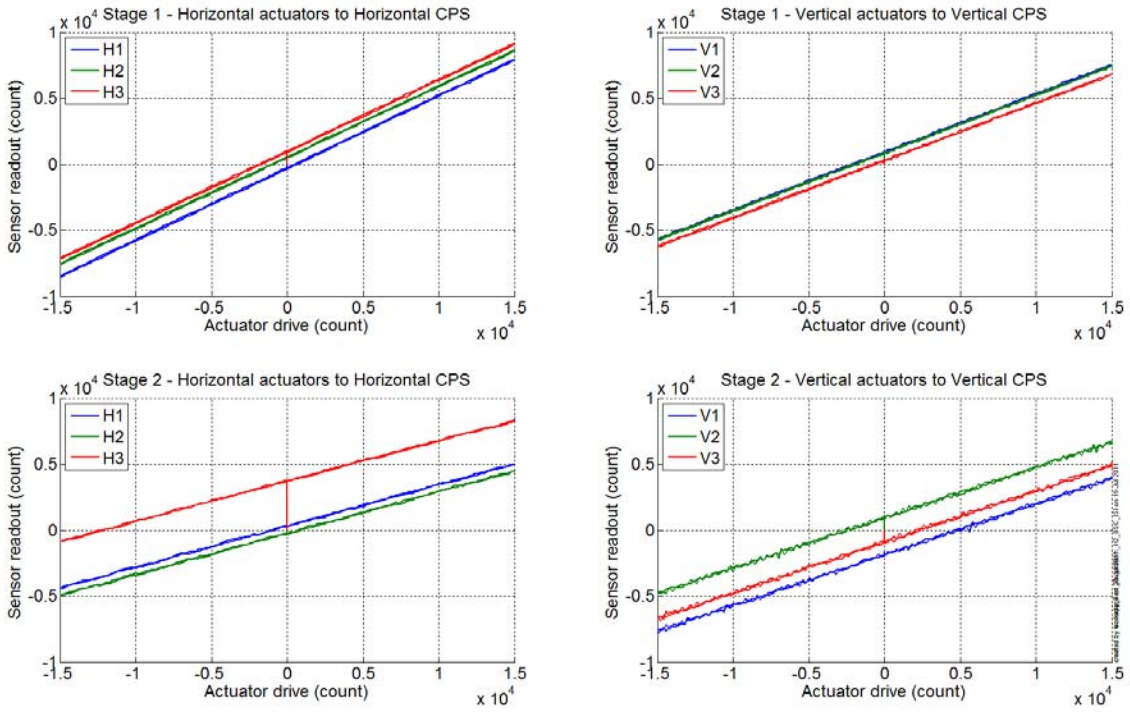


Figure 1 - Linearity test - NO QUAD - No FMY - In the LVEA

		Slope	Offset	Average slope	Variation from average(%)
Stage 1	ST1 - H1	0.548	-284	0.5432	0.85
	ST1 - H2	0.539	534		-0.75
	ST1 - H3	0.543	974		-0.10
	ST1 - V1	0.440	929	0.4380	0.55
	ST1 - V2	0.439	855		0.14
	ST1 - V3	0.435	296		-0.69
Stage 2	ST2 - H1	0.313	325	0.3110	0.73
	ST2 - H2	0.314	-223		1.09
	ST2 - H3	0.305	3723		-1.82
	ST2 - V1	0.386	-1851	0.3855	0.22
	ST2 - V2	0.383	945		-0.78
	ST2 - V3	0.388	-878		0.56

Table 8 - Slope – Offset Linearity test

Note:
The average slopes are lower than those measured in the staging building due to the voltage drop created by the longer cables.

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

5. Static tests

1.Offset local drive

The test was performed on July 18, 2011.

Note: Due to longer cable s, offsets measured by CPS for a 7000 count drive are slightly lower than offsets measured in the staging building.

Results of this test can be found in the SVN at:
\seisvn\seismic\BSC-ISI\H2\ITMY\Data\Static_Tests

- LHO_ISI_BSC8_Offset_Local_Drive_20110718.mat

		Sensors					
		ST1 - H1	ST1 - H2	ST1 - H3	ST1 - V1	ST1 - V2	ST1 - V3
Actuators	ST1 - H1	3839	1536	1557	19	-6	-11
	ST1 - H2	1539	3774	1532	-5	11	-1
	ST1 - H3	1543	1535	3811	0	-21	24
	ST1 - V1	74	-134	106	3095	-570	-555
	ST1 - V2	84	32	-140	-553	3076	-571
	ST1 - V3	-156	84	38	-565	-538	3051

Table 9 - Static Tests – Local to Local - Stage 1

		Sensors					
		ST2 - H1	ST2 - H2	ST2 - H3	ST2 - V1	ST2 - V2	ST2 - V3
Actuators	ST2 - H1	2192	327	347	-12	-18	21
	ST2 - H2	326	2187	349	-10	-2	-6
	ST2 - H3	326	311	2162	-25	9	6
	ST2 - V1	69	114	-182	2717	283	-12
	ST2 - V2	-202	51	123	-27	2676	287
	ST2 - V3	120	-209	97	294	-7	2705

Table 10 - Static Tests – Local to Local - Stage 2

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

2. Offset Cartesian drive

Results of this test can be found in the SVN at:
\seisvn\seismic\BSC-ISI\H2\ITMY\Data\Static_Tests

- LHO_ISI_BSC8_Offset_Cartesian_Drive_20110719.mat

		Sensors					
		ST1 - X	ST1 - Y	ST1 - Z	ST1 - RY	ST1 - RY	ST1 - RZ
Actuators	ST1 - X	1529	-1	12	-8	-20	18
	ST1 - Y	-28	1504	2	19	-21	-9
	ST1 - Z	6	-13	652	1	-17	-9
	ST1 - RX	-2	315	-2	2656	-5	-15
	ST1 - RY	-327	23	7	5	2635	-6
	ST1 - RZ	14	-8	18	-3	-2	2900

Table 11 - Static Tests - Cartesian to Cartesian - Stage 1

		Sensors					
		ST2 - X	ST2 - Y	ST2 - Z	ST2 - RY	ST2 - RY	ST2 - RZ
Actuators	ST2 - X	1234	8	-6	-3	35	-14
	ST2 - Y	11	1230	-12	-21	-8	19
	ST2 - Z	0	2	984	-9	13	-3
	ST2 - RX	3	-12	-21	3939	12	-5
	ST2 - RY	9	9	5	24	3973	5
	ST2 - RZ	1	13	3	0	-6	2351

Table 12 - Static Tests - Cartesian to Cartesian - Stage 2

		Sensors					
		ST1 - H1	ST1 - H2	ST1 - H3	ST1 - V1	ST1 - V2	ST1 - V3
Actuators	ST1 - X	1547	-750	-745	27	-1	-15
	ST1 - Y	41	1286	-1312	-5	13	-12
	ST1 - Z	-1	-18	-8	656	645	638
	ST1 - RX	-15	123	-149	-2548	2161	394
	ST1 - RY	-180	75	67	-1006	-1692	2709
	ST1 - RZ	2858	2773	2787	16	-6	17

Table 13 - Static Tests - Cartesian to local - Stage 2

		Sensors					
		ST2 - H1	ST2 - H2	ST2 - H3	ST2 - V1	ST2 - V2	ST2 - V3
Actuators	ST2 - X	657	-1254	610	-15	-7	64
	ST2 - Y	1050	4	-1049	30	-14	30
	ST2 - Z	-17	4	5	991	971	1018
	ST2 - RX	-270	4	261	-2295	2316	-6
	ST2 - RY	181	-304	157	-1403	-1294	2738
	ST2 - RZ	1628	1647	1610	20	2	37

Table 14 - Static Tests - Cartesian to local - Stage 2

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

3. Transfer functions and Comparison with measurements done in the staging building.

The parameters for the measurements in the LVEA are slightly different from those in the staging building. It may be explained by the relative proximity of the cleanroom fans as well as the weaker power delivered by the actuators due to the longer in-air cables.

These parameters are summed up in the table below:

	Section	Freq min	Freq max	Fres	Amplitude (H –V)	Nrep	Time Stage 1 (min)
Stage 1	1	0.01	0.1	0.01	2000 - 2000	3	32
	2	0.1	0.7	0.02	140 - 200	25	127
	3	0.7	10	0.05	160 – 220	75	154
	4	10	100	0.1	120 – 120	50	53
	5	100	500	0.2	130 - 130	50	53
	6	500	1000	0.25	100 - 100	50	53
							472

	Section	Freq min	Freq max	Fres	Amplitude (H-V)	Nrep	Time Stage 2 (min)
Stage 2	1	0.01	0.1	0.01	2000 - 2000	3	32
	2	0.1	0.7	0.02	500 - 550	25	127
	3	0.7	10	0.05	450 - 400	75	154
	4	10	100	0.1	180 -180	50	53
	5	100	500	0.2	200 – 200	50	53
	6	500	1000	0.25	150 - 150	50	53
							472

Overall ID	944

Measurements data can be found in the SVN at:
SeiSVN/seismic/BSC-ISI/H2/ITMY/Data/Transfer_Functions/Measurements/Undamped:

- LHO_ISI_BSC8_Data_L2L_10mHz_100mHz_ST1_ST2_20110723-145046.mat
- LHO_ISI_BSC8_Data_L2L_100mHz_700mHz_ST1_ST2_20110723-101732.mat
- LHO_ISI_BSC8_Data_L2L_700mHz_10Hz_ST1_ST2_20110723-050631.mat
- LHO_ISI_BSC8_Data_L2L_10Hz_100Hz_ST1_ST2_20110722-211830.mat
- LHO_ISI_BSC8_Data_L2L_100Hz_1000Hz_ST1_ST2_20110722-184135.mat

Once the data are processed, they can be found in the SVN at:
SeiSVN/seismic/BSC-ISI/X1/Data/BSC8/Transfer_Functions/Simulations/Undamped

- LHO_ISI_BSC8_TF_L2L_Raw_10mHz_1000Hz_2011_06_22.mat

The script used to compare transfer function can be found in the SVN at:
SeiSVN/seismic/BSC-ISI/H2/ITMY/Scripts/Misc

- Comparison_TF_L2L_LHO_ISI_BSC8.m

The figure that shows the comparison between the transfer functions of the staging building and the LVEA are located in the SVN at:
SeiSVN/seismic/BSC-ISI/H2/ITMY/Data/Figures/Transfer_Functions/Measurements/Comparison/L2L/

- LHO_ISI_BSC8_Comparison_TF_L2L_ST1_ACT_H_to_ST1_CPS_H_20110622_vs_20110722.fig
- LHO_ISI_BSC8_Comparison_TF_L2L_ST1_ACT_H_to_ST1_L4C_H_20110622_vs_20110722.fig
- LHO_ISI_BSC8_Comparison_TF_L2L_ST1_ACT_V_to_ST1_CPS_V_20110622_vs_20110722.fig
- LHO_ISI_BSC8_Comparison_TF_L2L_ST1_ACT_V_to_ST1_L4C_V_20110622_vs_20110722.fig
- LHO_ISI_BSC8_Comparison_TF_L2L_ST2_ACT_H_to_ST2_CPS_H_20110622_vs_20110722.fig
- LHO_ISI_BSC8_Comparison_TF_L2L_ST2_ACT_H_to_ST2_GS13_H_20110622_vs_20110722.fig
- LHO_ISI_BSC8_Comparison_TF_L2L_ST2_ACT_V_to_ST1_CPS_V_20110622_vs_20110722.fig
- LHO_ISI_BSC8_Comparison_TF_L2L_ST2_ACT_V_to_ST2_GS13_V_20110622_vs_20110722.fig

Note 1: The transfer functions are measured from the Output filters bank excitation point to the input (IN1) of the input filters bank. The transfer functions presented below are raw transfer functions without any electronic compensation.

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: On the ST1-ACT-H to ST1-CPS-H transfer functions, we can see the first resonances of the LVEA teststand at 19.6Hz, 21.4Hz and 29.6Hz. The resonances of the staging building teststand are at 33.4Hz, 57.3Hz and 69.4Hz. The teststand in the LVEA has longer legs that the teststand in the staging building.

Note 4: The transfer functions measured in the LVEA and in the staging building are very similar (at LF and HF)

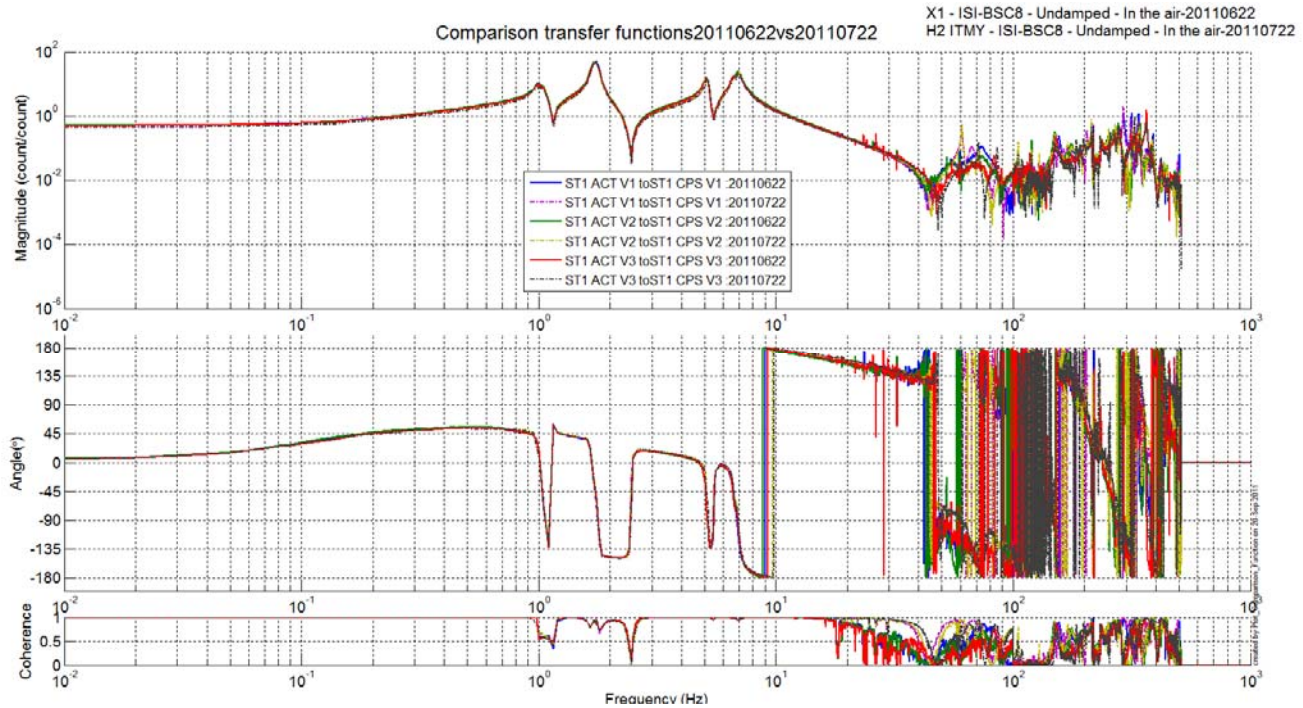


Figure 2 - Transfer functions comparison - ST1 ACT V to ST1 CPS V

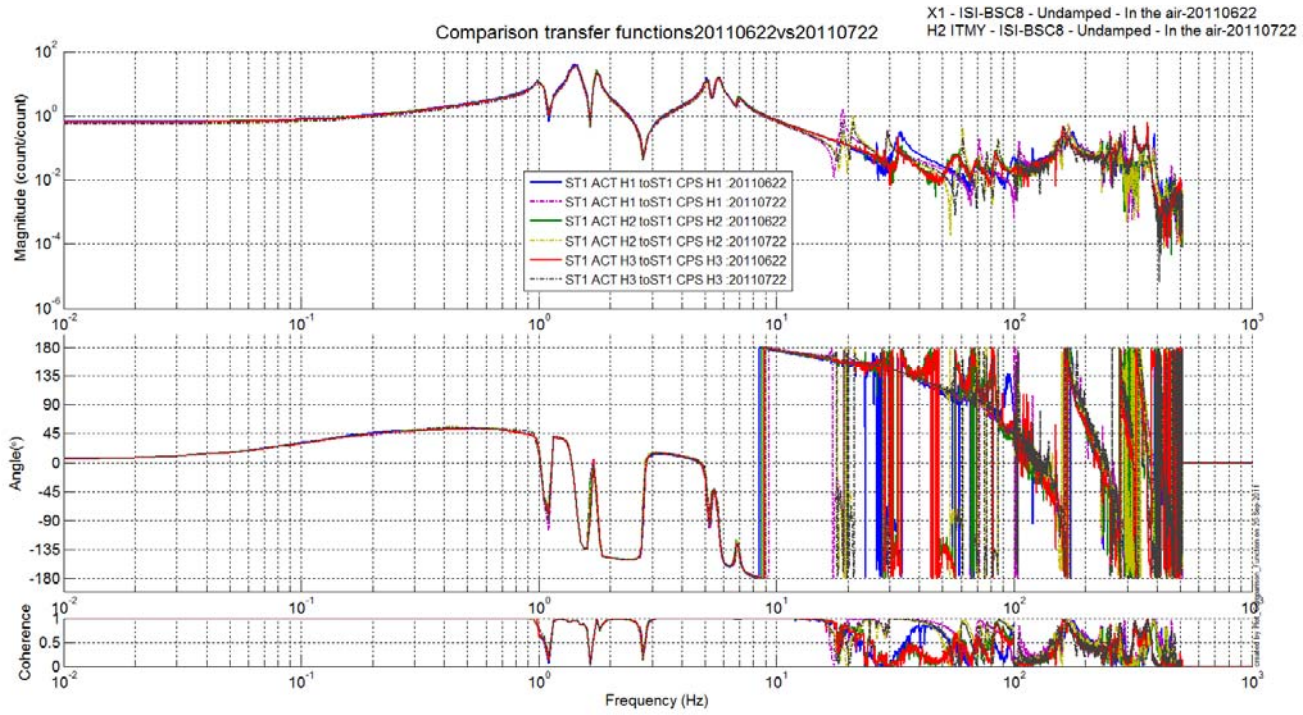


Figure 3 - Transfer functions comparison - ST1 ACT V to ST1 CPS V

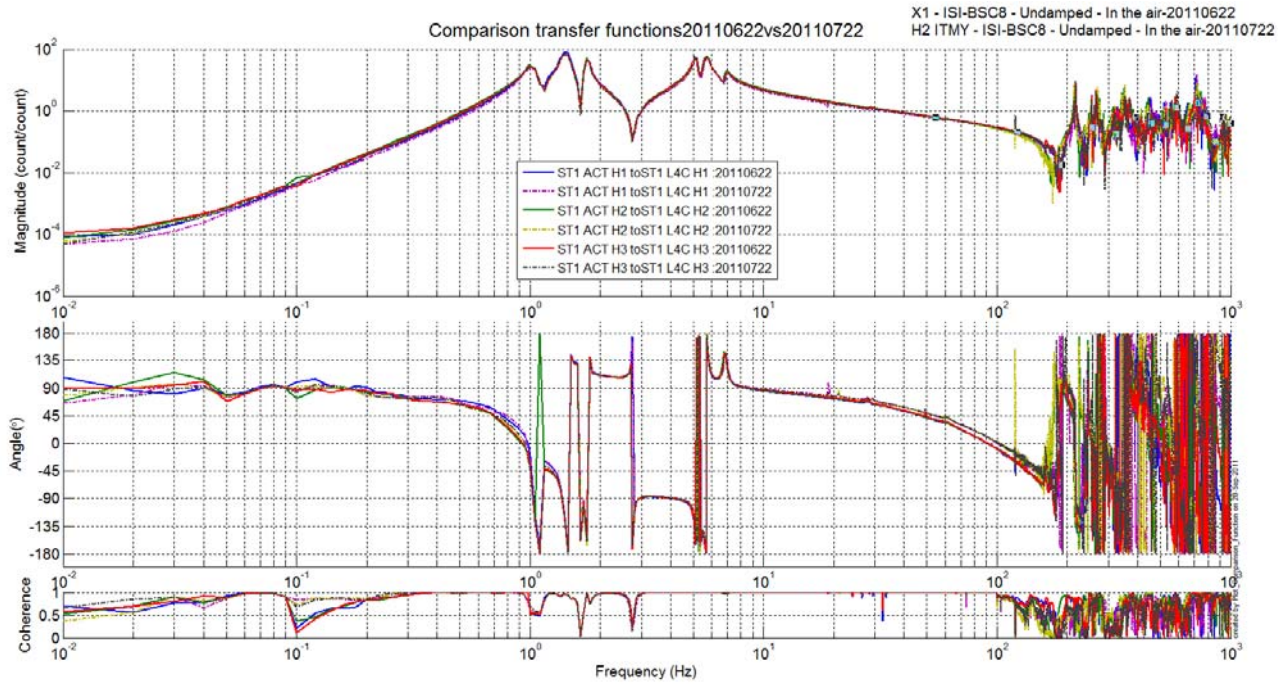


Figure 4 - Transfer functions comparison - ST1 ACT H to ST1 L4C H

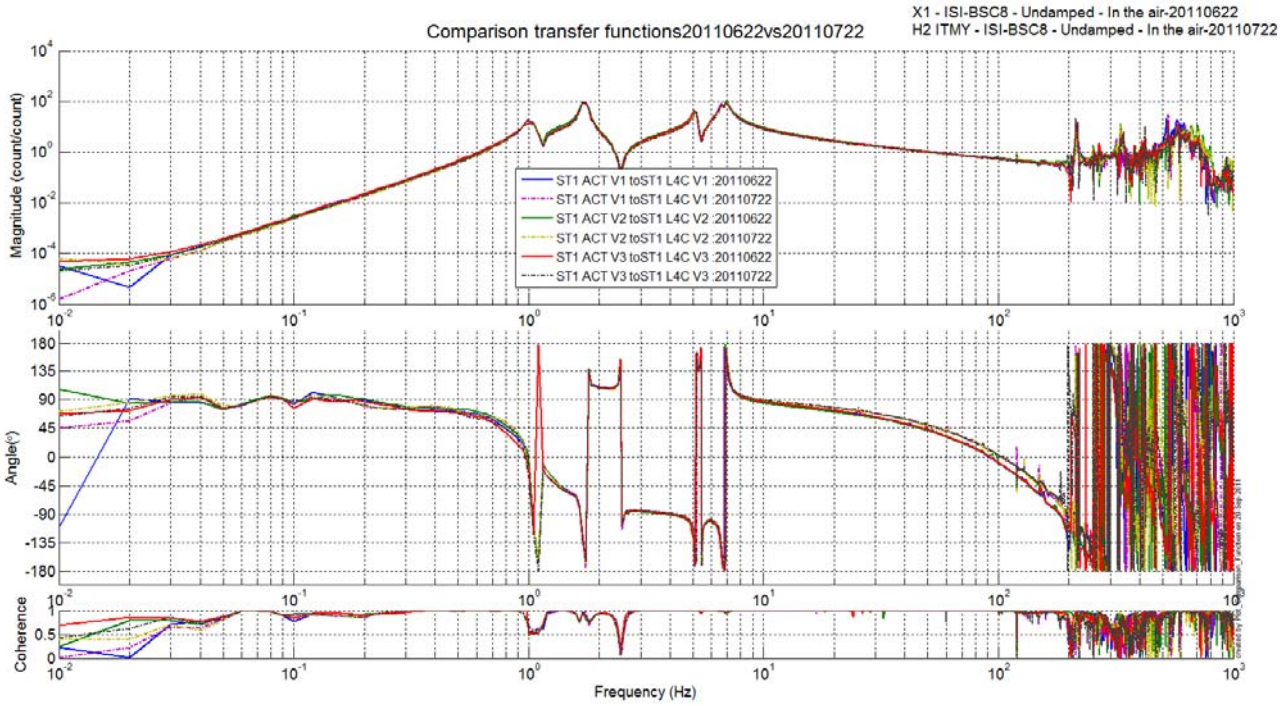


Figure 5 - Transfer functions comparison - ST1 L4C V to ST1 L4C V

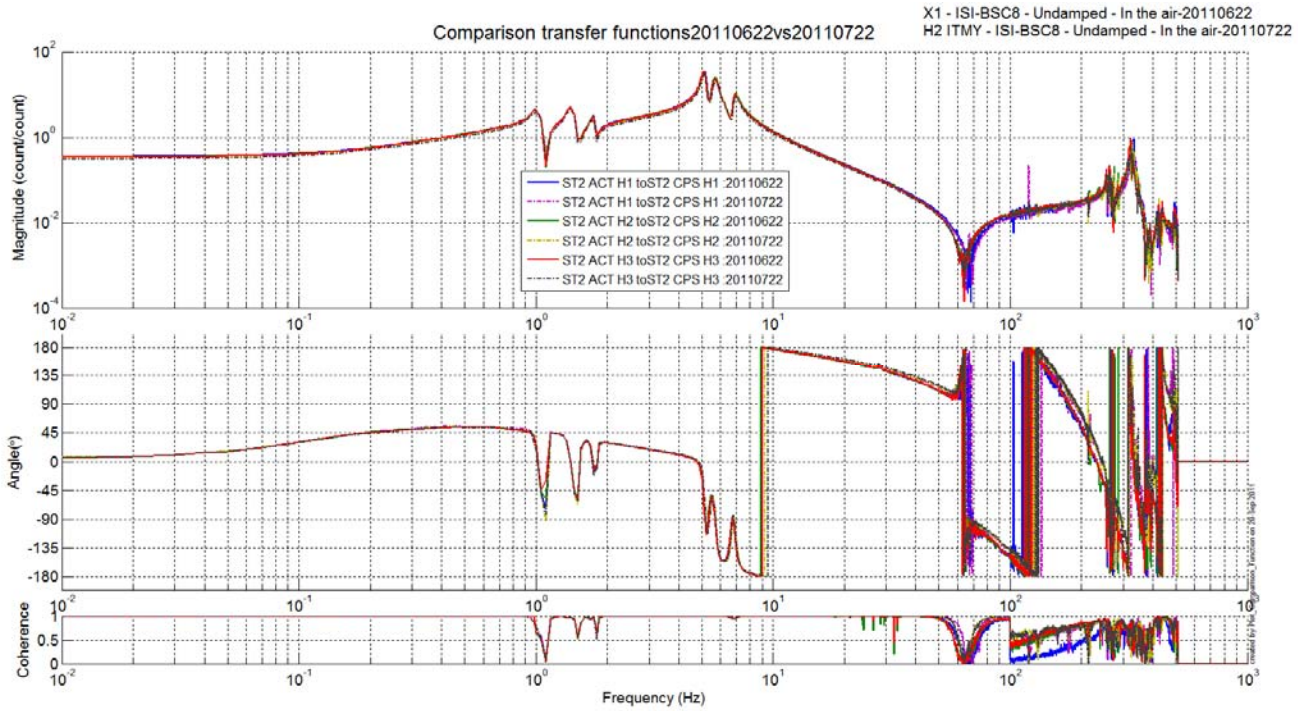


Figure 6 - Transfer functions comparison - ST2 ACT H to ST2 CPS H

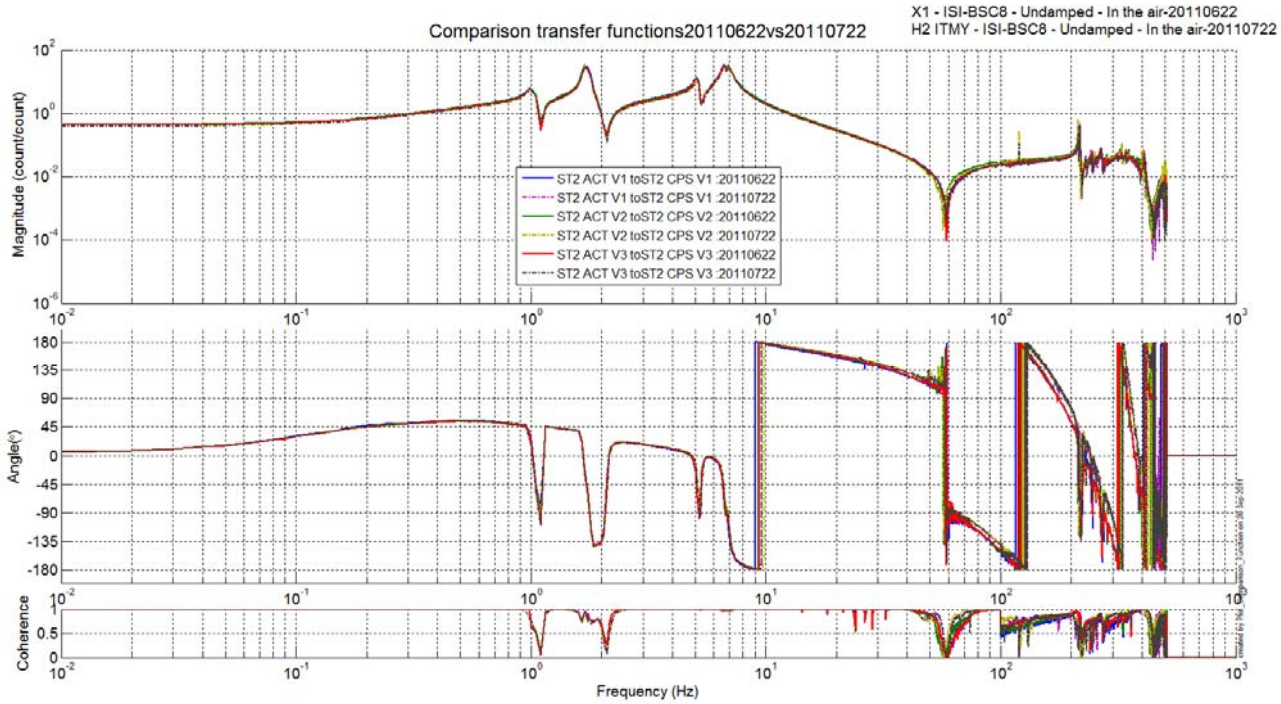


Figure 7 - Transfer functions comparison - ST2 ACT V to ST2 CPS V

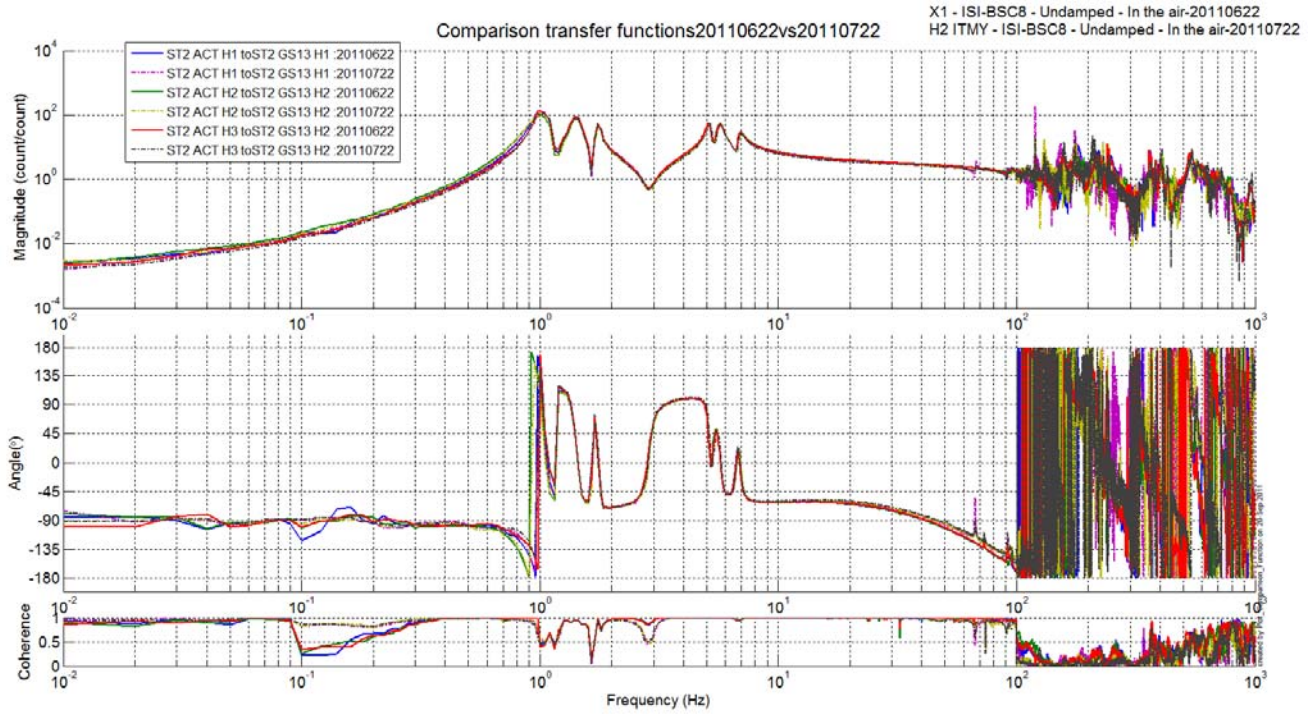


Figure 8 - Transfer functions comparison – ST2 ACT H to ST2 GS13 H

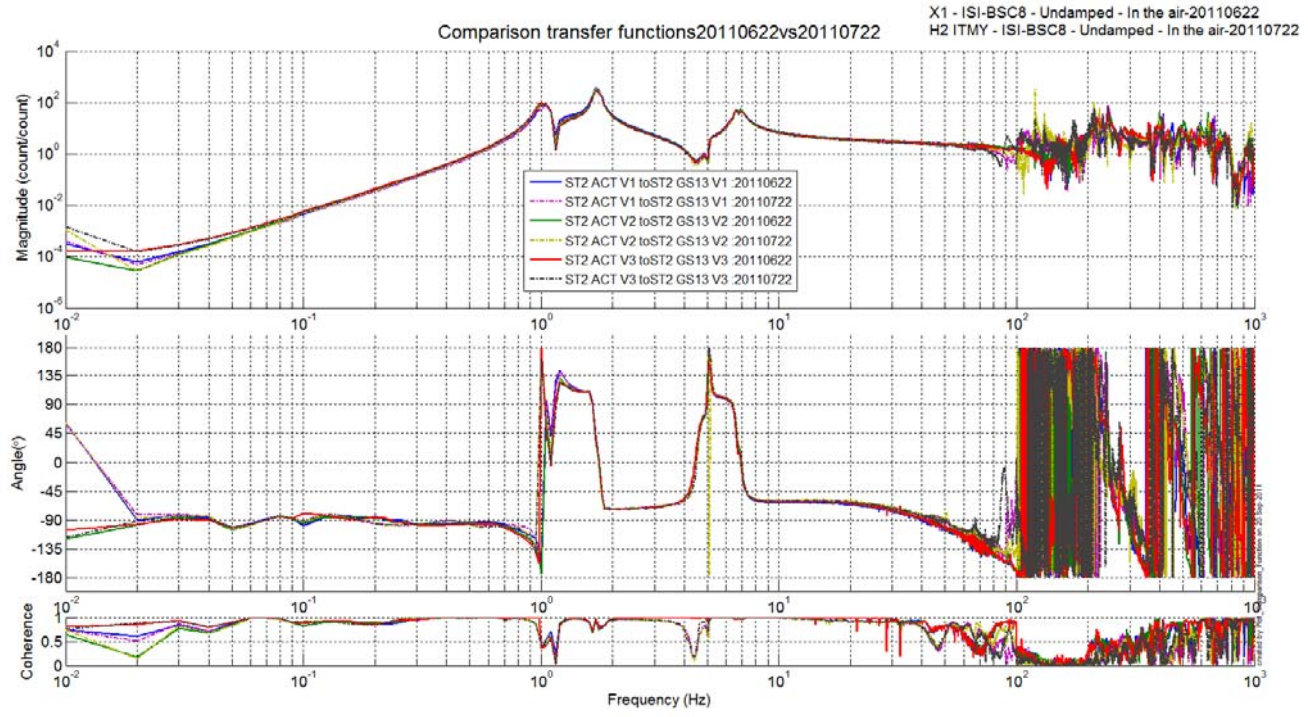


Figure 9 - Transfer functions comparison – ST2 ACT V to ST2 GS13 V

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

4. Controls work on the ISI before ITMY and FMY

1. Work prior to the control design

1. Calibration filters

The scripts used to build the calibration filters used to display calibrated ASD are located:
seismic/BSC-ISI/Common/Calibration_BSC_ISI/aLIGO/

- aLIGO_BSC_ISI_Calibration.m

This script creates a mat file in which the calibration filters are stored.

- aLIGO_BSC_ISI_Calibration.mat

aLIGO_BSC_ISI_Calibration.mat is called by scripts that calculate the calibrated ASD

The document E1100524 describes the input, output filters and the BIO switches that need to be engaged when the BSC-ISI is controlled. The input filters account for:
- the interface chassis electronic
- the sensor calibration
- the state of the BIO switches
- sign inversion if the instrument are badly connected

The output filters account for:
- the dynamic of the coil driver
- the dynamic of the actuators

The state of the BIO switches is also defined in E1100524.

All elements related to the input and out put filters are located in the SVN at the following location:
seismic/BSC-ISI/Common/Compensation_Filters_BSC_ISI/aLIGO/

The scripts to create the filters are the following.

- aLIGO_BSC_ISI_Input_Filters.m
- aLIGO_BSC_ISI_Output_Filters.m

The filters are stored:

- aLIGO_BSC_ISI_Input_Filters.mat
- aLIGO_BSC_ISI_Output_Filters.mat

The scripts that digitalize the filters are:

- aLIGO_BSC_ISI_Input_Filters_Digitalization.m
- aLIGO_BSC_ISI_Ouput_Filters_Digitalization.m

The text files that contain the coefficients of the input and the output filters are:

- aLIGO_BSC_ISI_Input_Filters_27-Jul-2011.txt
- aLIGO_BSC_ISI_Output_Filters_27-Jul-2011.txt

Figures that show the input and the output filters are:

- aLIGO_BSC_ISI_Input_Filters_2011_06_29.fig
- aLIGO_BSC_ISI_Output_Filters_2011_06_29.fig

The figures below shows the filters that are used to compensated for the electronics and the actuators.

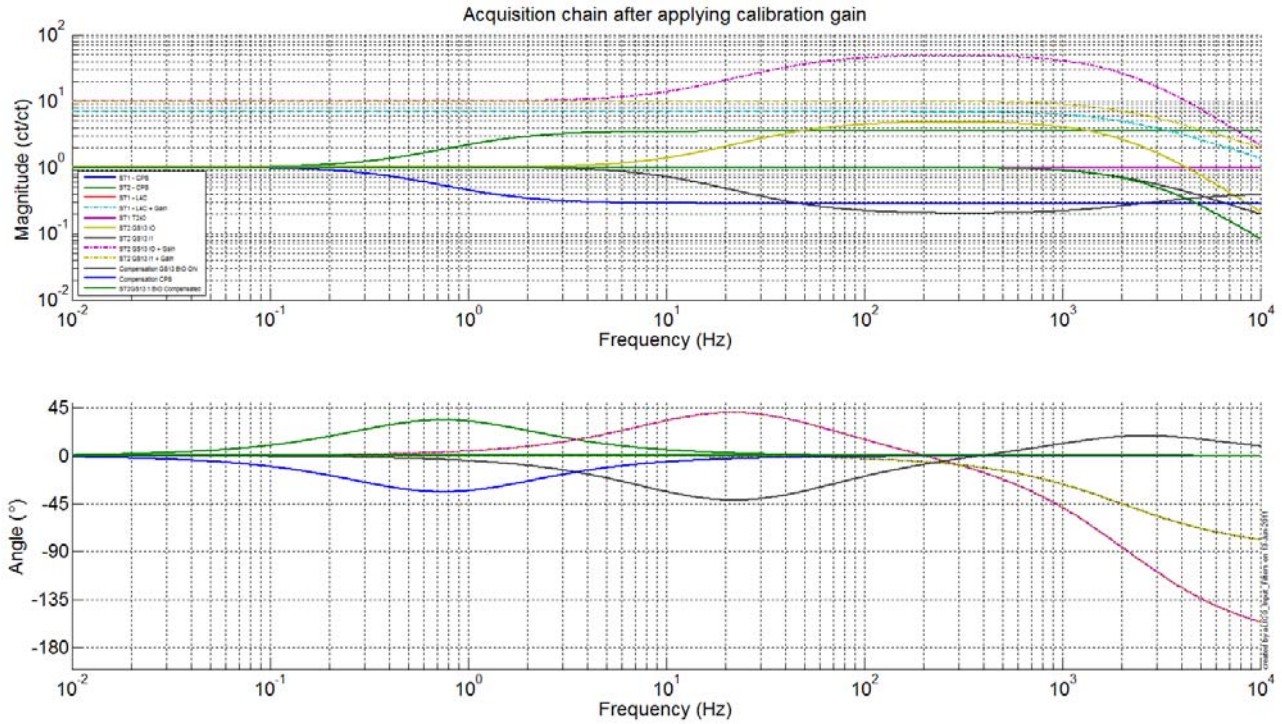


Figure 10 - Input filters after gain calibration (1ct/nm) and (1ct/(nm/s))

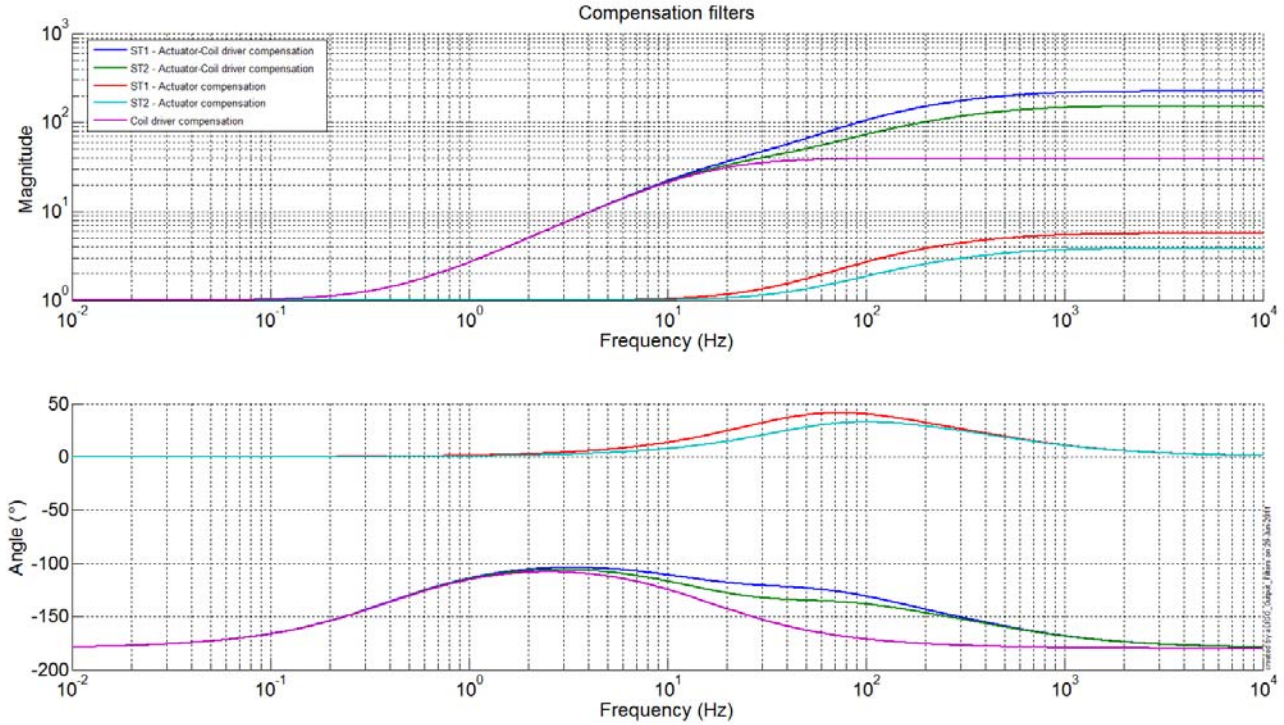


Figure 11 - Output filters

2. Complementary filters

The complementary filters that have been used to blend the capacitive position sensors and the geophones are located in the SVN at:
seismic/BSC-ISI/Common/Complementary_Filters_BSC_ISI/aLIGO/

- aLIGO_BSC_ISI_Complementary_Filters.mat

These filters are very basic. They will be retrofitted later.

2. Control work – Tools - Programs

The design and the implementation of the control on the BSC-ISI are segmented into 15 steps. Each one of these step is associated with a main scripts.

For instance, Step_1_TF_L2L_10mHz_1000Hz_LHO_ISI_BSC8.m compiles the transfer functions into a unique structure (frd).

The scripts mentioned below may be subject with modifications.

These control scripts are located on the SVN at:
\seisvn\seismic\BSC-ISI\H2\ITMY\Scripts\Control_Scripts

- Step_0_Run_all_LHO_ISI_BSC8.m
- Step_1_TF_L2L_10mHz_1000Hz_LHO_ISI_BSC8.m
- Step_2_Symmetrization_Calibration_LHO_ISI_BSC8.m
- Step_3_TF_Basis_Change_L2C_LHO_ISI_BSC8.m
- Step_4_C2D_Sym_Filters_LHO_ISI_BSC8.m
- Step_5_Damping_Loops_ST2_LHO_ISI_BSC8.m
- Step_6_Damping_Loops_ST1_LHO_ISI_BSC8.m
- Step_7_C2D_Damping_Filters_LHO_ISI_BSC8.m
- Step_8_Blend_Filters_LHO_ISI_BSC8.m
- Step_9_C2D_Blend_Filters_LHO_ISI_BSC8.m
- Step_10_Isolation_Loops_ST1_Z_RX_RY_LHO_ISI_BSC8.m
- Step_11_Isolation_Loops_ST2_Z_RX_RY_LHO_ISI_BSC8.m
- Step_12_Isolation_Loops_ST1_X_Y_RZ_LHO_ISI_BSC8.m
- Step_13_Isolation_Loops_ST2_X_Y_RZ_LHO_ISI_BSC8.m
- Step_14_Open_Loop_check_LHO_ISI_BSC8.m
- Step_15_C2D_Isolation_Filters_LHO_ISI_BSC8.m

The main scripts mentioned above call lots of other functions that are common to every BSC-ISIs located in the SVN at:
\seisvn\seismic\BSC-ISI\Common\Control_Scripts_Functions_3_BSC_ISI\

- Plot_Comparison_TF_L2L_BSC_ISI.m
- Plot_Damping_Filters_MIMO_BSC_ISI.m
- Plot_Damping_Filters_MIMO_BSC_ISI_Presentation.m
- Plot_Damping_Filters_ST1_SISO_BSC_ISI.m
- Plot_Damping_Filters_ST2_SISO_BSC_ISI.m
- Plot_Full_MIMO_Suppression_BSC_ISI.m
- Plot_Isolation_Full_MIMO_BSC_ISI.m
- Plot_L4C_Fitt_BSC_ISI.m
- Plot_L4C_Fitt_all_BSC_ISI.m
- Plot_L4C_Fitt_report_display_BSC_ISI.m
- Plot_L4C_GS13_Fitt_BSC_ISI.m
- Plot_L4C_GS13_Fitt_all_BSC_ISI.m
- Plot_L4C_GS13_Fitt_with_sys_BSC_ISI.m
- Plot_L4C_GS13_Fitt_without_sys_BSC_ISI.m
- Plot_L4C_GS13_Symmetrization_Filters_BSC_ISI.m
- Plot_L4C_without_sys_L2L_vs_C2L_BSC_ISI.m
- Plot_Open_Loops_check.m
- Plot_Super_Sensors_Isolation_MIMO_BSC_ISI.m
- Plot_Super_Sensors_Isolation_SISO_BSC_ISI.m
- Plot_Super_Sensors_MIMO_BSC_ISI.m
- Plot_Super_Sensors_SISO_BSC_ISI.m
- Plot_TF_C2C_BSC_ISI.m
- Plot_TF_C2C_Fit_BSC_ISI.m
- Plot_TF_C2C_Fit_all_BSC_ISI.m
- Plot_TF_C2C_meas_BSC_ISI.m
- Plot_TF_L2L_BSC_ISI.m
- Plot_TF_L2L_Comparison_BSC_ISI.m
- Plot_TF_L4C_GS13_Symmetrization_BSC_ISI.m
- Plot_TF_L4C_GS13_Symmetrization_all_BSC_ISI.m

3. Transfer functions measurements

The transfer functions are measured in the local basis from the excitation point in the output filters bank and the input IN1 of the input filters bank.

