LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

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Advanced LIGO OSEM Final Design Document

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LIGO Science Collaboration

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1. Introduction

The Initial LIGO OSEMs will be utilized in various stages of many Advanced LIGO suspensions. They should not be confused with the Birmingham OSEMs (BOSEMs.) In preparation for the procurement of these OSEM, we are performing some value engineering. There were 23 separate procurements and 31 assembly steps involved in fabricating these OSEMs during Initial LIGO. Our current revision streamlines many of these steps and processes in order to increase the reproducibility and reliability of these units and cuts down on the labor time for assembly.

There are a few parameters identified which cannot change, as this would make interfacing to the suspensions designed earlier, and utilized again in Advanced LIGO, difficult or impossible. These constraints are identified in each section below, when recognized.

The Initial LIGO (iLIGO) OSEMs used for Advanced LIGO (aLIGO) will incorporate materials which have been approved for use in the aLIGO vacuum over the last few years, such as carbon loaded PEEK. Mounting of the circuit boards has been drastically improved and have been migrated over to flexi-circuit boards. We have replaced the custom pigtail with cable harness design used with the BOSEM.

There will be no "Short" OSEMs (LIGO-D000067). One "long" design will reduce/simplify fabrication effort. The long design is compatible with the UK OSEM holder design and is designed into the large and small triple suspensions. The long AOSEMs are compatible with, and are assembled into, the HAM Auxiliary single pendulum suspensions.

All OSEMs will be equipped with Sensors and Actuators even though some suspensions do not require sensors to be used. Details on this may be found in RODA M060043, Determine Need for OSEM Sensors for UIM and PUM in the ETM and ITM and Determine Need for OSEM Cable Electrical Shielding.

-v3 Revision is an update to this document, as of June 4, 2014

2. Reference Documents

E0900168	AOSEM Assembly Specification
E960050	LIGO Vacuum Compatible Materials
M060043	RODA Determine Need for OSEM Sensors for UIM and PUM in the ETM and ITM and Determine Need for OSEM Cable Electrical Shielding
D1000234	Custom Cable V25X-TBD (Assembly)

3. Parts List

D0901065	AOSEM Assembly
D0901048	AOSEM Head
D0901066	OSEM Insert Assembly
D0901252	Flexible Circuit
D0901049	Alumina Flexi-Circuit Stiffener
D000209	Photodiode Optical Filter

4. Fabrication of Heads

Constraints: Overall size of head cannot change. Keep cost of machining heads low.

For iLIGO, the heads were made from Zirconium Nitride plated Alumina. The costs of these materials and plating were quite high, and plating was a difficult endeavor. For this reason, we looked at some other possibilities for head materials. Stainless Steel and nickel plated PEEK were both considered, but determined to be insufficient candidates. We choose 30% Carbon Loaded PEEK (CL PEEK) material for the head fabrication.

Mark Barton correspondence Sept 2008:

"Carbon loaded PEEK would very likely be acceptable from the point of view of both ESD discharge and eddy-current damping. A bit of googling reveals that a typical grade has resistivity of 10^5 ohm-cm, i.e., 10^7 ohm-m: http://www.boedeker.com/peek_p.htm . This can be compared to $\approx 10^{19}$ for unloaded PEEK and $\approx 10^{-6}$ for stainless. That should be plenty of conductivity to bleed away charges but is still many orders of magnitude away from causing an eddy current problem (damping is inversely proportional to resistivity), even without a slot."

When fabricated from CL PEEK, the head weighs less than the original design. The quad suspensions have the initial LIGO osems mounted on the reaction chain so their weight is important as it is suspended. For these suspensions, we will provide a metal clamp to meet the RAL weight requirement of 68 grams, per J. O'Dell, 15 June 2009.

5. Circuit Board Assembly

- ### Contraints

LED and PD must be located 0.24" apart.

- ### Devices

The devices used in the iLIGO design will not be changed. We will continue to use the Honeywell Photodiode SMD-2420-001 and LED SME-2470-001.

- ### Circuit Boards

The iLIGO circuit boards were glued into the round bore of the head using Ceramabond. A fixture was used to assist in this, but it still proved a difficult task to place glue inside the small space of the head at just the right location. As well, alignment of the boards relative to each other was a bit difficult to maintain during the gluing process. Ceramabond was very difficult to remove once cured. As there are issues with vacuum compatible glue sources and availability, we moved away from this. We've spent a fair amount of time looking into various ways of mounting the circuit boards into the head mechanically via screws and inserts and/or rearranging the shape of the bore down the center of the head. Rich Abbott brought forth the idea of utilizing the Kapton flexi-circuit design used in the BOSEMs. After a few renditions, we settled on a circuit which is a single piece of Kapton, which bends to form inserts into the head. This board also fits around the end of the head and gets captured in the mounting of the connector. The arms of the flexi-circuit are thickened and strengthened by alumina stiffeners.

- **Photodiode filters**

It was determined that the photodiode filters will again be a necessary component of these OSEMs. The original filters were custom cut from off-the-shelf microscope slide glass, after they had been custom coated. We explored a few avenues for filtering the photodiode from stray 1064nm light, however we could not foresee any of these alternatives as actually being an easier and/or more cost effective way to go.

We custom-coated and cut the glass slides as per the original specification of D000209. We have found vendors who are able to bid on both the cutting and coating, so what was previously a 3-part procurement will now be only 1 procurement. The filters will be held to the alumina stiffeners of the flexi-circuit assembly with EP30-2 epoxy, which is approved for LIGO in-vacuum use. See the AOSEM Assembly Specification, E0900168, for more information on this assembly.

6. Magnet Coil

The position and geometry of the magnet coil winding groove will stay the same as for the initial LIGO osems. The Kapton magnet coil wire is MWS Industries's 32HML, the same as in the initial LIGO osems. The coil has 400 turns, as before. The magnet sweet spot, with respect to the magnet coil, is the same as for the initial LIGO osem.

7. Pigtail Assembly and OSEM connector

The iLIGO pigtail assembly was a custom piece from the connector on one end, to the connector on the other. We will use the Birmingham connector/cable/connector unit used for the BOSEMs, D1000234, Custom Cable V25X-TBD (Assembly)

This pigtail will connect to the head via a 9-pin straight micro D connector mounted directly on the flexi-circuit: GlenAir GMR7580-9P1BSN-MC255

8. PAM Screw Assemblies

We do not believe PAM Screws will be needed for use on aLIGO suspensions. However, there is real estate available on the OSEM in the event of a PAM assembly attachment bracket. The iLIGO PAM bracket would need to be redesigned since the mounting holes are no longer available, and the bracket would have to be accommodated by a new mounting hole pattern.