INTRODUCTION

This paper will give a presentation of the vibration isolators used for Advanced LIGO observatories [1]. These systems are designed to isolate and align the payloads in all directions of translation and rotation [2-4]. They are equipped with very-low noise inertial instruments to provide active isolation from 0.1 Hz to 30 Hz. Passive and active isolation are combined to provide more than three orders of magnitude of isolation at frequencies above 1 Hz. The paper will summarize the design concepts and the controls strategy. It will present the experimental results that have been obtained with the systems recently installed at the LIGO observatories.

DESIGN AND CONTROL CONCEPTS

This section will summarize the general design concepts and the active control strategy.

FIGURE 1. Sealed inertial instruments

The design presentation will focus on challenging components such as flexures, in-vacuum instrumentation (FIGURE 1), and low-noise electronics.

The controls presentation will describe how relative and inertial controls are combined to provide both alignment and isolation capabilities (FIGURE 2).

FIGURE 2. Control block diagram.

SYSTEMS OVERVIEW

This section will give an overview of the three types of systems designed for Advanced LIGO: the hydraulic pre-isolator, the single stage isolator, and the two-stage isolator.

A CAD representation of the two–stage system is shown in FIGURE 3. The system is made of three stages in series. Stage 0 is the base (input stage). Stage 1 and Stage 2 are the active stages. The equipment to be isolated is attached
to the output stage (Stage 2). Each stage is suspended from the previous one using a combination of blades and flexures providing six degrees of freedoms. The platform is instrumented with capacitive relative sensors used for very low frequency controls and a combination of seismometers and geophones for inertial isolation. Voice coil actuators are used for the drive. The passive isolation provided by the two stages in series is function of the fourth power of frequency above the system’s natural frequencies. The inertial active isolation provides more than three orders of magnitude of isolation in the control bandwidth.

FIGURE 3. Two-Stage Isolator

PERFORMANCE

This section will present experimental isolation results. We will show the transmissibility curves both for the translational and rotational degrees of freedom. An example is presented in FIGURE 4. Rotation transmissibility is shown by the red curve. It reaches -20 dB just above 1 Hz and -40 dB near 10 Hz. Horizontal transmissibility is shown by the black curve. It reaches -60 dB a bit above 1 Hz and maintain three orders of magnitudes of isolation at higher frequencies.

Absolute motion performance will also be presented. Amplitude spectral densities will show that the isolator is very near or below the inertial sensor noise at most frequencies.

CONCLUSION

The conclusion will summarize the status of the Advanced LIGO vibration isolation project. It will highlight the features of interest for the precision engineering community.

FIGURE 4. Transmissibility

ACKNOWLEDGMENTS

LIGO was constructed by the California Institute of Technology and Massachusetts Institute of Technology with funding from the National Science Foundation and operates under cooperative agreement PHY-0107417. This document is a short abstract of LIGO document number LIGO-P1400137.

REFERENCES