*LIGO Laboratory / LIGO Scientific Collaboration*

LIGO-T1200416-v1 *ADVANCED LIGO* 27 August 2012

First Contact and its Effect on Pitch of Optics

Mark Barton

Distribution of this document:

DCC

This is an internal working note

of the LIGO Laboratory.

|  |  |
| --- | --- |
| **California Institute of Technology****LIGO Project – MS 18-34****1200 E. California Blvd.****Pasadena, CA 91125**Phone (626) 395-2129Fax (626) 304-9834E-mail: info@ligo.caltech.edu | **Massachusetts Institute of Technology****LIGO Project – NW22-295****185 Albany St****Cambridge, MA 02139**Phone (617) 253-4824Fax (617) 253-7014E-mail: info@ligo.mit.edu |
| **LIGO Hanford Observatory****P.O. Box 1970****Mail Stop S9-02****Richland WA 99352**Phone 509-372-8106Fax 509-372-8137 | **LIGO Livingston Observatory****P.O. Box 940****Livingston, LA 70754**Phone 225-686-3100Fax 225-686-7189 |

http://www.ligo.caltech.edu/

**Table of Contents**

1 Introduction 3

1.1 Purpose and Scope 3

1.2 Version history 3

2 Background 3

3 Theory 3

4 Conclusion 4

5 Appendix 4

# Introduction

## Purpose and Scope

A quick compilation of calculations of the amount a film of First Contact on a hanging optic perturbs its pitch. QUAD (monolithic, CP, and ERM), HSTS, HLTS and BSFM are considered.

## Version history

8/27/12: -v1.

# Background

It is desirable to leave a film of First Contact on optics as long as possible during installation and initial alignment, to protect the optics and keep them clean. However the pitch offset on a hanging optic due to the weight of the film is significant compared to the precision the pitch needs to be measured and set.

To help set requirements, Mathematica models of the major types of suspension, QUAD (monolithic, CP, and ERM), HLTS, HSTS, and BSFM, were used to calculate the effect of added mass on the surface of optics.

# Theory

The compliance of the optic in pitch can be calculated as the real part of the DC value of the transfer function from pitch torque at the optic to pitch displacement of the optic, by the Mathematica command

Re[calcTFf[eom2, makefinputvector[pitch3], makeoutputvector[pitch3], 0]]

The torque due to a mass m on the surface is

m\*g\*tx/2

where g is gravity and tx is the thickness of the optic. The mass of a layer of thickness t is

rho\*t\*Pi\*tr^2

where rho is the mass-volume density of the dried First Contact, and tr is the optic radius (assuming First Contact applied over the whole face). The product rho\*t can also be considered jointly as a mass-area density.

Since it might be convenient to do further calculations in any of torque, mass and areal density, the pitch compliance w.r.t. all three were all calculated and are presented in Table 1. For ease of scaling, a hopefully representative reference area density of 1000 kg/m3 \* 0.0001 m = 0.1 kg/m2 was chosen.

Table 1

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Quantity | Monolithic | CP | ERM[[1]](#footnote-1) | BSFM | HLTS | HSTS |
| pitch compliance rad/(N.m) | 0.116 | 0.108 | 0.107 | 0.784 | 0.609 | 2.92 |
| mass compliance rad/kg, or mrad/g | 0.113 | 0.0532 | 0.0528 | 0.220 | 0.299 | 1.06 |
| areal density compliancemrad/(0.1 kg/m2) | 1.03 | 0.484 | 0.479 | 2.36 | 1.65 | 1.88 |

# Conclusion

The effect on pitch of a layer of fixed areal density of First Contact is moderately clustered - plus or minus a bit over a factor of two. The most sensitive is the BSFM and the least sensitive is the CP (as noted in a footnote to Table 1, the value for the ERM is an underestimate).

# Appendix

In the PDF version of this report, printouts of the Mathematica notebooks with the calculations will be appended, to serve as documentation of the exact cases used.

1. In the course of the calculations for this document, a non-trivial error was noticed in the ERM case based on the Matlab parameter set ^/trunk/QUAD/Common/MatlabTools/QuadModel\_Production/quadopt\_erm.m r2731 in the SUS SVN: the optic thickness was 100 mm (as for the CP) rather than 130 mm. The main effect is to reduce the lever arm converting mass to torque, so that the mass and area density numbers above are underestimates. This will be corrected as soon as possible. [↑](#footnote-ref-1)