Note: The transfer functions are measured using a strong drive in order to reduce the measurements time (~13h). Due to the important drive, the T240s saturate. No work will be done will be done with the T240 at low frequency using this set of measurements.

The transfer functions used to design the controller have been measured on July 27, 2011.

4. Concatenating the data

This step consists in concatenating the data into a unique frd. It also saves a parameters file that is updated throughout the design of the controllers.

The concatenated data can be found in the SVN at:
seismic/BSC-ISI/H2/ITMY/Data/Transfer_Functions/Simulations/Undamped/

- LHO_ISI_BSC8_TF_L2L_Raw_10mHz_1000Hz_2011_07_27.mat

The parameter files can be found in the SVN at :
seismic/BSC-ISI/H2/ITMY/Data/Transfer_Functions/Simulations/Parameters/

- Parameters_LHO_ISI_BSC8_2011_07_27.mat

5. Symmetrization – Calibration – Idealization of the geophones

The symmetrization step realizes the following tasks:

- Correct the actuator signs (shouldn't be corrected if the actuators have been wired properly in the staging building – but here just in case)
- Add an actuator symmetrization gain using the CPSs as references
- Apply the Input filters (Calibration gain, whitening, BIO compensation)
- Correct the sign of the geophones (L4C)
- Symmetrize and "idealize" geophones
- Recalculate the transfer functions once all the input filters are applied. The symmetrized transfer functions are calculated from the excitation point of the output filters bank and the output point of the input filters bank.

1. Actuators symmetrization

The actuator symmetrization gains are reported in the table below:

Actuator	Gain
ST1 ACT H1	1.009
ST1 ACT H2	1.000
ST1 ACT H3	0.992
ST1 ACT V1	0.989
ST1 ACT V2	1.002
ST1 ACT V3	1.010
ST2 ACT H1	0.990
ST2 ACT H2	0.990
ST2 ACT H3	1.022
ST2 ACT V1	1.001
ST2 ACT V2	1.008
ST2 ACT V3	0.991

Table 15 - Actuator symmetrization gains

Note: Symmetrization gains of the actuators are within 2% and with a positive sign.

2. L4C Symmetrization

The L4C has a low Q and its internal resonance is in the vicinity of the BSC-ISI first suspension mode. Consequently, identifying the L4C dynamic is tricky. But, the BSC-ISI motions are also sensed by CPS. At low frequency, when driving the actuators, the platform motion of the ISI is not dominated by the ground motion or the air turbulence in the clean room. CPS of stage 1 and L4C observe approximately the same motion (one is relative, one is absolute). Consequently, the L4C transfer functions (the instrument itself) can be calculated by removing the BSC-ISI response to the measured L4C transfer functions using the CPS transfer functions. The Cartesian to local transfer functions are preferred to local to local because the CPS and the L4C are not collocated (on aLIGO BSC-ISI). Next, the L4C transfer function (the instrument itself) can be fitted.
At low frequency, we can estimate the transfer function of the instrument ($L4C_{Sensor}$) using:

$$L4C_{Sensor} = \frac{TFC2L\ L4C_{Measured}}{TFC2L\ CPS_{Measured}}$$

Symmetrization filters gains: The symmetrization filters gains are computed such that the symmetrized transfer functions (H1-H2-H3 & V1-V2-V3) can be superposed to the "averaged initial transfer function" of H1-H2-H3 & V1-V2-V3.

Curve fitting the L4C after removing the BSC-ISI response

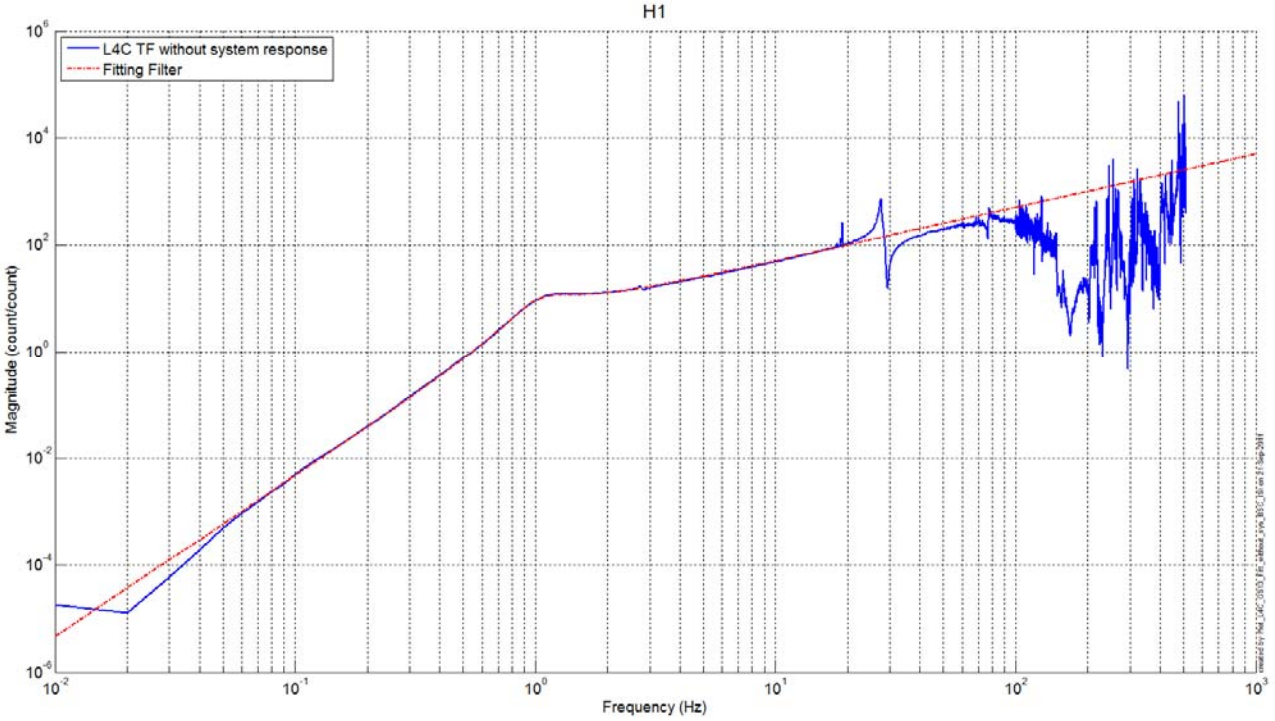


Figure 12 - Fitting the Horizontal L4C on corner 1

Figures that show the symmetrization of the L4C are located in the SVN at:
seismic/BSC-ISI/H2/ITMY/Data/Misc/

- LHO_ISI_BSC8_Curve_Fitting_L4C_H1.fig
- LHO_ISI_BSC8_Symmetrized_Idealized_TF_ST1_ACT_H1_ST1_L4C_H1.fig

The symmetrized-idealized-calibrated transfer functions can be calculated by applying the calibration gain, the whitening and symmetrization filters to the raw transfer functions.

Note 1: The L4C has a pair of complex conjugate poles at 1Hz with a phase of 74°.

Note 2: Due to the idealization of the geophones (L4C and GS13) by 3 zeros at 0Hz and a pair of complex conjugate poles at 1Hz with a phase of 45°, the symmetrized-idealized-calibrated transfer functions are very different from the raw transfer function around 1Hz.

Note 3: A minus sign is added in the symmetrization filters to account for the bad phase measured on the raw L4C transfer functions.

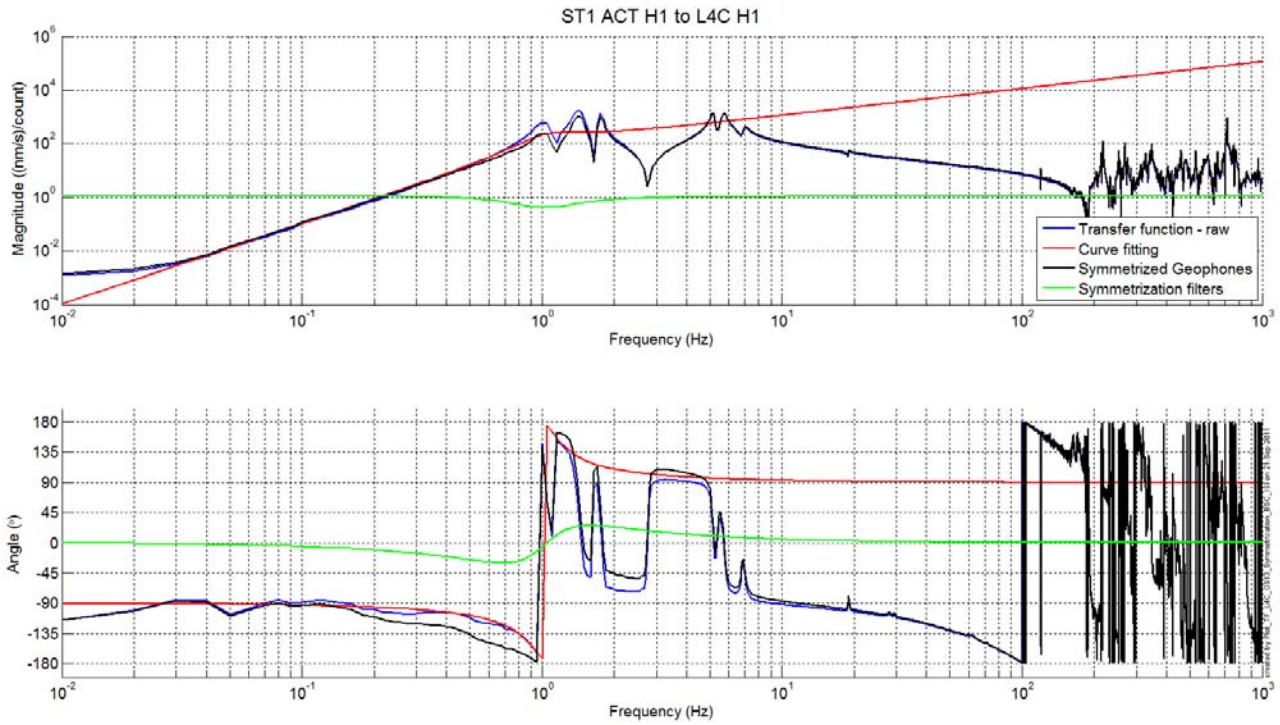


Figure 13 - Applying the input filters to raw transfer functions

3.Symmetrization of the GS13

The identification of the L4C and the GS13 cannot be done the same way. The identification of the GS13 is done using the raw transfer functions.
In section 7.5, you can notice that the nature and the location of the payload (on top of stage 2 or hanging from the optic table) strongly affect the dynamic of the ISI and not only at high frequencies. When the QUAD (only) was installed, the first suspension resonance of the ISI was measured at 1.15Hz instead of 1Hz with the stack of masses on top of stage 2.
The program is written to work with a real payload (first resonance at 1.15Hz). In that case it is quite easy to fit the GS13s that have a pole at 1Hz with a phase of 83degree (sharp bump before the first ISI suspension mode). In the present case (first ISI resonance at 1Hz), the commissioner tweaked a little bit (5 minutes for 6 geophones) to fit the GS13s.

The following figures present the fitting realized on the GS13 transfer functions and the recalculated transfer functions after applying the input filters.
These figures are located in the SVN at:
seismic/BSC-ISI/H2/ITMY/Data/Misc/

- LHO_ISI_BSC8_Curve_Fitting_GS13_H1.fig
- LHO_ISI_BSC8_Curve_Fitting_GS13_V1.fig
- LHO_ISI_BSC8_Symmetrized_Idealized_TF_ST1_ACT_H1_ST2_GS13_H1.fig

Note 1: The GS13 has a pair of complex conjugate poles at 1Hz with a phase of 83°.

Note 2: When driving horizontally the stage 2 horizontal actuator in 1 corner, Stage 2 tilts. The tilt is observed by the horizontal GS13 below 100mHz.

Note 3: It is difficult to consider the GS13 well fitted (example in figure 14). But, the recalculated symmetrized-idealized transfer functions (in IV.5.5) confirm the good fitting of the GS13s.

The two figures below present the fitting step on the horizontal and the vertical GS13 in corner 1.

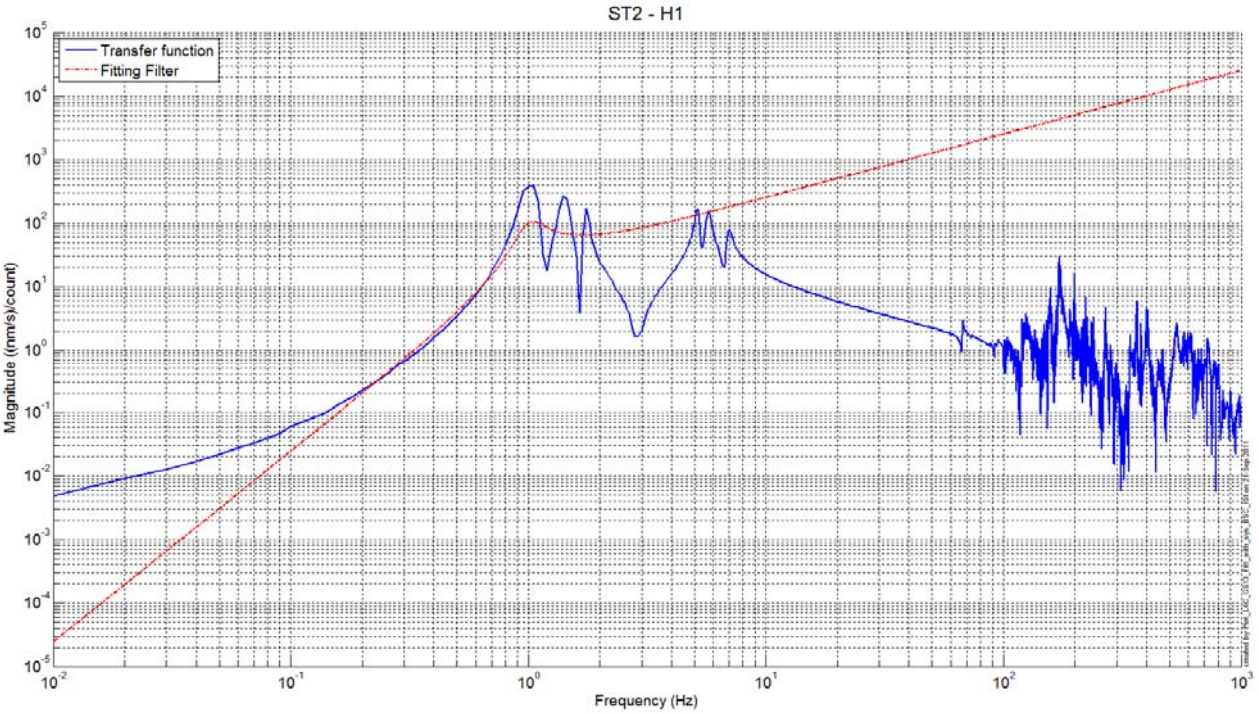


Figure 14 - Curve fitting ST2 GS13 H1 – Transfer functions - ST2 ACT H1 to ST2 GS13 H1

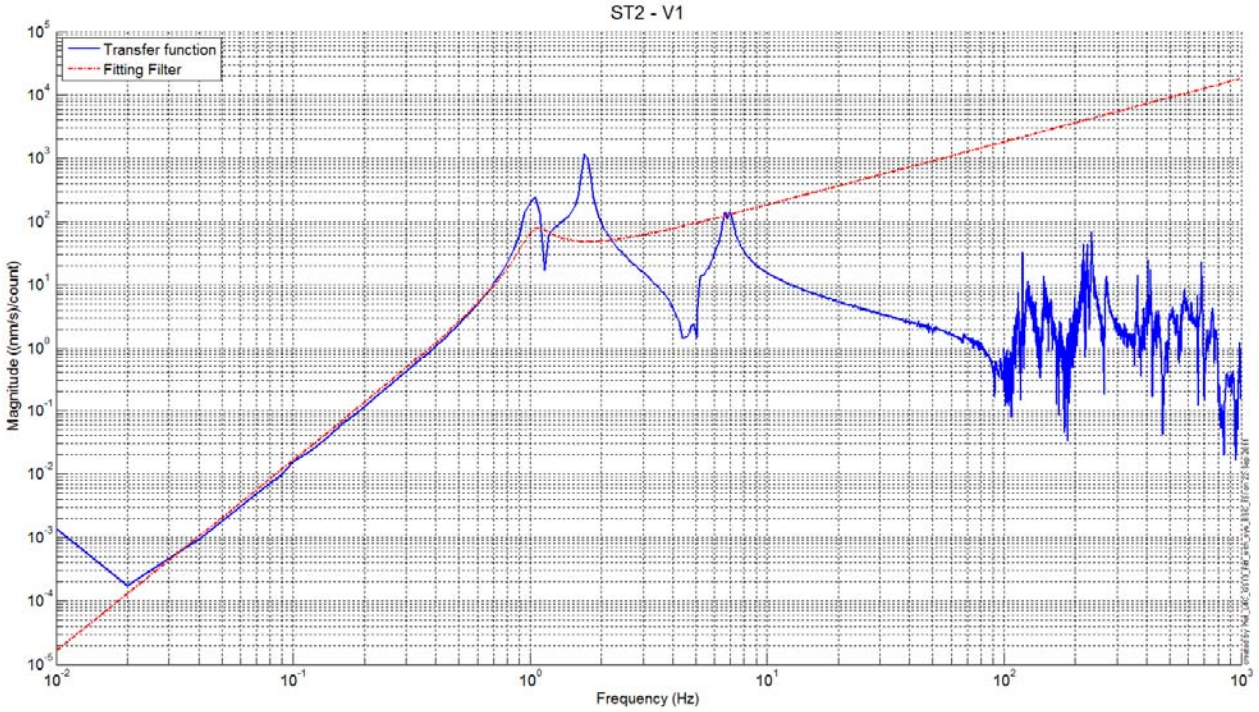


Table 16 - Curve fitting ST2 GS13 H1 – Transfer functions - ST2 ACT V1 to ST2 GS13 V1

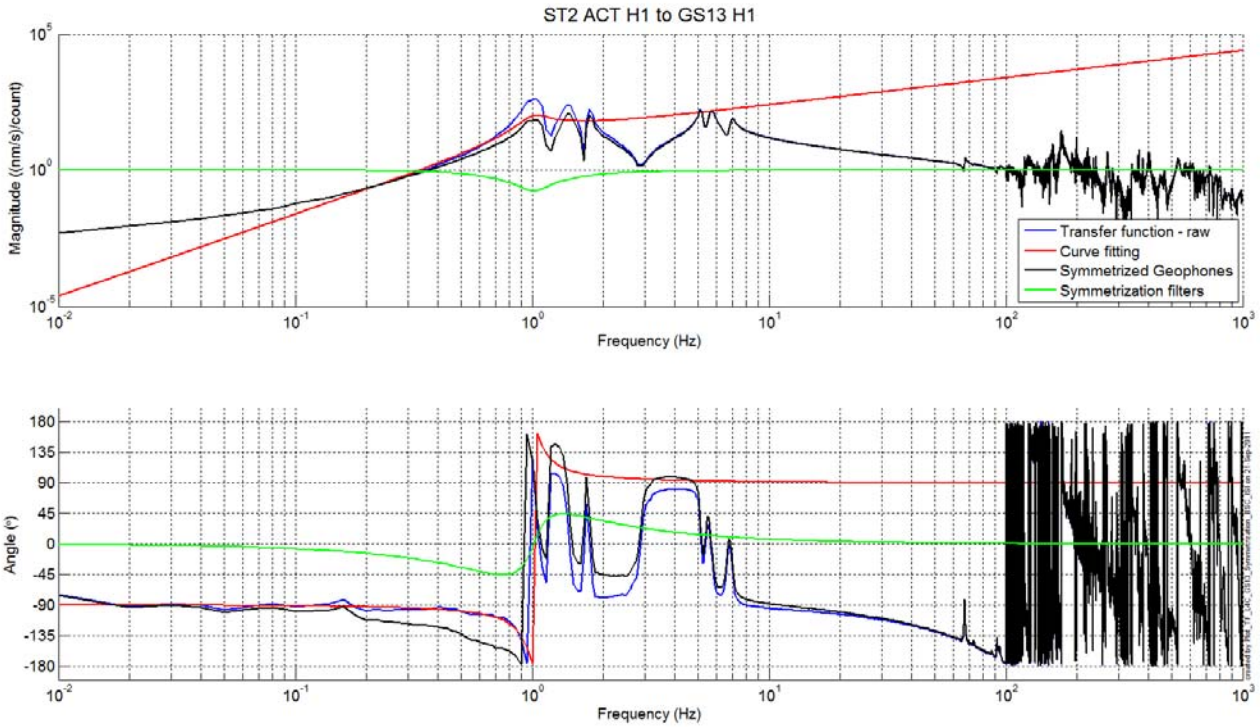


Figure 15 - Symmetrized transfer functions

4.Symmetrization filters

The symmetrization filters are presented below:

```
% Horizontal L4C fitting filters
Fitt_L4C_GS13(1) = zpk(-2*pi*[0 0 0],-2*pi*pair(1.03,75),1);
Fitt_L4C_GS13(2) = zpk(-2*pi*[0 0 0],-2*pi*pair(.96,73),1);
Fitt_L4C_GS13(3) = zpk(-2*pi*[0 0 0],-2*pi*pair(0.98,74),1);

% Vertical L4C fitting filters
Fitt_L4C_GS13(4) = zpk(-2*pi*[0 0 0],-2*pi*pair(1.07,76),1);
Fitt_L4C_GS13(5) = zpk(-2*pi*[0 0 0],-2*pi*pair(1.07,78),1);
Fitt_L4C_GS13(6) = zpk(-2*pi*[0 0 0],-2*pi*pair(1.02,74),1);

% Horizontal GS13 fitting filters
Fitt_L4C_GS13(7) = zpk(-2*pi*[0 0 0],-2*pi*pair(1.01,83),1);
Fitt_L4C_GS13(8) = zpk(-2*pi*[0 0 0],-2*pi*pair(0.96,85),1);
Fitt_L4C_GS13(9) = zpk(-2*pi*[0 0 0],-2*pi*pair(1.06,83),1);

% Vertical GS13 fitting filters
Fitt_L4C_GS13(10) = zpk(-2*pi*[0 0 0],-2*pi*pair(1.05,83),1);
Fitt_L4C_GS13(11) = zpk(-2*pi*[0 0 0],-2*pi*pair(0.99,83),1);
Fitt_L4C_GS13(12) = zpk(-2*pi*[0 0 0],-2*pi*pair(0.99,83),1);
```

Note 1: The measured resonances of the L4C are measured between 0.96Hz and 1.07Hz. The measured resonances can be considered very accurate since the identification is realized using the Cartesian to Local measurements after extracting the ISI dynamic

Note 2: The measured resonances of the GS13 are measured between 0.96Hz and 1.07Hz. Given the quality of the symmetrization, the measured GS13 internal resonance can be considered accurate.

The figure that shows the symmetrization filters are located in the SVN at:
seismic/BSC-ISI/H2/ITMY/Data/Misc/

- LHO_ISI_BSC8_Symmetrization_Filters.fig

The continuous symmetrization-calibration-idealization filters are located in the SVN at:
seismic/BSC-ISI/H2/ITMY/Filters/Continuous/

- LHO_ISI_BSC8_Symmetrization_Filters_2011_07_27.mat
-

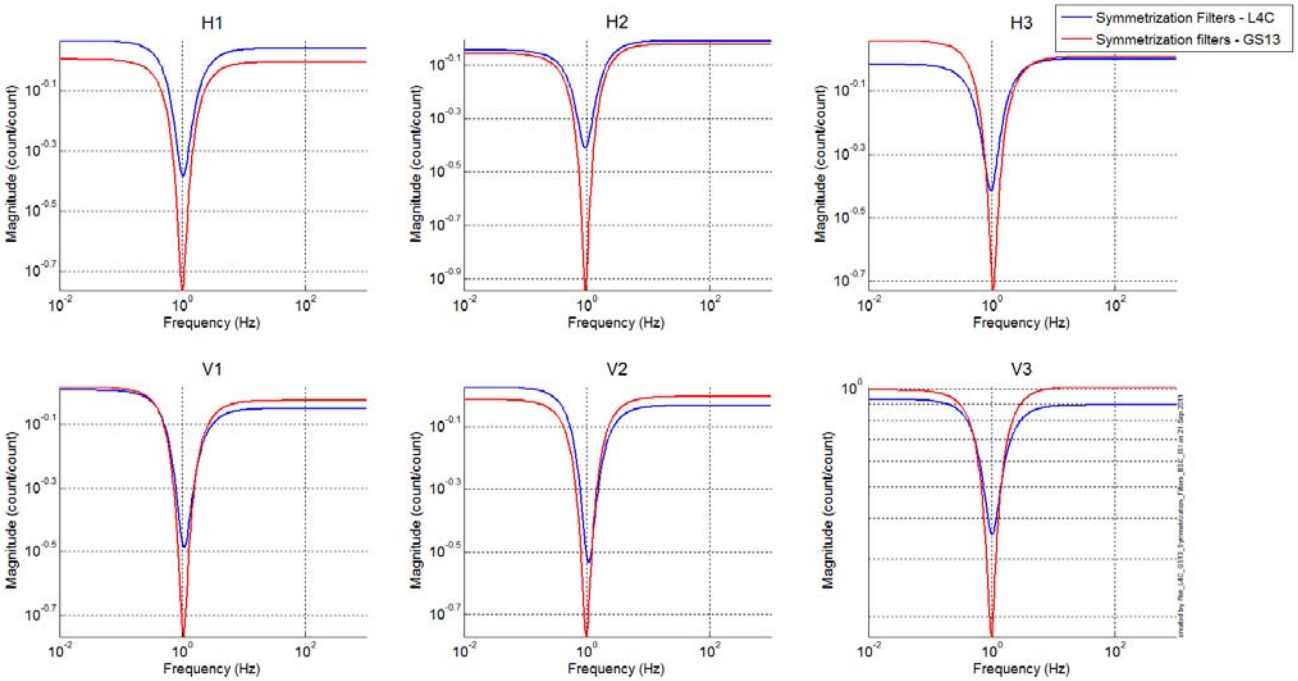


Figure 16 - Symmetrization filters

5.Symmetrized transfer functions

The figures of the symmetrized-idealized-calibrated transfer functions presented hereinafter can be found in the SVN at:
seismic/BSC-ISI/H2/ITMY/Data/Figures/Transfer_Functions/Simulations/Undamped/

- LHO_ISI_BSC8_TF_L2L_Symmetrized_from_ST1_ACT_to_ST1_CPS_2011_07_27.fig
- LHO_ISI_BSC8_TF_L2L_Symmetrized_from_ST1_ACT_to_ST1_L4C_2011_07_27.fig
- LHO_ISI_BSC8_TF_L2L_Symmetrized_from_ST2_ACT_to_ST2_CPS_2011_07_27.fig
- LHO_ISI_BSC8_TF_L2L_Symmetrized_from_ST2_ACT_to_ST2_GS13_2011_07_27.fig

The symmetrized transfer functions (data) can be found in the SVN at:
seismic/BSC-ISI/H2/ITMY/Data/Transfer_Functions/Simulations/Undamped/

- LHO_ISI_BSC8_TF_C2C_Sym_10mHz_1000Hz_2011_07_27.mat

Note : The sensor electronics are also compensated. For instance, in the CPS transfer functions, the zero at 0.14Hz and the pole at 1.4Hz have been compensated.

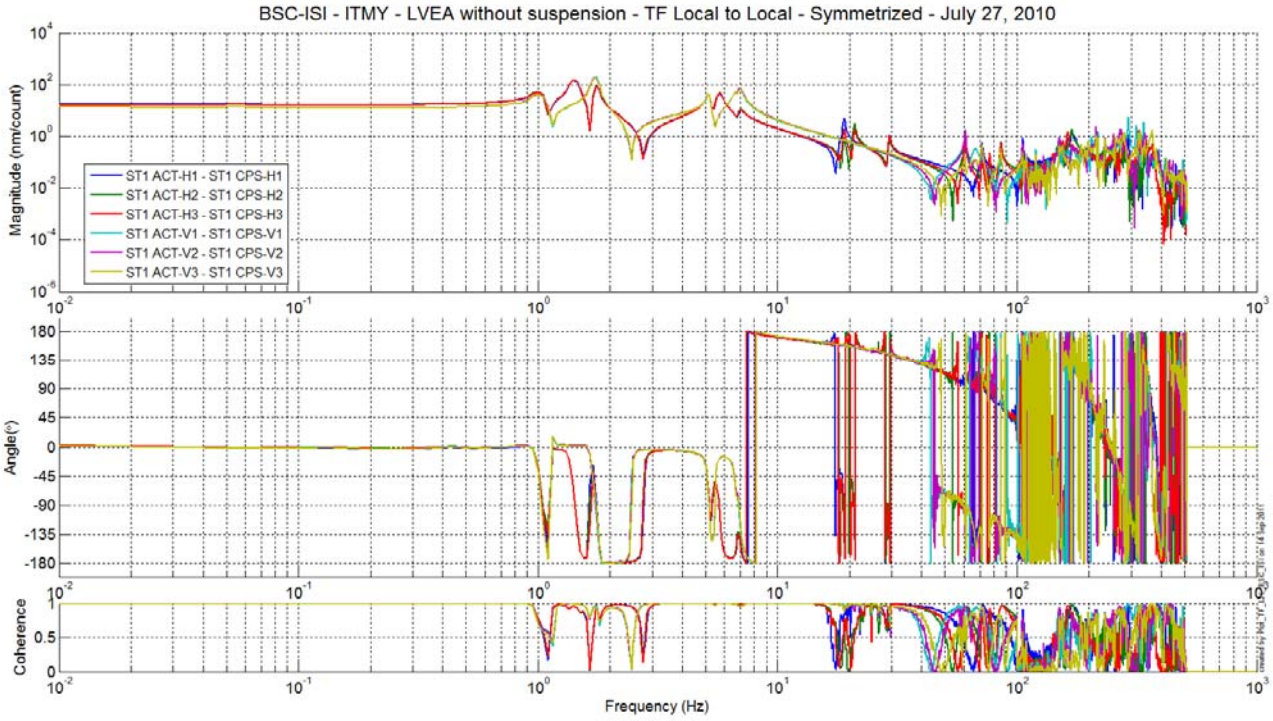


Figure 17 - Symmetrized transfer functions - ST1 ACT to ST1 CPS

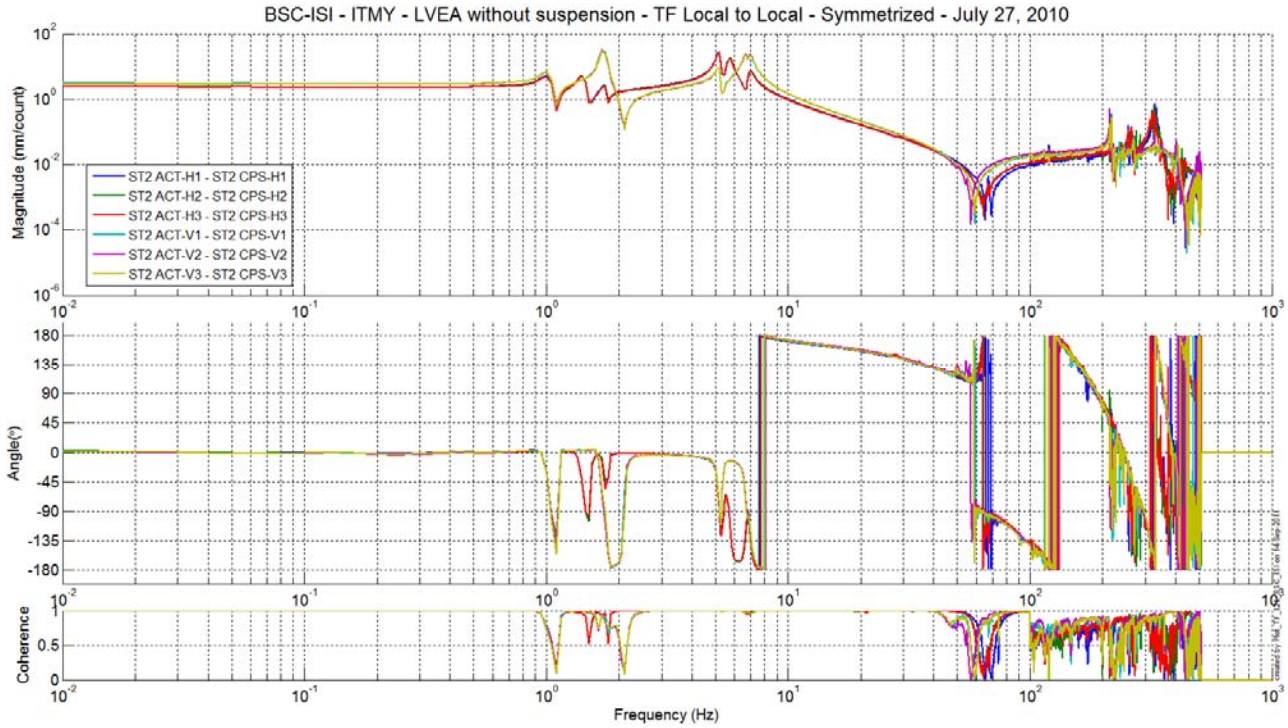


Figure 18 - Symmetrized transfer functions – ST2 ACT to ST2 CPS

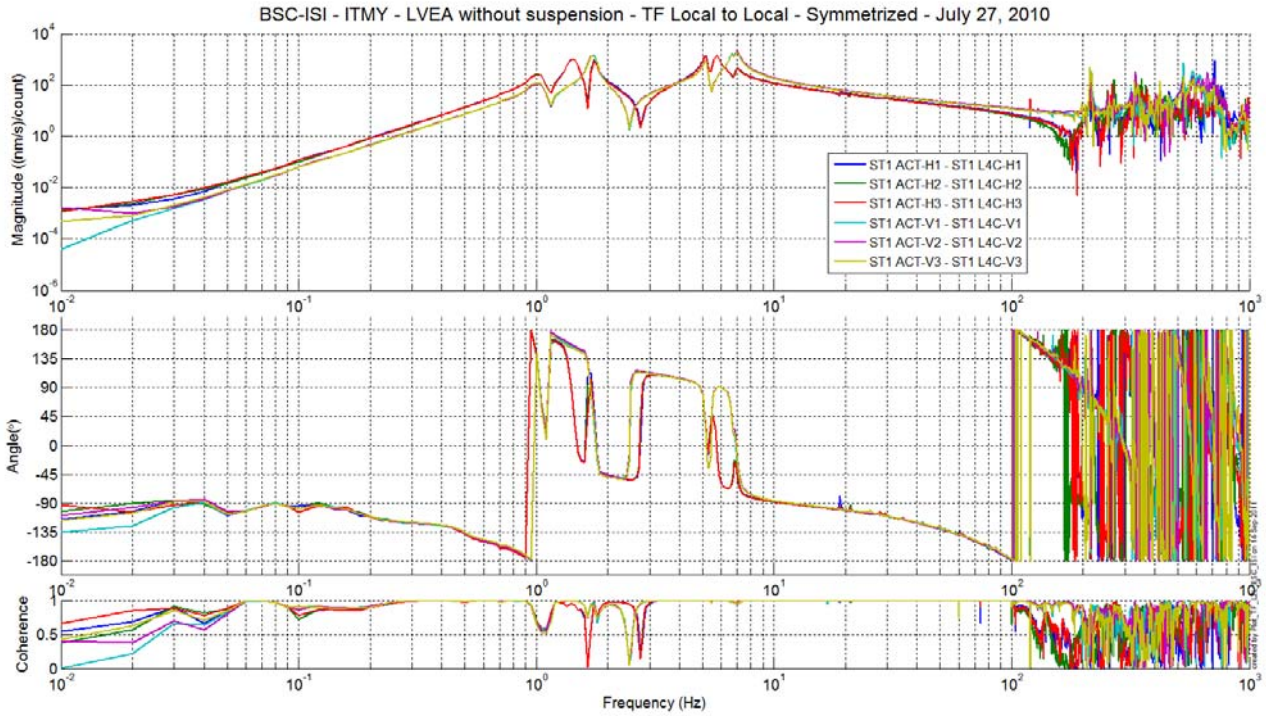


Figure 19 - Symmetrized transfer functions – ST1 ACT to ST1 L4C

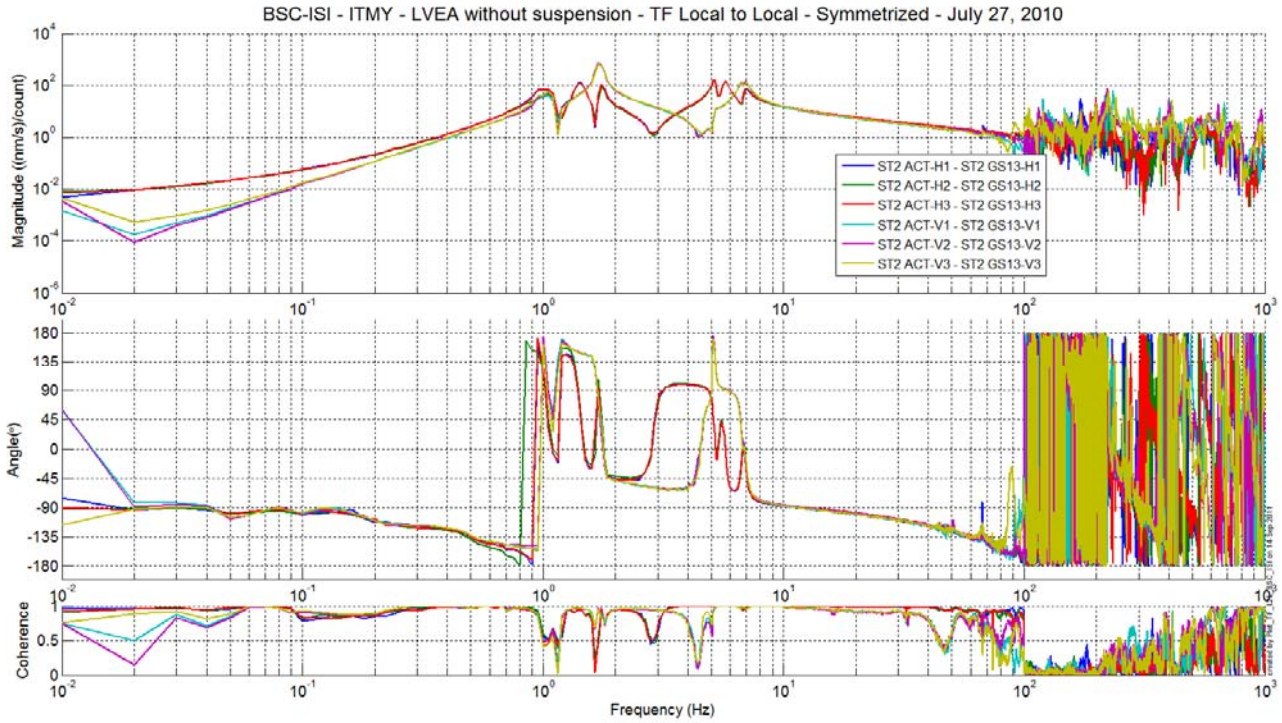


Figure 20 - Symmetrized transfer functions - ST2 ACT to ST2 GS13

6.Calibration check

The goal of this step is to verify that the input filters (symmetrization, calibration, idealization and the whitening filters) are correctly implemented.
The CPS transfer functions and the Geophones transfer functions are compared once the geophones are inverted.

The figures of the calibration check can be found in the SVN at:
seismic/BSC-ISI/H2/ITMY/Data/Misc/

- LHO_ISI_BSC8_Curve_Fitting_L4C_H1.fig
- LHO_ISI_BSC8_Curve_Fitting_GS13_H1.fig

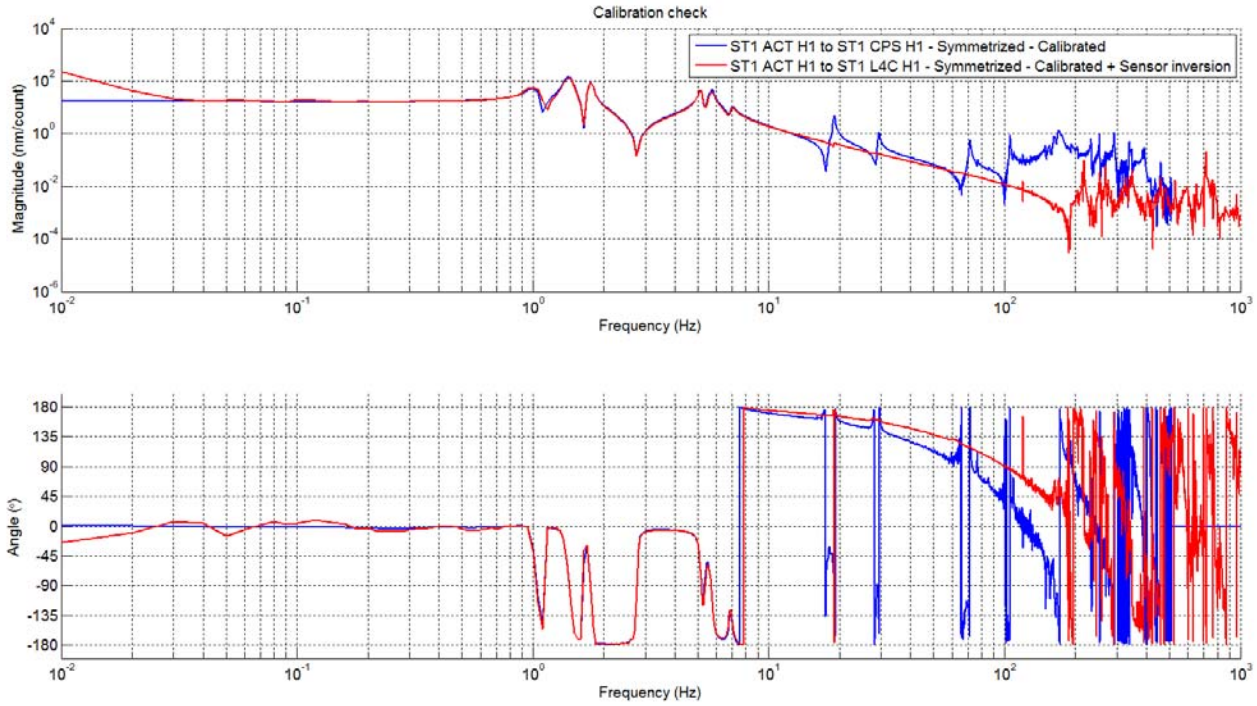


Figure 21 - Calibration check - L4C Local basis

Note 1: The stage 1 CPS transfer functions and the L4C transfer functions with the inverted geophone matches very good below 10 Hz. Since the ISI is not dominated by the ground motion when transfer functions are measured, the CPS of stage 0-1 and the L4C are sensing the same motion.

Note 2: Below the first suspension resonance, the CPS of stage 1-2 and the GS13 should sense the same motion. That is not the case. Some investigations are ongoing to find out why there is a slight gain between the CPS transfer functions and the GS13 transfer functions with the geophone inversion.

