LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-E1300887-v3 *Advanced LIGO* 27 November 2014

aLIGO HAM Tip-Tilt Suspension Testing and Installation Procedure

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Distribution of this document:
LIGO Science Collaboration

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1 Introduction

This document describes the testing and installation procedure for the HAM Tip-Tilt Suspension (HTTS).

The HTTS design and performance is found in 'aLIGO ISC Beam Steering – Tip-Tilt Mirror Design' (T1000042).

The HTTS is assembles according to 'Advanced LIGO HAM Tip-Tilt Suspension Assembly Procedure' (E1100440).

Prior and during installation some tests are performed. The suspensions have three testing phases, numbered 1, 2 and 3. For the HTTS, the Phases 1a and 1b and Phases 2a and 2b are merged into a single Phase 1 and Phase 2, depending at the current assembly or installation stage. In the Phases 1 and 2 there is no access to the CDS system, and no measurements are done.

Phase 3a and 3b are done during and after the installation and verify the performance of the units.

1.1 Clean room standards

For a clean assembly all LIGO standards should be followed, as presented in the latest version of the **LIGO Contamination Control Plan (E0900047).** Clean room garb including UHV gloves should be worn when working with parts.

All tools that come in contact with assembly should be cleaned to class B standards.

Assembly will be done under a portable clean room. Any time a part of the assembly is not covered by the portable clean room or not being actively worked on it should be covered with appropriate clean covers. (C3 polyester or equivalent).

All parts that will be included in the final assembly must be cleaned to LIGO standards, Class A. The list of parts to be Class A-cleaned includes screws, washers, inserts, and assorted other hardware. All tooling and other parts that are not included in the final assembly, but that contact Class A parts during assembly must be cleaned to LIGO standards, Class B.

2 Phase 1 – Assembly and Balancing optic

The HTTS is assembled according to ‘Advanced LIGO HAM Tip-Tilt Suspension Assembly Procedure’ (E1100440).

The HTTS holds a 2” diameter, 3/8” thick optic within an aluminium ‘optic-holder’. This holder including the optic needs to be balanced so the optics hangs vertically.

1. Balancing the optic ±1 mrad
    a. The initial balancing is done using a dummy optic with the same dimensions (2” diameter, 3/8” thick). A leveled laser (at 4” height) and a ruler is sufficient.
    b. The metal wire stand-offs on the side of the aluminium ring can be slide ‘back and forth’ to coarsely balance the optics, while a 1” long grub screw at the bottom of the aluminium ring can be screwed back and forth to fine balance the optics.
2. When the optics is balanced, the BOSEMs are roughly positioned, about 7 mm between the optic-holder and the front of the BOSEM.
3. Once balanced, the dummy optic is replaced with the actual optic.

For storage or transportation within the lab (e.g. next to chamber):

a) The optic-holder with the optic is wrapped in multiple layers of alpha wipes.

b) Lock the mirror in place using the Eddy Current Dampers.

c) Lower the Blade stoppers to remove the tension in the suspension wires.

3 Phase 2 – Unwrap and Sanity Check

This phase takes place next to the chamber, prior installation of the HTTS on the HAM table. Check for the correct serial numbers used for installation, the unit serial number is the same as that of the baseplate.

Take the HTTS out of the double wrapped bag and unwrap the alpha wipes from the optic-holder. Be careful, as the in-vacuum optic is installed in the optic-holder.

Check if the optic-holder is still suspended, and the BOSEMs are in place. If a leveled surface is available, one can check the flag positions inside the BOSEMs.

Look at the BOSEM holes and see if the tip of the BOSEM flags are centered. If not, change blade angles to move the mirror up or down or rotate the mirror around the axis vertical to the mirror. To move the mirror side ways, or rotate around the vertical, loosen the four (4) screws which bolt the blade assemblies to the top-plate. Move the blade assemblies (using the slop in the screw holes) to move the mirror side ways or rotate the mirror around the vertical axis. See E1100440, section 9 ‘Finalsing the Assembly’ for details of the HTTS assembly.

You can lock the mirror again to make it easier to transport the unit into the chamber (reduce the tension in the suspension wires).

Check if the ¼-20 screws holding the sides to the base, and the top-plate are secured. They have been found loose on some units.

4 Phase 3 – Installation and Measurements

4.1 In-Chamber Installation

The HTTS will be installed in the chamber, in the vicinity of its final position. Once the 25-pin connector is in place, the BOSEM readout is checked.

The BOSEM open voltage is recorded, by moving the BOSEM all the way out, or by holding the optic-holder with the PEEK flags out of the BOSEMs. On the MEDM screen the open voltage count from the ADC should be between 20000 to 32000. Also see E1200343 OSEM Chart for OSEM open light values.

