Test Plan and Acceptance Criteria for the Advanced LIGO Faraday Isolator

APPROVALS	DATE	REV	DCN NO.	BY	CHECK	DCC	DATE
AUTHORs: R. Martin, D. Reitze							
CHECKED: G. Mueller							
CHECKED:							
APPROVED:							
DCC RELEASE							

SCOPE

This document lays out the test plan and acceptance criteria for the Advanced LIGO Faraday Isolator.

APPLICABLE DOCUMENTS

T060269-01-D Input Optics Preliminary Design
G070591-00-D Input Optics Preliminary Design Review
T060267-00-D Upgrading the Input Optics for High Power Operation
E0900301-v6 IOO Faraday Isolator Assembly and Certification Procedures
T020020-02-D Input Optics Subsystem Design Requirements Document

APPLICABLE SPECIFICATIONS[1]

LIGO-E080125: aLIGO TGG crystals for Input Optics Faraday isolator
LIGO-E0900330: ALIGO IO CALCITE WEDGE POLARIZER
LIGO-E1100122: Quartz Rotators for aLIGO Input Optics Faraday isolators
LIGO-E1100222: aLIGO HWP for IO PSL and HAM2 Tables

APPLICABLE DRAWINGS

LIGO-D1000332: ALIGO IO L1 FI ASSEMBLY
LIGO-D1000333: ALIGO IO H1 FI ASSEMBLY
LIGO-D1002987: ALIGO IO FI L1 H1 BREADBOARD
LIGO-D1000877: ALIGO IO FI CALCITE MOUNT ASSEMBLY
LIGO-D0902253: ALIGO IO FI CALCITE WEDGE POLARIZER
LIGO-D1000874: ALIGO IO FI CALCITE MOUNT
LIGO-D0901488: ALIGO HAM TABLE FORK
LIGO-D1101505: ALIGO IO IN VACUUM POST
LIGO-D1101677: ALIGO IO L1 INDIUM ROD
LIGO-D1101667: ALIGO IO FI DKDP ASSEMBLY

[1] *We discussed with many vendors to provide coatings for the crystals of the Faraday isoalator, and in the end no vendor agreed to 100 ppm reflectance for any of these crystals, although earlier discussions were more optimistic. The specifications were revised prior to ordering to take into account vendor capabilities.*

LIGO-D1101569: ALIGO IO HWP MOUNT
LIGO-D1101668: ALIGO IO HWP RETAINING RING
LIGO-D0901488: ALIGO HAM TABLE FORK
LIGO-D1101505: ALIGO IO IN VACUUM POST
LIGO-D1101566: ALIGO IO FI RHWP ASSEMBLY
LIGO-D1101567: ALIGO IO FI RHWP ROTATIONAL ADAPTER
LIGO-D1200982: ALIGO IO FI RHWP H1 HEIGHT ADAPTER
LIGO-D1101568: ALIGO IO FI RHWP BASE
LIGO-D1101569: ALIGO IO HWP MOUNT
LIGO-D1101570: ALIGO IO FI RHWP UPPER SPRING MOUNT
LIGO-D1101572: ALIGO IO FI RHWP LOWER SHORT SPRING MOUNT
LIGO-D1101574: ALIGO IO FI RHWP LOWER TALL SPRING MOUNT
LIGO-D1101579: ALIGO IO FI RHWP BEARING BLOCK
LIGO-D1101581: ALIGO IO FI RHWP PICOMOTOR MOUNT
LIGO-D1101582: ALIGO IO FI RHWP PICOMOTOR CLAMP
LIGO-D1101592: ALIGO IO FI RHWP RISER
LIGO-D1101593: ALIGO IO FI RHWP BEARING COVER
LIGO-D1101594: ALIGO IO FI RHWP BEARING STOP
LIGO-D1101668: ALIGO IO HWP RETAINING RING
LIGO-D1101660: ALIGO IO L1 FR ASSEMBLY
LIGO-D1101661: ALIGO IO FI FR QUARTZ CAP
LIGO-D1101662: ALIGO IO FI FR QUARTZ HOLDER
LIGO-D1101663: ALIGO IO FI FR TGG CAP
LIGO-D1101666: ALIGO IO FI FR TGG HOLDER
LIGO-D070466: ELIGO IO FI FR LLO DUST SHIELD
LIGO-D1101664: ALIGO IO FI FR POSITIONING SCREW
LIGO-D1101665: ALIGO IO FI FR SLEEVE LOCK
LIGO-D1101211: ALIGO IO L1 FI FR SPACER
LIGO-D1200981: ALIGO IO H1 FI FR SPACER
LIGO-D070469: ELIGO IO FI FR STAND
LIGO-D080176: ELIGO IO FI FR THIN CLAMP
LIGO-D1101682: ALIGO IO L1 FR TGG
LIGO-D1101683: ALIGO IO L1 FR QUARTZ
LIGO-D1101753: ALIGO IO FI FR L1 HEAT SINK
LIGO-D1200983: ALIGO IO FI FR H1 HEAT SINK
LIGO-D1101888: ALIGO IO FI FR SINK CLAMP
LIGO-D1003033: ALIGO IO L1 FR MAGNET ASSEMBLY
LIGO-D0902391: ALIGO IO STRAIGHT HA4 BAFFLE ASSEMBLY
LIGO-D0902390: ALIGO IO STRAIGHT HA4 BAFFLE PLATE
LIGO-D1003011: ALIGO IO HARD APERTURE TABLE BRACKET
LIGO-D0902393: ALIGO IO STRAIGHT HA5 BAFFLE ASSEMBLY
LIGO-D0902392: ALIGO IO STRAIGHT HA5 BAFFLE PLATE