Note 3: The geophones and the CPS are not recorded at the same sample rate (CPS: 1024Hz – L4C-GS13: 2048Hz)

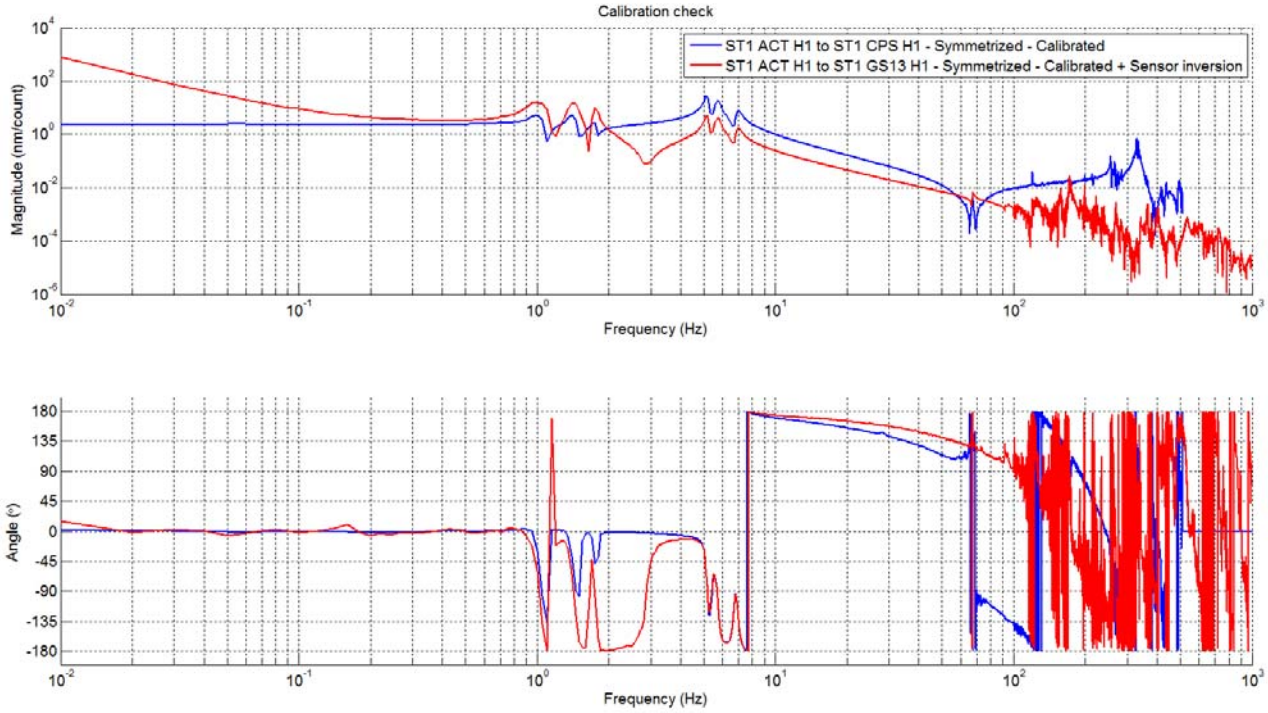


Figure 22 - Calibration check - Local GS13

6. Change of Base – Local to Cartesian - Simulations

The change of base matrices are located in the SVN at:
seismic/BSC-ISI/Common/Base_Change_BSC_ISI/aLIGO/Y/:

- aLIGO_BSC_ISI_Matrices_Y_Direction.mat

The simulated Cartesian to Cartesian transfer functions (calculated after symmetrization) are located in the SVN at:
seismic/BSC-ISI/H2/ITMY/Data/Figures/Transfer_Functions/Simulations/Undamped/

- LHO_ISI_BSC8_TF_C2C_Symmetrized_from_ST1_ACT_to_ST1_CPS_2011_07_27.fig
- LHO_ISI_BSC8_TF_C2C_Symmetrized_from_ST1_ACT_to_ST1_L4C_2011_07_27.fig
- LHO_ISI_BSC8_TF_C2C_Symmetrized_from_ST2_ACT_to_ST2_CPS_2011_07_27.fig
- LHO_ISI_BSC8_TF_C2C_Symmetrized_from_ST2_ACT_to_ST2_GS13_2011_07_27.fig

The data structure that contains the symmetrized transfer functions is located in the SVN at:
seismic/BSC-ISI/H2/ITMY/Data/Transfer_Functions/Simulations/Undamped/

- LHO_ISI_BSC8_TF_C2C_Sym_10mHz_1000Hz_2011_07_27.mat

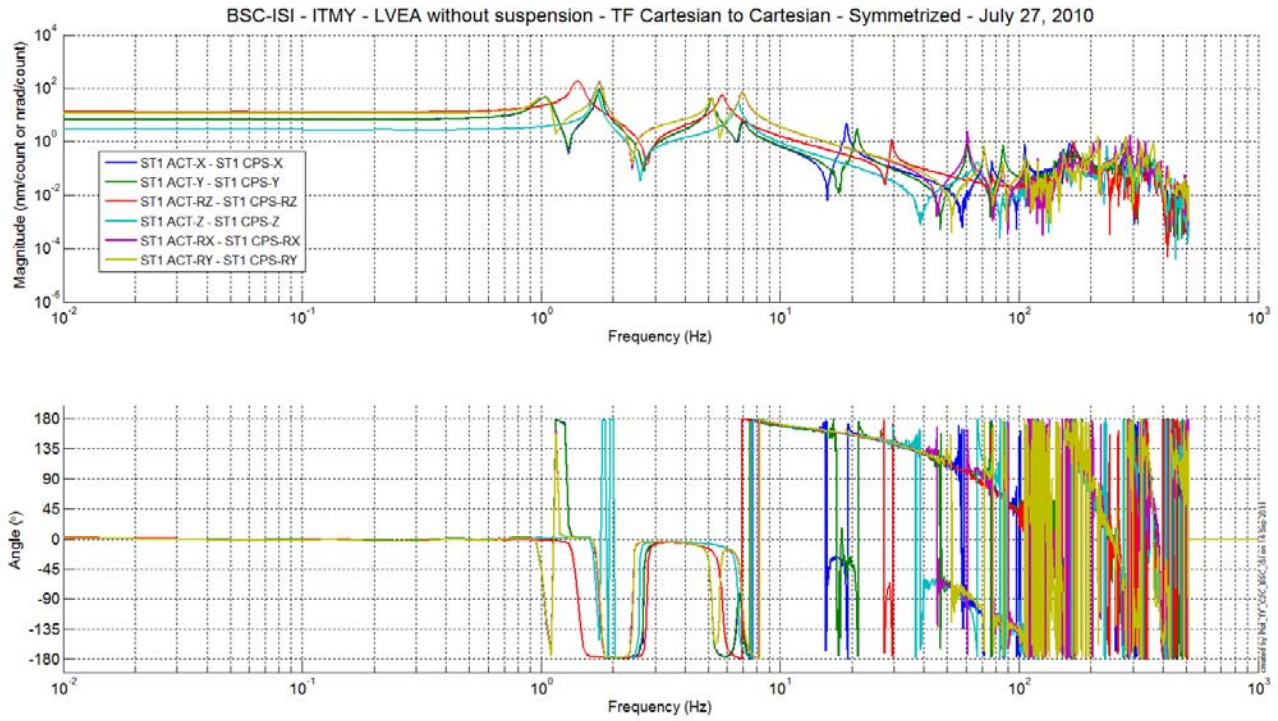


Figure 23 - Transfer functions in the Cartesian basis - ST1 ACT to ST1 CPS

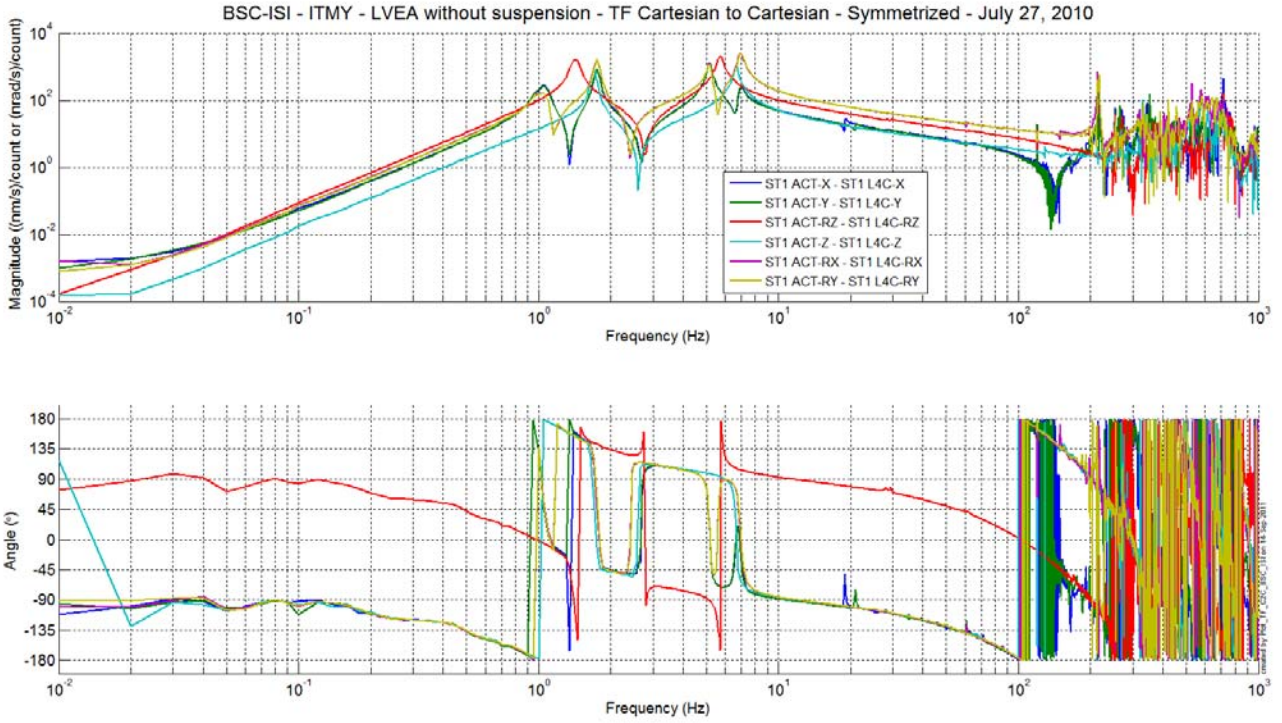


Figure 24 - Transfer functions in the Cartesian basis - ST1 ACT to ST1 L4C

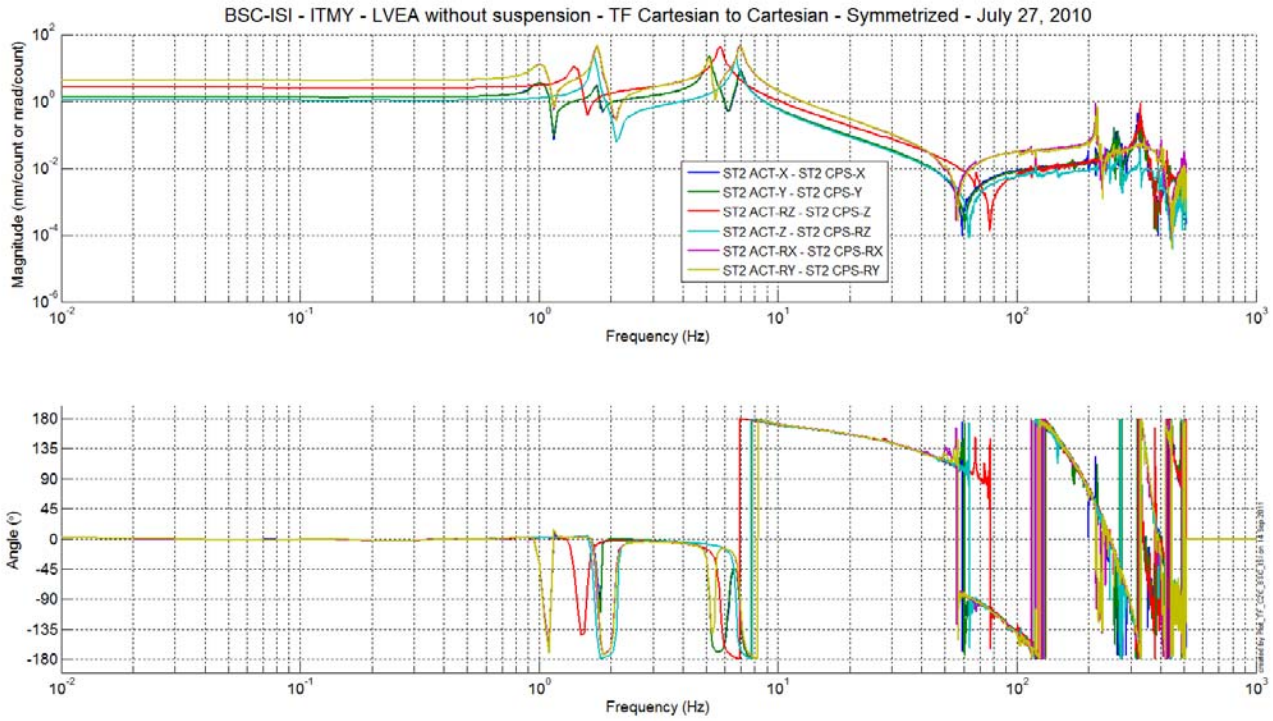


Figure 25 - Transfer functions in the Cartesian basis – ST2 ACT to ST2 CPS

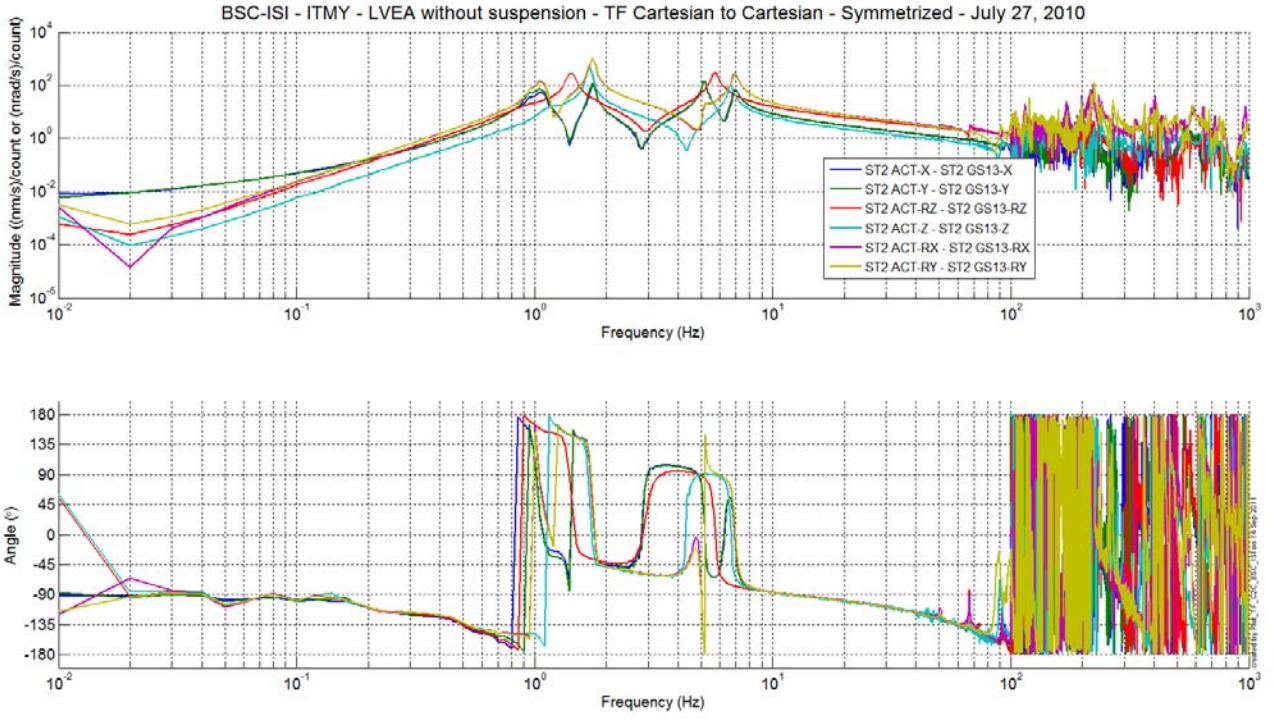


Figure 26 - Transfer functions in the Cartesian basis – ST2 ACT to ST2 GS13

7. Digitalization of the symmetrization filters

The digitized filters can be found in the SVN at
seismic/BSC-ISI/H2/ITMY/Filters/Digitized/

- LHO_ISI_BSC8_Symmetrization_Filters_28-Jul-2011.txt

8. Design of the damping filters of stage 2

The damping filters are first designed on stage 2. The damping filters of stage 1 and stage 2 have the same poles and zeros. Only gains differ.

Here is the piece of code where to filters are defined:

```
L4C_GS13_Idealized_Model=zpk([0 0 0],-2*pi*[pair(1,45)],1);
Damping_Filters(ST2)=zpk(pole(L4C_GS13_Idealized_Model),-2*pi*[pair(0.1,55)],1);
Cut_Off_Filter([ST1 ST2])=zpk(-2*pi*[],-2*pi*[pair(30,65) pair(95,80)],1);
Damping_Filters(ST2)=Damping_Filters(ST2).*Cut_Off_Filter(ST2);
```

Only the gain is adjusted for every degree of freedom.

The data structure that contains the transfer functions of the damped ISI (by stage 2) can be found in the SVN:
seismic/BSC-ISI/H2/ITMY/Data/Transfer_Functions/Simulations/Damping/

- LHO_ISI_BSC8_TF_C2C_ST2_Damped_10mHz_1000Hz_2011_07_27.mat

The damping filters (continuous form) can be found in the SVN at:
seismic/BSC-ISI/H2/ITMY/Filters/Continuous/

- LHO_ISI_BSC8_Damping_Filters_2011_07_27.mat

The figures that show the effect of the damping on stage 1 when stage 2 is damped are located in the SVN at:
seismic/BSC-ISI/H2/ITMY/Data/Misc/

- LHO_ISI_BSC8_MIMO_ST2_Damping_ONLY_TF_ST1_L4C_RZ.fig
- LHO_ISI_BSC8_MIMO_ST2_Damping_ONLY_TF_ST1_L4C_Z.fig

The figures that show how the damping filters are tuned are located in the SVN
seismic/BSC-ISI/H2/ITMY/Data/Figures/Transfer_Functions/Simulations/Damping/

- LHO_ISI_BSC8_ST2_Damping_TF_SISO_ST2_ACT_RX_to_ST2_GS13_RX_2011_07_27.fig
- LHO_ISI_BSC8_ST2_Damping_TF_SISO_ST2_ACT_RY_to_ST2_GS13_RY_2011_07_27.fig
- LHO_ISI_BSC8_ST2_Damping_TF_SISO_ST2_ACT_RZ_to_ST2_GS13_RZ_2011_07_27.fig
- LHO_ISI_BSC8_ST2_Damping_TF_SISO_ST2_ACT_X_to_ST2_GS13_X_2011_07_27.fig
- LHO_ISI_BSC8_ST2_Damping_TF_SISO_ST2_ACT_Y_to_ST2_GS13_Y_2011_07_27.fig
- LHO_ISI_BSC8_ST2_Damping_TF_SISO_ST2_ACT_Z_to_ST2_GS13_Z_2011_07_27.fig

Note 1: Once stage 2 is damped, stage 1 is also damped due to the important mass of stage 2 in comparison with stage 1.

Note 2: The motion of stage 1 around 2.5Hz is amplified on the damping loops on stage 2 are implemented**.**

Note 3: Once the ISI is damped on stage 2, the effect of the damping filters of stage 1 will be almost negligible.

The two following figures present the SISO responses of the ISI when the damping loops are engaged on stage 1.

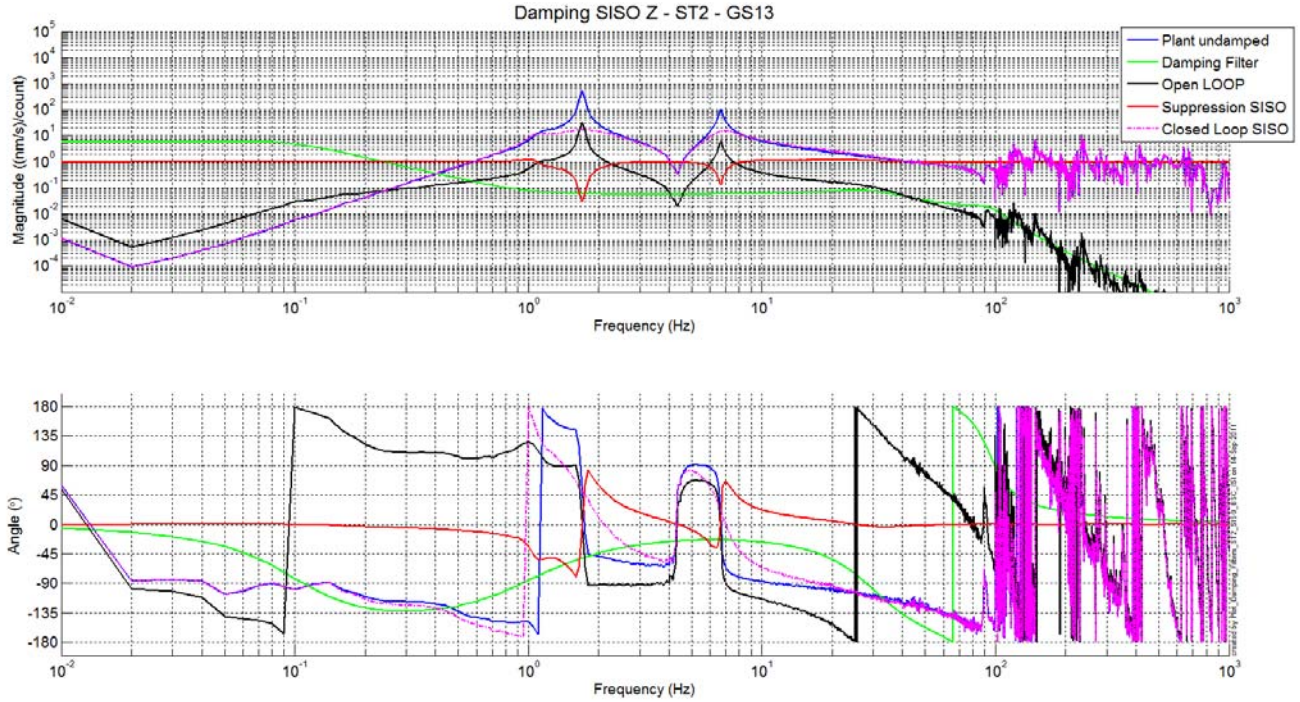


Figure 27 - Damping Loops Tuning - TF SISO ST2 ACT Z to ST2 GS13 Z

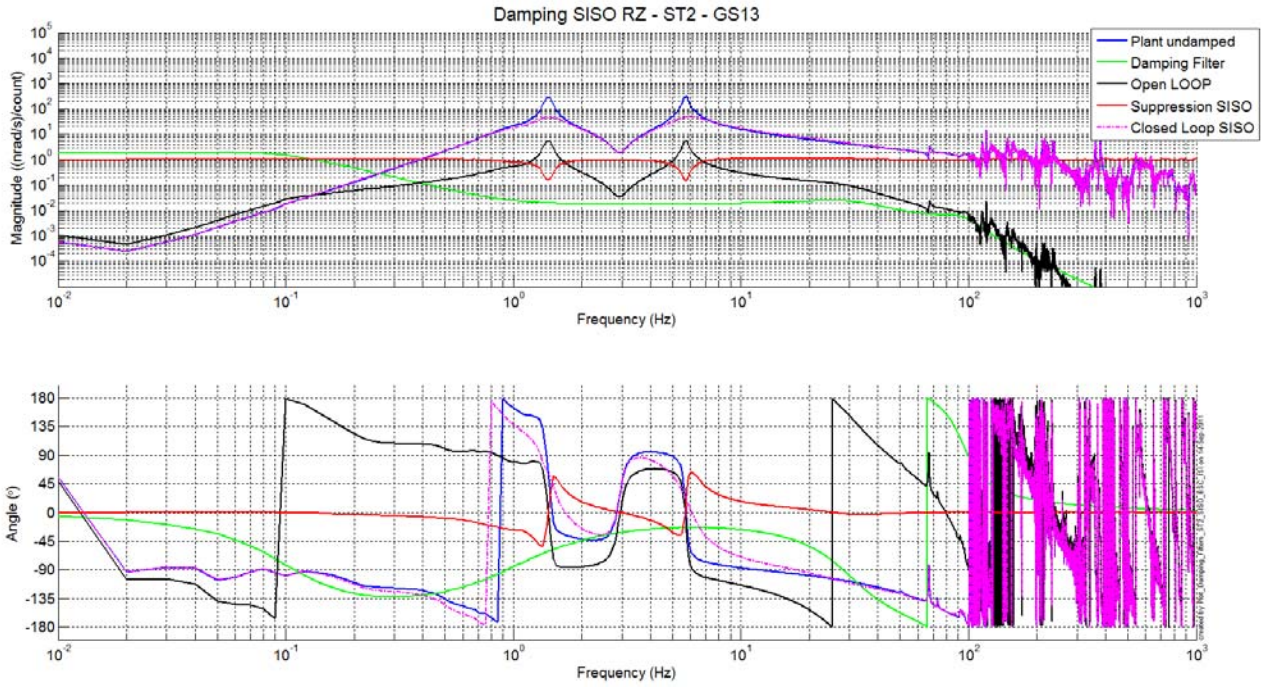


Figure 28 - Damping Loops Tuning - TF SISO ST2 ACT RZ to ST2 GS13 RZ

The two following figures present some transfer functions of the ISI on stage 1 when stage 2 is damped.

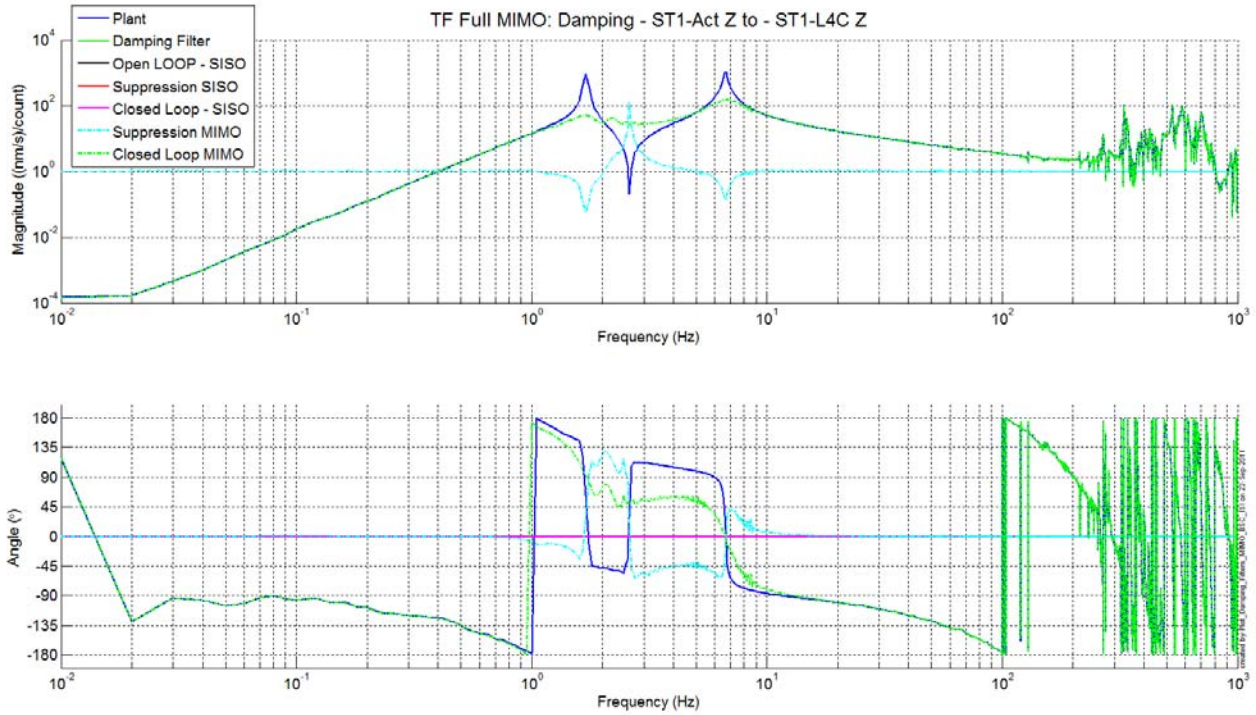


Figure 29 – Effect of stage 2 damping loops on stage 1 – MIMO transfer function - ST1 ACT Z to ST1 L4C Z

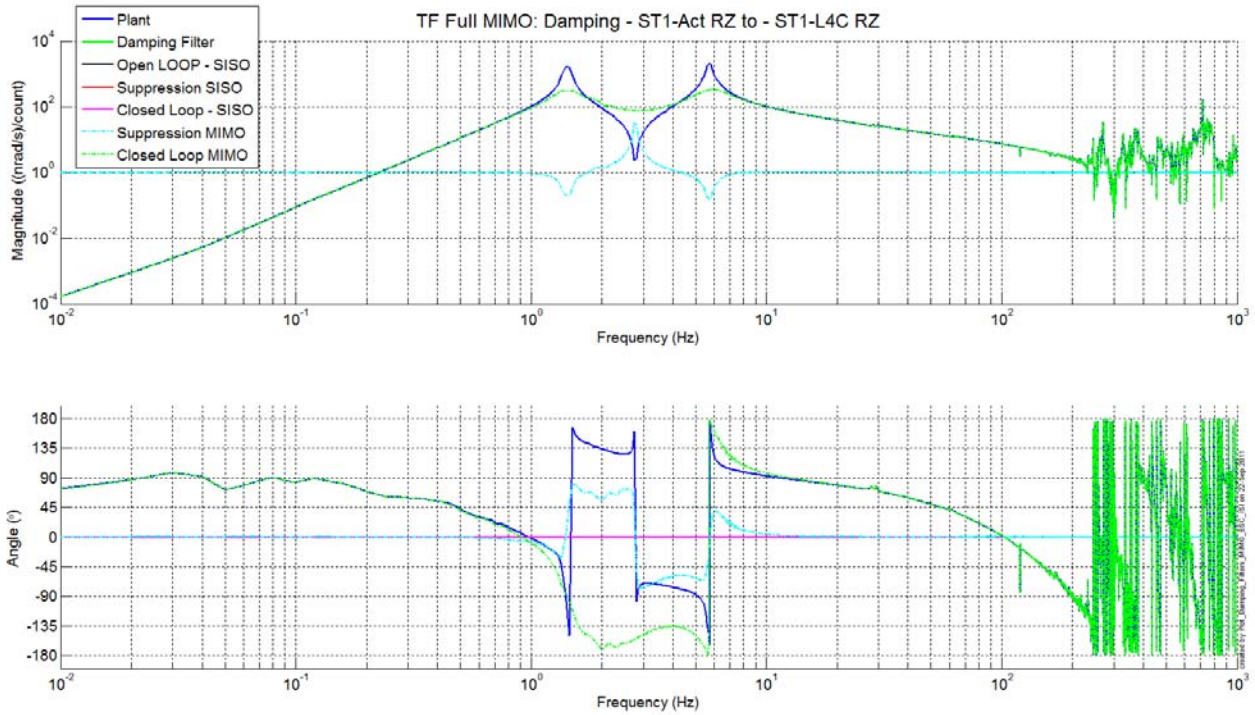


Figure 30 - Effect of stage 2 damping loops on stage 1 – MIMO transfer function - ST1 ACT RZ to ST1 L4C RZ

9. Design of the damping filters of stage 1

Once stage 2 is damped, stage 1 is also. The damping filters of stage 2 have a very light effect. The gain of the damping filters are calculated using the reconstructed transfer functions (with stage 2 damped).

The figures that show how the damping filters are tuned are located in the SVN seismic/BSC-ISI/H2/ITMY/Data/Figures/Transfer_Functions/Simulations/Damping/

- LHO_ISI_BSC8_ST1_ST2_Damping_TF_SISO_ST1_ACT_RX_to_ST1_GS13_RX_2011_07_27.fig
- LHO_ISI_BSC8_ST1_ST2_Damping_TF_SISO_ST1_ACT_RY_to_ST1_GS13_RY_2011_07_27.fig
- LHO_ISI_BSC8_ST1_ST2_Damping_TF_SISO_ST1_ACT_RZ_to_ST1_GS13_RZ_2011_07_27.fig
- LHO_ISI_BSC8_ST1_ST2_Damping_TF_SISO_ST1_ACT_X_to_ST1_GS13_X_2011_07_27.fig
- LHO_ISI_BSC8_ST1_ST2_Damping_TF_SISO_ST1_ACT_Y_to_ST1_GS13_Y_2011_07_27.fig
- LHO_ISI_BSC8_ST1_ST2_Damping_TF_SISO_ST1_ACT_Z_to_ST1_GS13_Z_2011_07_27.fig

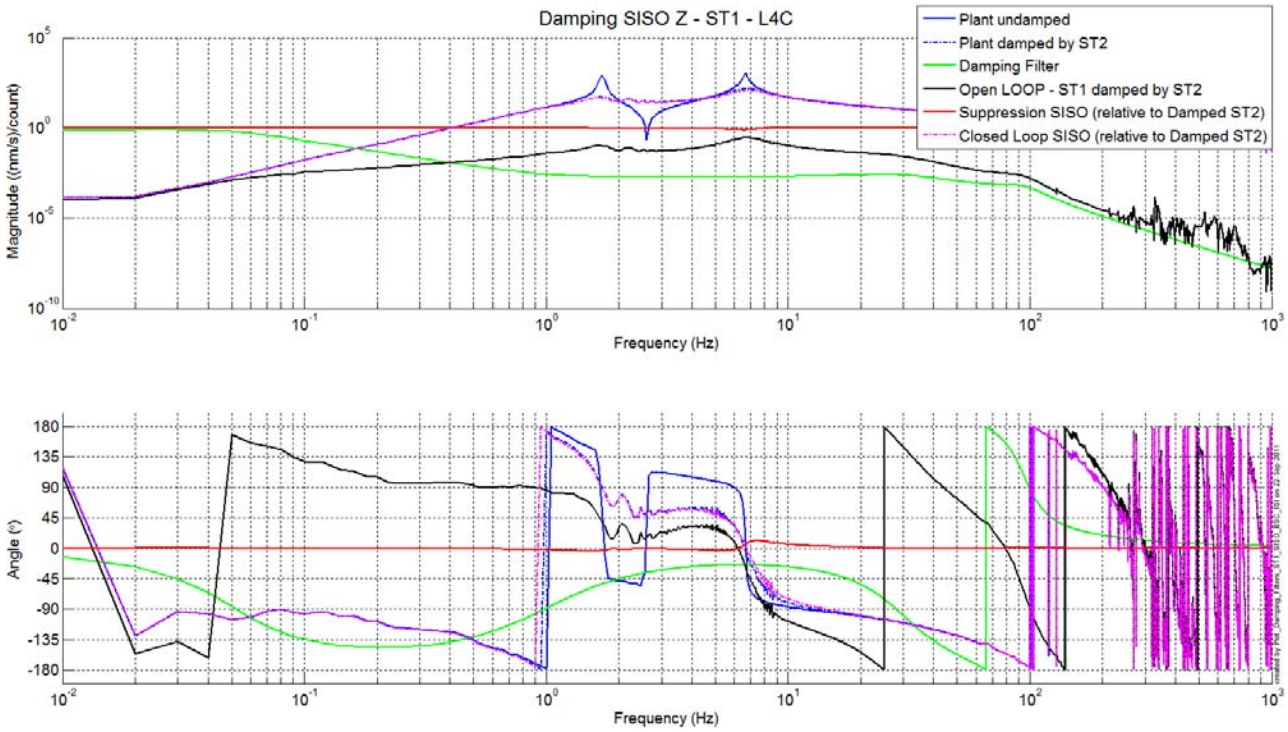


Figure 31 - Damping Loops Tuning - TF SISO ST1 ACT Z to ST1 L4C Z

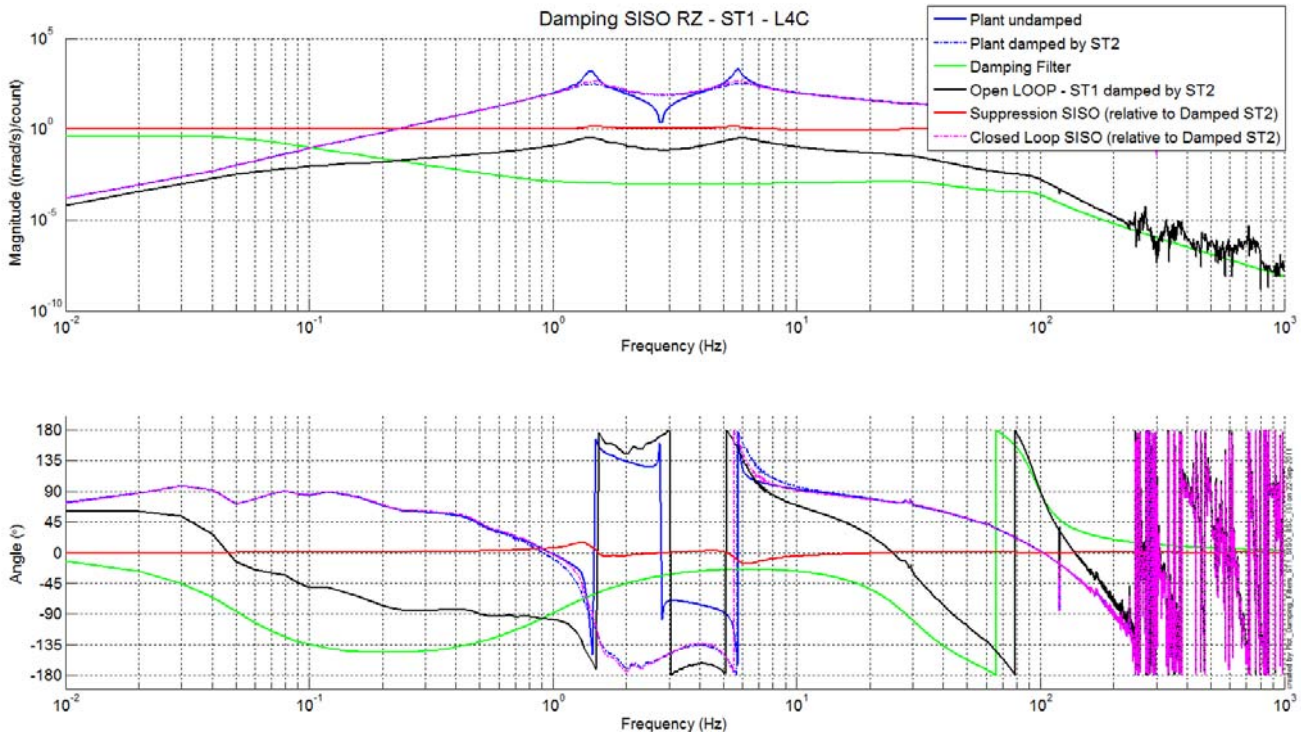


Figure 32 - Damping Loops Tuning - TF SISO ST1 ACT RZ to ST1 L4C RZ

The figure below presents the effect of the damping filters of stage 1 on stage 1 when stage 2 is not damped

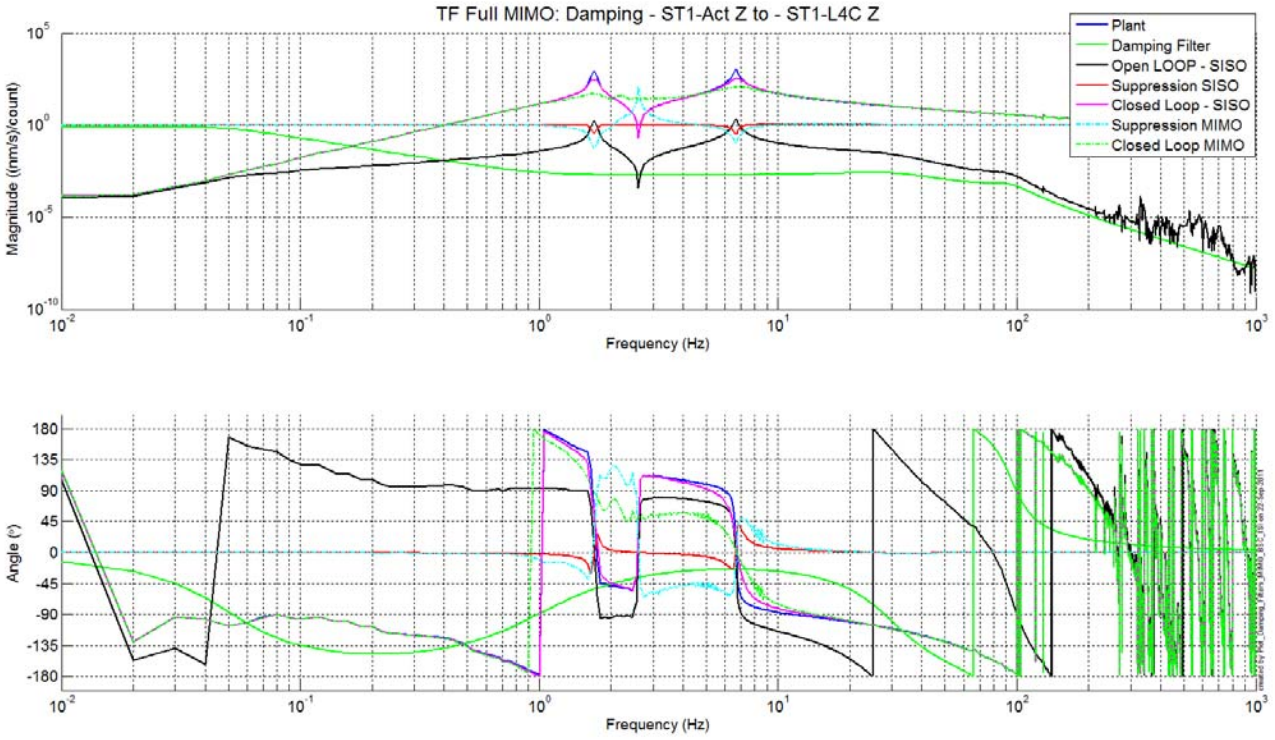


Figure 33 - MIMO transfer function – ST1 ACT Z to ST1 L4C Z – Damping both stages

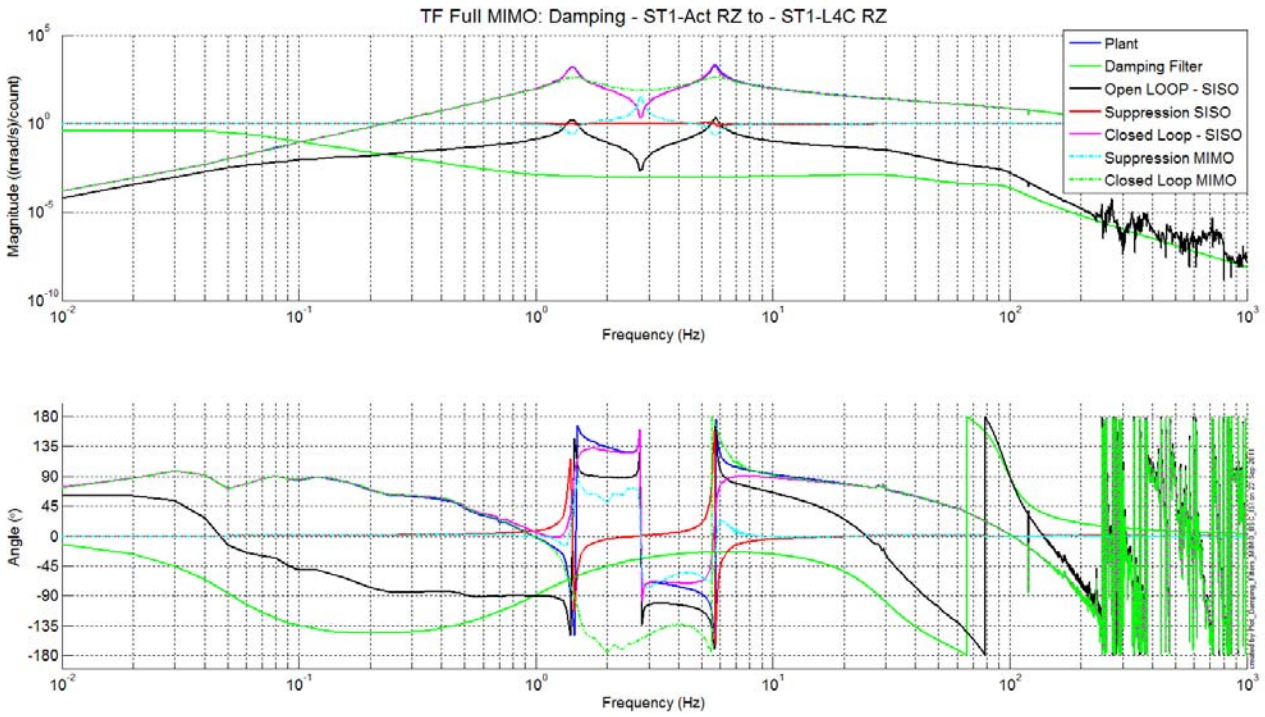


Figure 34 - MIMO transfer function – ST1 ACT RZ to ST1 L4C RZ – Damping both stages

The symmetrized and damped transfer functions (MIMO response) in the Cartesian basis are saved in a data structure located in the SVN at:
seismic/BSC-ISI/H2/ITMY/Data/Transfer_Functions/Simulations/Damping/

- LHO_ISI_BSC8_TF_C2C_Damped_ST1_ST2_10mHz_1000Hz_2011_07_27.mat

10. Digitalization of the damping filters

The digitized damping filters are saved in the SVN at:
seismic/BSC-ISI/H2/ITMY/Filters/Digitized/

- LHO_ISI_BSC8_Damping_Filters_28-Jul-2011.txt

11. ASD with Damping loops closed

The figures of the damped ISI ASD are located in the SVN at:
seismic/BSC-ISI/H2/ITMY/Data/Figures/Spectra/Damping/

- LHO_ISI_BSC8_Powerspectra_CT_ST1_L4C_Undamped_Damped_2011_07_29.fig
- LHO_ISI_BSC8_Powerspectra_CT_ST2_GS13_Undamped_Damped_2011_07_29.fig
- LHO_ISI_BSC8_Powerspectra_m_ST1_L4C_Undamped_Damped_2011_07_29.fig
- LHO_ISI_BSC8_Powerspectra_m_ST2_GS13_Undamped_Damped_2011_07_29.fig

The calibrated ASD data are located in the SVN at:
seismic/BSC-ISI/H2/ITMY/Data/Spectra/Damping/

- LHO_ISI_BSC8_Calibrated_PSD_L4C_GS13_Undamped_Damped_2011_07_29.mat

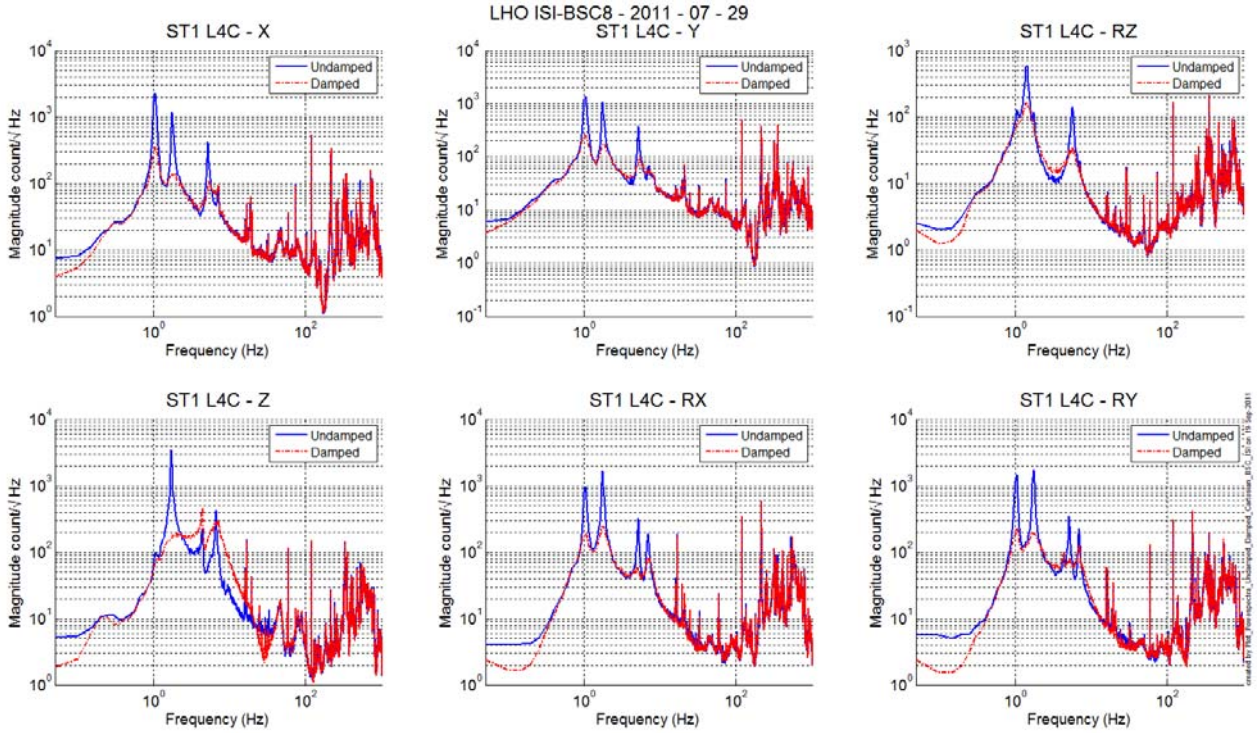


Figure 35 - ASD ST1 L4C - ST1 & ST2 Damped

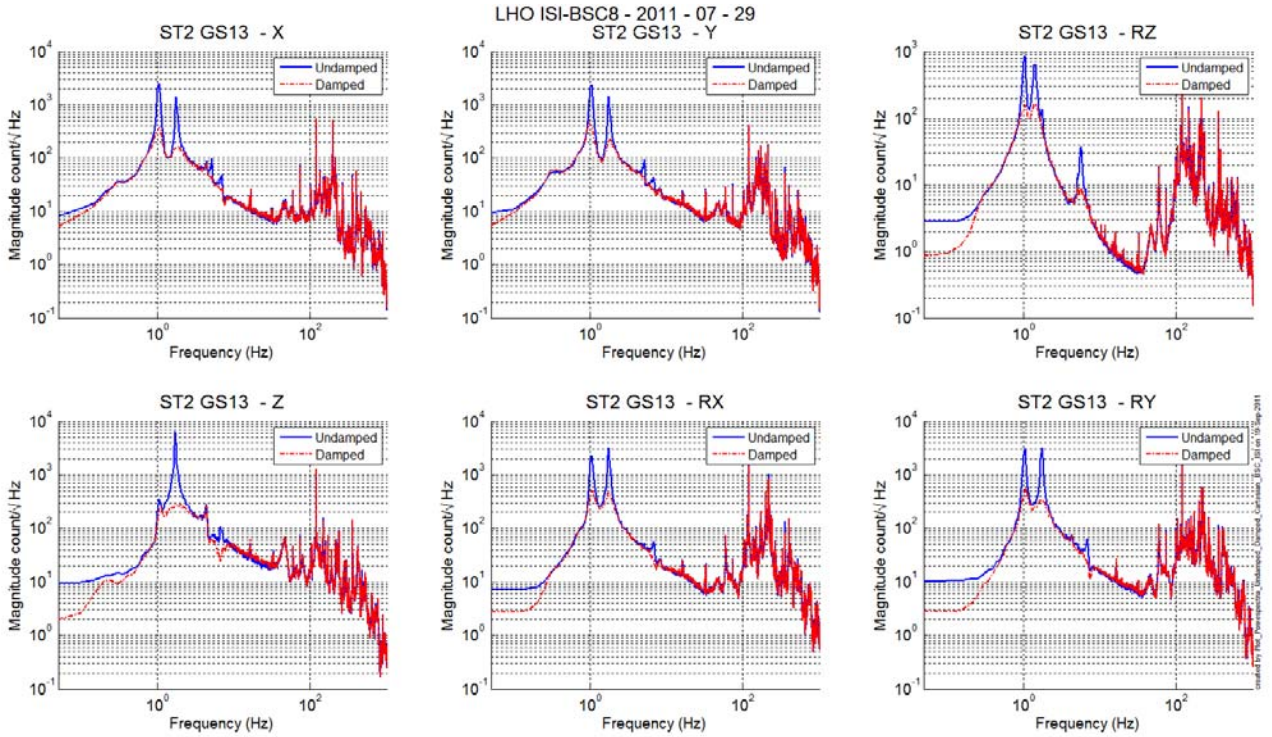


Figure 36 - ASD ST2 GS13 - ST1 & ST2 Damped

12. Blending CPS and Geophones signals - Super Sensors

For this quick implementation of the isolation loops, basic complementary filters are used.
The complementary filters used for the blend are located in the SVN at:
seismic/BSC-ISI/Common/Complementary_Filters_BSC_ISI/aLIGO/

- aLIGO_Complementary_Filters_BSC_ISI.mat

A blend frequency of 750mHz was chosen for this test.