4.1.1 Mirror ECD Settings

The ECD on he HTTS are ½" disks in front and behind the mirror holder, on both the left and right side. The ECD is mounted at the end of a Titanium #8-32 set screw. The Titanium makes the screws not to interact with the magnets on the mirror holder. For effective damping the ECD need to be 0.8-1 mm away from the magnets. The #8-32 screws have a screw pitch of 0.8 mm (a single turn will move the tip by 0.8 mm).

Tools

1. 5/64 Allen Key (90 deg angled one is easy to see the 360 deg turn)

Steps to set the optimal distance

1. Check the mirror is hanging freely and the unit is level.
2. Turn the #8-32 set screw until the ECD touches the magnet.
    a. This can be tricky as it is possible that the ECD is not perpendicular to the screw.
    b. You could use the OSEM readout (YAW, PIT or LONG) to check when the ECD touches the magnet/mirror holder.
3. Retract the #8-32 set screw between one (1) and one-and-a-quarter (1.25) of a turn.
    a. An angled Allen-key can be used to more easily determine the full turn.
4. Repeat steps 1-3 for the other three ECD screws.
5. Secure the #8-32 set screw on the front if the HTTS using the PEEK nut.

6. Secure the #8-32 set screw at the back of the HTTS using the #2-56 set screw on the side of the ‘Backplane’.

4.1.2 Vertical Blade Stop Settings

Lower the ¼-20 screws above the blades to about 1 mm above the blades. Use the nut to secure the screw into place.

Position the HTTS to its final location. Check if the optic is hanging vertical, see to use the reflected beam from the optic to centered the beam around the ‘target’ (next optic).

Check the optic is hanging freely.

4.1.3 Installation

Secure the HTTS in place using the SYS provided clamps (usually 3 or 4).

Centre the BOSEMs along the flag, with the BOSEM reading at half of the open voltage.

Do a hammer test to check if there are any resonances are above 150 Hz. If not, check the ¼-20 screws on the side the units.

Measure the LONG, PIT and YAW transfer functions, check them against the modeled performance.

4.2 Phase 3a – In-Chamber Testing

This testing is done at atmospheric pressure, with the HAM doors open (the doors can be closed but when and issue if found chamber access may be required). The main aim is to validate that all is working and according to requirements.

Tests to carry out

1. Assess absence of Ground Loops in Cabling Routing
2. Assess Cable Routing stiffness/compliance from optical table, through ISI to feedthrough
3. Determine BOSEM Open light Current/Voltage
4. Ability to Sense/Actuate on optic (using E1400316 - HAM TIP-TILT SUSPENSION Controls Arrangement)
5. DC Alignment (from levels)
6. Final Alignment/Centring of BOSEM Sensors
7. Final Setting of the Eddy Current Dampers (1 mm spacing from magnets)
8. Expected Watchdog /Damping Loop behavior, incl. interaction with HAM-ISI
9. Assess Table Mounting / Dog Clamping with B&K Hammer & Accelerometer
10. Final Setting of Blade stop

11. Final Rubbing Checks
12. Damping Loop Closure

Results to expect

1. Hard to quantify, but mains harmonics in the BOSEM power spectra is one indication that there are ground loops.
2. No tight cables, or cable slippage or rubbing
3. BOSEM Openlight counts, 20k – 32k (also dependent on the Satellite Amplifier)
4. Drive the coils to tip and tilt the optic, using the readback form the OSEMs.
5. See 4.
6. BOSEM flags are not touching the housing and have full range.
7. Spacing between ECD and magnet 0.8 mm to 1 mm, visual inspected that the ECD are not touching the mirror holder.
8. Watchdog not tripper with monitor values of TBD
9. Final position (Tolerance Pass/Fail)
10. Final Calibrated BOSEM Spectra (Resonance & Noise floor Pass/Fail)
    a. Comparison with reference level
11. Final LONG, PIT and YAW Transfer Functions (damping engaged)
    a. Measure in-loop and out-loop transfer functions
12. Check B&K Hammer Test
    a. No resonance < 150 Hz (Pass/Fail)

4.3 Phase 3b – In-Vacuum Testing

This testing is done at vacuum pressure and will validate the actual performance of the units.

Measure the LONG, PIT and YAW performance, check them again the modeled performance.

Test to carry out

1. Measure the LONG, PIT and YAW performance, check them again the modeled performance.
2. Measure BOSEM Sensor Spectra
    a. Compare with noise level

Expected Results

1. Final Calibrated BOSEM Spectra

   a. Compare to 3a levels and reference level.
2. Final LONG, PIT and YAW TF
   a. Compare to 3a levels and reference level.
3. Assess Rubbing from the measurements 1. And 2. (Fail/Pass)