Test Plan and Acceptance Criteria for the Advanced LIGO Faraday Isolator

LIGO-D1003011: ALIGO IO HARD APERTURE TABLE BRACKET
LIGO-D0902395: ALIGO IO STRAIGHT HA6 BAFFLE ASSEMBLY
LIGO-D0902394: ALIGO IO STRAIGHT HA6 BAFFLE PLATE

A FARADAY ISOLATOR COMPONENTS – PRELIMINARY INSPECTION

As the material for the Faraday isolator assembly is received, the following procedures apply.

1. Optical Components (TGG crystals, quartz rotator, waveplate, DKDP, polarizers)
    a. Test Method
        i. Visual inspection of all components for chips, inhomogeneities, surface scratches; follow up by microscope if needed
        ii. Measurement of anti-reflection coating performance – low angle reflectance measurements
    b. Acceptance Criteria
        i. No evidence of chips, scratches, inhomogeneities, surface damage
        ii. AR performance measures within required specification.
2. Mechanical Components (custom fabricated and purchased parts)
    a. Test method
        i. Visual inspection of all parts
        ii. Form and fit tests – building up subassemblies
    b. Acceptance Criteria
        i. No evidence of damage or obvious deviations from design
        ii. Successful assembly of all components
3. Picomotors
    a. Test method
        i. Verify that the picomotor can be powered up and functions properly
    b. Acceptance Criterion
        i. Proper function – unit works and performs five calibrated rotations successfully
4. Magnets
    a. Test Method
        i. Visual Inspection of magnet surfaces for chips, foreign materials
        ii. Measurement of the magnetic field strength
    b. Acceptance Criteria
        i. No evidence of damage
        ii. Magnetic field meets specification

NOTE: The mechanical components and magnets must be re-inspected after baking. In particular, the magnetic field should be remeasured to verify that it has not degraded.

B FARADAY ISOLATOR ASSEMBLY – BENCH PERFORMANCE

These tests should be performed when assembling the Faraday isolator in air in the PSL enclosure. Assembly procedures can be found in E0900301-v6 "IOO Faraday Isolator Assembly and Certification Procedures".

1. Optical throughput
    a. Test method
        i. Measurement of the input power and the power transmitted through the Faraday isolator assembly
    b. Acceptance criterion
        i. The total power throughput exceeds 95%
2. Isolation ratio
    a. Test method
        i. Measurement of the power leaking through the upstream polarizer (retroreflector slightly misaligned to allow for pick-off)
    b. Acceptance criterion
        i. The isolation ratio exceeds 40 dB, optimized at 20 W
3. Thermal Lensing
    a. Test method
        i. Measurement of transmitted mode size at low (1 W) and high (100 W or greater) power using a Z-scan measurement
    b. Acceptance criterion
        i. The change in mode matching is less than 5%, ie, does not degrade the interferometer mode matching to below that specified in T020020-02-D "Input Optics Subsystem Design Requirements Document"
4. Thermal beam steering
    a. Test method
        i. QPD measurement of the angular displacement of the forward going beam (into the interferometer) and the rejected beam as the power is changed impulsively from 1 W to 100 W.
    b. Acceptance criterion
        i. The in-air change for both forward going beam and isolated beam used for the REFL signal should be less than 1/10 the beam diameter at about 1 m away (400 urad) at all powers.

C FARADAY ISOLATOR ASSEMBLY – INSTALLATION

These tests should be performed once the Faraday isolator has been installed in the vacuum

1. In vacuum isolation ratio
    a. Test method
        i. Measurement of the power leaking back to the PSL table
    b. Acceptance criterion
        i. The isolation ratio is greater than 30 dB, the IOO requirement in T020020, "Input Optics Subsystem Design Requirements Document"
2. Thermal Lensing
    a. Test method
        i. Measurement of the interferometer visibility at low and high power.
        ii. One arm cavity scan at 1 W and 100 W.
    b. Acceptance criterion
        i. The mode matching is better than 95% at all powers (max 125 W out of IO) for the nominal interferometer mode.
3. Thermal beam steering
    a. Test method
        i. QPD measurement of the angular displacement of the forward going beam (into the interferometer) and the REFL beam as the power is changed stepwise from 1 W to full power
    b. Acceptance criterion
        i. The change for both the forward going beam and the REFL beam should be accommodated by the REFL beam steering (RBS) system.