The figure that shows the fitting of the Cartesian to Cartesian transfer functions can be found in the SVN at:
seismic/BSC-ISI/H2/ITMY/Data/Misc/

- LHO_ISI_BSC8_Fitting_TF_C2C.fig

The continuous form of the blend filters can be found in the SVN at:
seismic/BSC-ISI/H2/ITMY/Filters/Continuous/

- LHO_ISI_BSC8_Blend_Filters_2011_07_27.mat

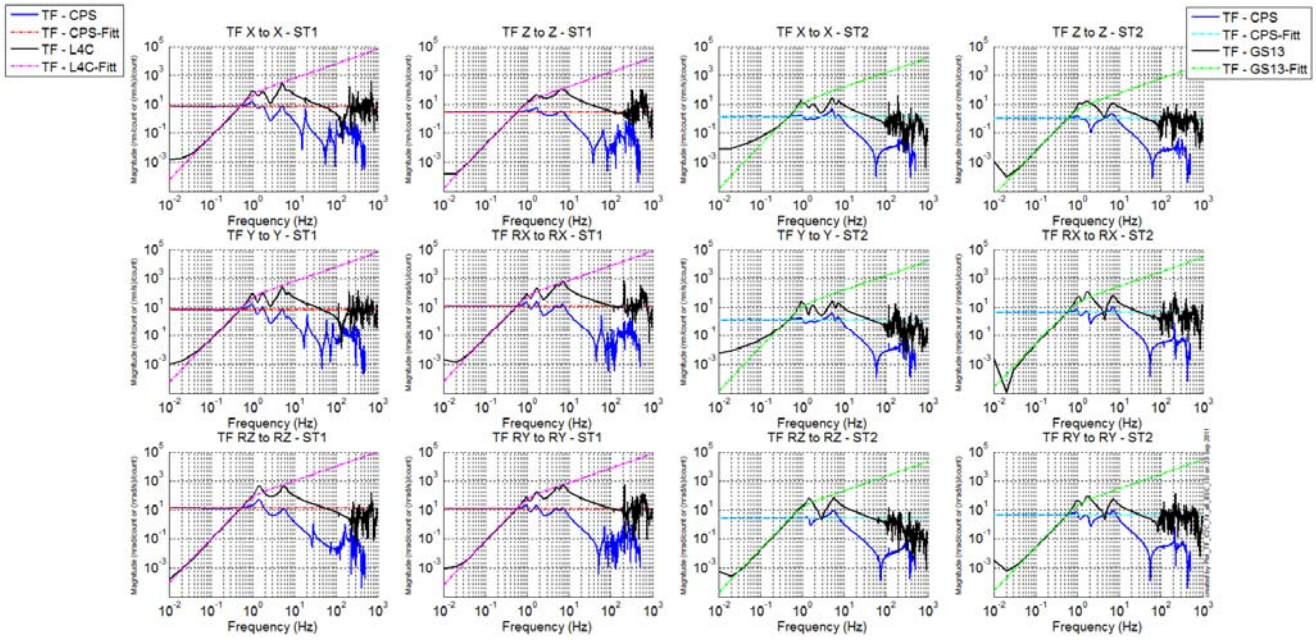


Figure 37 - Automatic curve fitting - ST1 & ST2 CPS - ST1 L4C & ST2 GS13

The two figures below show the contribution of the CPS and the geophones in the super sensors responses. These figures can be found in the SVN at:
seismic/BSC-ISI/H2/ITMY/Data/Figures/Transfer_Functions/Simulations/Super_Sensors/

- LHO_ISI_BSC8_Super_Sensor_SISO_ST1_Z_Blend_Freq_0.75Hz.fig
- LHO_ISI_BSC8_Super_Sensor_SISO_ST2_RZ_Blend_Freq_0.75Hz.fig

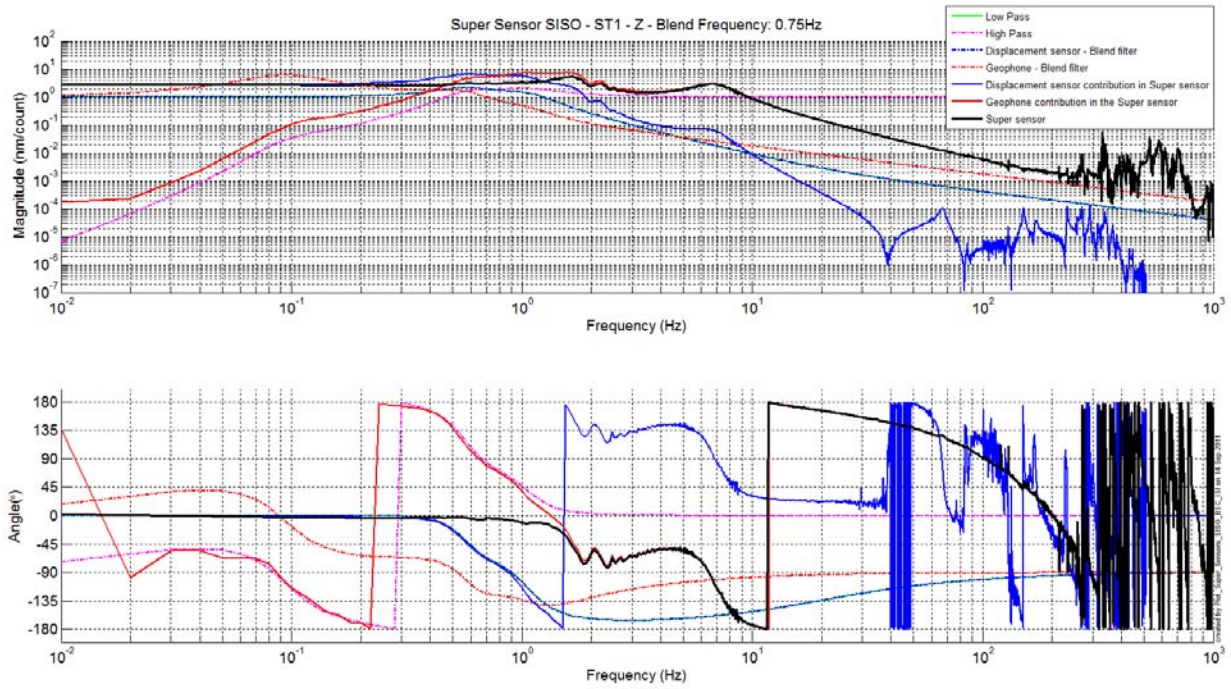


Figure 38 – Transfer function from ST1 ACT Z to ST1 Super sensors Z

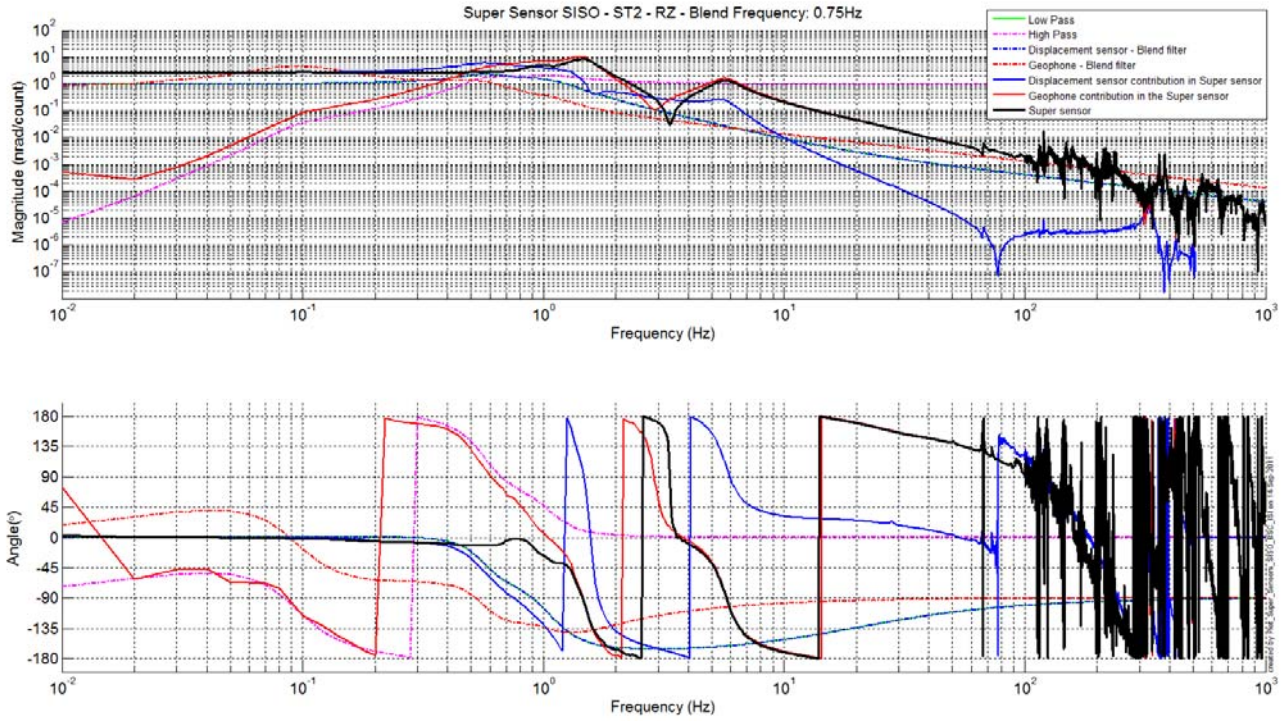


Figure 39 – Transfer function from ST2 ACT RZ to ST2 Super sensor RZ

Note: The blend filters used during this test are very basic. They will need to be reworked.

13. Digitalization of the Blend filters

The digitized blend filters are located in the SVN at:
seismic/BSC-ISI/H2/ITMY/Filters/Digitized/

- LHO_ISI_BSC8_Blend_Filters_04-Aug-2011.txt

14. Isolation filters – Stage 1 – Z – RX – RY

The isolation filters are designed in 4 steps. Between each of these steps, the MIMO response of the ISI is calculated. Then the MIMO response is used to design the next batch of isolation filters. The design steps are the followings:

1- Stage 1 – Z – RX – RY
2- Stage 2 – Z – RX – RY
3- Stage 1 – X – Y – RZ
4- Stage 2 – X – Y – RZ

All isolation filters have been tuned respecting the following criteria:

- UUG=15Hz
- Phase margin>45 degree
- Gain margin > 20dB

This first set of isolation filters (continuous form) are stored in the SVN at:
seismic/BSC-ISI/H2/ITMY/Filters/Continuous/

- LHO_ISI_BSC8_Isolation_Filters_ST1_V_2011_07_27.mat

The figures that show the tuning of the stage 1 – Z – RX – RY isolation filters are located in the SVN:
seismic/BSC-ISI/H2/ITMY/Data/Figures/Transfer_Functions/Simulations/Isolation/

- LHO_ISI_BSC8_Isolation_Loops_TF_SISO_ST1_ACT_Z_to_ST1_SS_Z_2011_07_27.fig
- LHO_ISI_BSC8_Isolation_Loops_TF_SISO_ST1_ACT_RX_to_ST1_SS_RX_2011_07_27.fig
- LHO_ISI_BSC8_Isolation_Loops_TF_SISO_ST1_ACT_RY_to_ST1_SS_RY_2011_07_27.fig

An example is given with the Super sensor on stage 1.

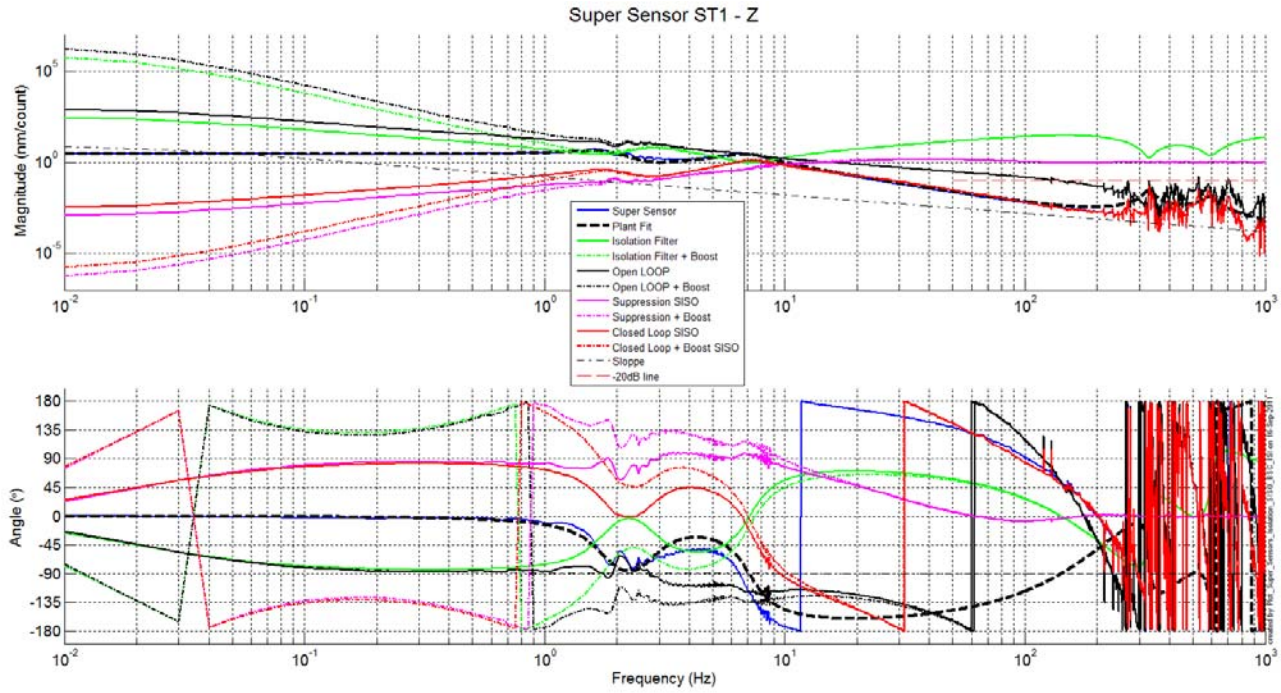


Figure 40 – Transfer function from ST1 ACT Z to Super sensor ST1 – Z - SISO - Isolation filter

15. Isolation filters – Stage 2 – Z – RX - RY

These two first set of isolation filters (continuous form) are stored in the SVN at:
seismic/BSC-ISI/H2/ITMY/Filters/Continuous/

- LHO_ISI_BSC8_Isolation_Filters_ST1_ST2_V_2011_07_27.mat

The figures that show the tuning of the stage 2 – Z – RX – RY isolation filters are located in the SVN:
seismic/BSC-ISI/H2/ITMY/Data/Figures/Transfer_Functions/Simulations/Isolation/

- LHO_ISI_BSC8_Isolation_Loops_TF_SISO_ST2_ACT_Z_to_ST1_SS_Z_2011_07_27.fig
- LHO_ISI_BSC8_Isolation_Loops_TF_SISO_ST2_ACT_RX_to_ST1_SS_RX_2011_07_27.fig
- LHO_ISI_BSC8_Isolation_Loops_TF_SISO_ST2_ACT_RY_to_ST1_SS_RY_2011_07_27.fig

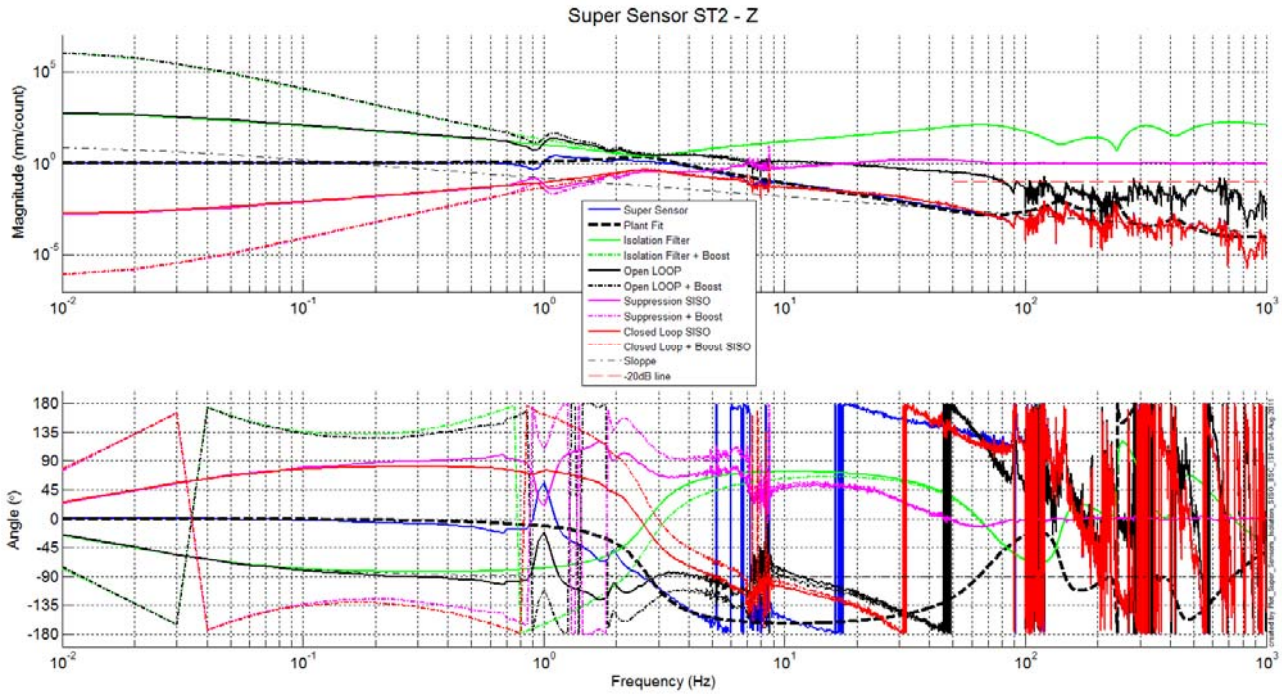


Figure 41 - Transfer function from ST2 ACT Z to Super sensor ST2 –Z - SISO - Isolation filter

16. Isolation filters – Stage 1 – X – Y - RZ

These three first set of isolation filters (continuous form) are stored in the SVN at:
seismic/BSC-ISI/H2/ITMY/Filters/Continuous/

- LHO_ISI_BSC8_Isolation_Filters_ST1_ST2_V_ST1_H_2011_07_27.mat

The figures that show the tuning of the stage 2 – X – Y – RZ isolation filters are located in the SVN:
seismic/BSC-ISI/H2/ITMY/Data/Figures/Transfer_Functions/Simulations/Isolation/

- LHO_ISI_BSC8_Isolation_Loops_TF_SISO_ST1_ACT_X_to_ST1_SS_X_2011_07_27.fig
- LHO_ISI_BSC8_Isolation_Loops_TF_SISO_ST1_ACT_Y_to_ST1_SS_Y_2011_07_27.fig
- LHO_ISI_BSC8_Isolation_Loops_TF_SISO_ST1_ACT_RZ_to_ST1_SS_RZ_2011_07_27.fig

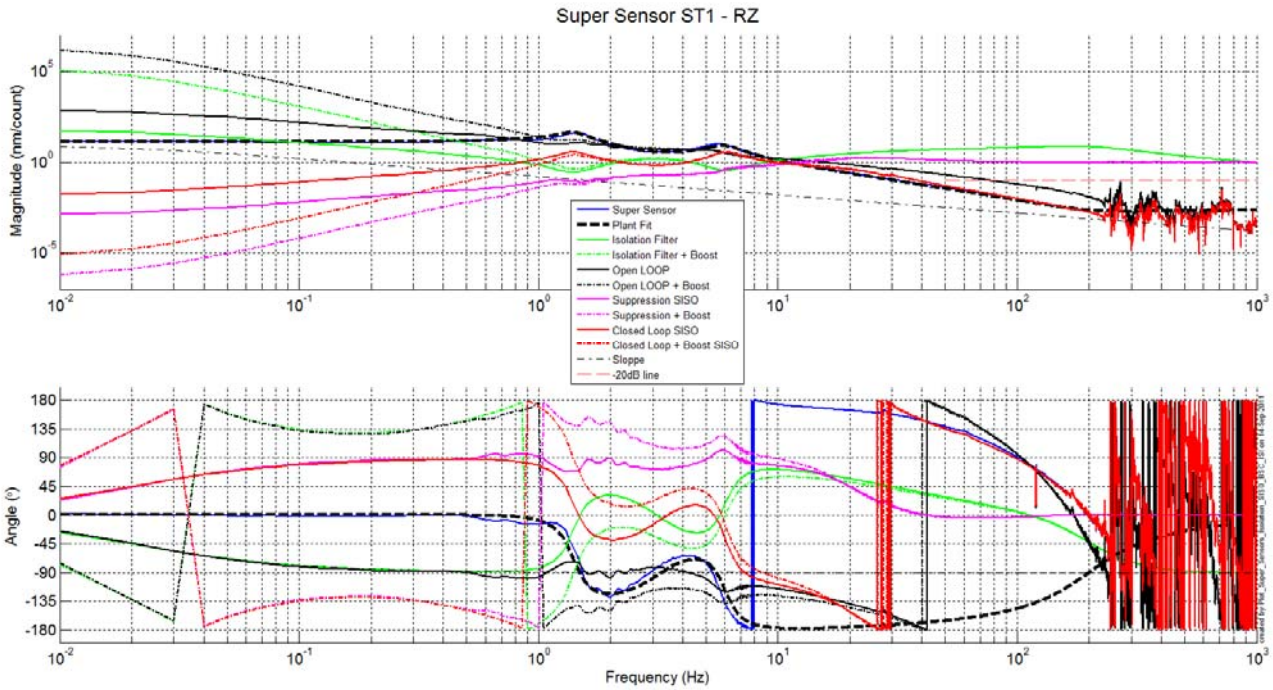


Figure 42 - Super sensor ST1 – RZ - SISO - Isolation filter

17. Isolation filters – Stage 2 –X – Y - RZ

The isolation filters (continuous form) are stored in the SVN at:
seismic/BSC-ISI/H2/ITMY/Filters/Continuous/

- LHO_ISI_BSC8_Isolation_Filters_ST1_ST2_V_ST1_ST2_H_2011_07_27.mat

The figures that show the tuning of the stage 2 – X – Y – RZ isolation filters are located in the SVN:
seismic/BSC-ISI/H2/ITMY/Data/Figures/Transfer_Functions/Simulations/Isolation/

- LHO_ISI_BSC8_Isolation_Loops_TF_SISO_ST2_ACT_X_to_ST1_SS_X_2011_07_27.fig
- LHO_ISI_BSC8_Isolation_Loops_TF_SISO_ST2_ACT_Y_to_ST1_SS_Y_2011_07_27.fig
- LHO_ISI_BSC8_Isolation_Loops_TF_SISO_ST2_ACT_RZ_to_ST1_SS_RZ_2011_07_27.fig

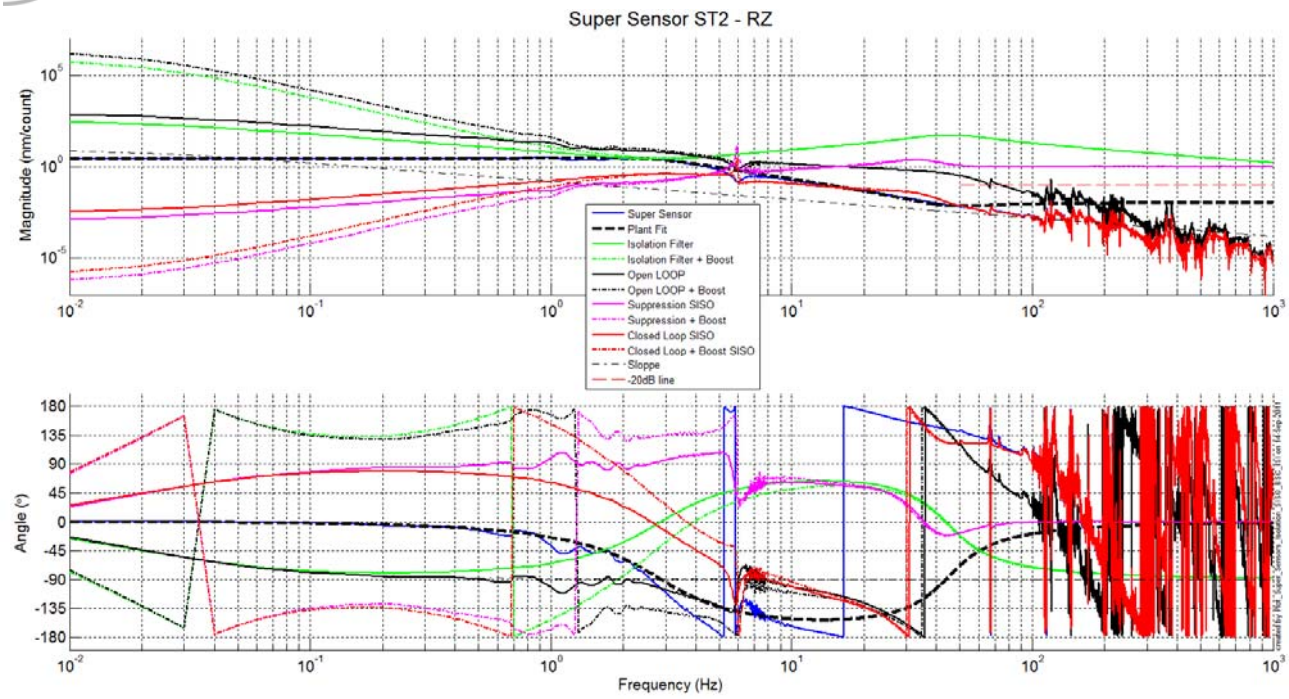


Figure 43 - Super sensor ST2 – RZ - SISO - Isolation filter

Once damping and isolation filters are implemented, the MIMO response is calculated.

The transfer functions (figures) can be found in the SVN at:
seismic/BSC-ISI/H2/ITMY/Data/Figures/Transfer_Functions/Simulations/Isolation/

- LHO_ISI_BSC8_Isolation_Loops_TF_MIMO_ST1_ACT_RX_to_ST1_L4C_RX_2011_07_27.fig
- LHO_ISI_BSC8_Isolation_Loops_TF_MIMO_ST1_ACT_RY_to_ST1_L4C_RY_2011_07_27.fig
- LHO_ISI_BSC8_Isolation_Loops_TF_MIMO_ST1_ACT_RZ_to_ST1_L4C_RZ_2011_07_27.fig
- LHO_ISI_BSC8_Isolation_Loops_TF_MIMO_ST1_ACT_X_to_ST1_L4C_X_2011_07_27.fig
- LHO_ISI_BSC8_Isolation_Loops_TF_MIMO_ST1_ACT_Y_to_ST1_L4C_Y_2011_07_27.fig
- LHO_ISI_BSC8_Isolation_Loops_TF_MIMO_ST1_ACT_Z_to_ST1_L4C_Z_2011_07_27.fig
- LHO_ISI_BSC8_Isolation_Loops_TF_MIMO_ST2_ACT_RX_to_ST2_GS13_RX_2011_07_27.fig
- LHO_ISI_BSC8_Isolation_Loops_TF_MIMO_ST2_ACT_RY_to_ST2_GS13_RY_2011_07_27.fig
- LHO_ISI_BSC8_Isolation_Loops_TF_MIMO_ST2_ACT_RZ_to_ST2_GS13_RZ_2011_07_27.fig
- LHO_ISI_BSC8_Isolation_Loops_TF_MIMO_ST2_ACT_X_to_ST2_GS13_X_2011_07_27.fig
- LHO_ISI_BSC8_Isolation_Loops_TF_MIMO_ST2_ACT_Y_to_ST2_GS13_Y_2011_07_27.fig
- LHO_ISI_BSC8_Isolation_Loops_TF_MIMO_ST2_ACT_Z_to_ST2_GS13_Z_2011_07_27.fig

The transfer functions hereinafter show how the BSC-ISI is affected by the implementation of the isolation filters.

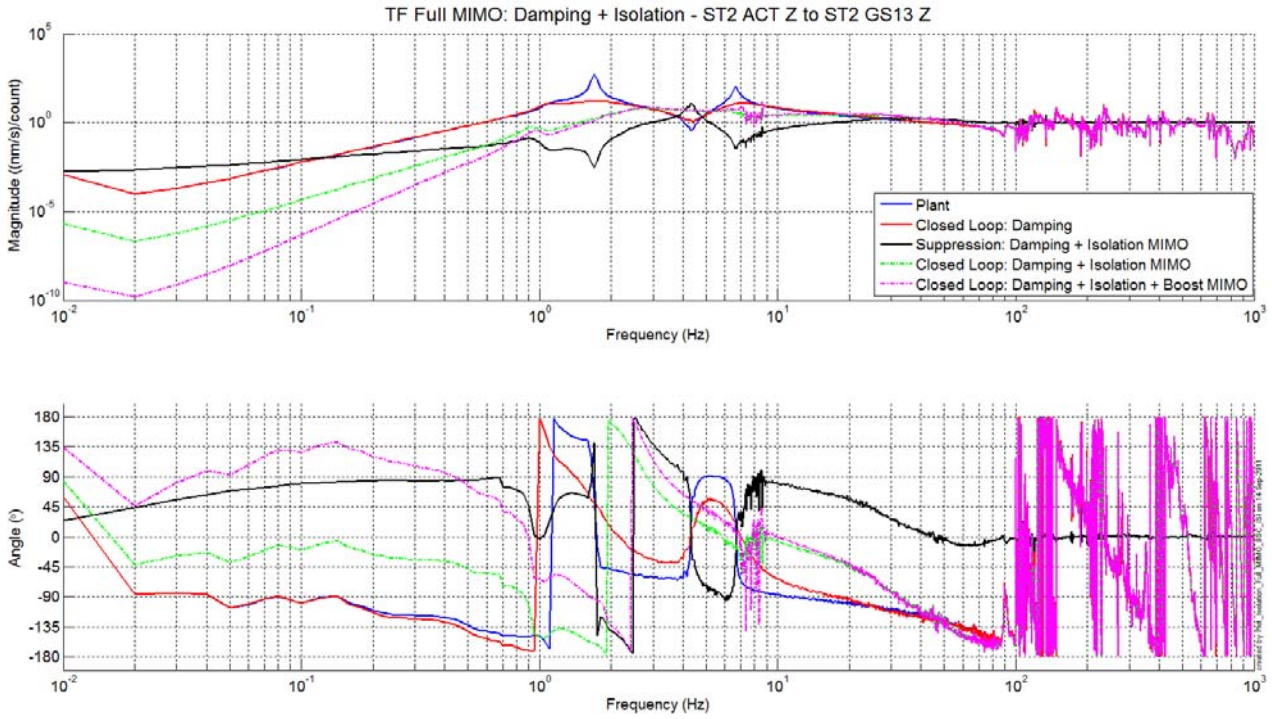


Figure 44 - Transfer functions ST2 ACT Z to ST2 GS13 Z - Damping & Isolation on ST1 & ST2

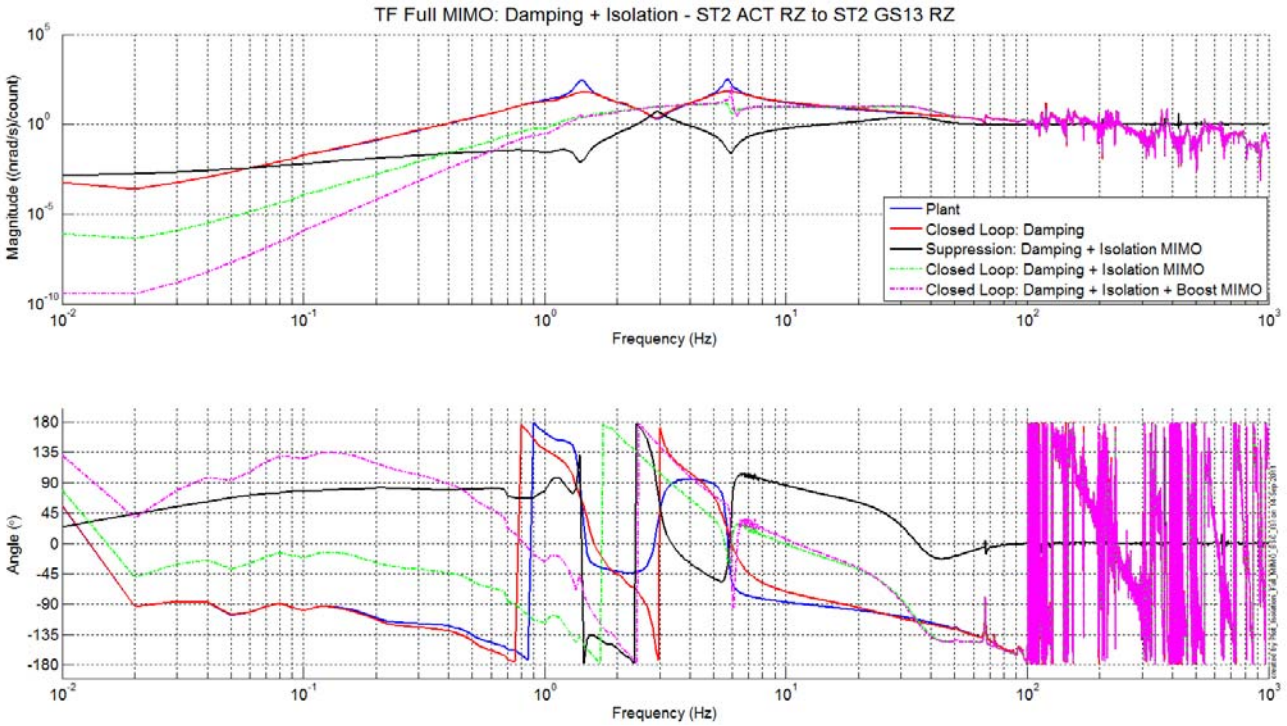


Figure 45 - Transfer functions ST2 ACT RZ to ST2 GS13 Z - Damping & Isolation on ST1 & ST2

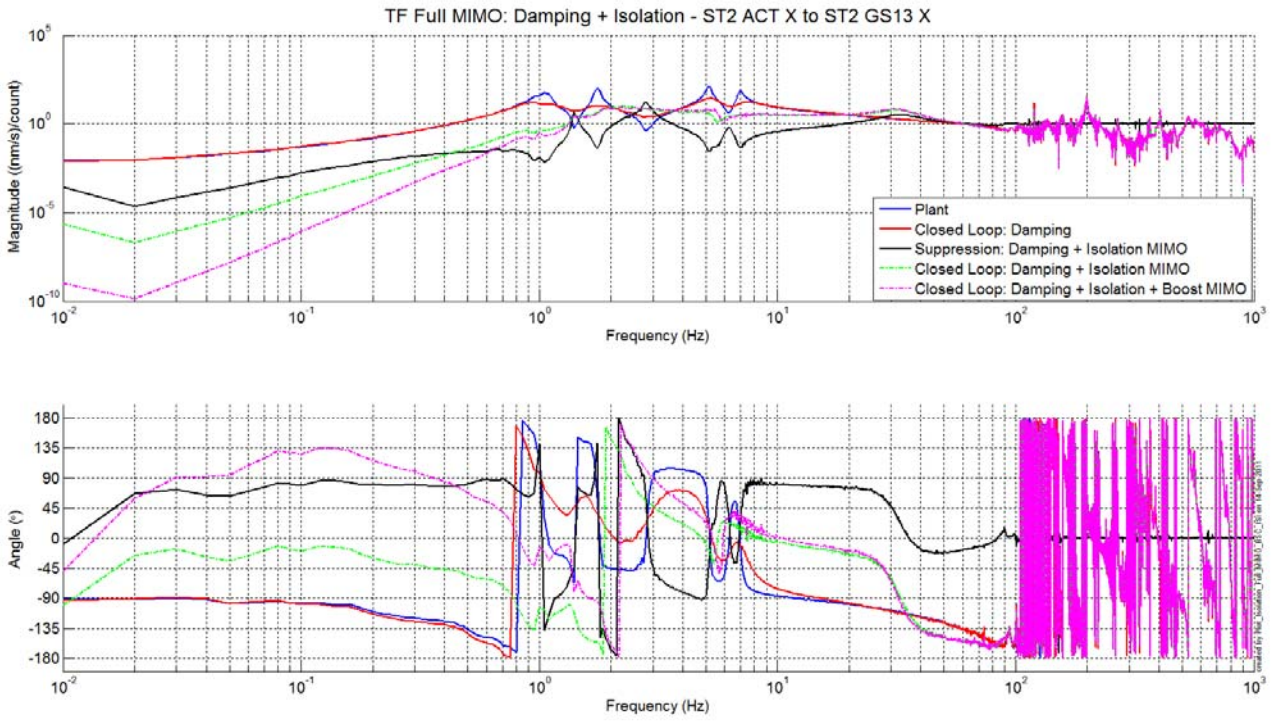


Figure 46 - Transfer functions - ST2 ACT X to ST2 GS13 X - Damping & Isolation on ST1 & ST2

18. Open loop check

This step enables to check the importance of the order of implementation of the isolation filters. It computes open loops when isolation filters are engaged in three different configurations:

- When the damping loops are engaged (first) and no other isolation filter is engaged
- Plant in the state used to design the isolation filters
- When all other filters are engaged

The figures “Open loop check” can be found in the SVN at seismic/BSC-ISI/H2/ITMY/Data/Figures/Transfer_Functions/Simulations/Open_Loop_Check/

- LHO_ISI_BSC8_Open_Loop_ST1_X_Y_RZ_2011_07_27.fig
- LHO_ISI_BSC8_Open_Loop_ST1_Z_RX_RY_2011_07_27.fig
- LHO_ISI_BSC8_Open_Loop_ST2_X_Y_RZ_2011_07_27.fig
- LHO_ISI_BSC8_Open_Loop_ST2_Z_RX_RY_2011_07_27.fig

The following figure shows an example with the stage 2 vertical isolation filters. These filters are designed in second (after stage 1 vertical isolation filters). It is clearly shown that the filters would be instable if there were engaged before isolation stage 1 vertically (blue curve).

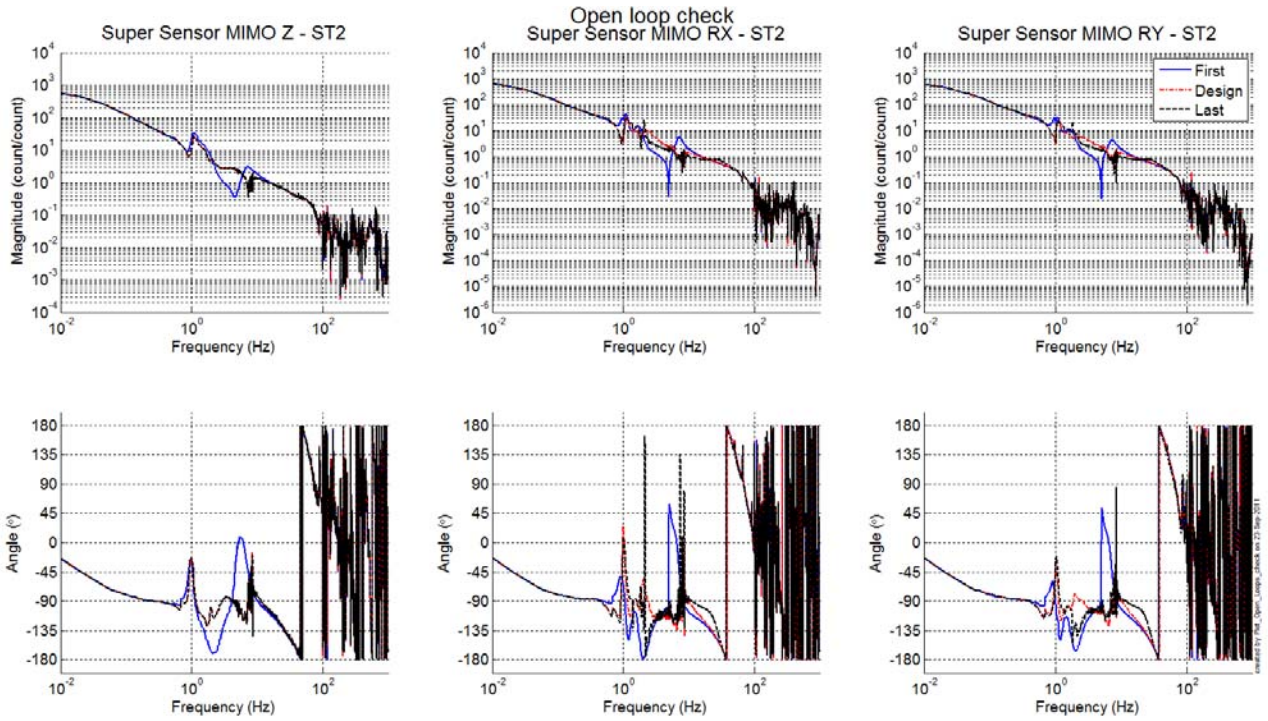


Figure 47 - Open look check - ST2 Vertical Isolation filters

19. Digitalization of the isolation filters

The digitized isolation filters can be found in the SVN.
seismic/BSC-ISI/H2/ITMY/Filters/Digitized/

- LHO_ISI_BSC8_Isolation_Filters_ST1_ST2_V_ST1_ST2_H_04-Aug-2011.txt

20. ASD of the isolated ISI

Once the isolation filters were engaged, some ASD were measured. **These measurements were realized in a clean room with the fans turned on.**

The figures of the ASD can be found in the SVN at:
seismic/BSC-ISI/H2/ITMY/Data/Figures/Spectra/Isolation/

- LHO_ISI_BSC8_Powerspectra_CT_ST1_L4C_Undamped_Isolated_FULL_2011_08_05.fig
- LHO_ISI_BSC8_Powerspectra_CT_ST2_GS13_Undamped_Isolated_FULL_2011_08_05.fig

The ASD are saved in a data structure and can be found in the SVN at:
seismic/BSC-ISI/H2/ITMY/Data/Spectra/Isolation/

- LHO_ISI_BSC8_Calibrated_PSD_L4C_GS13_Damped_Isolated_ST1_ST2_2011_08_05.mat

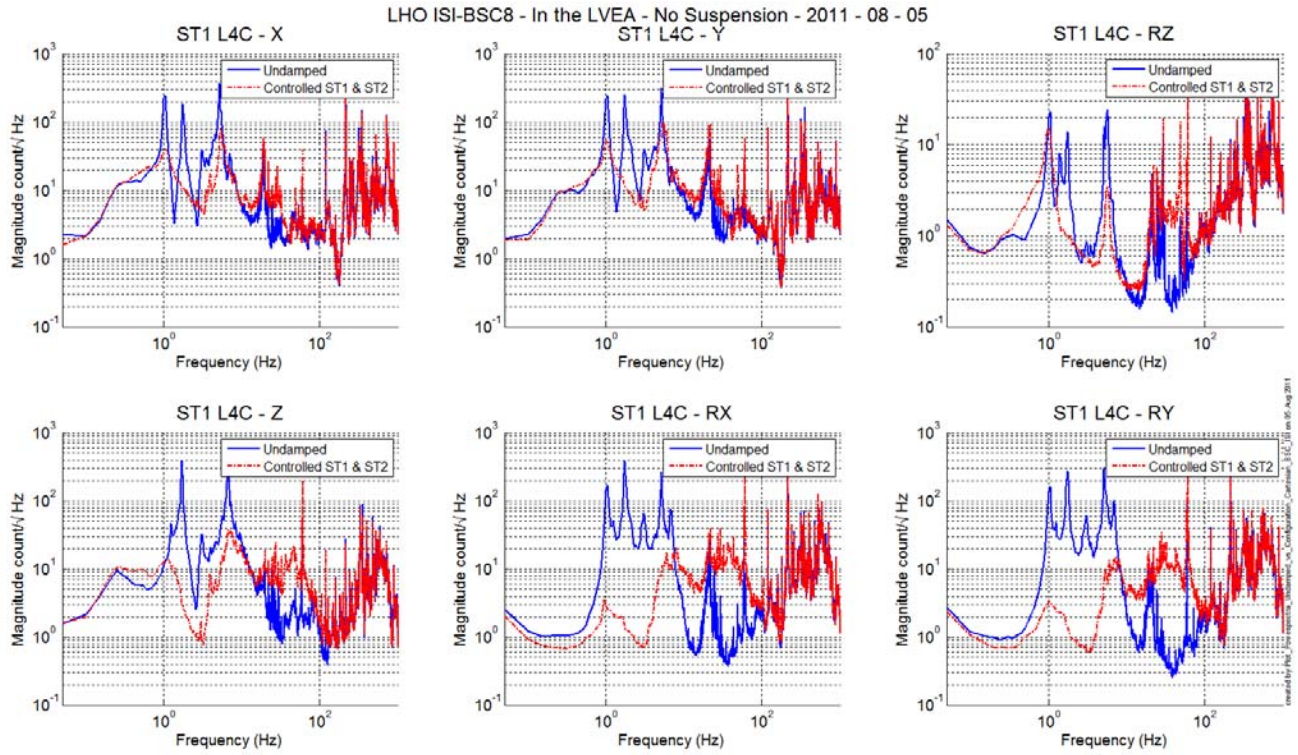


Figure 48 – ASD ST1 L4C - Damped + Isolated (ST1 & ST2)

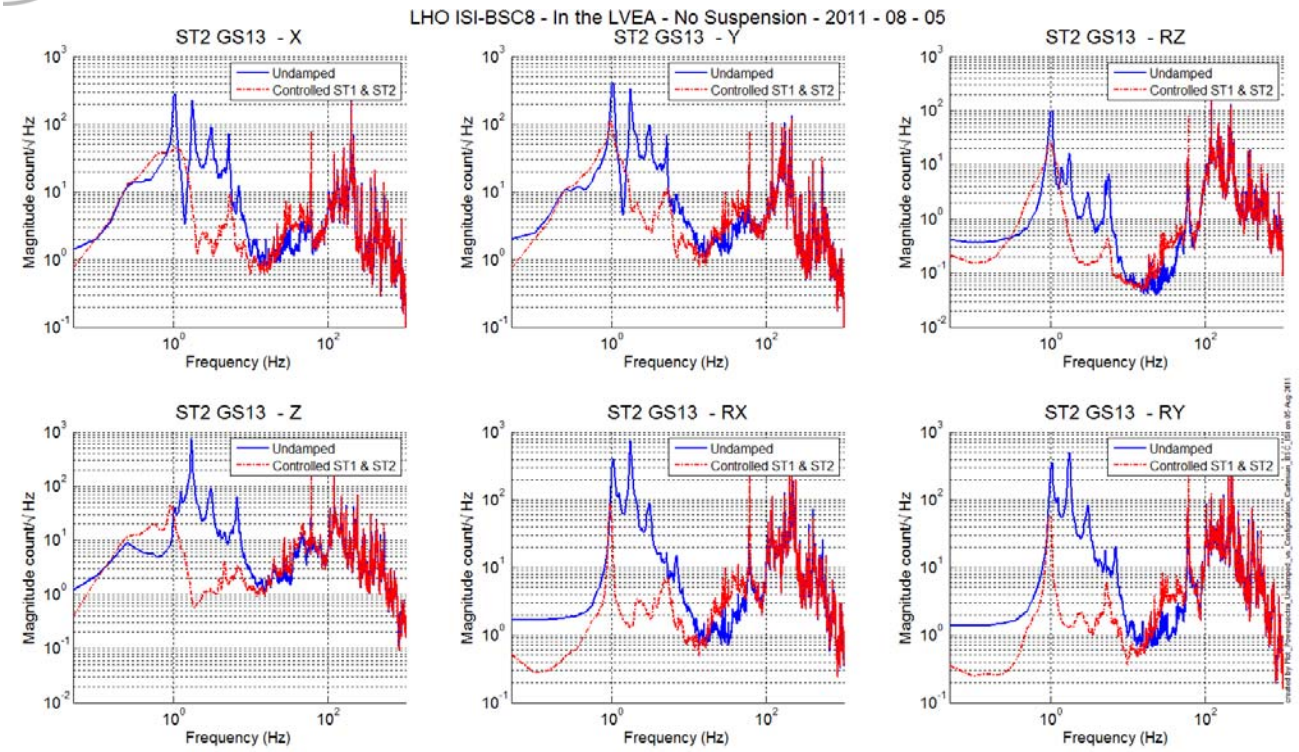


Figure 49 - ASD ST2 GS13 - Damped + Isolated (ST1 & ST2)

Note: The measurements are realized in a clean room with the fans turned on. It mainly explains why the performances are not good.

5. Test with the QUAD (ITMY) and without FMY

The QUAD (dummy test mass) was hung under the ISI on August 17, 2011. Some measurements were done on August 31, 2011.

The segmented transfer functions are located in the SVN at
seismic/BSC-ISI/H2/ITMY/Data/Transfer_Functions/Measurements/Undamped/

- LHO_ISI_BSC8_Data_L2L_1Hz_10Hz_ST1_ST2_20110901-044859.mat
- LHO_ISI_BSC8_Data_L2L_10Hz_100Hz_ST1_ST2_20110901-021159.mat
- LHO_ISI_BSC8_Data_L2L_100Hz_500Hz_ST1_ST2_20110831-215702.mat
- LHO_ISI_BSC8_Data_L2L_500Hz_1000Hz_ST1_ST2_20110831-183234.mat

The transfer functions are concatenated in one data tructure located in the SVN at:
seismic/BSC-ISI/H2/ITMY/Data/Transfer_Functions/Simulations/Undamped/

- LHO_ISI_BSC8_TF_L2L_Raw_10mHz_1000Hz_2011_08_31.mat

The figures that show the transfer functions with the QUAD are located in the SVN.
seismic/BSC-ISI/H2/ITMY/Data/Figures/Transfer_Functions/Measurements/Comparison/

- LHO_ISI_BSC8_Comparison_TF_L2L_ST1_ACT_H_to_ST1_CPS_H_20110722_vs_20110831.fig
- LHO_ISI_BSC8_Comparison_TF_L2L_ST1_ACT_H_to_ST1_L4C_H_20110722_vs_20110831.fig
- LHO_ISI_BSC8_Comparison_TF_L2L_ST1_ACT_V_to_ST1_CPS_V_20110722_vs_20110831.fig
- LHO_ISI_BSC8_Comparison_TF_L2L_ST1_ACT_V_to_ST1_L4C_V_20110722_vs_20110831.fig
- LHO_ISI_BSC8_Comparison_TF_L2L_ST2_ACT_H_to_ST2_CPS_H_20110722_vs_20110831.fig
- LHO_ISI_BSC8_Comparison_TF_L2L_ST2_ACT_H_to_ST2_GS13_H_20110722_vs_20110831.fig
- LHO_ISI_BSC8_Comparison_TF_L2L_ST2_ACT_V_to_ST2_CPS_V_20110722_vs_20110831.fig
- LHO_ISI_BSC8_Comparison_TF_L2L_ST2_ACT_V_to_ST2_GS13_V_20110722_vs_20110831.fig

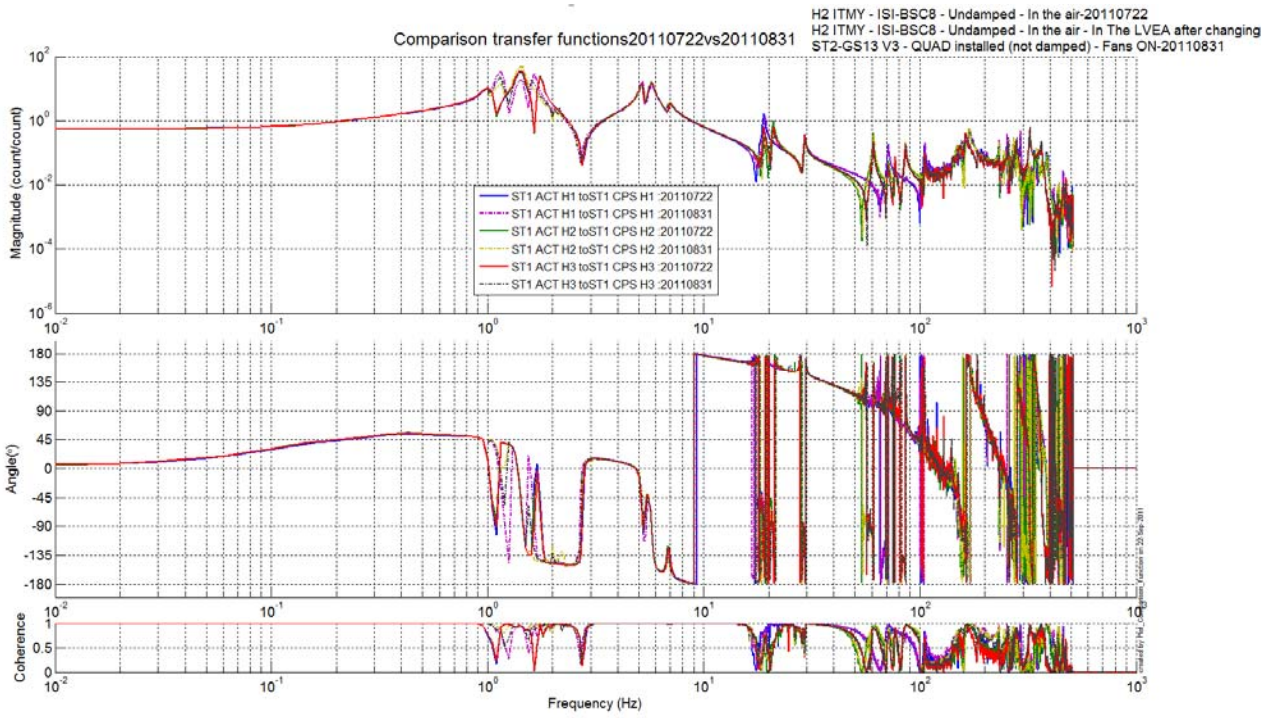


Figure 50 - Transfer function comparison - ISI with/without QUAD - TF ST1 ACT H to ST1 CPS H

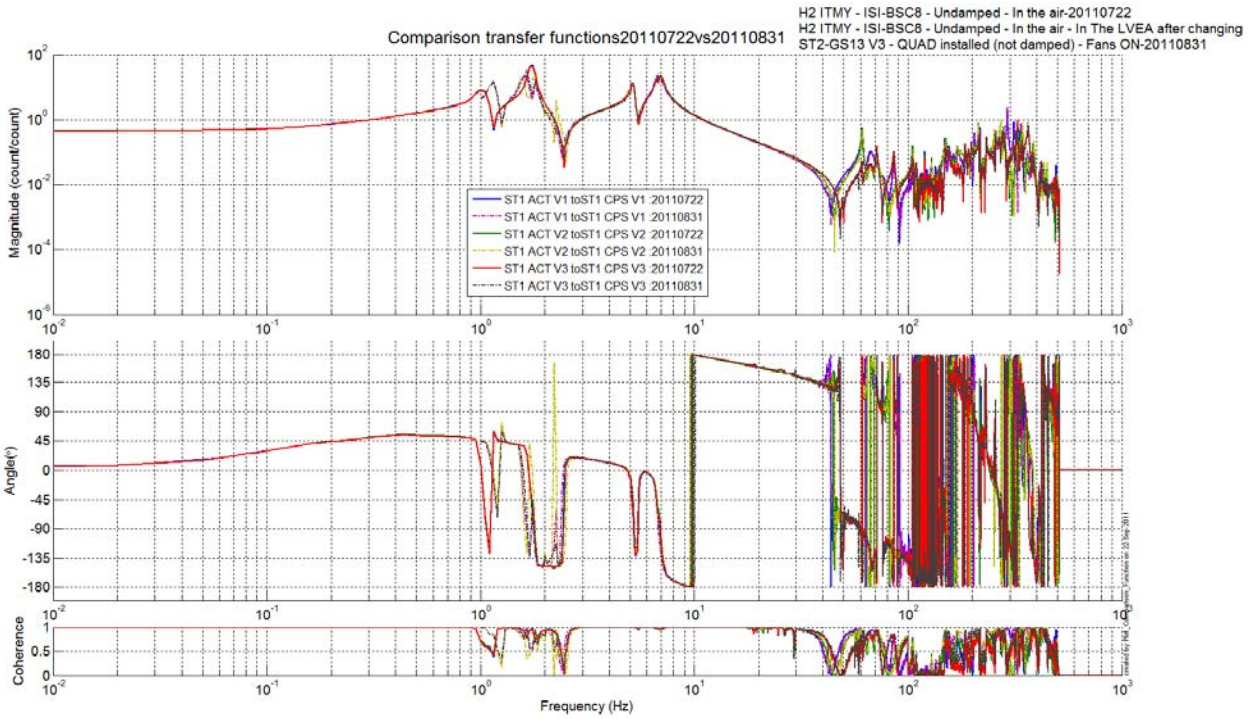


Figure 51 - Transfer function comparison - ISI with/without QUAD - TF ST1 ACT V to ST1 CPS V

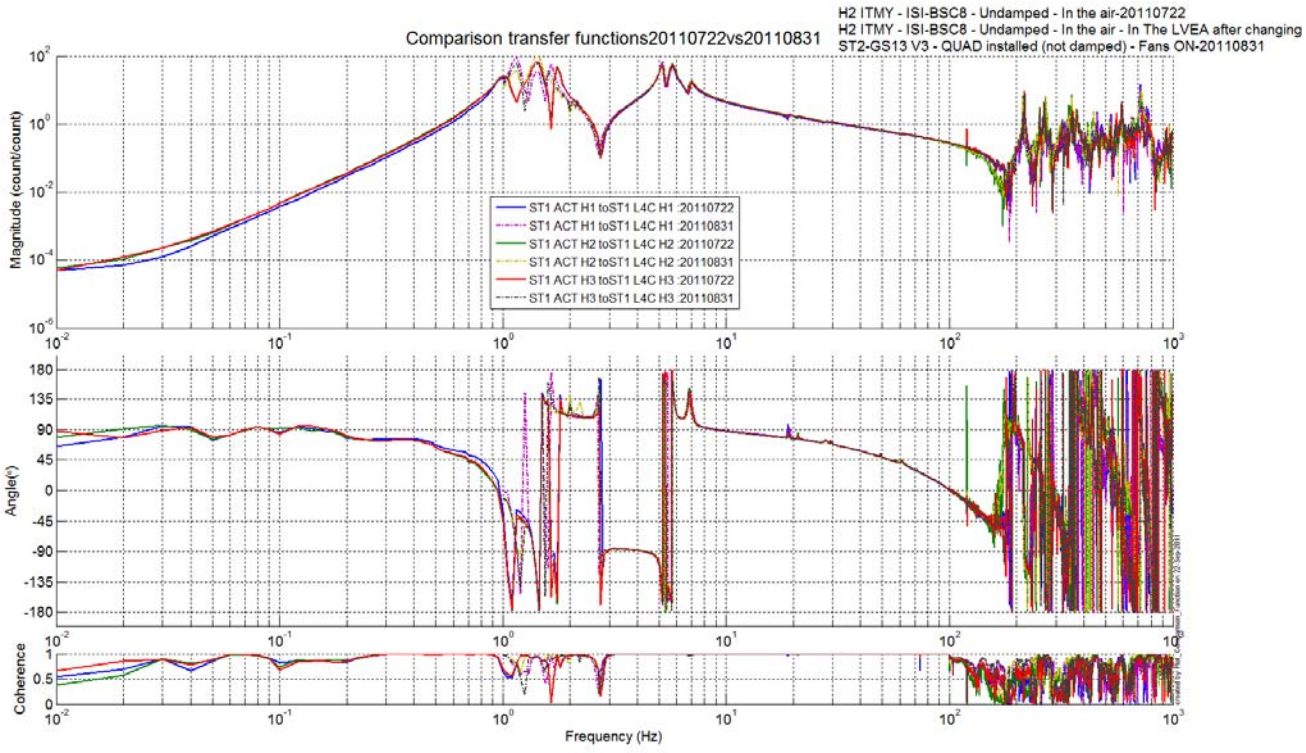


Figure 52 - Transfer function comparison - ISI with/without QUAD - TF ST1 ACT H to ST1 L4C H

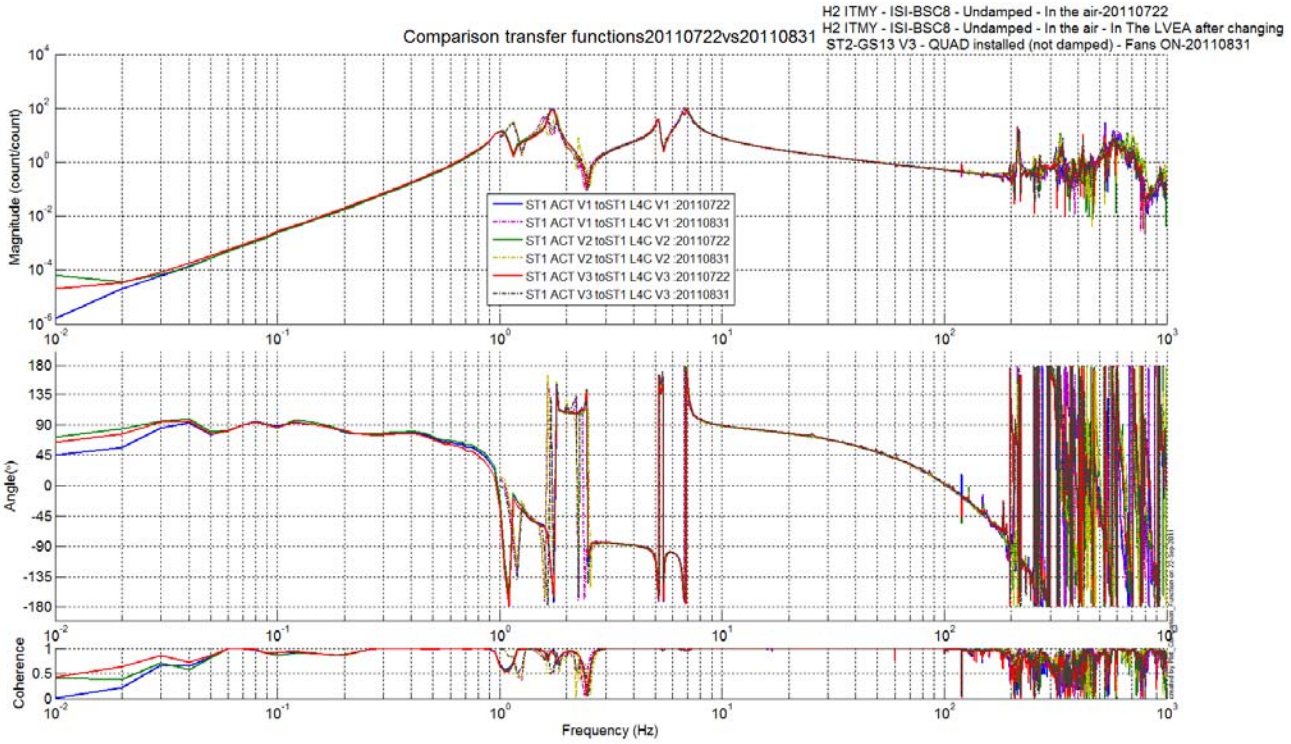


Figure 53 - Transfer function comparison - ISI with/without QUAD - TF ST1 ACT V to ST1 L4C V

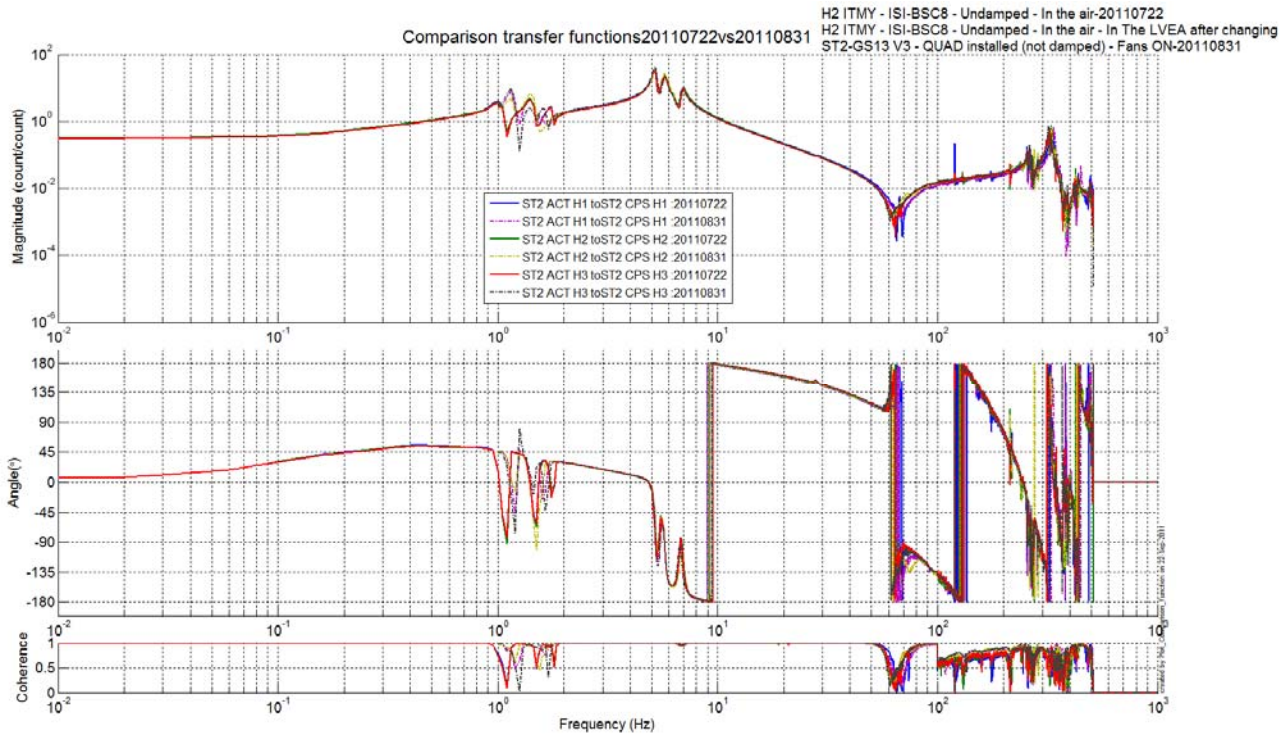


Figure 54 - Transfer function comparison - ISI with/without QUAD - TF ST2 ACT H to ST2 CPS H

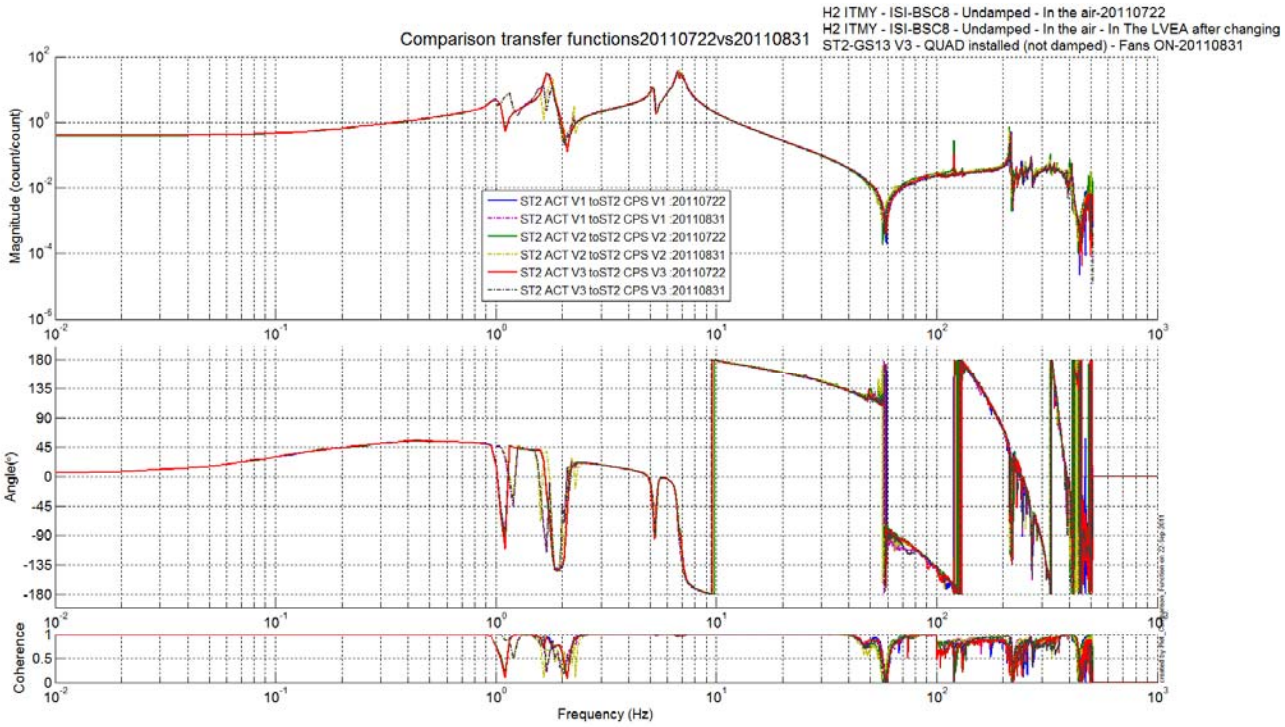


Figure 55 - Transfer function comparison - ISI with/without QUAD - TF ST2 ACT V to ST2 CPS V

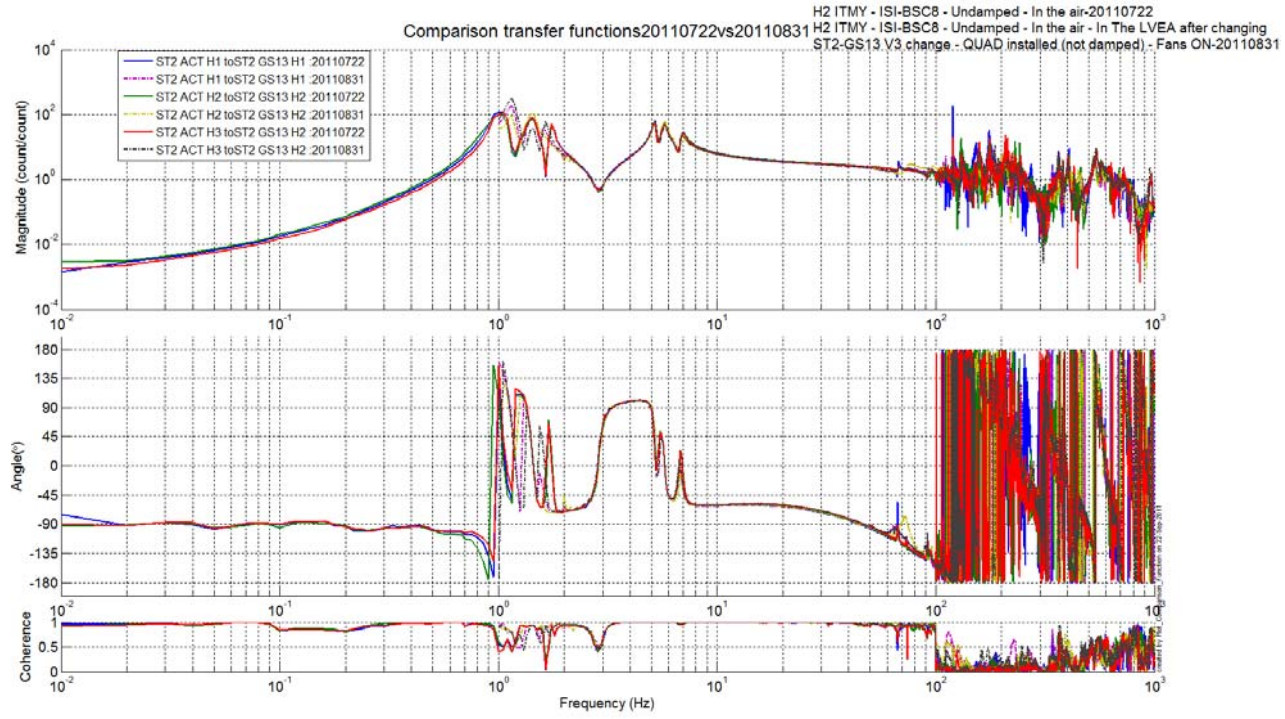
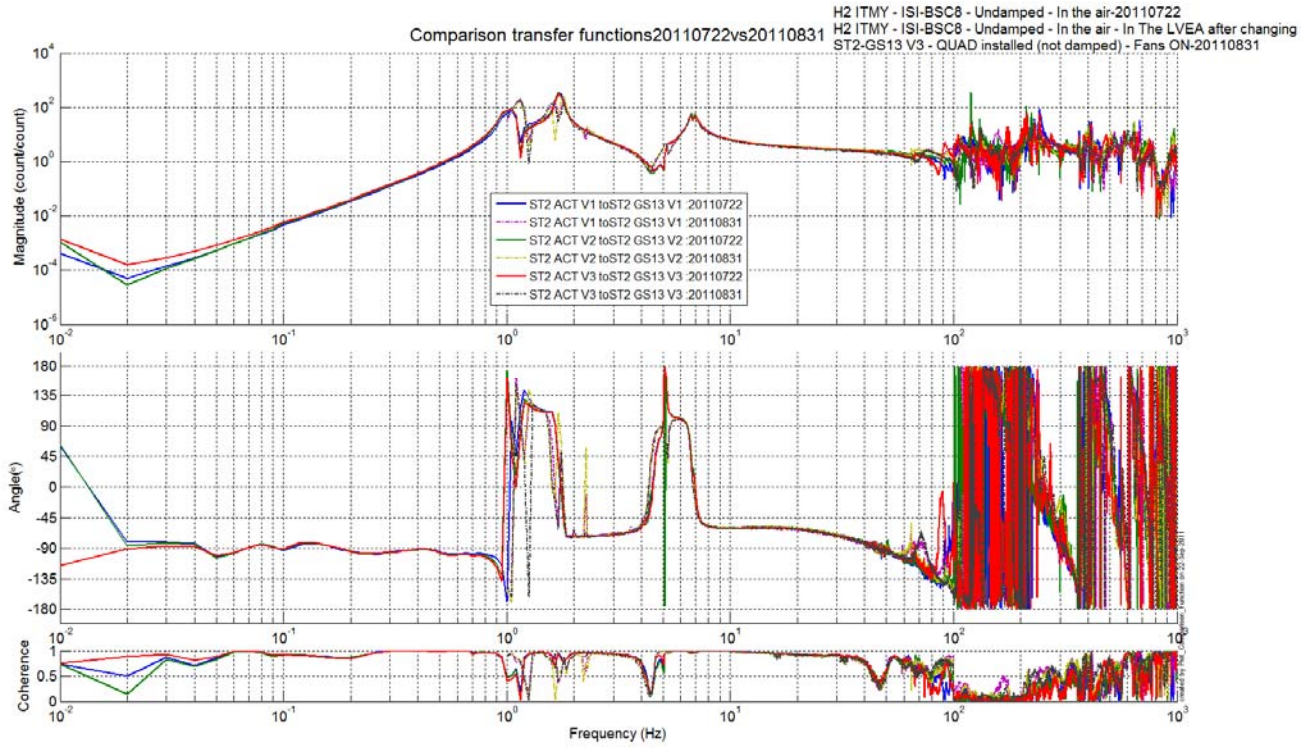


Figure 56 – Transfer function comparison - ISI with/without QUAD - TF ST2 ACT H to ST2 CPS H



6. Test with the QUAD (ITMY) and FMY before cartridge install

1. Instrument changes

After the incident on Tuesday October 18, 2011 (aLOG 1587), testing activities were stopped on BSC8 for few weeks. While SUS were welding fibers on the QUAD, Seismic swapped some geophones.

GS13 and T240 installed for final testing are reported in the tables below.

Unit	Location GS13	Serial Number	POD	Comments
BSC8	**H1**	Not noted at LLO	33	Class A – RGA OK
BSC8	**H2**	801	31	Class A – RGA OK
BSC8	**H3**	783	16	Class A – RGA OK
BSC8	**V1**	740	79	Class A – RGA OK
BSC8	**V2**	739	94	Class A – RGA OK
BSC8	**V3**	677	26	Class A – RGA OK

Table 17 - GS13 installed for final testing

Unit	Location T240	Serial Number	POD	Comments
BSC8	**Corner 1**	112	32	Surge protector installed
BSC8	**Corner 2**	118	20	Surge protector installed
BSC8	**Corner 3**	101	19	Surge protector installed

Table 18 - L4C installed for final testing

Note: Rainer Weiss gave his approval on the GS13 pods after checking the RGA scans.

2. Sensors check

Few ASD were measured to check the sensors and built reference amplitude spectral density. These spectra were measured in different conditions:

- Locked
- Unlocked
- ISI tilted

State	GPS Time
ISI Unlocked	1007321196
ISI Locked	1007334800

Table 19 - ASD - ISI Locked & unlocked

Note: The GS13 were installed once the ISI was in the LVEA. Tests were performed using the actuators to tilt the table. In that configuration, the tilt angle is not as large as it should be using masses on stage 2. However, it is sufficient to validate the functioning of the geophones.

	Time	Tilt	Offset drive
ISI Tilted 1	1007327576	+RX	40000
ISI Tilted 2	1007327824	-RX	-40000
ISI Tilted 3	1007328175	+RY	32000
ISI Tilted 4	1007328449	-RY	-32000
ISI Tilted 5	1007328907		25K RX-25KRY
ISI Tilted 6	1007329120		25K RX+25KRY

Table 20 - ISI Tilted - Different angles

ASD of the unlocked, locked and titled ISI can be found in the SVN at:
/seismic/BSC-ISI/H2/ITMY/Data/Spectra/Undamped/

- LHO_ISI_BSC8_ASD_m_CPS_T240_L4C_GS13_2011_12_07_112621.mat (**Unlocked**)
- LHO_ISI_BSC8_ASD_m_CPS_T240_L4C_GS13_2011_12_07_151305.mat (**Locked**)
- LHO_ISI_BSC8_ASD_m_L4C_GS13_Stage_Tilted_2011_12_07.mat

Figures of these spectra can be found in the SVN at:
/seismic/BSC-ISI/H2/ITMY/Data/Figures/Spectra/Undamped/

- LHO_ISI_BSC8_ASD_m_CPS_T240_L4C_GS13_2011_12_07_112621.fig
- LHO_ISI_BSC8_ASD_m_CPS_T240_L4C_GS13_2011_12_07_151305.fig
- LHO_ISI_BSC8_Tilted_ASD_m_ST1_L4C_2011_12_07.fig
- LHO_ISI_BSC8_Tilted_ASD_m_ST2_GS13_2011_12_07.fig

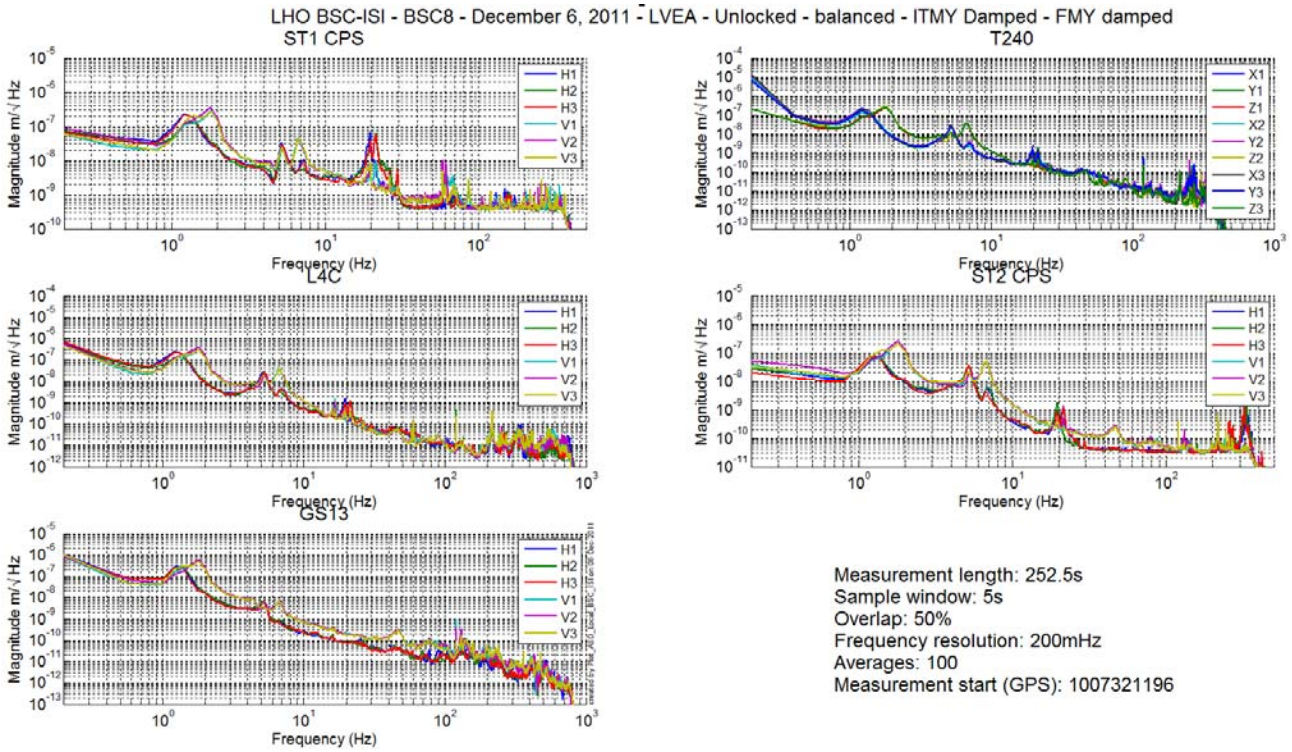


Figure 57 - ASD ISI Unlocked

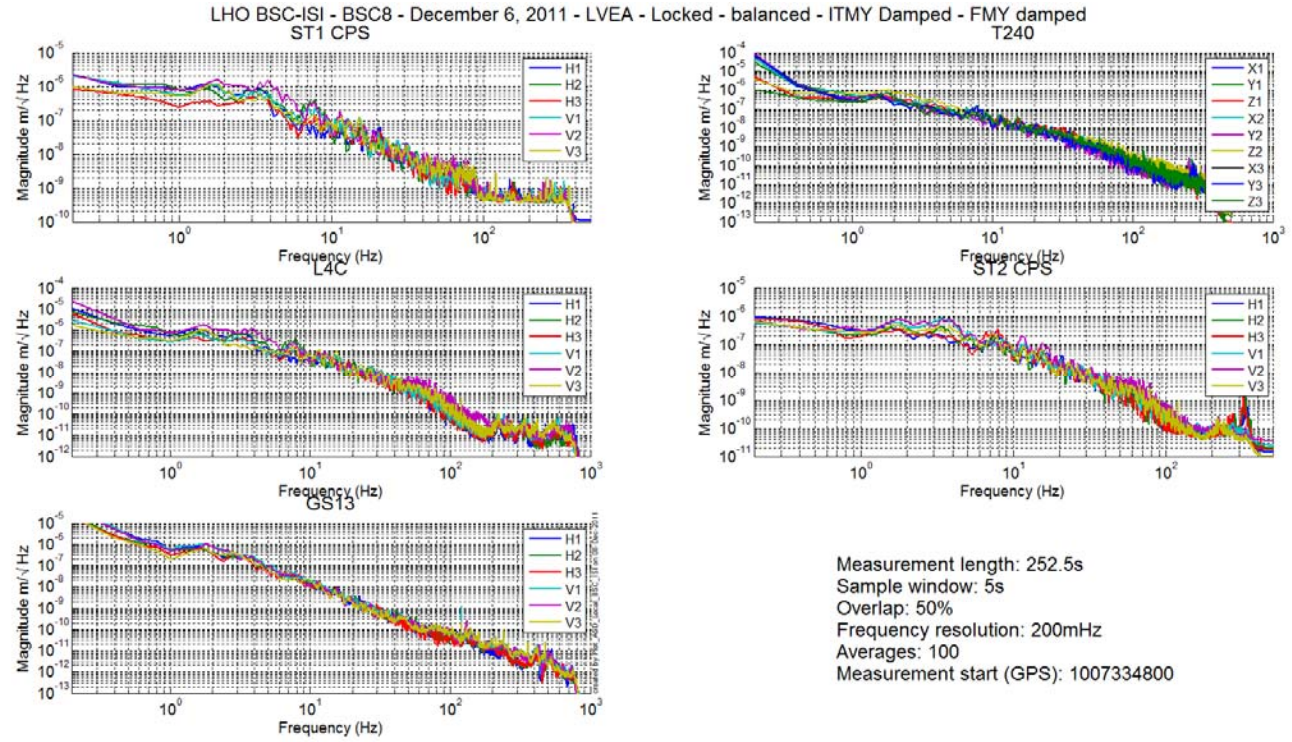


Figure 58 - ASD ISI Locked

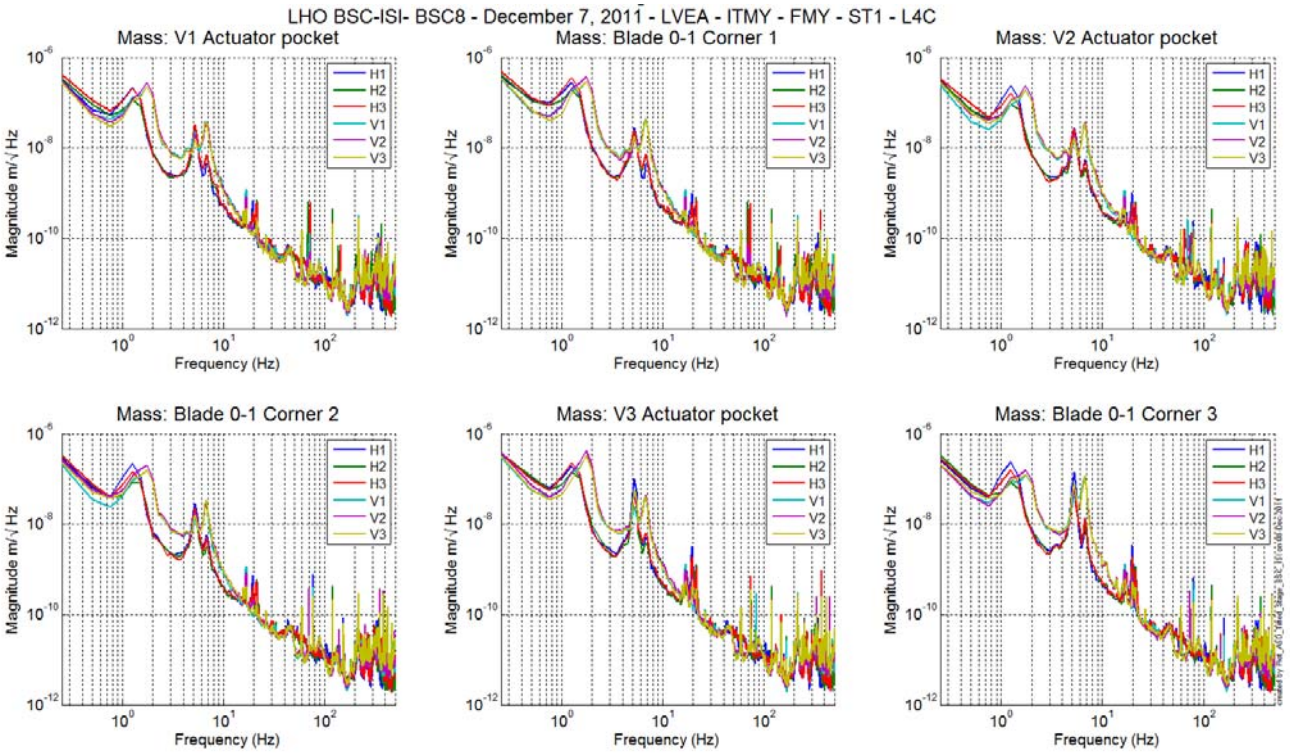


Figure 59 - ASD of L4C when the stage 2 is tilted

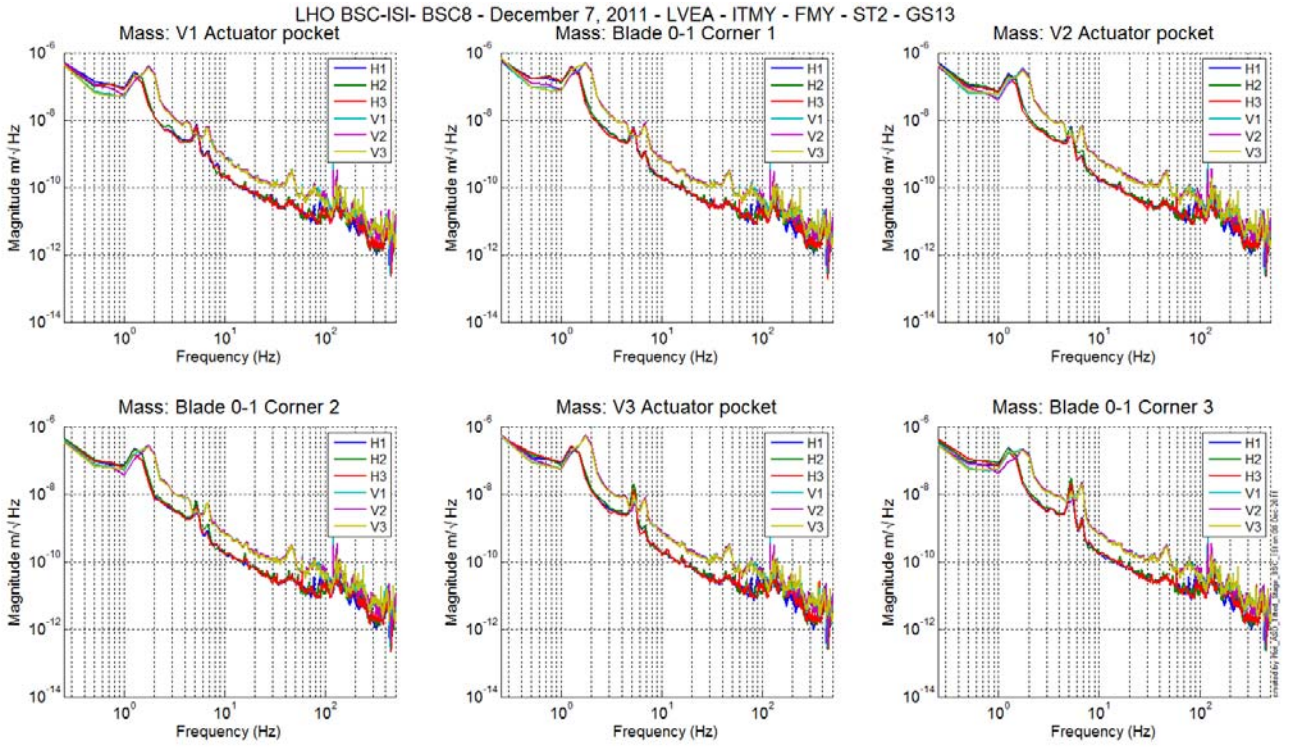


Figure 60 - ASD GS13 when the stage 2 is tilted

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

3. Mass budget

The mass budget is presented in the tables below.

Stage 1

Mass Type	Location	Weight (lb)	Weight (Kg)
D0902612	C1-1	12	5.5
D0902616-1,2,2,3	C1-2	21.1	9.7
D0902612	C2-1	12	5.5
D0902616--1,1,2	C2-2	11.1	5.1
D0902612	C3-1	12	5.5
D0902616--5	C3-2	20.1	9.2
	Total	88.3	40.4

Table 21 – Stage 1 – Mass budget

Total stage 1 payload: 40.4Kg

Stage 2

Mass type	Quantity	Total Weight (lb)	Total Weight (Kg)	Location
D1003136	12	600	272.2	On Keel
D071200-06	1	27.2	12.3	On Keel
D071200: 6,5,5;4,4,3,2,2,2;1,1,1,0	13	89.2	40.5	Corner1 SideWall
D071200:6,3,3,1,0;5,1;1	8	55.7	25.3	Corner2 SideWall
D071200:-;4,4;-	2	9	4.1	Corner3 SideWall
	Total	**781.1**	**354.3**	

Table 22 - Stage 2 - Mass budget – Keel and side walls

Stage 2

Mass Type	Quantity	Weight	Total weight (Kg)	Total weight (lb)	Location
D1003163	6	10	60.0	132.3	Optical Table
D1003164	6	5	30.0	66.1	Optical Table
D1003123	6	3	18.0	39.7	Optical Table
D1003166	6	1	6.0	13.2	Optical Table
D1003167	6	0.5	3.0	6.6	Optical Table
D1003168	12	0.25	3.0	6.6	Optical Table
		Total	120.0	264.6	

Table 23 - Stage 2 - Mass budget optic table

Stage 2 added masses (Keel + optical + Sidewall): 474.3Kg

SUS Payload:
44 lbs = 8 x 5.5 lbs for Vibration Absorbers
~60 lbs = FMy Stays
~2 lbs = FMy Sheer Plate dampers
10 lbs = Cabling
2 lbs = Cable Brackets
3 lbs = Ring Heater + Brackets + Cables
266 lbs = ITMy QUAD Upper Structure
531 lbs = ITMy QUAD Lower Structure
44 lbs = QUAD Sleeve
2 lbs = QUAD sleeve wedges
394 lbs = FMy SUS
55 lbs = 1.26 lbs X Dog Clamps (33 long + 22 short)
TOTAL = 1413 lbs = 641 kg

Total stage 2 payload: 1115Kg

Nominal payload on stage 1: 109Kg – 240lb
Nominal payload on stage 2: 1185Kg – 2612lb

During phase I testing, the mass budget was:
- Stage 1: 35.6Kg
- Stage 2: 1082.4Kg

Note Seismic: There is a 20Kg difference in the total payload between Phase I and Phase II testing.

Note Suspension: For the duration of the SUS testing phase which occurred between Fri Dec 2nd and Wed Dec 7th, a small subset of payload was still needing to be added (not added prior due to variety of reasons). The items are the following:

- 2 of the 4 QUAD Sleeve Wedges (the ones opposite each other perpendicular to the optic beam axis). The last of these were installed on the QUAD on Friday Dec 9, just prior to installing the cartridge.
- The AOS FMy elliptical baffle - still waiting to install in-chamber

The total weight of the assembly was measured at 9260lbs using the load cell.

Acceptance criteria:
- Defined in E1000486

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

4. Balancing check

The balancing of the ISI is evaluated by measuring the difference of the CPS offsets when the ISI is locked and unlocked.

The CPS offsets in the two configurations can be found in the SVN at:
/seismic/BSC-ISI/H2/ITMY/Data/Static_Tests/

- LHO_ISI_BSC8_Locked_20111207.mat
- LHO_ISI_BSC8_Unlocked_20111207.mat

	Table locked		Table unlocked		Difference locked - unlocked	
Sensors	Offset (Mean)	Std deviation	Offset (Mean)	Std deviation	Offset (Mean)	mil
ST1 - H1	260.6	36.6	417.3	62.7	-156.7	-0.19
ST1 - H2	-219.0	22.4	106.2	40.9	-325.2	-0.39
ST1 - H3	-100.5	16.4	569.4	73.0	-669.9	-0.80
ST1 - V1	-160.9	75.5	78.7	71.4	-239.7	-0.29
ST1 - V2	-60.9	138.5	-312.7	93.0	251.8	0.30
ST1 - V3	-112.0	46.8	287.3	69.3	-399.3	-0.48
ST2 - H1	-138.1	25.3	591.0	98.3	-729.1	-0.22
ST2 - H2	857.1	66.9	835.4	97.7	21.7	0.01
ST2 - H3	-345.3	48.4	836.2	59.0	-1181.5	-0.35
ST2 - V1	923.6	35.6	1020.2	209.1	-96.6	-0.03
ST2 - V2	706.3	55.7	468.9	244.2	237.4	0.07
ST2 - V3	-470.1	54.0	-147.2	203.4	-322.9	-0.10

Table 24 – CPS Offsets – Locked vs Unlocked

Acceptance criteria:

- Defined in E1000486 – III.2

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

5. Static test – Local Basis

The results of the static test in the local basis are located in the SVN at:
seismic/BSC-ISI/H2/ITMY/Data/Static_Tests/

- LHO_ISI_BSC8_Offset_Local_Drive_20111206.mat

Actuators \ Sensors	ST1 - H1	ST1 - H2	ST1 - H3	ST1 - V1	ST1 - V2	ST1 - V3
ST1 - H1	3836	1537	1535	19	-8	-9
ST1 - H2	1519	3756	1509	0	15	-4
ST1 - H3	1517	1515	3756	2	-5	13
ST1 - V1	59	-130	87	2892	-496	-468
ST1 - V2	78	30	-144	-479	2909	-500
ST1 - V3	-146	79	16	-506	-467	2918

Actuators \ Sensors	ST2 - H1	ST2 - H2	ST2 - H3	ST2 - V1	ST2 - V2	ST2 - V3
ST2 - H1	2146	318	323	-27	-17	-17
ST2 - H2	321	2147	318	-19	-13	-27
ST2 - H3	338	333	2237	-20	24	-7
ST2 - V1	62	110	-174	2609	370	4
ST2 - V2	-184	59	89	10	2606	303
ST2 - V3	106	-178	61	299	25	2585

Table 25 – Static Test – Local drive – Offsets in the local basis

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

6. Static Test – Cartesian Basis

The results of the static test in the Cartesian basis are located in the SVN at:
seismic/BSC-ISI/H2/ITMY/Data/Static_Tests/

- LHO_ISI_BSC8_Offset_Cartesian_Drive_20111206.mat

Actuators	ST1 - X	ST1 - Y	ST1 - Z	ST1 – RX	ST1 - RY	ST1 - RZ
ST1 - X	1523	2	-7	-12	-7	31
ST1 - Y	-7	1506	-25	11	-9	3
ST1 - Z	27	-1	656	5	5	-7
ST1 - RX	5	305	0	2469	-6	-10
ST1 - RY	-291	19	-2	-1	2472	-9
ST1 - RZ	14	2	-1	1	0	2884

Actuators	ST2 - X	ST2 - Y	ST2 - Z	ST2 – RX	ST2 - RY	ST2 - RZ
ST2 - X	1229	-19	57	25	5	15
ST2 - Y	0	1234	-27	7	1	-42
ST2 - Z	9	3	964	10	15	-3
ST2 - RX	3	-6	-5	3755	-1	-11
ST2 - RY	21	2	-15	11	3747	-2
ST2 - RZ	12	-33	-27	-5	16	2341

Figure 61 - Static Test – Cartesian Drive – Offsets in the Cartesian Basis

	Sensors					
Actuators	ST1 - H1	ST1 - H2	ST1 - H3	ST1 - V1	ST1 - V2	ST1 - V3
ST1 - X	1548	-730	-736	28	-1	-7
ST1 - Y	-25	1298	-1272	12	19	0
ST1 - Z	-48	-7	-23	649	657	657
ST1 - RX	-17	127	-146	-2367	2015	369
ST1 - RY	-181	78	58	-936	-1580	2541
ST1 - RZ	2787	2758	2764	5	-4	-5

	Sensors					
Actuators	ST2 - H1	ST2 - H2	ST2 - H3	ST2 - V1	ST2 - V2	ST2 - V3
ST2 - X	617	-1211	630	-36	-1	23
ST2 - Y	1056	1	-1083	-15	8	13
ST2 - Z	6	8	4	948	979	972
ST2 - RX	-247	-3	238	-2198	2227	-38
ST2 - RY	145	-268	152	-1341	-1211	2546
ST2 - RZ	1612	1613	1661	-18	18	21

Table 26 - Static Test – Cartesian Drive – Offsets in the Local Basis

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

7. Pressure sensors check

The pressure readout are located in the SVN are:

- seismic/BSC-ISI/H2/ITMY/Data/Static_Tests/LHO_ISI_BSC8_Pressure_Sensors_Check_20111206.mat

	Pressure (counts)		
Sensors	**Corner 1**	**Corner 2**	**Corner 3**
ST1-L4C-D	37	124	231
ST1-L4C-P	24642	24647	24589
ST1-GS13-D	625	1165	4065.0
ST1-GS13-P	24425	24324	24266
ST1-T240-P	14073	13642	13829

Figure 62 - Pressure sensor readout

Acceptance criteria:

- The absolute pressure on the L4Cs and the GS13s must be 24700 +/- 1000 counts (100+/- 3 KPA)
- The differential pressure on the L4Cs and the GS13s must be <5200 counts (3 KPa)
- The absolute pressure on the T240 must be 14300 +/-600 counts (100 +/- 3 KPA)

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

8. Range of motion test

The results of the range of motion test are located in:

- seismic/BSC-ISI/H2/ITMY/Data/Static_Tests/LHO_ISI_BSC8_Range_Of_Motion_20111206.mat

Sensor readout (counts)	Negative drive	no drive	Positive drive	Amplitude count	mil
ST1 - H1	-15865	357	16290	32155	38.3
ST1 - H2	-16123	21	15849	31972	38.1
ST1 - H3	-15596	562	15304	30900	36.8
ST1 - V1	-12525	-30	12483	25007	29.8
ST1 - V2	-12793	-354	12069	24862	29.6
ST1 - V3	-12064	321	12668	24732	29.4
ST2 - H1	-8794	539	9846	18640	5.5
ST2 - H2	-8512	814	10166	18678	5.6
ST2 - H3	-8431	800	10025	18456	5.5
ST2 - V1	-10135	983	12128	22263	6.6
ST2 - V2	-10512	512	11492	22004	6.5
ST2 - V3	-11252	-95	11035	22287	6.6

Figure 63 - Range of motion

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

9. Linearity-hysteresis test

The linearity-hysteresis test enables to eventually detect cable contacts. It is started before measuring long transfer functions.

The data measured in this test are located in the SVN at:
/seismic/BSC-ISI/H2/ITMY/Data/Linearity_Test/

- LHO_ISI_BSC8_Linearity_test_20111206.mat

The figure of the linearity test is located in the SVN at:
/seismic/BSC-ISI/H2/ITMY/Data/Figures/Linearity_Test/

- LHO_ISI_BSC8_Linearity_test_20111206.fig

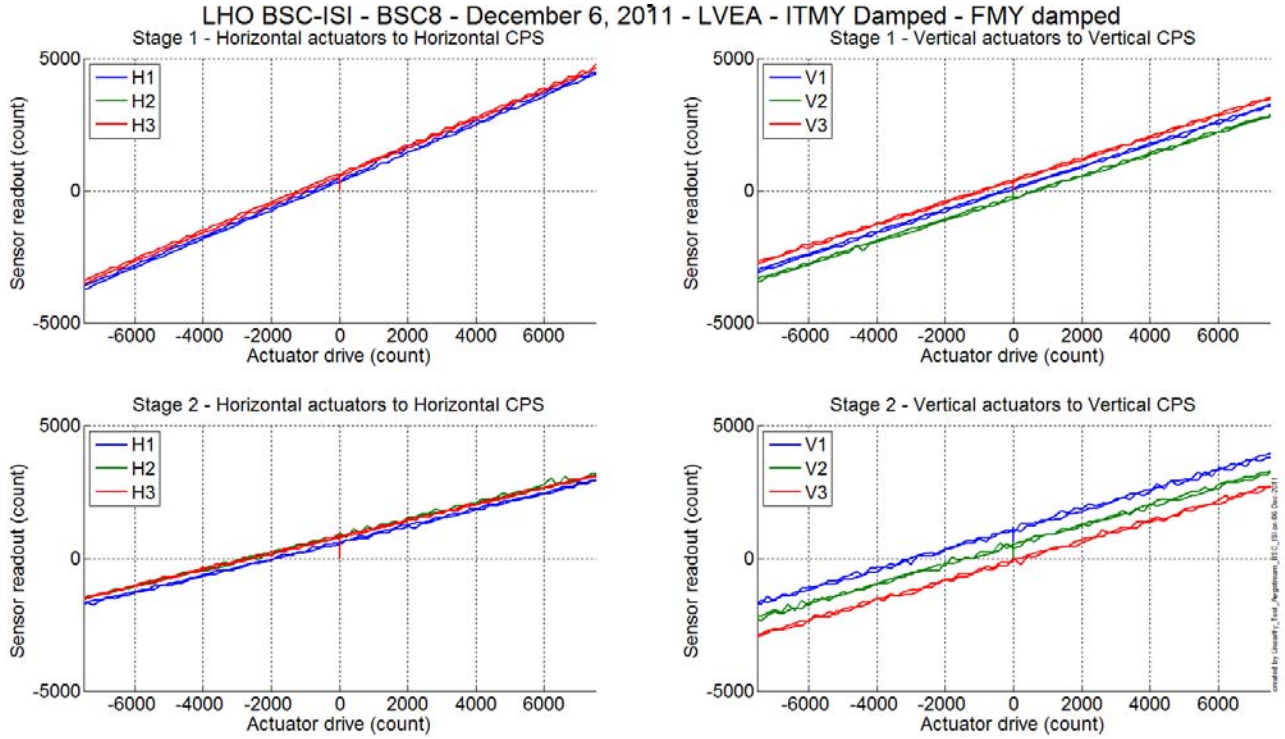


Figure 64 - Linearity Test

		Slope	Offset	Average slope	Variation from average(%)
Stage 1	ST1 - H1	0.541	389	0.5402	0.20
	ST1 - H2				
	ST1 - H3	0.539	595		-0.20
	ST1 - V1	0.417	86	0.4146	0.47
	ST1 - V2	0.414	-270		-0.10
	ST1 - V3	0.413	383		-0.37
Stage 2	ST2 - H1	0.312	589	0.3105	0.33
	ST2 - H2	0.312	833		0.56
	ST2 - H3	0.308	803		-0.89
	ST2 - V1	0.373	1077	0.3711	0.38
	ST2 - V2	0.368	510		-0.75
	ST2 - V3	0.373	-100		0.37

Table 27 - Linearity Test - Before the move

Note: The interpolation function that is used to smooth and reduce the number of points used for display failed for the ST1-ACT-H2 to ST1-CPS-H2 measurement. That's why no data is provided for ST1-H2.

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

10. Transfer function measurements

The segmented transfer functions are located in the SVN at
seismic/BSC-ISI/H2/ITMY/Data/Transfer_Functions/Measurements/Undamped/:

- LHO_ISI_BSC8_Data_L2L_10mHz_100mHz_ST1_ST2_20111206-052309.mat
- LHO_ISI_BSC8_Data_L2L_100mHz_700mHz_ST1_ST2_20111205-235951.mat
- LHO_ISI_BSC8_Data_L2L_700mHz_10Hz_ST1_ST2_20111206-191136.mat
- LHO_ISI_BSC8_Data_L2L_10Hz_100Hz_ST1_ST2_20111205-212245.mat
- LHO_ISI_BSC8_Data_L2L_100Hz_500Hz_ST1_ST2_20111205-200228.mat
- LHO_ISI_BSC8_Data_L2L_500Hz_1000Hz_ST1_ST2_20111205-185743.mat

The transfer functions are concatenated in one data structure located in the SVN at:
seismic/BSC-ISI/H2/ITMY/Data/Transfer_Functions/Simulations/Undamped/:

- LHO_ISI_BSC8_TF_L2L_Sym_10mHz_1000Hz_2011_12_06.mat

The figures that show the transfer functions with ITMY and FMY are located in the SVN at:
seismic/BSC-ISI/H2/ITMY/Data/Figures/Transfer_Functions/Measurements/Undamped/

- LHO_ISI_BSC8_TF_L2L_Raw_from_ST1_ACT_to_ST1_CPS_2011_12_06.fig
- LHO_ISI_BSC8_TF_L2L_Raw_from_ST1_ACT_to_ST1_T240_2011_12_06.fig
- LHO_ISI_BSC8_TF_L2L_Raw_from_ST1_ACT_to_ST1_L4C_2011_12_06.fig
- LHO_ISI_BSC8_TF_L2L_Raw_from_ST2_ACT_to_ST2_CPS_2011_12_06.fig
- LHO_ISI_BSC8_TF_L2L_Raw_from_ST2_ACT_to_ST2_GS13_2011_12_06.fig

Note: The transfer functions were measured the actuator symmetrization engaged**.**

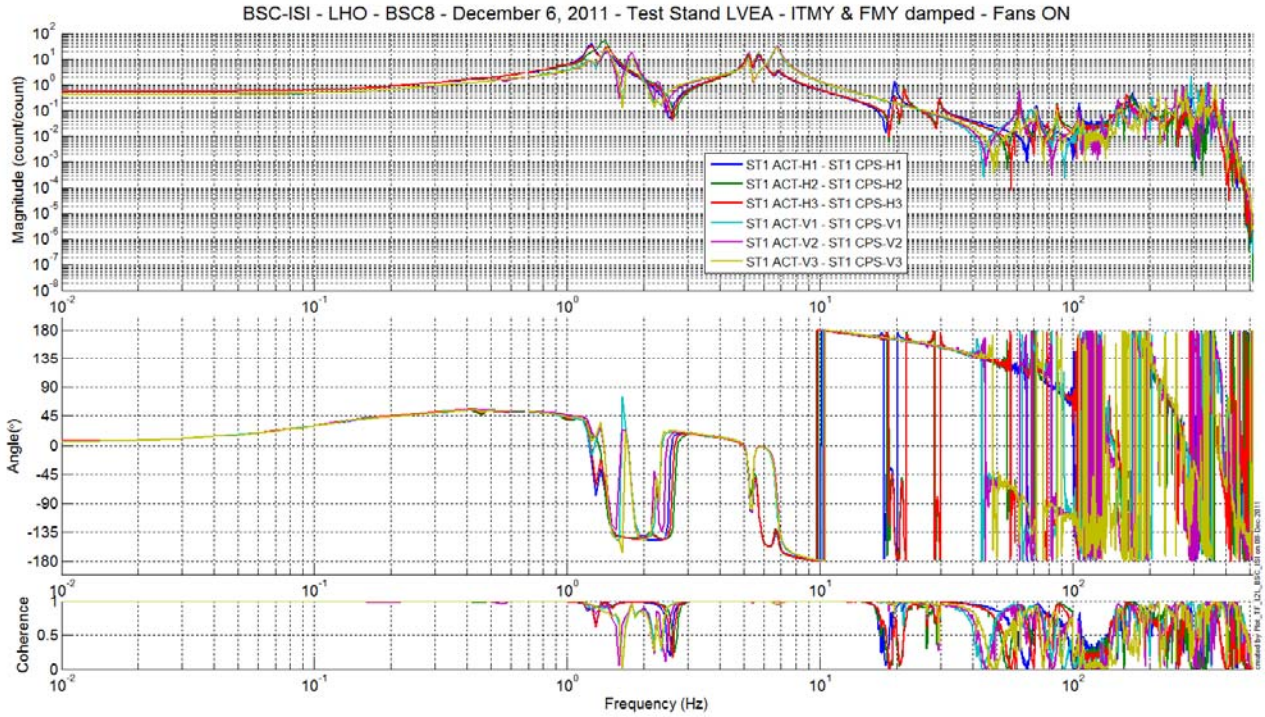


Figure 65 – Transfer functions – With Damped QUAD and FMY – ST1 ACT to ST1 CPS

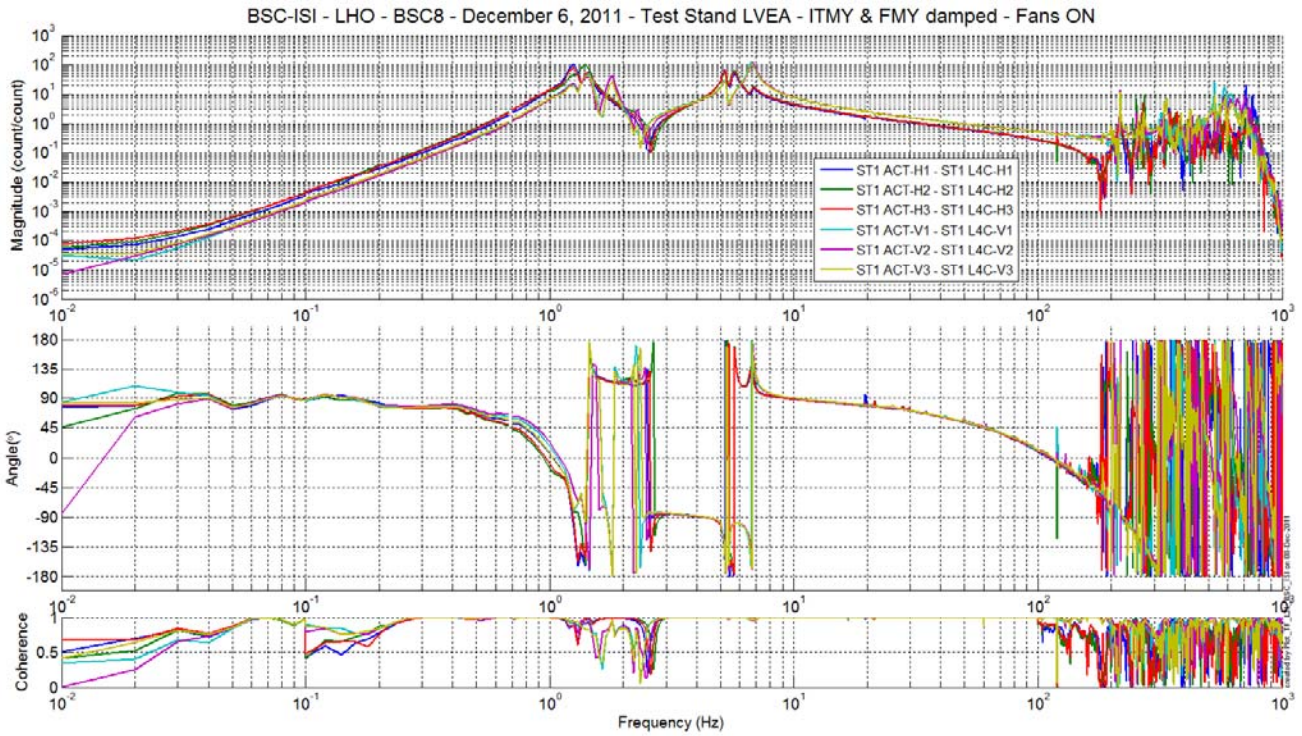


Figure 66 - Transfer functions – With Damped QUAD and FMY – ST1 ACT to ST1 L4C

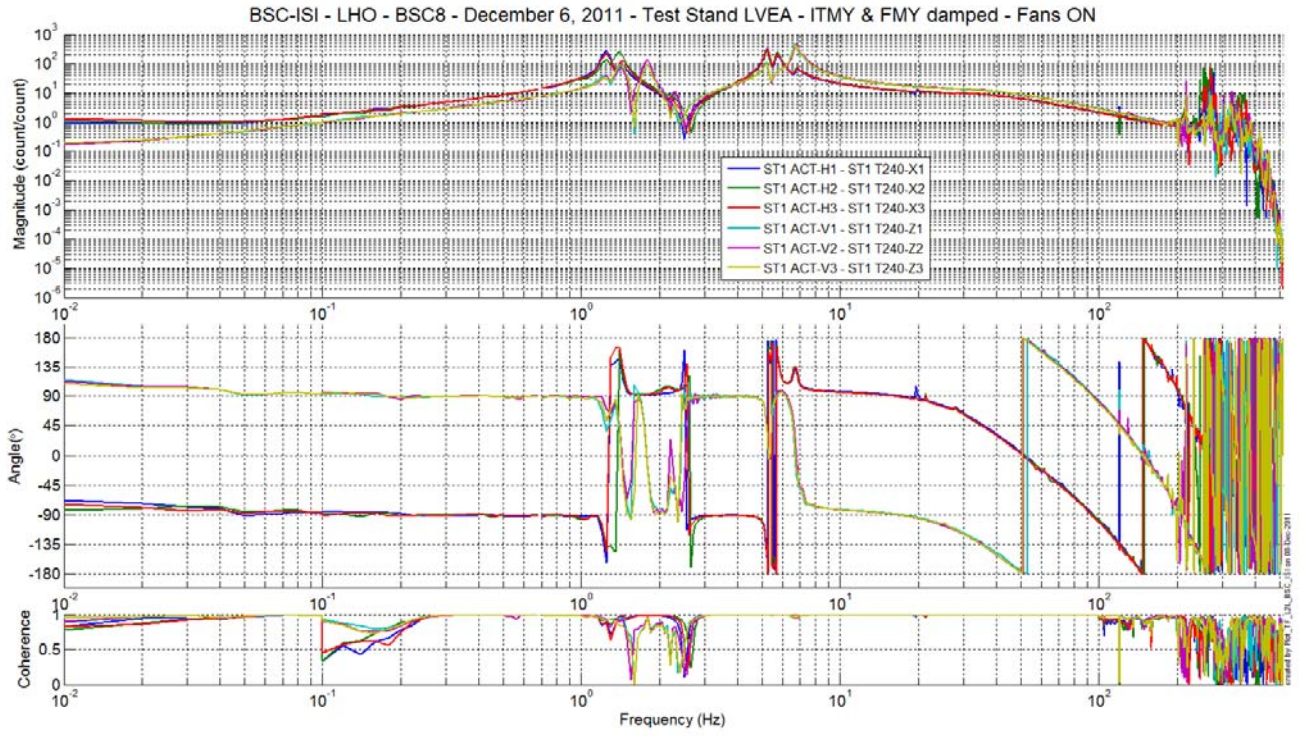


Figure 67 - Transfer functions – With Damped QUAD and FMY – ST1 ACT to ST1 T240

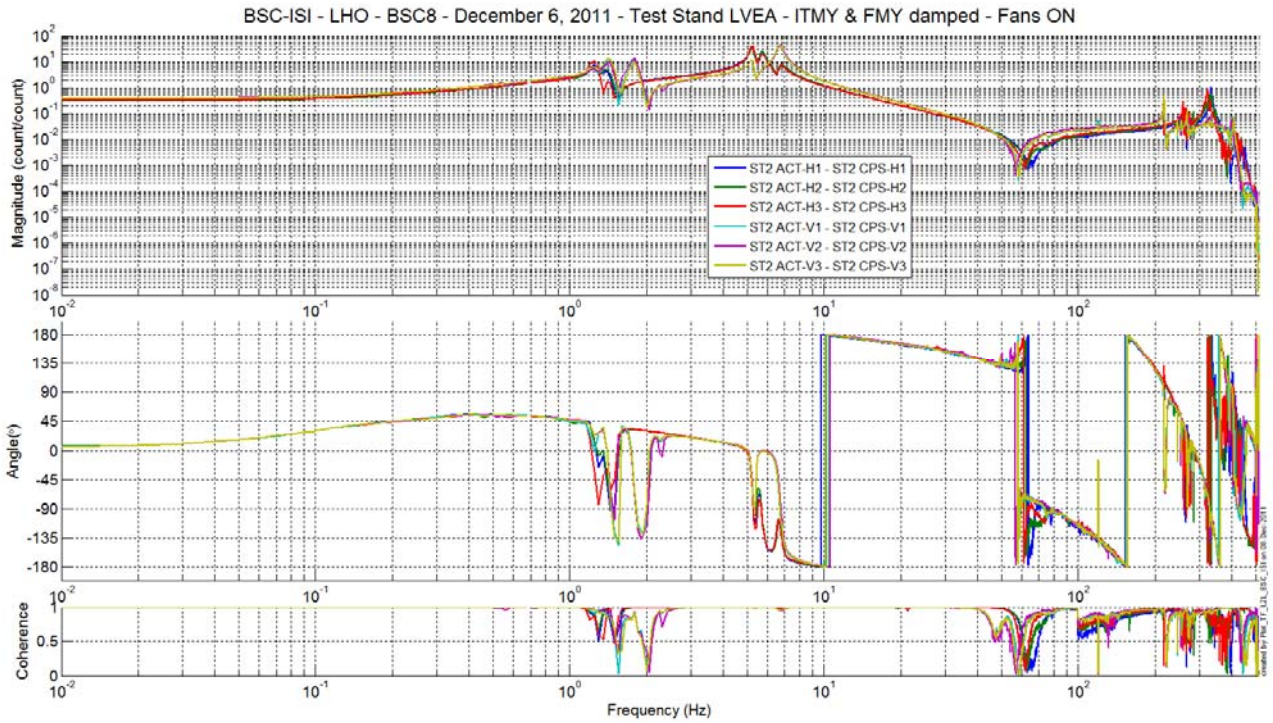


Figure 68 - Transfer functions – With Damped QUAD and FMY – ST2 ACT to ST2 CPS

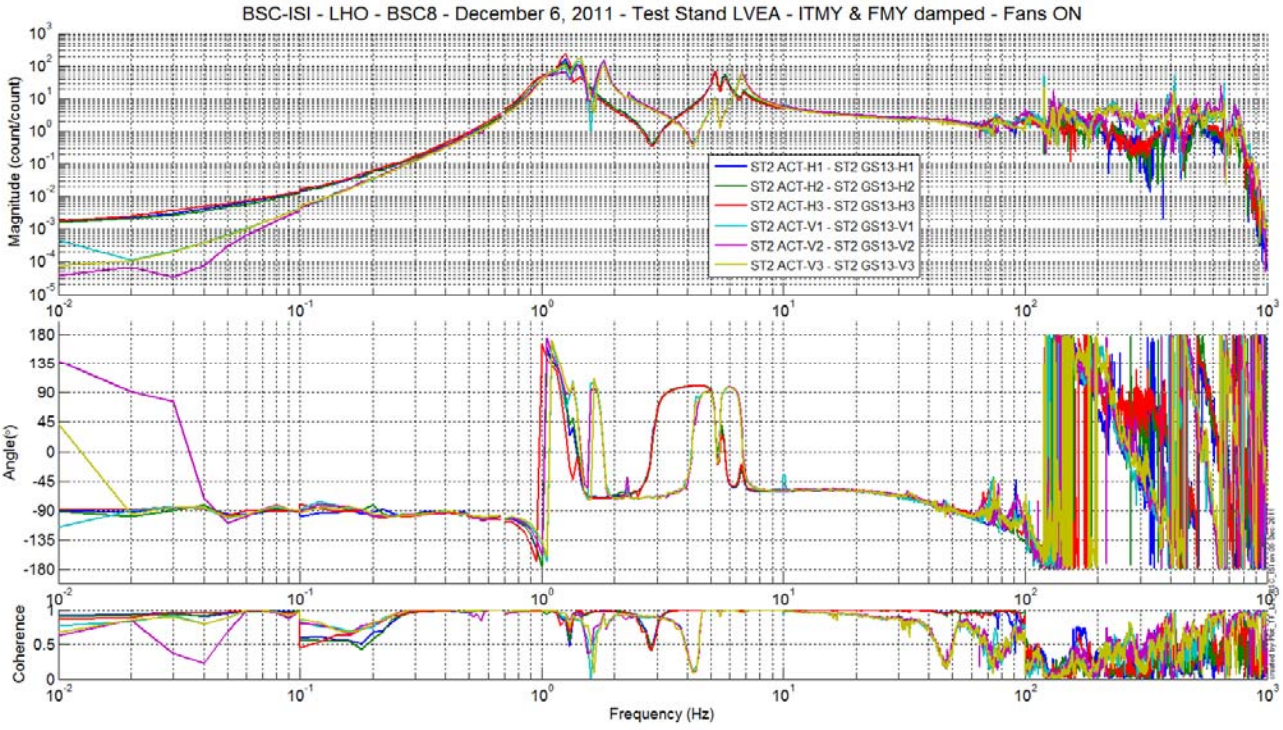


Figure 69 - Transfer functions – With Damped QUAD and FMY – ST2 ACT to ST2 GS13

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

11. Damping loops

The damping filters were designed using BSC-ISI transfer functions without FMY and ITMY. The goal of this test was to show the robustness of the damping filters (Payload change).

State	GPS Time
ISI with the Damping Loops	1007316891
ISI Unlocked	1007321196

Table 28 - GPS Time - Damping loops ON and OFF

The ASD can be found in the SVN at:
/seismic/BSC-ISI/H2/ITMY/Data/Spectra/Damping/

- LHO_ISI_BSC8_ASD_m_L4C_GS13_Undamped_vs_Damping_2011_12_07_101436.mat

The figure of the ASD when the ISI is damped and undamped can be found in the SVN at:
/seismic/BSC-ISI/H2/ITMY/Data/Figures/Spectra/Damping/

- LHO_ISI_BSC8_ASD_m_ST1_L4C_Undamped_vs_Damping_2011_12_07_101436.fig
- LHO_ISI_BSC8_ASD_m_ST2_GS13_Undamped_vs_Damping_2011_12_07_101436.fig

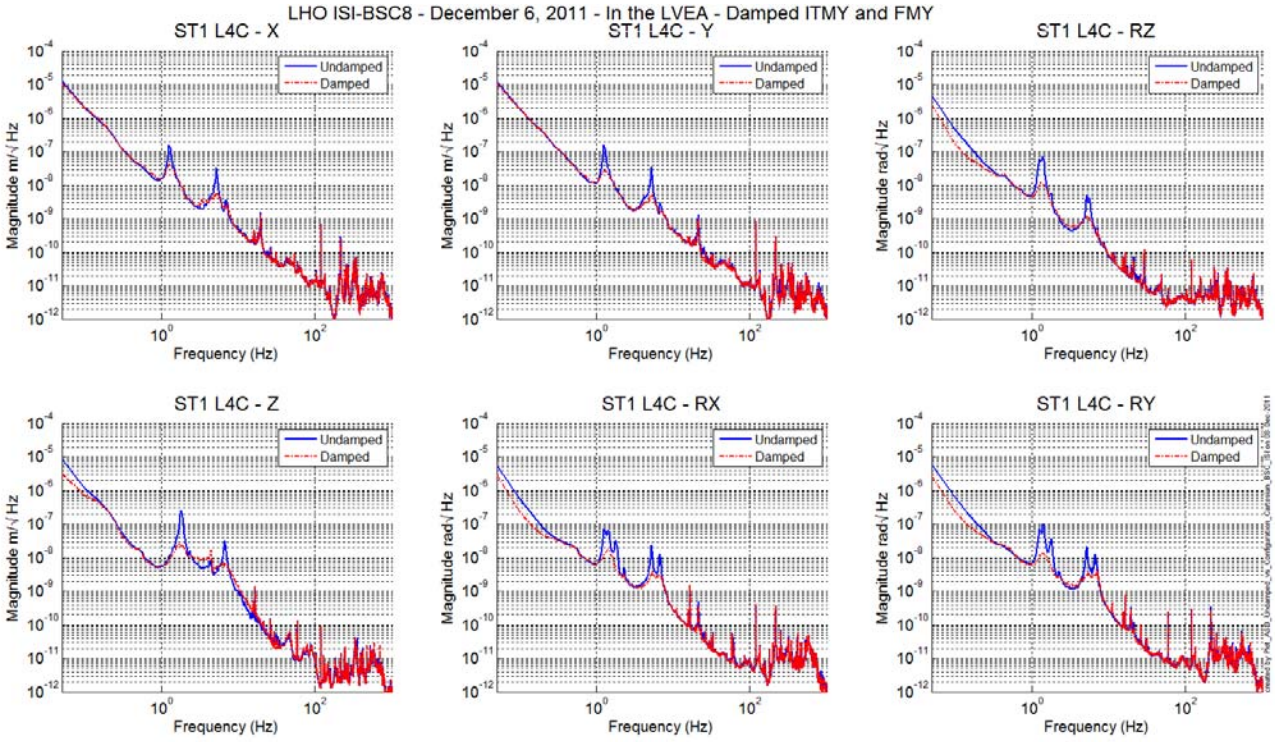


Figure 70 - Damping Loops stage 1

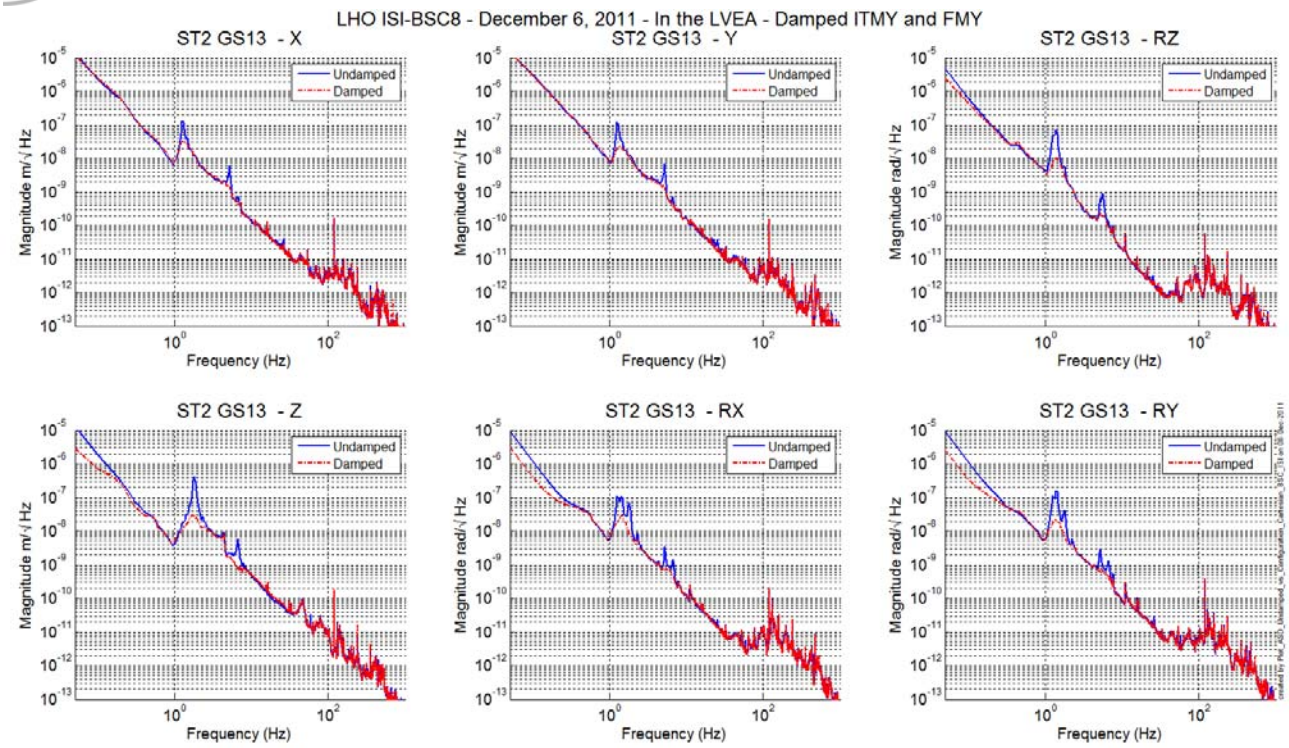


Figure 71 - Damping Stage 2

Acceptance criteria:

- Damping loops are stable

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

Cartridge install

After two day of testing, the ISI was validated on Wednesday 7 december 2011. The cartridge install occurred on Friday 09 December 2011 (LHO Alog 1887).

7. Tests after Cartridge install

1. Transfer functions after cartridge install

Reference transfer functions L2L without baffle – No TMD – No vibration absorbers – No Viton under the keel masses - ITMY and FMY damped:

- LHO_ISI_BSC8_Data_L2L_10Hz_100Hz_ST1_ST2_20120106-214333.mat
- LHO_ISI_BSC8_Data_L2L_100Hz_500Hz_ST1_ST2_20120106-190824.mat
- LHO_ISI_BSC8_Data_L2L_500Hz_1000Hz_ST1_ST2_20120106-170349.mat

L2L concatenated

- LHO_ISI_BSC8_TF_L2L_Raw_10mHz_1000Hz_2012_01_06.mat

Reconstructed C2C with Step_3_TF_C2C_from_L2L_with_Resymmetrization and loading LHO_ISI_BSC8_Symmetrization_Filters_2011_07_27.mat

- LHO_ISI_BSC8_TF_C2C_Reconstructed_Sym_10mHz_1000Hz_2012_01_06.mat

Data before the Cartridge install used for comparison

- LHO_ISI_BSC8_TF_L2L_Raw_10mHz_1000Hz_2012_12_06.mat

Comparison Transfer functions Teststand vs Cartridge

Comparison_TF_L2L_LHO_ISI_BSC8.m
Comparison_TF_C2C_LHO_ISI_BSC8.m

In the local basis:

seismic/BSC-ISI/H2/ITMY/Data/Figures/Transfer_Functions/Comparison/
LHO_ISI_BSC8_Comparison_TF_L2L_ST1_ACT_H_to_ST1_CPS_H_20111206_vs_20120106.fig
LHO_ISI_BSC8_Comparison_TF_L2L_ST1_ACT_V_to_ST1_CPS_V_20111206_vs_20120106.fig
LHO_ISI_BSC8_Comparison_TF_L2L_ST1_ACT_H_to_ST1_L4C_H_20111206_vs_20120106.fig
LHO_ISI_BSC8_Comparison_TF_L2L_ST1_ACT_V_to_ST1_L4C_V_20111206_vs_20120106.fig
LHO_ISI_BSC8_Comparison_TF_L2L_ST2_ACT_H_to_ST2_CPS_H_20111206_vs_20120106.fig
LHO_ISI_BSC8_Comparison_TF_L2L_ST2_ACT_V_to_ST2_CPS_V_20111206_vs_20120106.fig
LHO_ISI_BSC8_Comparison_TF_L2L_ST2_ACT_H_to_ST2_GS13_H_20111206_vs_20120106.fig
LHO_ISI_BSC8_Comparison_TF_L2L_ST2_ACT_V_to_ST2_GS13_V_20111206_vs_20120106.fig

In the Cartesian basis:

seismic/BSC-ISI/H2/ITMY/Data/Figures/Transfer_Functions/Comparison/
LHO_ISI_BSC8_Comparison_TF_C2C_ST1_ACT_H_to_ST1_CPS_H_20111206_vs_20120106.fig
LHO_ISI_BSC8_Comparison_TF_C2C_ST1_ACT_V_to_ST1_CPS_V_20111206_vs_20120106.fig
LHO_ISI_BSC8_Comparison_TF_C2C_ST1_ACT_H_to_ST1_L4C_H_20111206_vs_20120106.fig
LHO_ISI_BSC8_Comparison_TF_C2C_ST1_ACT_V_to_ST1_L4C_V_20111206_vs_20120106.fig
LHO_ISI_BSC8_Comparison_TF_C2C_ST2_ACT_H_to_ST2_CPS_H_20111206_vs_20120106.fig
LHO_ISI_BSC8_Comparison_TF_C2C_ST2_ACT_V_to_ST2_CPS_V_20111206_vs_20120106.fig
LHO_ISI_BSC8_Comparison_TF_C2C_ST2_ACT_H_to_ST2_GS13_H_20111206_vs_20120106.fig
LHO_ISI_BSC8_Comparison_TF_C2C_ST2_ACT_V_to_ST2_GS13_V_20111206_vs_20120106.fig

Note 1:
Transfer functions are measured between 10Hz and 1Kz. The ISI was not available for low frequency measurements.

Note 2:
The transfer functions in the Cartesian basis are computed using the local to local transfer functions. Filters of the input bank are introduced during reconstruction

Note 3:
After comparing with the measurements before the cartridge install, we can notice:

- The resonances of the teststand are not visible anymore (First teststand resonance are at 19.6Hz, 21.4Hz, 29.6Hz). HEPI resonances are visible on ST1 CPS transfer functions.
- First resonance of stage 1 is 217Hz (it will be damped by the vibration absorbers on the door of stage 1) on ST1 ACT to ST1 L4C transfer functions
- Second resonance observed on stage 1 at ~250 Hz. The HAM-ISI TMDs retuned for BSC-ISI (E1100963-v1) will be subsequently installed.
- New resonances in the stage 2 transfer functions (53Hz). It is more visible in the Cartesian to Cartesian transfer functions.

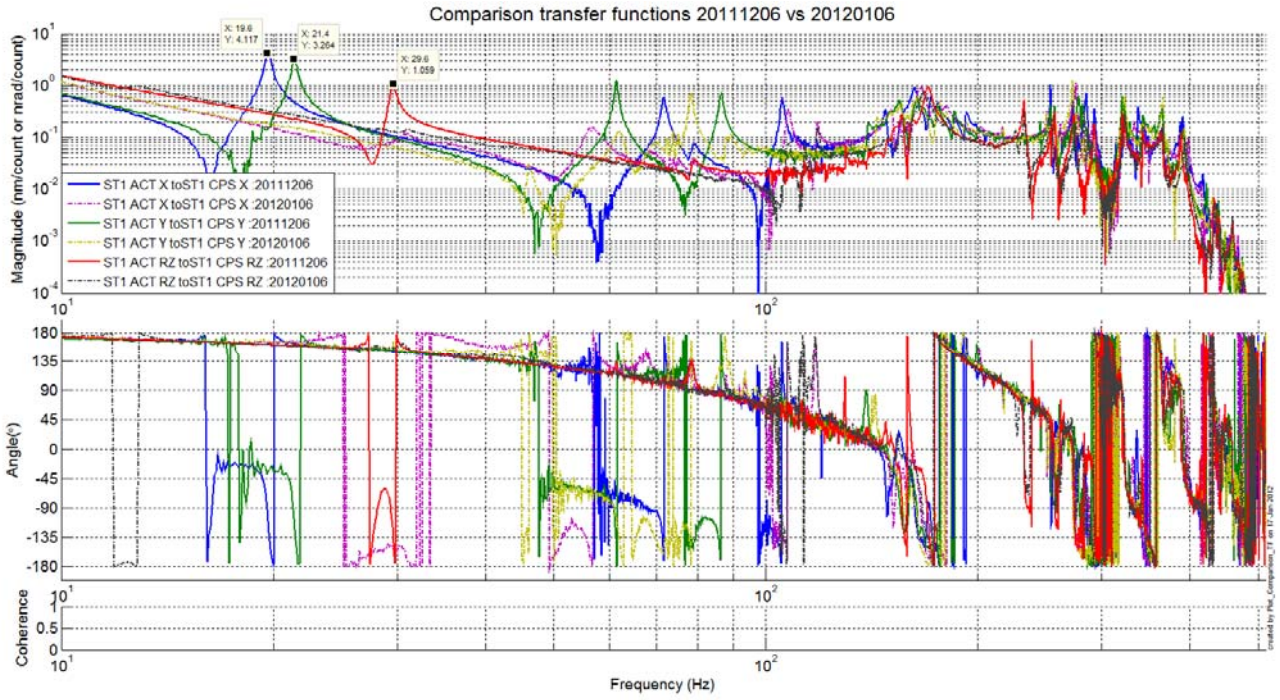


Figure 72 – Comparison TF C2C reconstructed - ST1 ACT H to ST1 CPS H

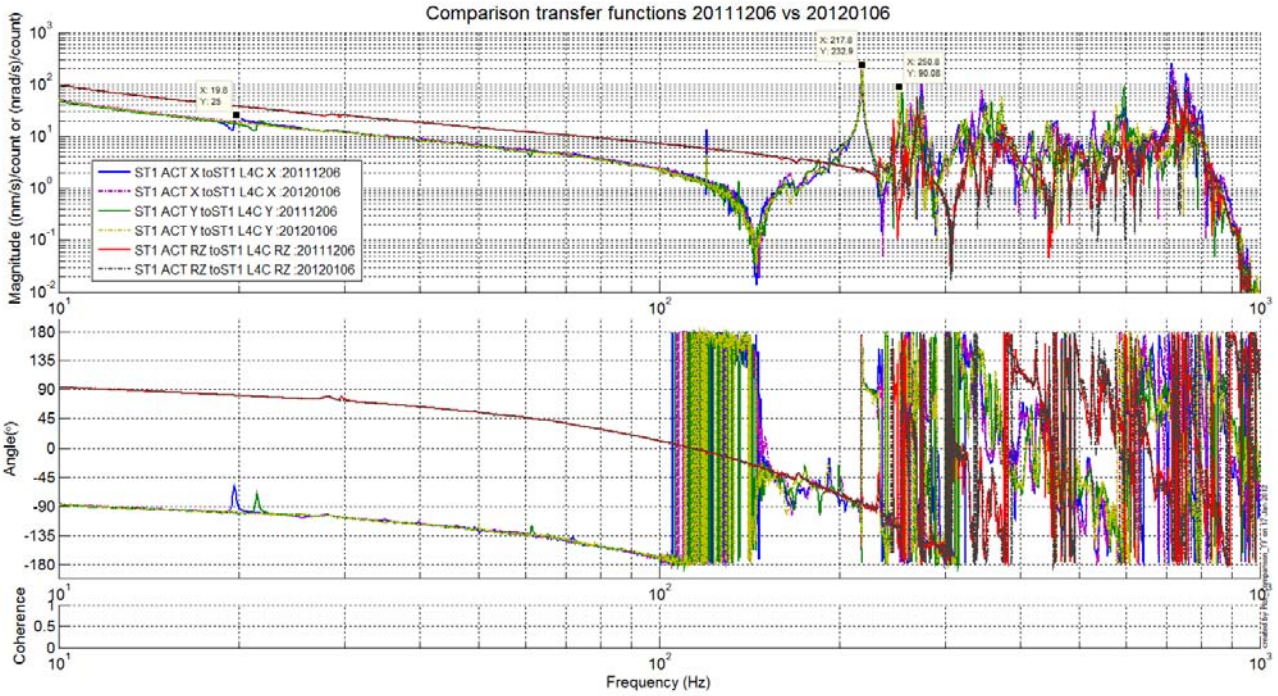


Figure 73 - Comparison TF C2C reconstructed - ST1 ACT H to ST1 L4C H

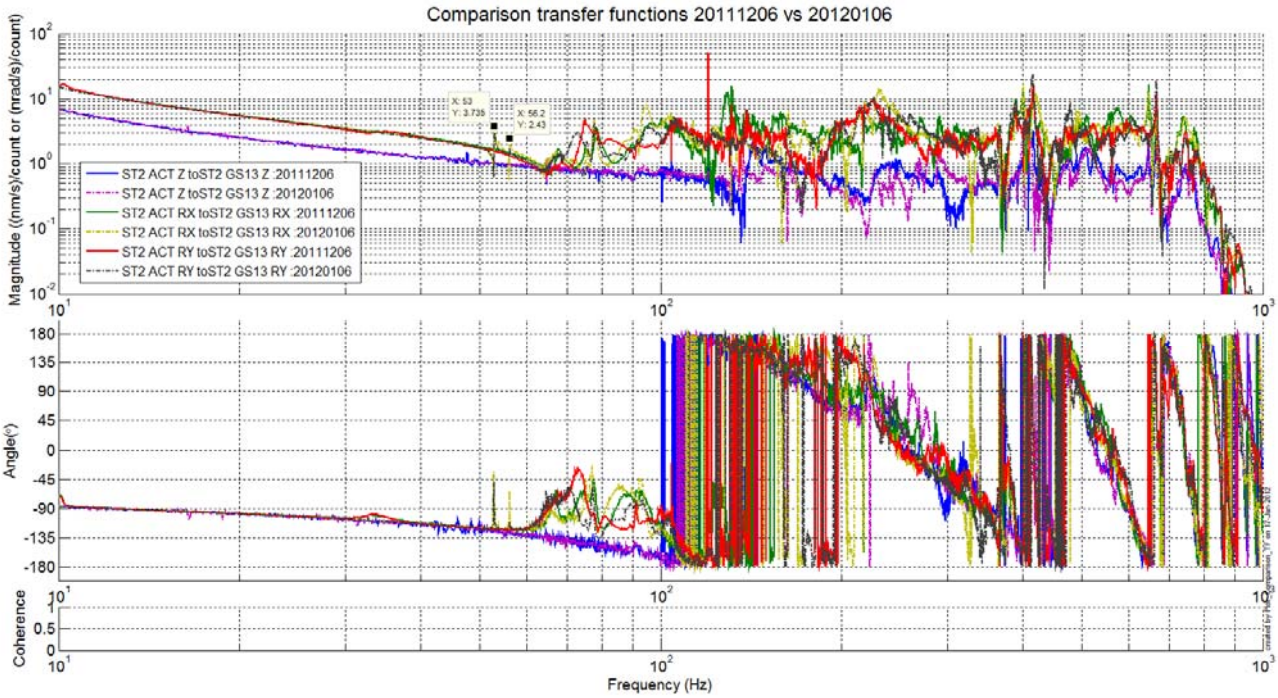


Figure 74 - Comparison - TF C2C reconstructed – ST2 ACT V to ST2 GS13 V

2. Addition of Vibration absorbers – Viton pads – TMDs

Transfer functions with the final configuration for the TMDs, vibration absorbers and Viton pads are presented at the end of the subsection.

1. Vibration absorbers (0.25”x0.25”xThickness”)

Vibration Absorbers (217Hz resonance)
We performed tests with different thicknesses of Viton Pads with and without the lids. These configurations (S=0.25”x0.25”) are:
- Thickness: 0.0625”, 0.125”, 0.25” without lid
- Thickness: 0.0625” with lids and pads of 0.0625” and 0.125”

The best configuration:
- Bottom pads with a thickness of 0.0625”
- The top pads thickness doesn’t seem to affect the performance. Only 0.25”x0.25”x0.0625” pads are installed in the stage 1 vibration absorbers (for simplicity reasons)

Performance on the 217Hz resonance (the only resonance affected by the vibration absorbers):
- X, Y directions reduction by a factor of 7.8 on ST1 L4C
- RX, RY directions reduction by a factor of 6.5 on ST1 L4C
- the resonance is not visible on the GS13s

The figure below presents the transfer function in the Cartesian basis around the 217Hz with different pads thicknesses.

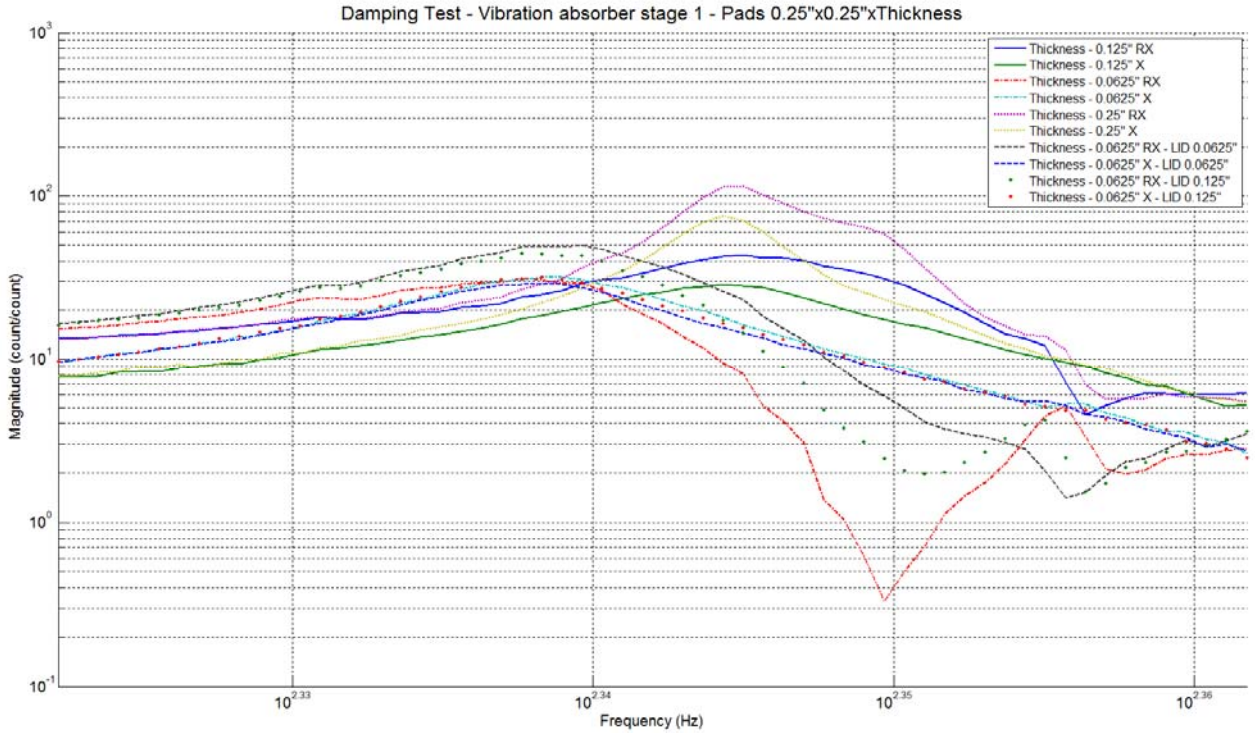


Figure 75 - Stage 1 - Vibration absorbers - Thickness test

Note: 6 vibrations absorbers were installed on stage 1 doors. After adding the lids, the stage 1 position is a little bit low (-2000 counts (2.5mils) on vertical CPS) and there is no contingency for adjustment masses. Since there is lots of room in the stage 1 lockers, the six vibration absorbers were kept to benefit from a maximal damping effect.

Dimensions:

- 4 pads at the bottom (0.25”x0.25”x0.0625”)
- 4 pads at the top (0.25”x0.25”x0.0625”)
- 2 precision washers with a 0.02” thickness

2. TMD (blade 0-1)

HAM-ISI TMDs were retuned at 252Hz for BSC-ISI stage 0-1 blades. Details are given in E1100963-v1. The TMDs (base) are installed at 11 inches from the post.

Tests realized:

- Try different TMDs on the same blade
- Try different location using the same TMD
- Measurement in the morning and the afternoon

Notes and Results:

- The TMDs are tuned at 252Hz +/-1Hz
- If the TMD is too close from the blade post or the tip of the blade, the TMDs seem to be less effective. When the base of the TMD is located at 11 inches from the post, the TMDs seem to be relatively efficient. Further tests will be on BSC6.
- During testing, measurements show performance variations for a same TMD on the same blade during the day. Temperature variations are probably the source of the performance changes. The temperature may slightly change the stiffness of the TMDs, consequently changing the resonance frequency of the TMDs. In some case, the TMD and the blade may or may not be tuned.
- Tuned mass dampers effect is mainly visible on the horizontal degrees of freedom. We can see a light effect on Z.

TMDs Serial numbers in the final configuration:

Corner 1: S/N 15
Corner 2: S/N 19
Corner 3: S/N 14

Figure 76 - TMD on the blade 0-1

3. Viton pads under the stage 2 stack mass

Viton pads with the dimensions (1”x1”x0.25”) were added under the stack of masses on stage 2 (8 pads per stack).

Results:
Effective on resonances at 162Hz, 180Hz and 227Hz.

4. The transfer functions comparisons

All the transfer functions presented below are measured in the local basis and recombine in the Cartesian basis.

Transfer functions L2L without baffle – No TMD – No vibration absorbers – No Viton under the keel masses - ITMY and FMY damped:

- LHO_ISI_BSC8_Data_L2L_10mHz_100mHz_ST1_ST2_20111206-052309.mat
- LHO_ISI_BSC8_Data_L2L_100mHz_700mHz_ST1_ST2_20111205-235951.mat
- LHO_ISI_BSC8_Data_L2L_700mHz_10Hz_ST1_ST2_20111206-191136.mat
- LHO_ISI_BSC8_Data_L2L_10Hz_100Hz_ST1_ST2_20111205-212245.mat
- LHO_ISI_BSC8_Data_L2L_100Hz_500Hz_ST1_ST2_20111205-200228.mat
- LHO_ISI_BSC8_Data_L2L_500Hz_1000Hz_ST1_ST2_20111205-185743.mat

L2L concatenated
- LHO_ISI_BSC8_TF_L2L_Raw_10mHz_1000Hz_2012_01_06.mat

Reconstructed C2C with Step_3_TF_C2C_from_L2L_with_Resymmetrization and loading LHO_ISI_BSC8_Symmetrization_Filters_2011_07_27.mat
- LHO_ISI_BSC8_TF_C2C_Reconstructed_Sym_10mHz_1000Hz_2012_01_06.mat

The set of that enables to evaluate the performance of the dampers is realized using the following measurements:
- LHO_ISI_BSC8_Data_L2L_100Hz_200Hz_ST1_ST2_20120130-225348.mat
- LHO_ISI_BSC8_Data_L2L_200Hz_300Hz_ST1_ST2_20120130-213347.mat
- LHO_ISI_BSC8_Data_L2L_300Hz_500Hz_ST1_ST2_20120130-201344.mat
- LHO_ISI_BSC8_Data_L2L_500Hz_750Hz_ST1_ST2_20120130-190908.mat
- LHO_ISI_BSC8_Data_L2L_750Hz_1000Hz_ST1_ST2_20120130-180434.mat

L2L concatenated
- LHO_ISI_BSC8_TF_L2L_Raw_10mHz_1000Hz_2012_01_30.mat

Reconstructed C2C with Step_3_TF_C2C_from_L2L_with_Resymmetrization and loading LHO_ISI_BSC8_Symmetrization_Filters_2011_07_27.mat
- LHO_ISI_BSC8_TF_C2C_Reconstructed_Sym_10mHz_1000Hz_2012_01_30.mat

Stage 1 transfer functions comparison – vibration absorbers and TMDs:
seismic/BSC-ISI/H2/ITMY/Data/Figures/Transfer_Functions/Comparisons/C2C/

- LHO_ISI_BSC8_Comparison_TF_C2C_ST1_ACT_V_to_ST1_L4C_V_20120106_vs_20120130.fig
- LHO_ISI_BSC8_Comparison_TF_C2C_ST1_ACT_H_to_ST1_L4C_H_20120106_vs_20120130.fig

Stage 2 transfer functions comparison – Stage 2 pads viton pads:
seismic/BSC-ISI/H2/ITMY/Data/Figures/Transfer_Functions/Comparisons/C2C/

- LHO_ISI_BSC8_Comparison_TF_C2C_ST2_ACT_H_to_ST2_GS13_H_20120106_vs_20120130.fig
- LHO_ISI_BSC8_Comparison_TF_C2C_ST2_ACT_H_to_ST2_GS13_H_20120106_vs_20120130.fig

Stage 1 – Transfer functions

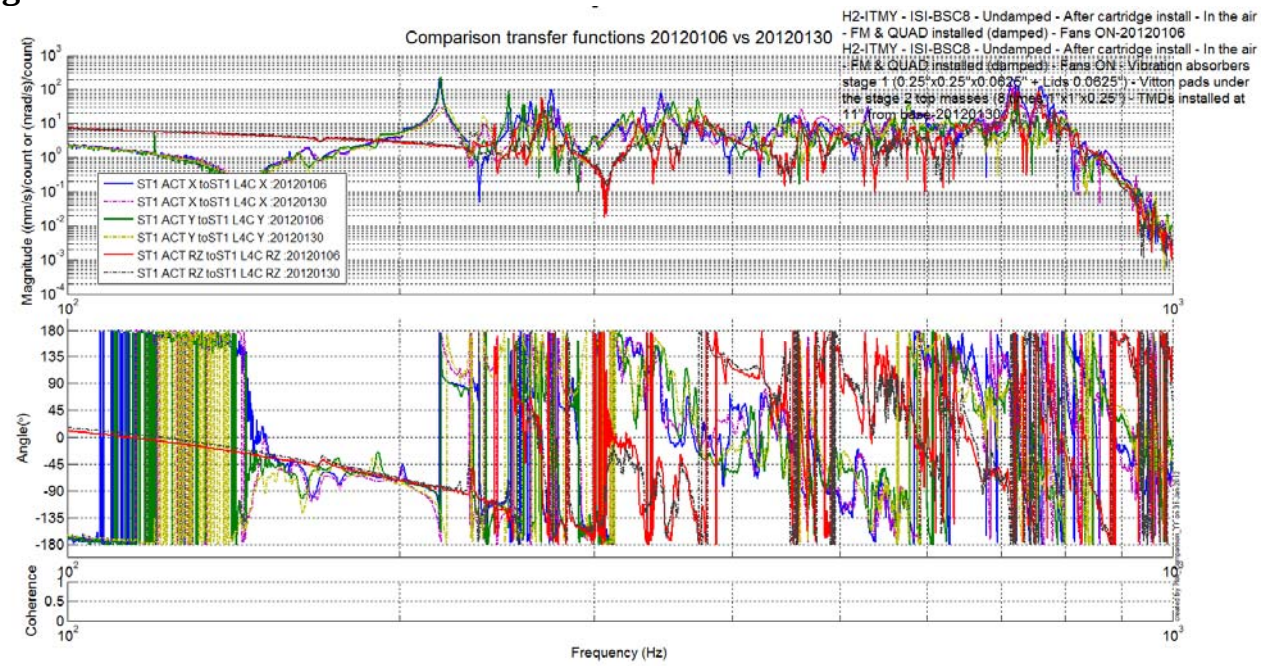


Figure 77 - TF C2C ST1 L4C H

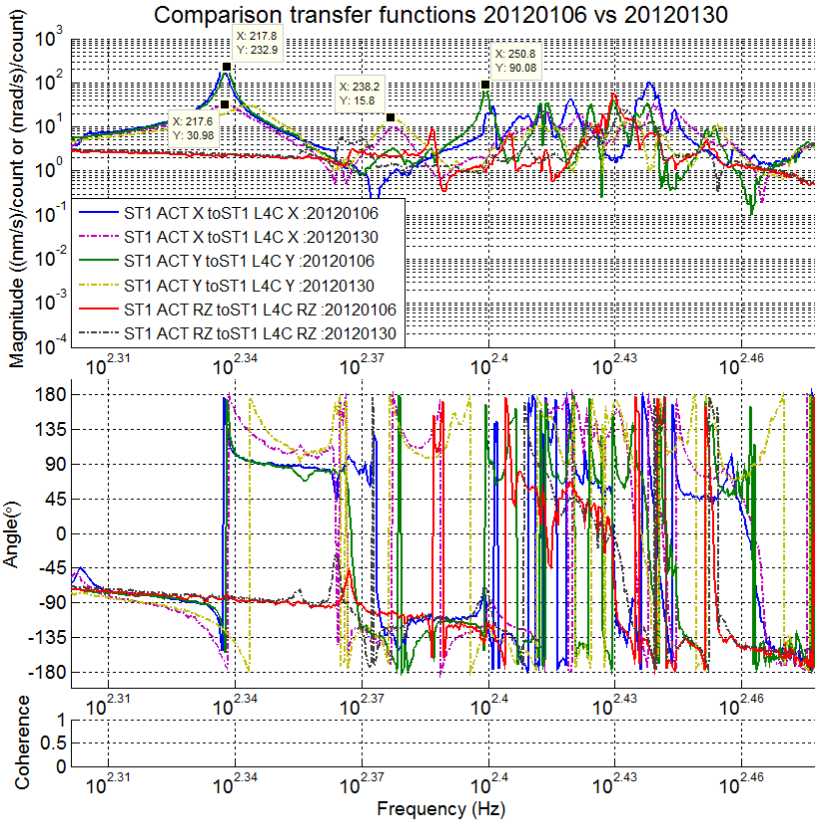


Figure 78 - TF C2C ST1 L4C H

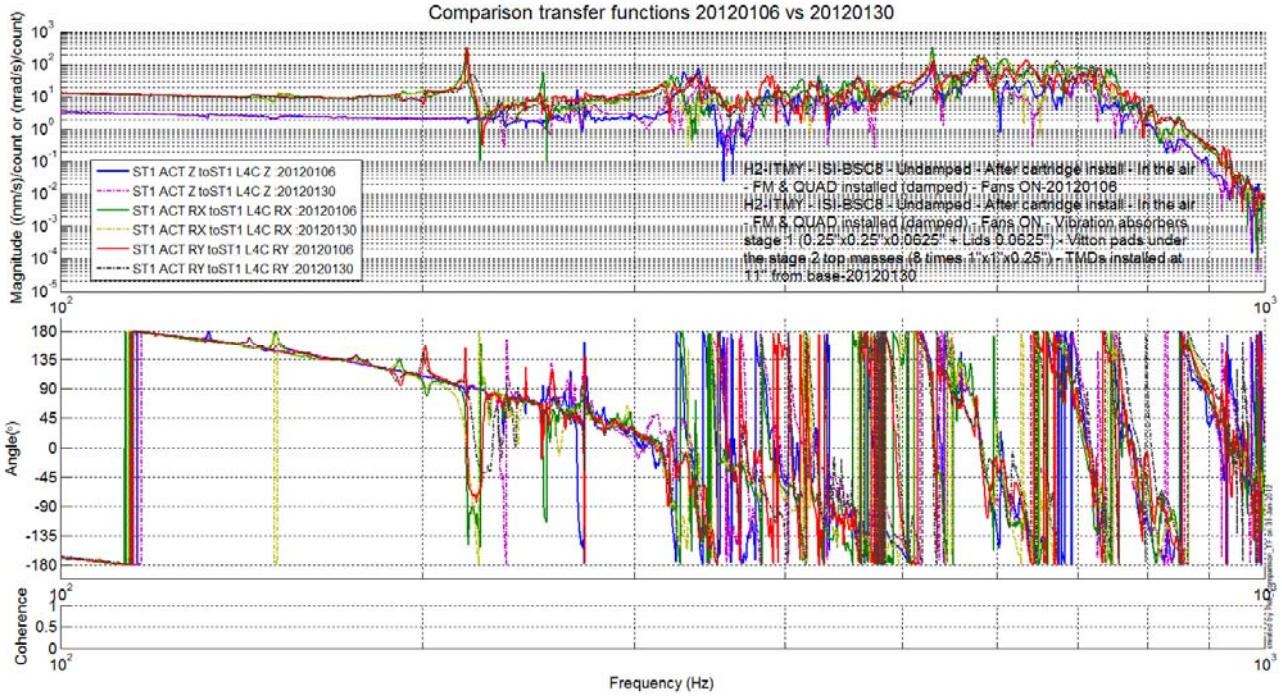


Figure 79 - TF C2C ST1 L4C V

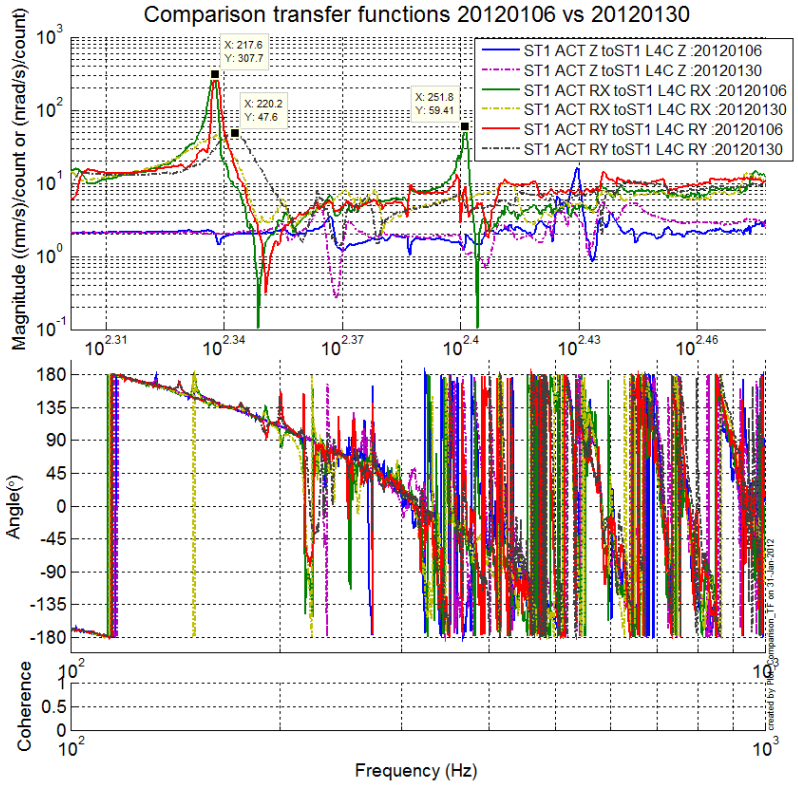


Figure 80 - TF C2C ST1 L4C V

Stage 2 – Transfer functions

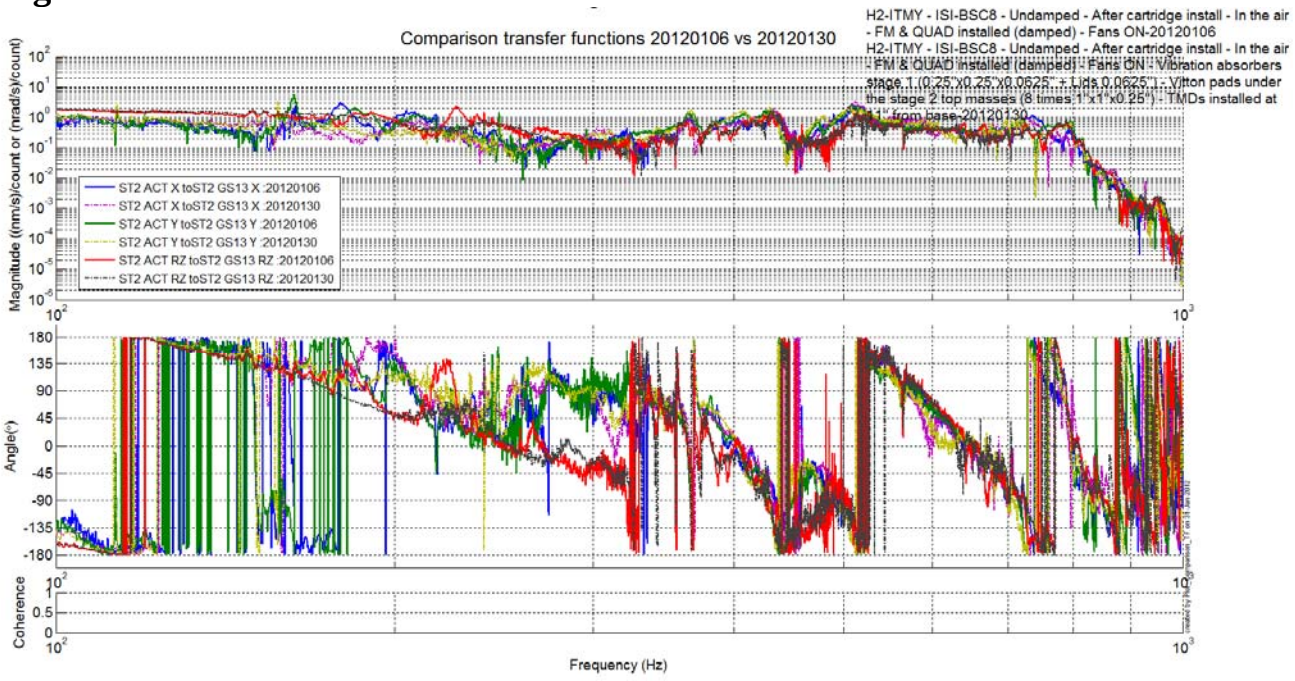


Figure 81 - TF C2C – ST2 GS13 Horizontals

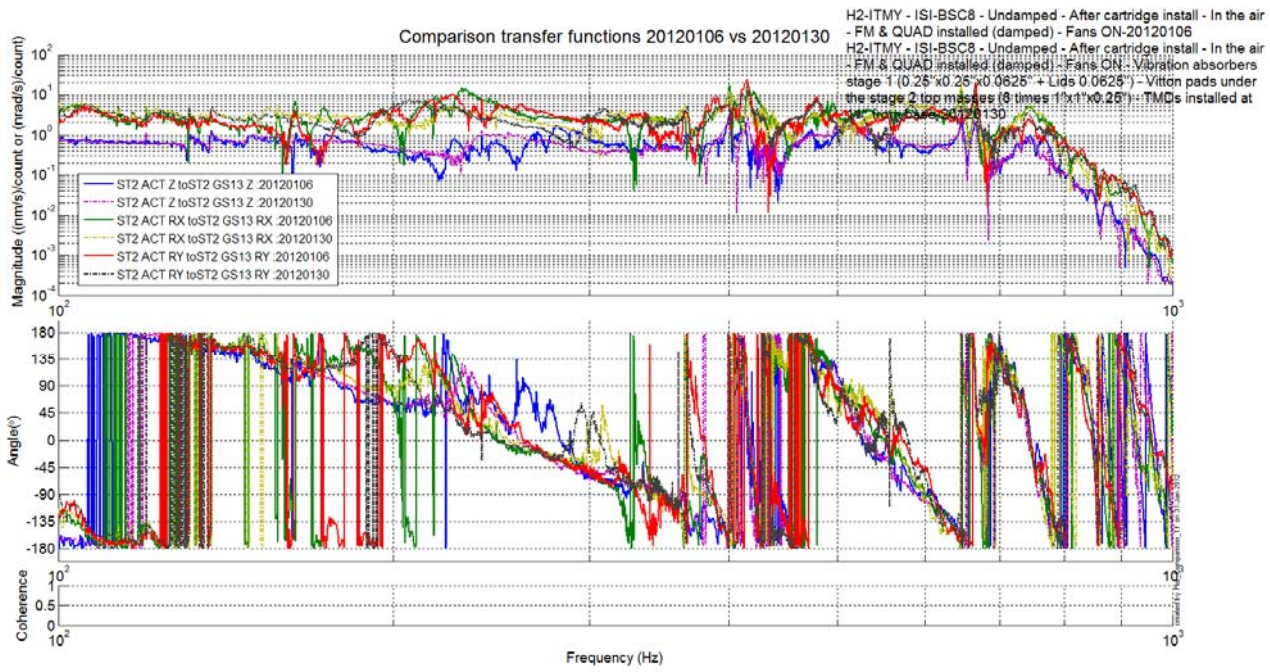


Figure 82 - TF C2C – ST2 GS13 Verticals

5. SUS resonances – Payload History

In this section, transfer functions of the ISI are presented for different types of payload, different stage 0 support (crossbeams vs teststand) and different dampers (vibration absorbers and TMDs).

The configurations are the following:

- LVEA teststand - Undamped - In the air - 2011 07 27
- LVEA teststand - Undamped - In the air - In The LVEA after the ST2-GS13 V3 change - QUAD installed (not damped) - Fans ON - 2011 08 31
- LVEA teststand - Undamped - In the air - FM % QUAD installed (damped) - Fans ON - 2011 12 06
- In chamber - Undamped - In the air - FM & QUAD installed (damped) - Fans ON - 2012 01 06
- H2-ITMY - ISI-BSC8 - Undamped - After cartridge install - In the air - FM & QUAD installed (damped) - Fans ON - Vibration absorbers stage 1 (0.25"x0.25"x0.25") - Vitton pads under the stage 2 top masses (8 times 1"x1"x0.25") - 2012 01 24
- H2-ITMY - ISI-BSC8 - Undamped - After cartridge install - In the air - FM & QUAD installed (damped) - Fans ON - Vibration absorbers stage 1 (0.25"x0.25"x0.0625" + Lids 0.125") - Vitton pads under the stage 2 top masses (8 times 1"x1"x0.25") - TMDs installed at 11" from base - 2012 01 25
- H2-ITMY - ISI-BSC8 - Undamped - After cartridge install - In the air - FM & QUAD installed (damped) - Fans ON - Vibration absorbers stage 1 (0.25"x0.25"x0.0625" + Lids 0.125") - Vitton pads under the stage 2 top masses (8 times 1"x1"x0.25") - TMDs installed at 11" from base - 2012 01 26

Concatenated data in the local basis can be found in the SVN at:
/BSC-ISI/H2/ITMY/Data/Transfer_Functions/Simulations/Undamped/

- LHO_ISI_BSC8_TF_L2L_Raw_10mHz_1000Hz_2011_07_27.mat
- LHO_ISI_BSC8_TF_L2L_Raw_10mHz_1000Hz_2011_08_31.mat
- LHO_ISI_BSC8_TF_L2L_Raw_10mHz_1000Hz_2011_12_06.mat
- LHO_ISI_BSC8_TF_L2L_Raw_10mHz_1000Hz_2012_01_06.mat
- LHO_ISI_BSC8_TF_L2L_Raw_10mHz_1000Hz_2012_01_25.mat
- LHO_ISI_BSC8_TF_L2L_Raw_10mHz_1000Hz_2012_01_26.mat

Concatenated data in the Cartesian basis can be found in the SVN at:
BSC-ISI/H2/ITMY/Data/Transfer_Functions/Simulations/Undamped/

- LHO_ISI_BSC8_TF_C2C_Reconstructed_Sym_10mHz_1000Hz_2011_07_27.mat
- LHO_ISI_BSC8_TF_C2C_Reconstructed_Sym_10mHz_1000Hz_2011_08_31.mat
- LHO_ISI_BSC8_TF_C2C_Reconstructed_Sym_10mHz_1000Hz_2011_12_06.mat
- LHO_ISI_BSC8_TF_C2C_Reconstructed_Sym_10mHz_1000Hz_2012_01_06.mat
- LHO_ISI_BSC8_TF_C2C_Reconstructed_Sym_10mHz_1000Hz_2012_01_25.mat
- LHO_ISI_BSC8_TF_C2C_Reconstructed_Sym_10mHz_1000Hz_2012_01_26.mat

ST1 ACT TO ST1 CPS

The comparison of the transfer functions are located in the SVN at:
/BSC-ISI/H2/ITMY/Data/Figures/Transfer_Functions/Comparisons/Evolution/

- LHO_ISI_BSC8_Evolution_TF_C2C_ST1_ACT_X_TO_ST1_CPS_X.fig
- LHO_ISI_BSC8_Evolution_TF_C2C_ST1_ACT_Y_TO_ST1_CPS_Y.fig
- LHO_ISI_BSC8_Evolution_TF_C2C_ST1_ACT_Z_TO_ST1_CPS_Z.fig
- LHO_ISI_BSC8_Evolution_TF_C2C_ST1_ACT_RX_TO_ST1_CPS_RX.fig
- LHO_ISI_BSC8_Evolution_TF_C2C_ST1_ACT_RY_TO_ST1_CPS_RY.fig
- LHO_ISI_BSC8_Evolution_TF_C2C_ST1_ACT_RZ_TO_ST1_CPS_RZ.fig

Evolution between transfer functions:

- Teststand (long legs) resonance frequencies at 19.6Hz, 21.4Hz and 29.6Hz. (2011_07_27 – 2011_08_31 – 2011_12_06)
- HEPI resonances at 9Hz, 13Hz and 35 Hz (cross beams) (2012_01_06 – 2012_01_24 – 2012_01_25 – 2012_01_26 – 2012_01_30)
- Change of the first resonance (ISI suspension modes) due to the change of inertia created by the different types of payload
- Effect of the vibration absorbers (217Hz) and the TMDs (252Hz) not visible on the CPS in the Cartesian basis
- 2012 01 06 – HEPI Unlocked – RY - X
- 2012 01 26 – HEPI locked
- QUAD resonances at 0.46Hz and 0.54Hz (SUS Model) – slightly visible in the main couplings. More visible on cross couplings (ST1 to ST2 and ST2 to ST1). See tables below.

SUS	L2L	P2P	R2R	T2T	V2V	Y2Y
ITMY	0.4398	0.4398	0.4632	0.4629	0.5507	0.5996
FMY	0.4193	0.4193	0.4236	0.4236	1.084	0.4934

Table 29 - First modes of the QUAD (ITMY) and the folding mirror (FMY)

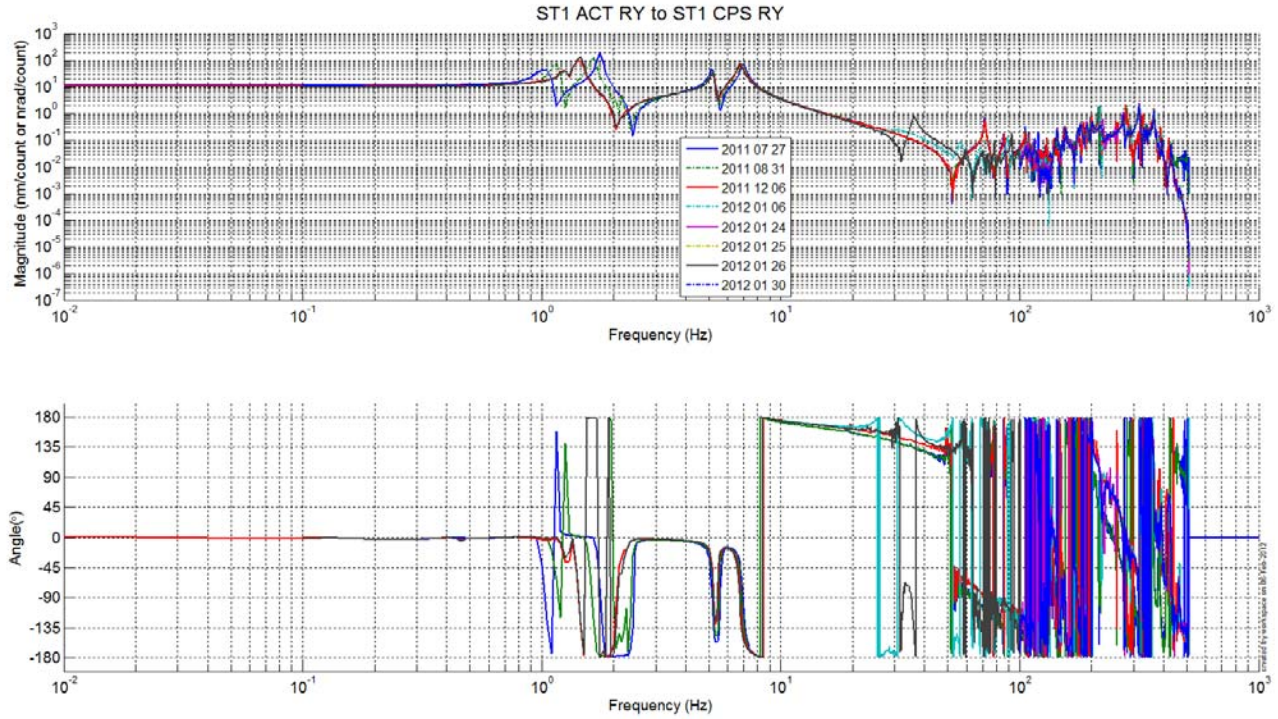


Figure 83 - ST1 ACT RY to ST1 CPS RY - Comparison payload

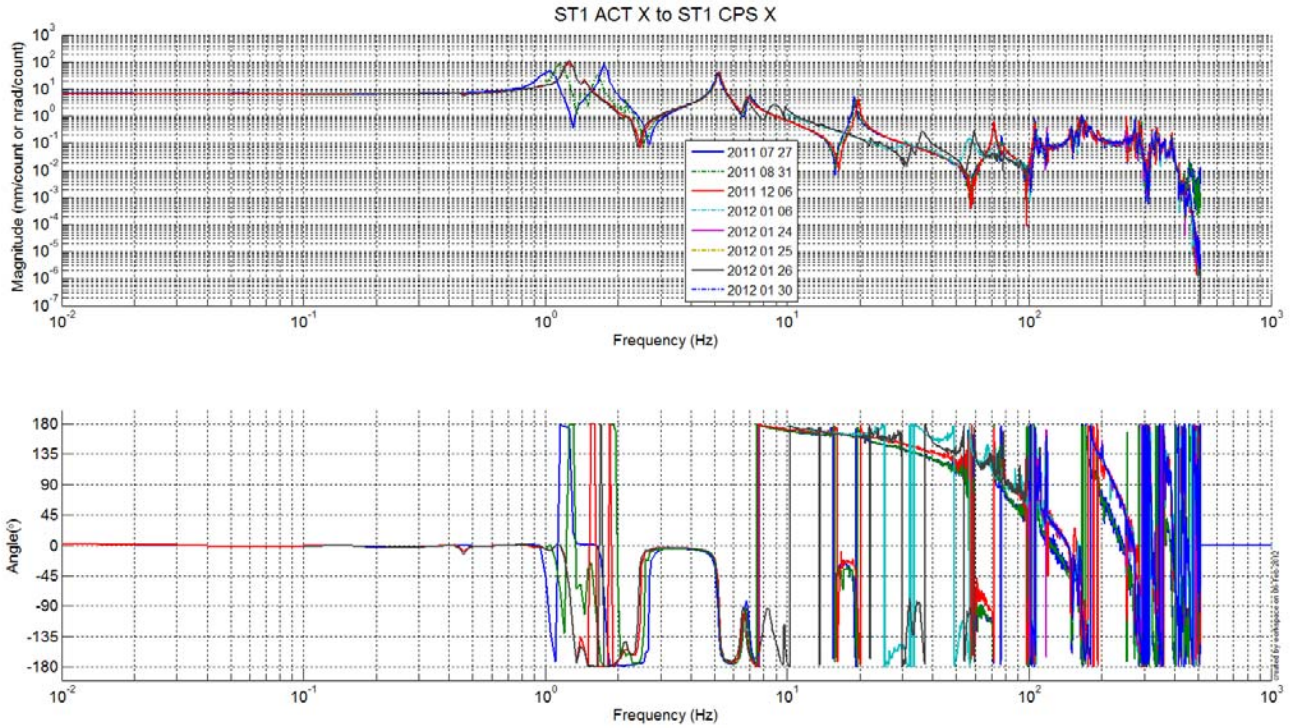
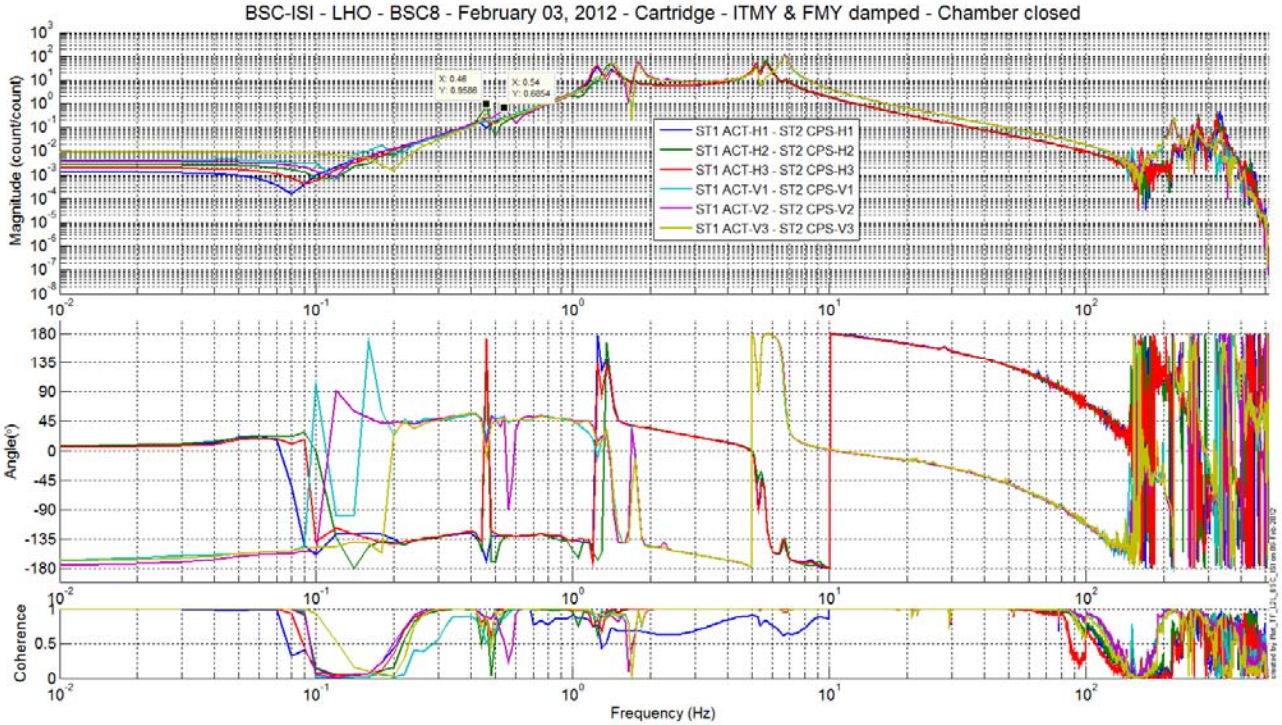


Figure 84 - ST1 ACT X to ST1 CPS X – Comparison payload


BSC-ISI - LHO - BSC8 - February 03, 2012 - Cartridge - ITMY & FMY damped - Chamber closed
Magnitude (count/count)
Angle(°)
Coherence
Frequency (Hz)
ST1 ACT-H1 - ST2 CPS-H1
ST1 ACT-H2 - ST2 CPS-H2
ST1 ACT-H3 - ST2 CPS-H3
ST1 ACT-V1 - ST2 CPS-V1
ST1 ACT-V2 - ST2 CPS-V2
ST1 ACT-V3 - ST2 CPS-V3

ST1 ACT TO ST1 L4C

/BSC-ISI/H2/ITMY/Data/Figures/Transfer_Functions/Comparisons/Evolution/

- LHO_ISI_BSC8_Evolution_TF_C2C_ST1_ACT_X_TO_ST1_L4C_X.fig
- LHO_ISI_BSC8_Evolution_TF_C2C_ST1_ACT_Y_TO_ST1_L4C_Y.fig
- LHO_ISI_BSC8_Evolution_TF_C2C_ST1_ACT_Z_TO_ST1_L4C_Z.fig
- LHO_ISI_BSC8_Evolution_TF_C2C_ST1_ACT_RX_TO_ST1_L4C_RX.fig
- LHO_ISI_BSC8_Evolution_TF_C2C_ST1_ACT_RY_TO_ST1_L4C_RY.fig
- LHO_ISI_BSC8_Evolution_TF_C2C_ST1_ACT_RZ_TO_ST1_L4C_RZ.fig

Evolution between transfer functions:

- Teststand resonances slightly visible at 19Hz, 21Hz and 29.6Hz (2011 07 27 – 2011 08 31 – 2011 12 06)
- Change of the first resonance (ISI suspension modes) due to the change of inertia created by the different payload
- Reduction of the resonance at 217Hz after introduction of the 6 vibration absorbers on the doors of stage 1
- Modification of the stage 0-1 blade frequency (252Hz) after introducing the TMDs (X, Y, RX, RY)

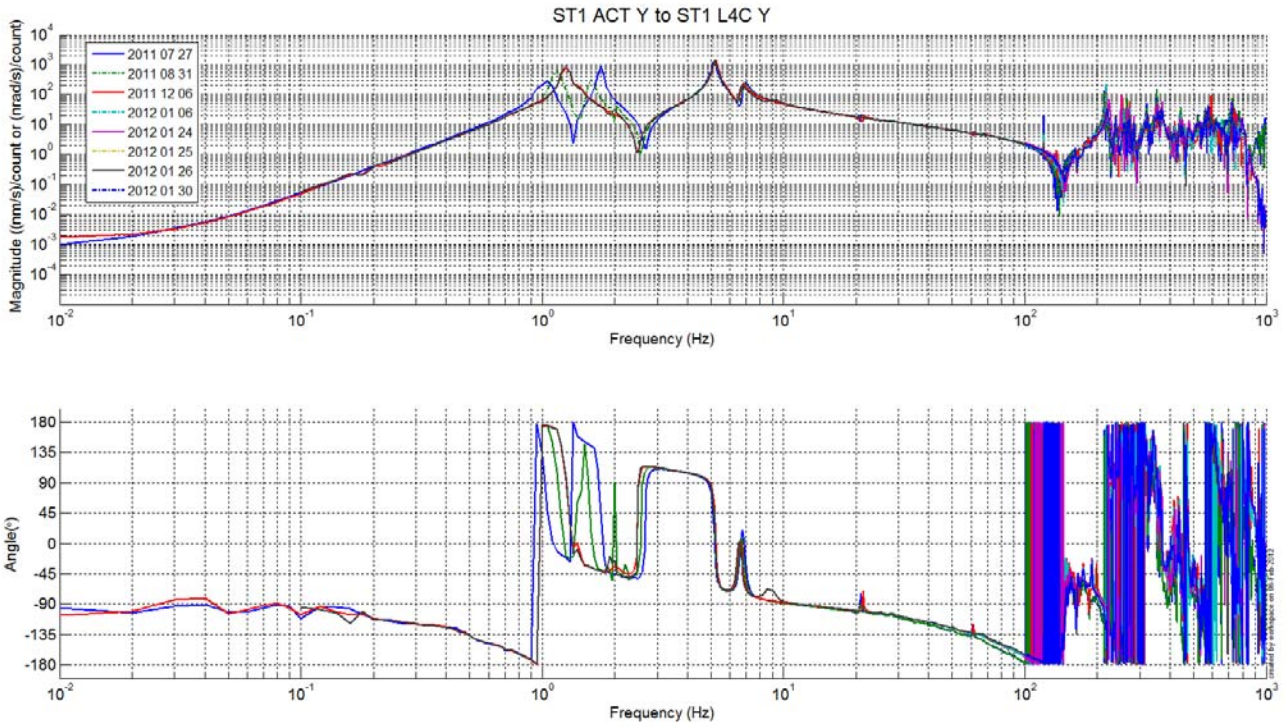


Figure 85 - ST1 ACT Y to ST1 L4C Y

ST2 CPS

/BSC-ISI/H2/ITMY/Data/Figures/Transfer_Functions/Comparisons/Evolution/

- LHO_ISI_BSC8_Evolution_TF_C2C_ST2_ACT_X_TO_ST2_CPS_X.fig
- LHO_ISI_BSC8_Evolution_TF_C2C_ST2_ACT_Y_TO_ST2_CPS_Y.fig
- LHO_ISI_BSC8_Evolution_TF_C2C_ST2_ACT_Z_TO_ST2_CPS_Z.fig
- LHO_ISI_BSC8_Evolution_TF_C2C_ST2_ACT_RX_TO_ST2_CPS_RX.fig
- LHO_ISI_BSC8_Evolution_TF_C2C_ST2_ACT_RY_TO_ST2_CPS_RY.fig
- LHO_ISI_BSC8_Evolution_TF_C2C_ST2_ACT_RZ_TO_ST2_CPS_RZ.fig

Evolution between transfer functions:

- Light DC change after 2011 08 31 – Transfer functions measured with the actuator symmetrization
- Change of the first resonance (ISI suspension modes) due to the change of inertia created by the different payload
- Effect of the Vibration absorbers (217Hz)
- Barely see the QUAD resonances at 0.46Hz and 0.54Hz in the main couplings

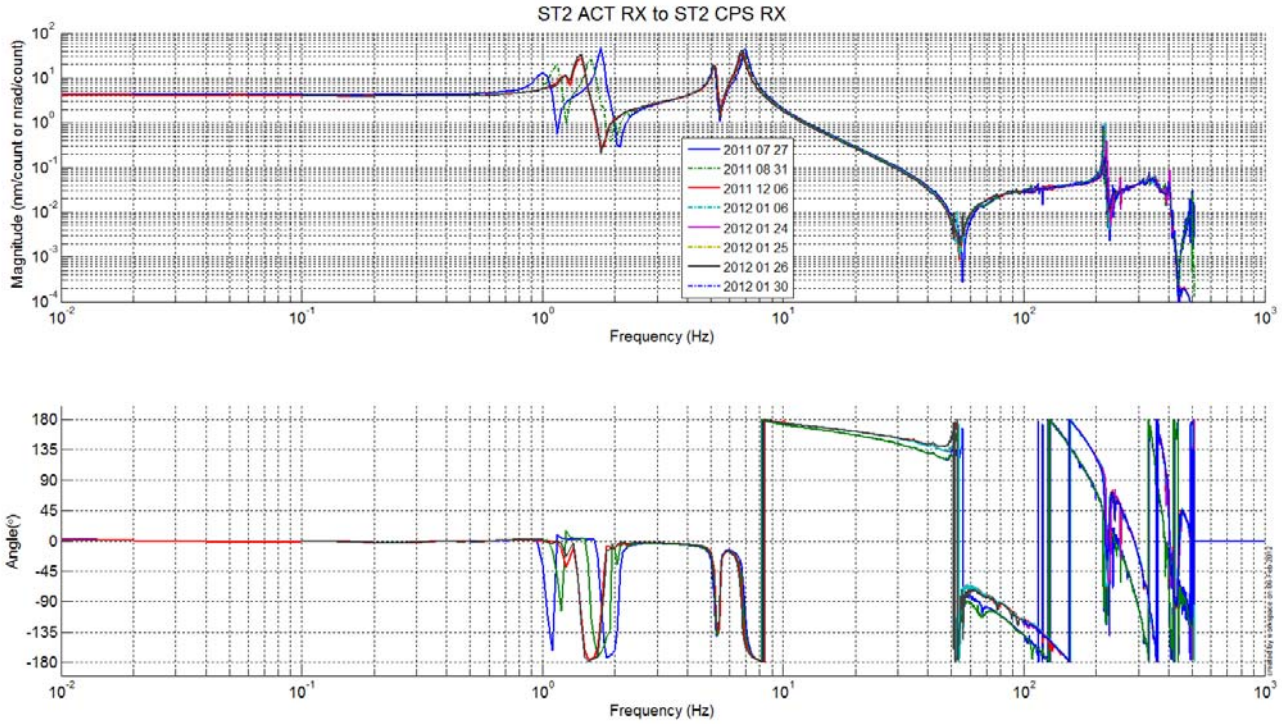


Figure 86 - ST2 ACT RX to ST2 CPS RX

ST2 GS13

/BSC-ISI/H2/ITMY/Data/Figures/Transfer_Functions/Comparisons/Evolution/

- LHO_ISI_BSC8_Evolution_TF_C2C_ST2_ACT_X_TO_ST2_GS13_X.fig
- LHO_ISI_BSC8_Evolution_TF_C2C_ST2_ACT_Y_TO_ST2_GS13_Y.fig
- LHO_ISI_BSC8_Evolution_TF_C2C_ST2_ACT_Z_TO_ST2_GS13_Z.fig
- LHO_ISI_BSC8_Evolution_TF_C2C_ST2_ACT_RX_TO_ST2_GS13_RX.fig
- LHO_ISI_BSC8_Evolution_TF_C2C_ST2_ACT_RY_TO_ST2_GS13_RY.fig
- LHO_ISI_BSC8_Evolution_TF_C2C_ST2_ACT_RZ_TO_ST2_GS13_RZ.fig

Evolution between transfer functions:

- Bump at 0.7Hz (end of a measurement section)
- Difficulties to measure high frequency transfer functions
- Mode at 51Hz (ST2 GS13 – No SUS) – Disappears after installation of the SUS items – After 2011 07 27.
- In general, Q at high frequencies are reduced after installing SUS items.
- Smooth resonance at 67.Hz (RX) after installing the QUAD
- New resonances around ~53 Hz after cartridge installation. Not visible in 2011 12 06.
- New resonance at 77Hz after installing the folding mirror (RX)
- Resonance at 67Hz which is damped after installation of the SUS items. (ST2 GS13 RX)
- Resonances around 0.4Hz slightly visible on the main couplings and more visible on the cross couplings.

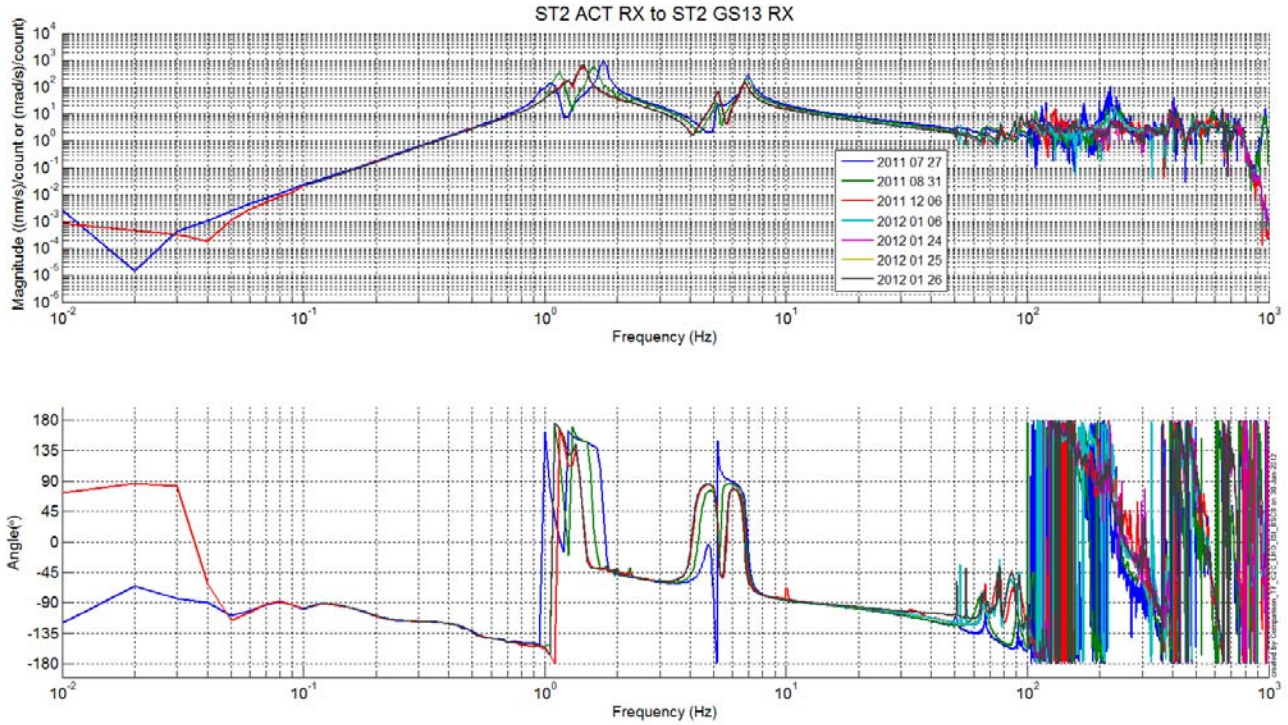


Figure 87 - ST2 ACT RX to ST GS13 RX

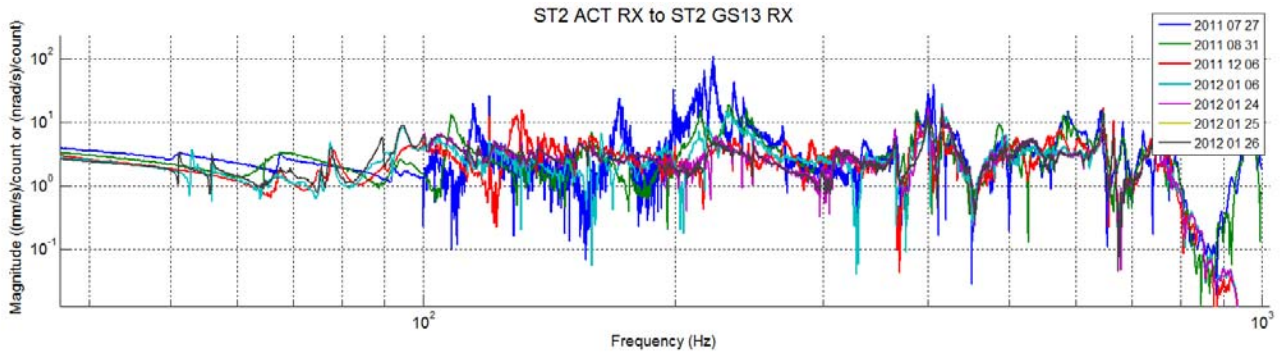


Figure 88 - ST2 ACT RX to ST GS13 RX - Zoom

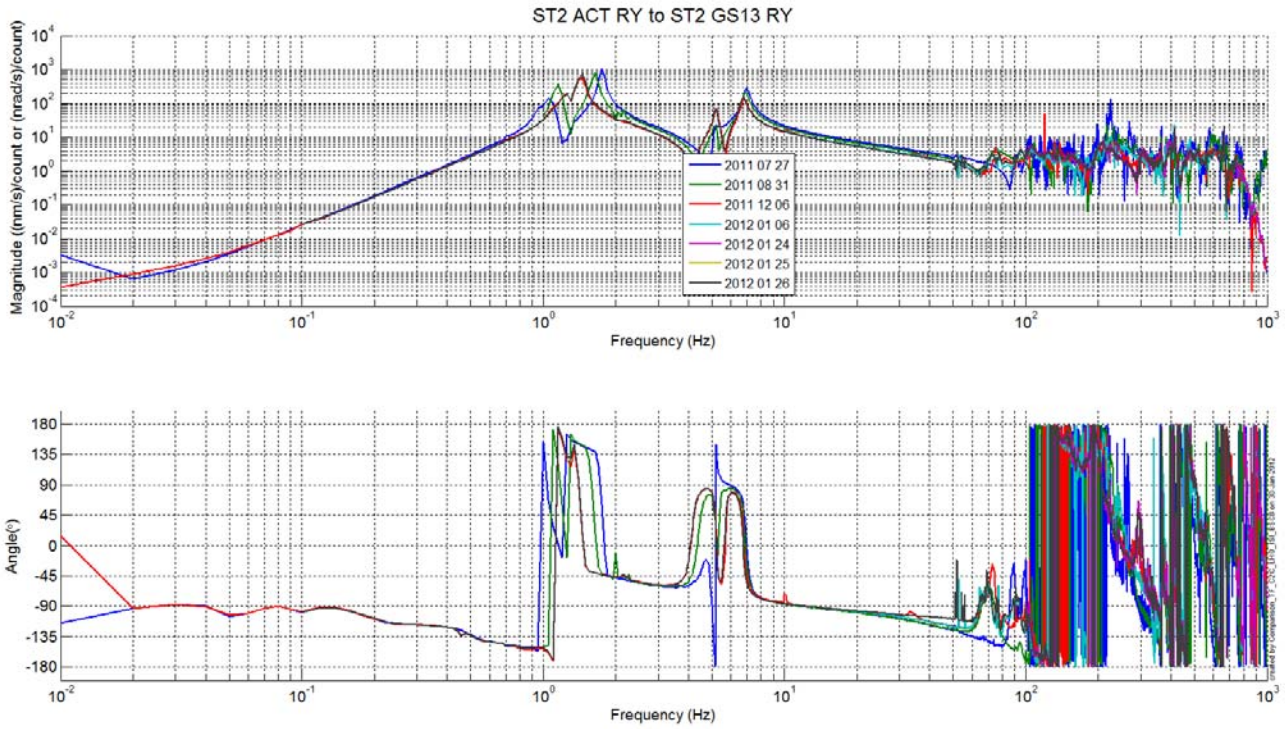


Figure 89 - ST2 ACT RY to ST2 GS13 RY

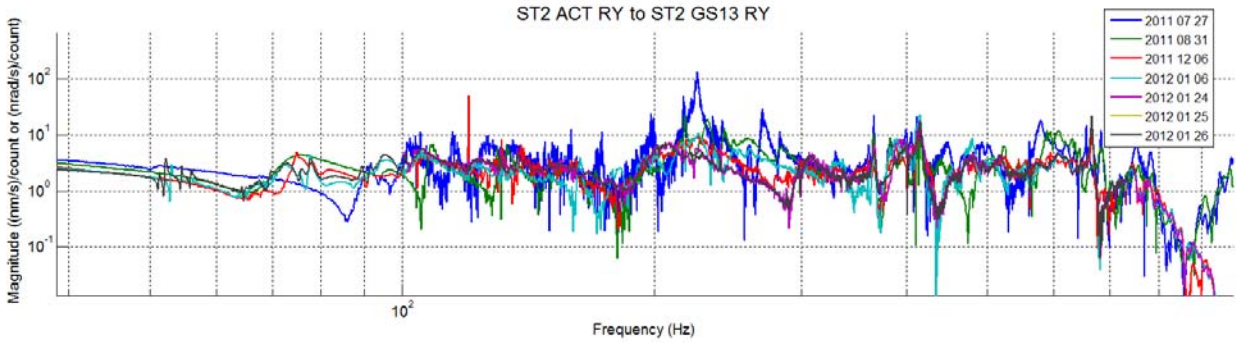


Figure 90 - ST2 ACT RY to ST2 GS13 RY - Zoom

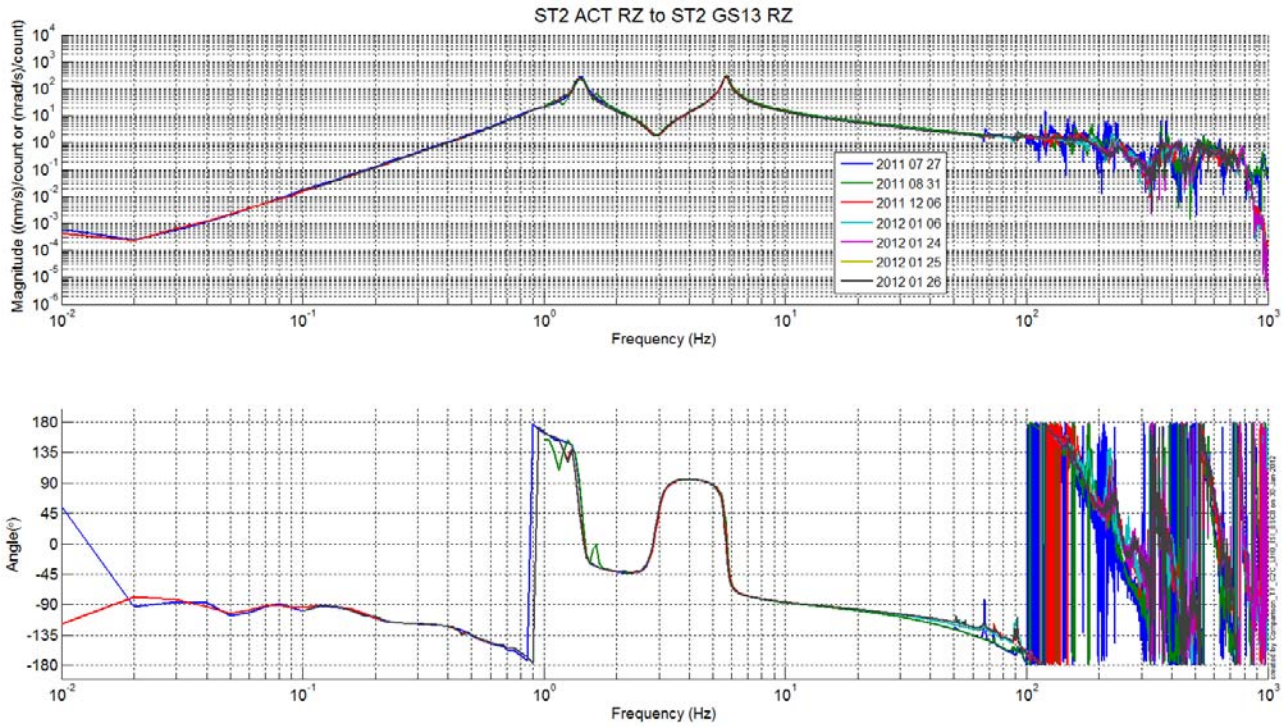


Figure 91 - ST2 ACT RZ to ST2 GS13 RZ

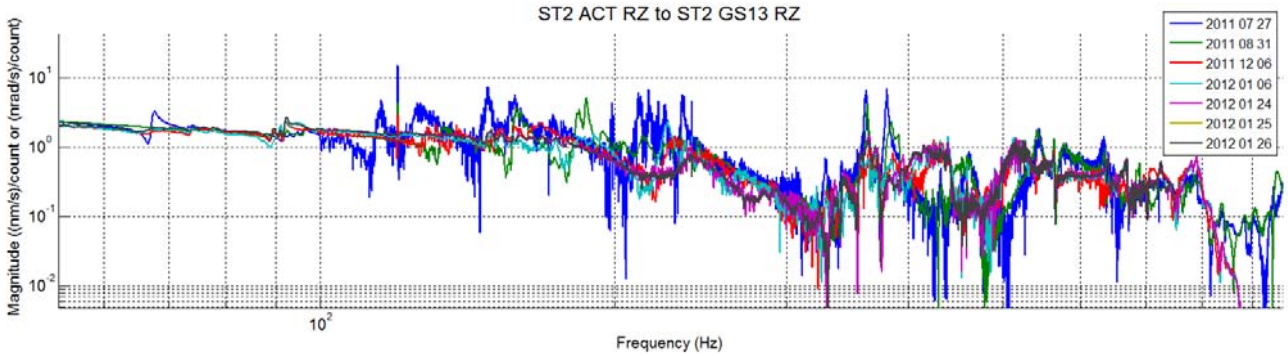


Figure 92 - ST2 ACT RZ to ST2 GS13 RZ - Zoom

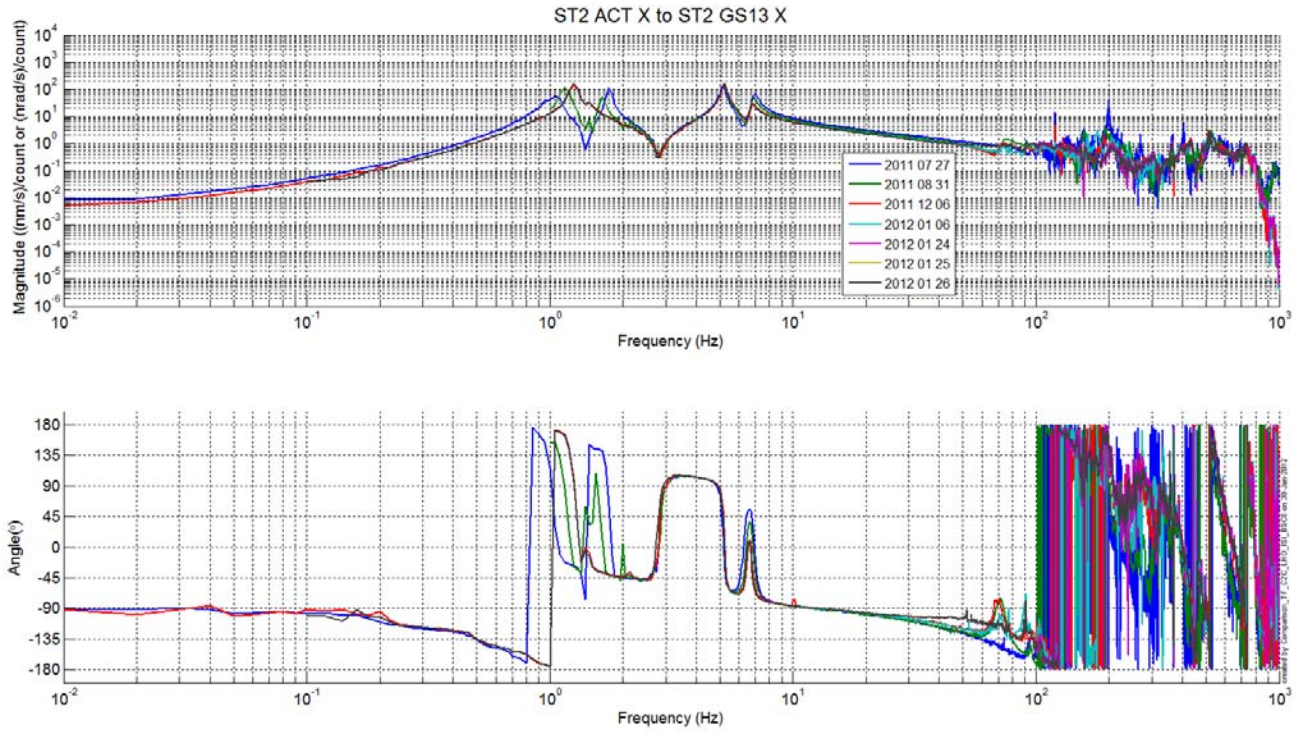


Figure 93 - ST2 ACT X to ST2 GS13 X

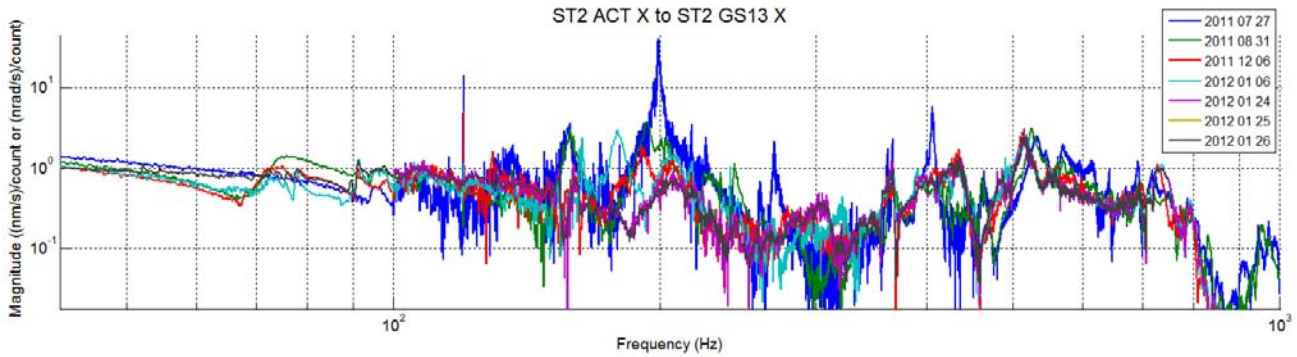


Figure 94 - ST2 ACT RY to ST2 GS13 X - Zoom

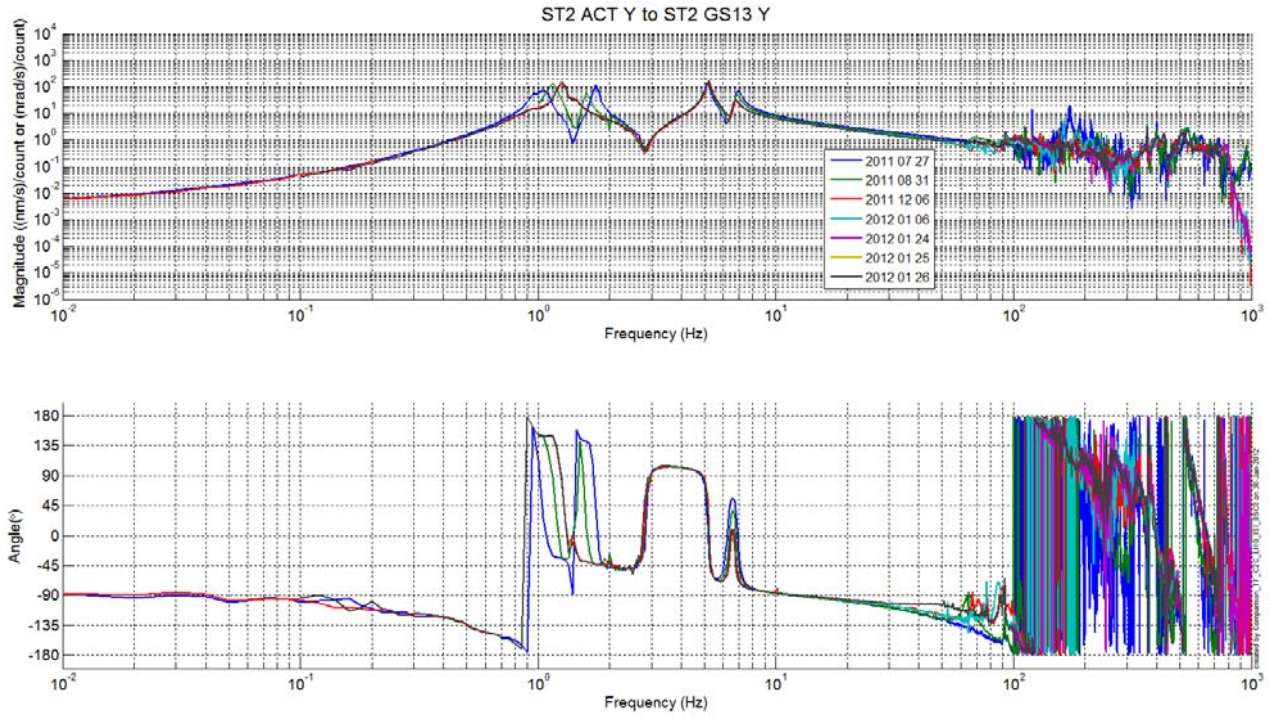


Figure 95 - ST2 ACT Y to ST2 GS13 Y

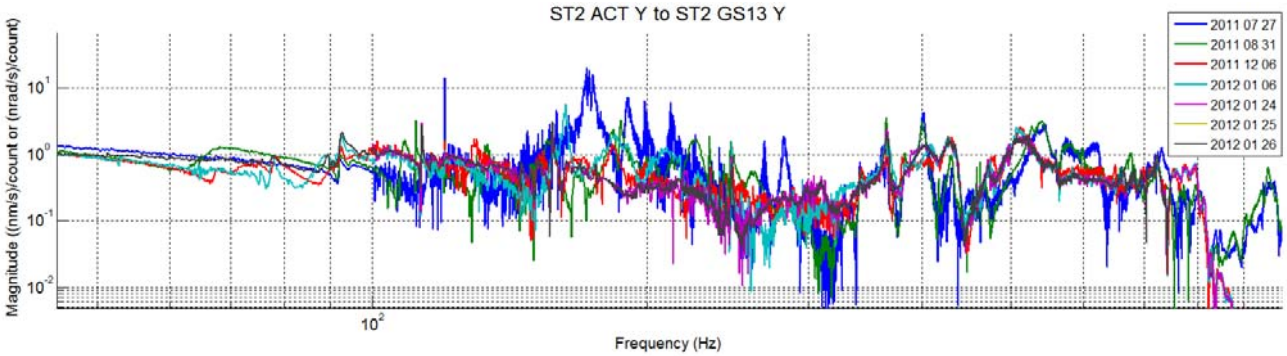


Figure 96 - ST2 ACT Y to ST2 GS13 Y - Zoom

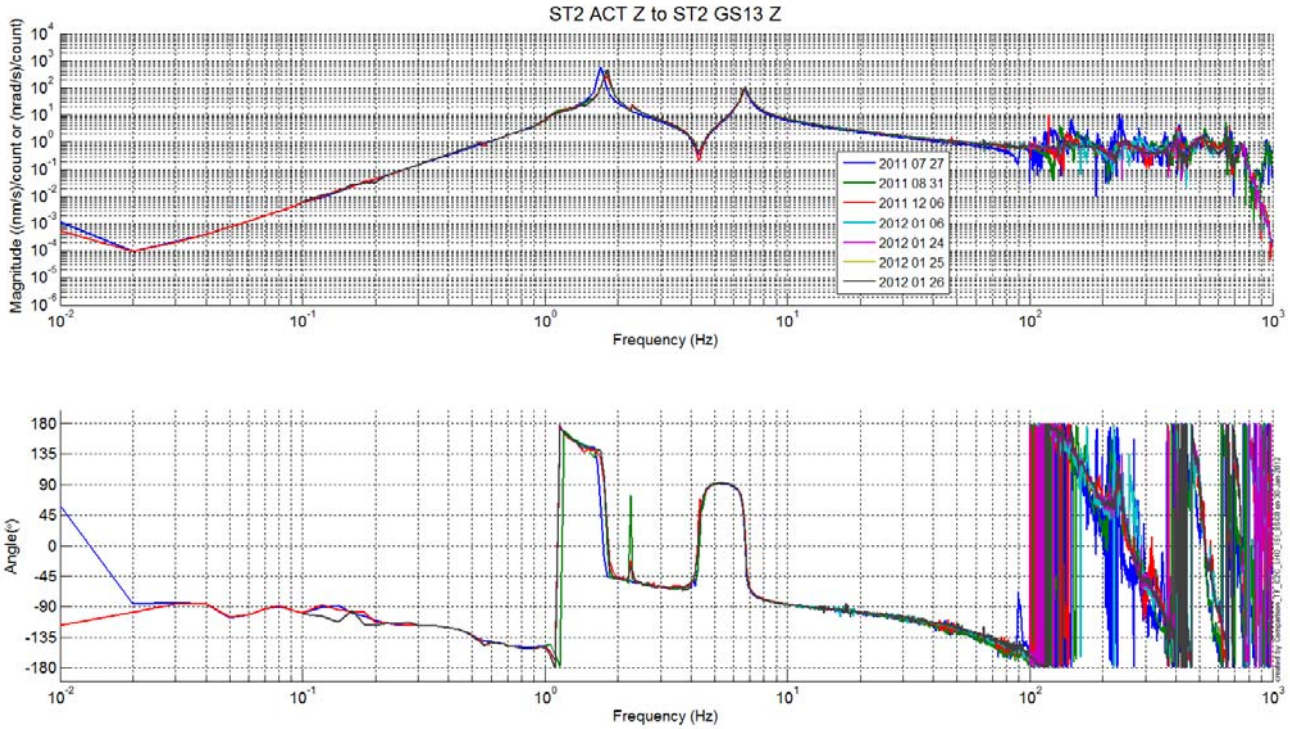


Figure 97 - ST2 ACT Z to ST2 GS13 Z

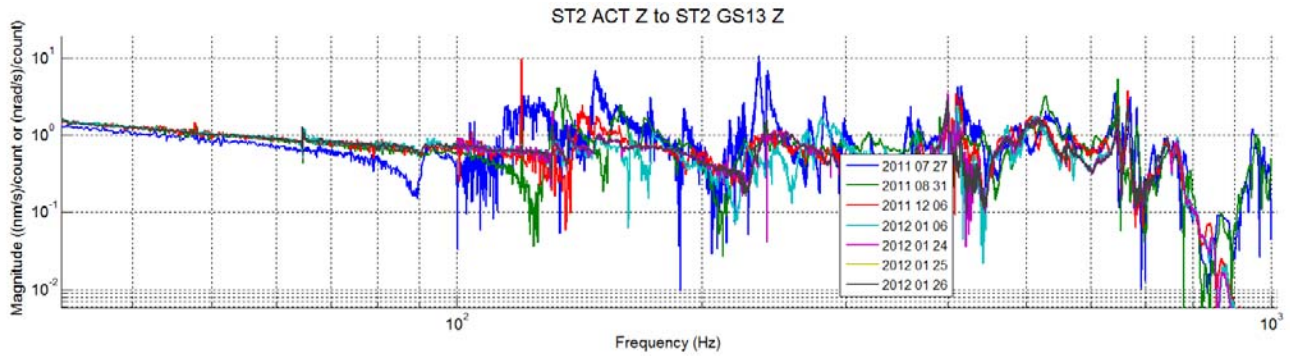


Figure 98 - ST2 ACT Z to ST2 GS13 Z - Zoom

6. Suspension modes

SUS transfer functions are reported in the seismic SVN at:
seismic/BSC-ISI/H2/ITMY/Misc/SUS_Model/

- FMY
- ITMY

The suspension modes are reported in the table below:

ITMY from ground

L2L	P2P	R2R	T2T	V2V	Y2Y
0.4398	0.4398	0.4632	0.4629	0.5507	0.5996
0.5625	0.564	0.8745	0.8745	2.215	1356
0.9997	0.9971	1.048	1.048	2.812	2.396
2.008	1.313	2.123	2.123	3.578	3.051
3.4411	1.605	2.633	2.633		
	2.007	3.317	3.317		
	2.812	5.074	5.069		
	3.317				
	3.417				

Table 30 - ITMY SUS pendulum modes

FMY from ground

L2L	P2P	R2R	T2T	V2V	Y2Y
0.4193	0.4193	0.4236	0.4236	1.084	0.4934
0.4684	0.4688	1.05	1.05	3.759	1.396
1.051	1.051	1.553	1.553	17.52	2.251
1.076	1.077	2.18	2.819		
1.698	1.392	3.206	3.206		
		25.97			

Table 31 - FMY SUS pendulum modes

8. Last tests before closing the chamber

1. Spectra

Spectra are measured in the locked and the unlocked configurations.

ISI Locked

Data:

seismic/BSC-ISI/H2/ITMY/Data/Spectra/Undamped/
LHO_ISI_BSC8_ASD_m_LOC_CPS_T240_L4C_GS13_2012_01_31_164413.mat

Figures :

seismic/BSC-ISI/H2/ITMY/Data/Figures/Spectra/Undamped/
LHO_ISI_BSC8_ASD_m_LOC_CPS_T240_L4C_GS13_2012_01_31_164413.fig

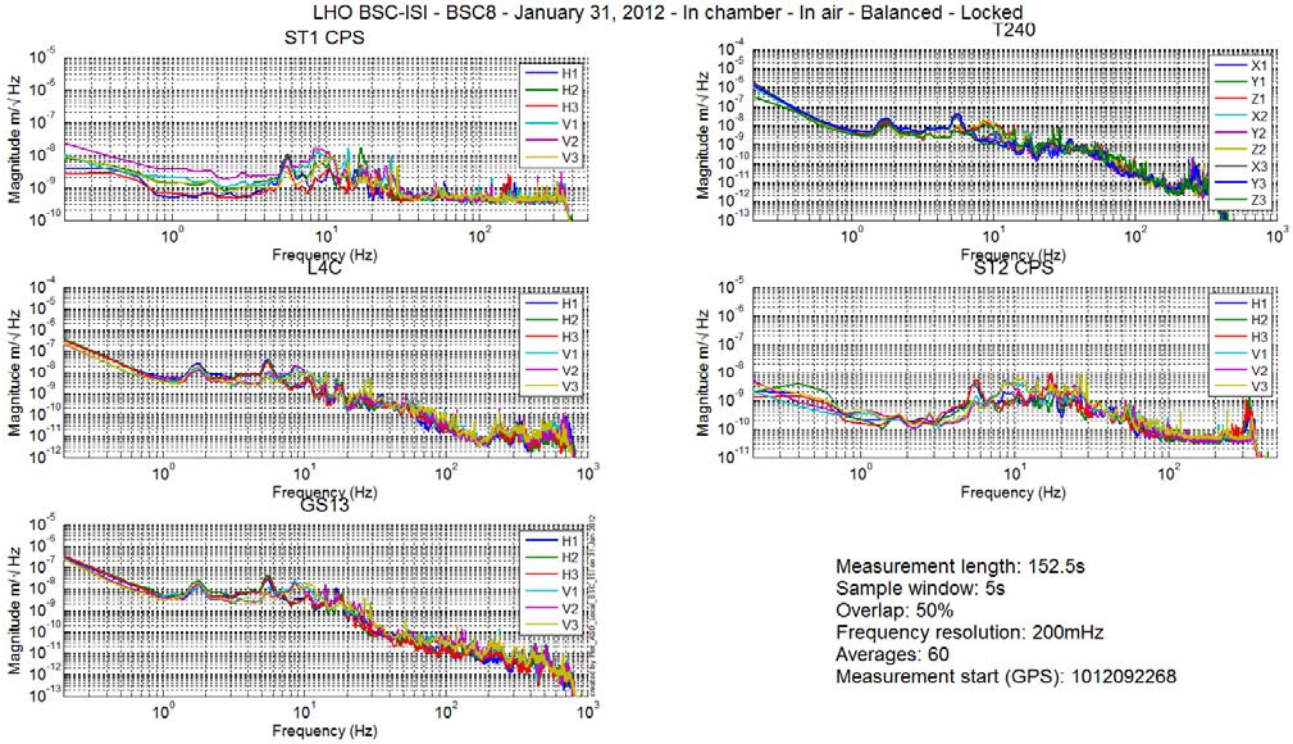


Figure 99 - Spectra - Locked position - Local basis

ISI unlocked:

Data:

seismic/BSC-ISI/H2/ITMY/Data/Spectra/Undamped/

- LHO_ISI_BSC8_ASD_m_LOC_CPS_T240_L4C_GS13_2012_02_01_102955.mat

Figures :

seismic/BSC-ISI/H2/ITMY/Data/Figures/Spectra/Undamped/

- LHO_ISI_BSC8_ASD_m_LOC_CPS_T240_L4C_GS13_2012_02_01_102955.fig

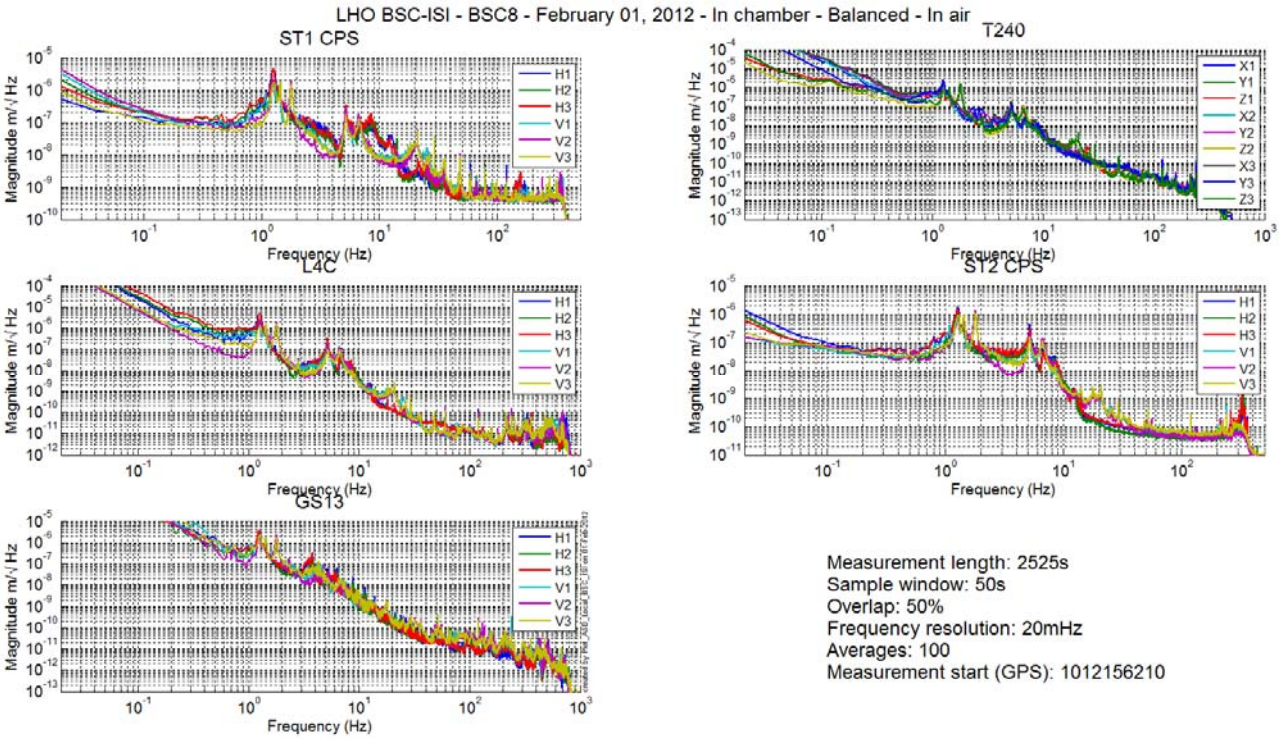


Figure 100 – Spectra - Unlocked position - Local basis

2. Geophones pressure sensors

The pressure sensors data are measured in two different ways:

- Using IOP input channels
- Using the model channels after calibration

/seismic/BSC-ISI/H2/ITMY/Data/Static_Tests/

- LHO_ISI_BSC8_Pressure_Sensors_Check_Raw_20120131.mat

	Pressure (counts)		
Sensors	**Corner 1**	**Corner 2**	**Corner 3**
ST1-L4C-D	81	260.0	231.0
ST1-L4C-P	24519	24502.0	24471.0
ST1-GS13-D	706	968.0	4067.0
ST1-GS13-P	24388	24313	24259
ST1-T240-P	14044	13622	13802

Table 32 – Pressure Raw values (Count)

/seismic/BSC-ISI/H2/ITMY/Data/Static_Tests/

- LHO_ISI_BSC8_Pressure_Sensors_Check_Calibrated_20120131.mat

	Pressure (KPA)		
Sensors	**Corner 1**	**Corner 2**	**Corner 3**
ST1-L4C-D	100.8	100.7	100.7
ST1-L4C-P	0.0	0.2	0.1
ST1-GS13-D	100.4	100.2	100.1
ST1-GS13-P	0.4	0.6	2.3
ST1-T240-P	101.7	99.6	100.5

Table 33 - Calibrate pressure (KPa)

3. Balancing – CPS Offset locked vs unlocked

CPS offsets are measured before and after locking the platform.

Results are posted in the SVN at:
/seismic/BSC-ISI/H2/ITMY/Data/Static_Tests/

- LHO_ISI_Locked_2_2012_01_31.mat
- LHO_ISI_Unlocked_3_2012_02_01.mat

	Table locked			Table unlocked			Difference locked - unlocked	
Sensors	**Offset (Mean)**	**Std deviation**	**mil**	**Offset (Mean)**	**Std deviation**	**mil**	**Offset (Mean)**	**mil**
ST1 - H1	1055.6	10.1	1.3	1412.7	30.8	1.7	-357.2	-0.43
ST1 - H2	-1813.4	11.6	-2.2	-1123.8	16.6	-1.3	-689.6	-0.82
ST1 - H3	-1110.7	6.7	-1.3	65.9	20.3	0.1	-1176.6	-1.40
ST1 - V1	-1311.7	8.1	-1.6	-2403.2	16.7	-2.9	1091.5	1.30
ST1 - V2	-1780.9	11.8	-2.1	-1250.4	28.0	-1.5	-530.5	-0.63
ST1 - V3	186.2	6.0	0.2	-1638.6	28.6	-2.0	1824.8	2.17
ST2 - H1	846.1	16.3	0.3	44.9	38.0	0.0	801.1	0.24
ST2 - H2	381.5	17.2	0.1	1929.0	34.6	0.6	-1547.6	-0.46
ST2 - H3	-635.3	19.4	-0.2	2094.9	44.7	0.6	-2730.2	-0.81
ST2 - V1	2051.7	20.4	0.6	3881.7	43.6	1.2	-1830.0	-0.54
ST2 - V2	-153.5	15.3	0.0	64.3	65.3	0.0	-217.8	-0.06
ST2 - V3	1754.8	22.1	0.5	1745.8	67.4	0.5	9.0	0.00

Figure 101 - Balancing

4. Static test – Local basis

Static tests in the local basis are located in the SVN:
/seismic/BSC-ISI/H2/ITMY/Data/Static_Tests/

- LHO_ISI_BSC8_Offset_Local_Drive_20120131.mat

		Sensors					
		ST1 - H1	**ST1 - H2**	**ST1 - H3**	**ST1 - V1**	**ST1 - V2**	**ST1 - V3**
Actuators	**ST1 - H1**	3811	1531	1523	33	-8	-7
	ST1 - H2	1507	3727	1492	-2	7	-3
	ST1 - H3	1503	1493	3720	11	-12	7
	ST1 - V1	70	-133	91	2869	-496	-470
	ST1 - V2	77	28	-139	-469	2881	-490
	ST1 - V3	-146	77	22	-481	-470	2890

Actuators \ Sensors	ST2 - H1	ST2 - H2	ST2 - H3	ST2 - V1	ST2 - V2	ST2 - V3
ST2 - H1	2138	337	332	6	-59	14
ST2 - H2	318	2159	334	14	-34	1
ST2 - H3	340	348	2255	-2	-27	5
ST2 - V1	55	119	-168	2614	315	0
ST2 - V2	-174	75	99	16	2581	314
ST2 - V3	108	-172	71	328	-2	2566

Table 34 – Static test local basis

5. Static Test – Cartesian basis

Static tests in the local basis are located in the SVN:
/seismic/BSC-ISI/H2/ITMY/Data/Static_Tests/

- LHO_ISI_BSC8_Offset_Cartesian_Drive_20120131.mat

Actuators \ Sensors	ST1 - X	ST1 - Y	ST1 - Z	ST1 – RX	ST1 - RY	ST1 - RZ
ST1 - X	1503	-2	-1	-13	-13	36
ST1 - Y	1	1483	-3	6	-10	4
ST1 - Z	9	3	639	6	-5	-9
ST1 - RX	4	295	-1	2449	-12	-13
ST1 - RY	-294	14	-5	-2	2446	-8
ST1 - RZ	19	4	2	-3	2	2854

Actuators \ Sensors	ST2 - X	ST2 - Y	ST2 - Z	ST2 – RX	ST2 - RY	ST2 - RZ
ST2 - X	1228	-3	17	12	21	21
ST2 - Y	-13	1250	9	-7	5	-33
ST2 - Z	11	8	997	6	-5	-6
ST2 - RX	6	3	10	3760	6	-6
ST2 - RY	27	11	12	12	3724	6
ST2 - RZ	20	-28	5	-13	7	2353

Table 35 - Static test - Cartesian basis drive – Cartesian results

Actuators \ Sensors	ST1 - H1	ST1 - H2	ST1 - H3	ST1 - V1	ST1 - V2	ST1 - V3
ST1 - X	1548	-728	-718	31	-6	-2
ST1 - Y	7	1284	-1279	6	9	1
ST1 - Z	4	-18	-12	647	642	634
ST1 - RX	-2	114	-143	-2337	1998	356
ST1 - RY	-152	78	52	-921	-1569	2517
ST1 - RZ	2772	2734	2732	10	5	12

Actuators \ Sensors	ST2 - H1	ST2 - H2	ST2 - H3	ST2 - V1	ST2 - V2	ST2 - V3
ST2 - X	607	-1227	643	26	6	13
ST2 - Y	1040	-3	-1099	13	3	9
ST2 - Z	3	-14	6	1005	979	964
ST2 - RX	-239	-6	236	-2152	2234	-26
ST2 - RY	148	-281	142	-1297	-1225	2522
ST2 - RZ	1609	1601	1657	22	-20	9

Table 36 - Static test - Cartesian basis drive - Local results

6. Range of motion – Actuators

Range of motion tests results are located in the SVN at:
/seismic/BSC-ISI/H2/ITMY/Data/Static_Tests/

- LHO_ISI_BSC8_Range_Of_Motion_20120131.mat

Sensor readout (counts)	Negative drive	no drive	Positive drive	Amplitude count	mil
ST1 - H1	-14891	1374	16765	31657	37.7
ST1 - H2	-17010	-1244	14703	31713	37.8
ST1 - H3	-15615	311	13784	29399	35.0
ST1 - V1	-14793	-2503	9799	24592	29.3
ST1 - V2	-13525	-1137	11211	24737	29.4
ST1 - V3	-13962	-1558	10799	24762	29.5
ST2 - H1	-8929	218	9361	18290	5.4
ST2 - H2	-7220	1962	11144	18364	5.5
ST2 - H3	-7664	1877	11404	19069	5.7
ST2 - V1	-7189	3929	15035	22225	6.6
ST2 - V2	-10908	196	11289	22197	6.6
ST2 - V3	-9251	1816	12850	22101	6.6

Table 37 - Range of motion

7. Linearity Test

Not performed

8. Transfer functions

Last set of measurements:

Seismic/BSC-ISI/H2/ITMY/Data/Transfer_Functions/Measurements/Undamped/

- LHO_ISI_BSC8_Data_L2L_700mHz_10Hz_ST1_ST2_20120201-041506.mat
- LHO_ISI_BSC8_Data_L2L_10Hz_100Hz_ST1_ST2_20120201-004803.mat
- LHO_ISI_BSC8_Data_L2L_100Hz_500Hz_ST1_ST2_20120131-230304.mat
- LHO_ISI_BSC8_Data_L2L_500Hz_1000Hz_ST1_ST2_20120131-213833.mat

Transfer functions figures are located in the SVN
https://svn.ligo.caltech.edu/svn/seismic/BSC-ISI/H2/ITMY/Data/Figures/Transfer_Functions/Measurements/Undamped/

- LHO_ISI_BSC8_TF_L2L_Raw_from_ST1_ACT_to_ST1_CPS_2012_01_31.fig
- LHO_ISI_BSC8_TF_L2L_Raw_from_ST1_ACT_to_ST1_L4C_2012_01_31.fig
- LHO_ISI_BSC8_TF_L2L_Raw_from_ST1_ACT_to_ST1_T240_2012_01_31.fig
- LHO_ISI_BSC8_TF_L2L_Raw_from_ST2_ACT_to_ST2_CPS_2012_01_31.fig
- LHO_ISI_BSC8_TF_L2L_Raw_from_ST2_ACT_to_ST2_GS13_2012_01_31.fig

9. State of health of the T240 on February 6, 2012

The state of health was realized on February 6, 2012.

Then snapshots of the SOF are presented below:

Corner 1

<Manufacture>"Nanometrics, Inc."</Manufacture>

<Product>"Trillium Firmware"</Product>

<Version>3.33</Version>

<Temperature>31.01</Temperature>

<Mass>U=0.006 V=-0.006 W=-0.034</Mass>

<Adc>U=3 V=-2 W=-15</Adc>

<Modes>Period=Long Channel=XYZ</Modes>

<Positions>U=-1772 V=-4704 W=1868</Positions>

<Level>U=0 V=0 W=0</Level>

<Range>U=+/-5000 V=+/-5000 W=+/-5000</Range>

Corner 2

<Manufacture>"Nanometrics, Inc."</Manufacture>

<Product>"Trillium Firmware"</Product>

<Version>3.33</Version>

<Temperature>31.44</Temperature>

<Mass>U=0.043 V=0.884 W=-0.446</Mass>

<Adc>U=20 V=400 W=-201</Adc>

<Modes>Period=Long Channel=XYZ</Modes>

<Positions>U=-400 V=215 W=56</Positions>

<Level>U=19 V=622 W=-659</Level>

<Range>U=+/-7005 V=+/-7301 W=+/-7273</Range>

Corner 3

<Manufacture>"Nanometrics, Inc."</Manufacture>

<Product>"Trillium Firmware"</Product>

<Version>3.33</Version>

<Temperature>27.92</Temperature>

<Mass>U=0.329 V=-1.222 W=-1.010</Mass>

<Adc>U=149 V=-552 W=-456</Adc>

<Modes>Period=Long Channel=XYZ</Modes>

<Positions>U=81 V=-471 W=272</Positions>

<Level>U=-491 V=323 W=66</Level>

<Range>U=+/-7179 V=+/-7139 W=+/-7139</Range>

10. Validation

After reviewing the testing results on February 3, 2012, the ISI passed the ISI-phase II tests. The Dome was put on.

Conclusion

The ISI-BSC8 was moved from the Staging building to the LVEA test stand on June 30, 2011.

This document presents the series of tests (Phase II) performed on the ISI-BSC8 (ITMY) in the LVEA. Some tests were done with and without the QUAD and the folding miror. Tests started on July 8, 2011. Damping loops were closed for the first time on July 22, 2011 and Isolation loops on August 4, 2011.

The cartridge installation occurred on Friday 9 December 2011 (LHO Alog 1887). TMDs and vibrations absorbers were installed mid January 2012.

The dome of the chamber was put on February 2, 2012.The first aLIGO BSC-ISI built in the LHO