KAGRA

INSTRUMENTS SUMMARY

KAGRA photon calibrator

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Abstract

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The Thesis Abstract is written here (and usually kept to just this page). The page is kept centered vertically so can expand into the blank space above the title too...

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2.1 Photon calibrator

One of the goals of the gravitational wave experiment is the accurate measurement of the gravitational waveform that is measured through the absolute displacement of the end test masses. A recent study that LIGO conducted in US showed that a displacement uncertainty could be controlled by the photon calibrator. The photon calibrator is one of the calibration tools to push the mirror surface using the photon pressure of the laser as shown in Fig XXX. The absolute displacement is described as

$$dx = \frac{P\cos\theta}{c} s(f) \left(1 + \frac{I}{M}\vec{a}\cdot\vec{b}\right), \tag{2.1}$$

where P is an absolute power of the laser, c is the speed of light, θ is an incident angle of the laser, I and M are moment of inertia and mass of test mass, $\vec{a}$ and $\vec{b}$ is position vector of photon calibrator lasers and interferometer laser. Then, $s(f)$ is transfer function of the test masses. We simulated the transfer function of test mass as shown in Fig. XXX. We assumed the masses, shapes and Young's modules of the each pendulum mass and fiber as shown in Fig.XXX. According to transfer function, we can regard the motion of high frequency as free mass due to higher than the natural frequency. Therefore, we are able to assume as follows:

$$s(f) = \frac{1}{M\omega^2}, \tag{2.2}$$

where ω is the angular frequency of test mass.

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Instruments overview

3.1 Layout of Photon calibrator

The KAGRA photon calibrator is placed around EXA/EYA chamber, which is installed 36 m away from the end test mass (ETM). We push the mirror surface with the modulted photon pressure directly. The photon calibrator consists of transmitter module (Tx module), receiver module (Rx module), periscope, and telephoto camera module (TCam module). We place the 20 W laser in Tx module, whose frequency is 1047 nm. We do not use 1064 nm laser due to avoid the coupling with main beams.

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5.1 Introduction

This section describes the in-situ calibration procedure of Photon Calibrator at each End station of KAGRA.

5.2 Theory of Operation

The Working Standard referred as WS is an integrating sphere with InGaAs photo detector, which has been calibrated against Gold Standard (GS) in the lab at LHO. The Gold Standard is calibrated by NIST. We will use this working standard to calibrate the Transmitter Module Photo Detector (TxPD) and Receiver Module Photo detector (RxPD), which are inside the Transmitter module and Receiver module of Photon calibrator respectively.

The following formula is used to obtain the calibration factor that will give the response of photodiodes in Photon calibrator modules in Watts/Volts:

$$\mathrm{TxPD} = \frac{\mathrm{TX}}{\mathrm{WS}} * \frac{\mathrm{WS}}{\mathrm{GS}} * \mathrm{GS} \tag{5.1}$$

$$\mathrm{RxPD} = \frac{\mathrm{RX}}{\mathrm{WS}} * \frac{\mathrm{WS}}{\mathrm{GS}} * \mathrm{GS} \tag{5.2}$$

5.3 Instrument Settings

5.3.1 DAC Calibration:

1. Provide a calibrated voltage using Martel voltage source and read it through the read back channel `($(IFO):CAL-PCAL$(END)_WS_PD_INMON)`. One unit voltage should give back 1638 counts. Provide 3 different voltages (0V, 1V and 2V) and record 15 seconds of data. Record the values in the Calibration Log (T1500062).

2. Check that the OFS loop is closed and stable.

5.3.2 Setting up the Current Amplifier

1. Plug the power cable of the Current Amplifier into a dedicated wall socket which no other equipment is using. It is very important that the Current Amplifier is on its own circuit as compromised data can result from using a shared power source.

2. Set the gain to 10E6 V/A

3. Set the Filter rise time = 100 ms
4. Turn filter on and make the sure the light is on.
5. Connect the BNC cable from the Working standard to the input and the BNC cable from the DAQ to the output.
6. Zero-check the instrument by pressing, " Shift " and " zero check " after the setup is complete and the laser is blocked at the Working Standard.
7. Make sure the " zero check " light is off before taking measurements.
8. Unplug the BNC cable from the Working Standard.
9. Remove small-side cover from TX module.
10. Place Working Standard into small-side of TX module. Take extra care when moving Working Standard from floor level to TX module.
11. Reconnect BNC cable to Working Standard.

5.3.3 Additional Checks

Do the following checks before proceeding to ratio measurements:

1. Check that the test mass is aligned, that the ISI is isolated with sensor correction turned off. Open the appropriate test mass suspension MEDM screen from the SITEMAP. The Guardian node `(SUS_ETM$(END))` is located at the top-center position of the MEDM screen. Select ALIGNED from the drop-down menu.
2. Check that the ISI sensor correction is off.
3. Check that both beams are entering the RX integrating sphere. If they are not, realignment is required before this procedure can be completed.
4. Turn off all excitations, including hardware injections. `$(IFO):CAL-PCAL(END)_OSC_SUM_ON` = 0, `$(IFO):CAL-PCAL(END)_SWEPT_SINE_ON` = 0, and `$(IFO):CAL-PINJ(END)_HARDWA` = OFF.
5. Let the Optical Follower Servo (OFS) stabilize before each reading. This is done by visual observation of the OFSPD signal (`$(IFO):CAL-PCAL(END)_OFS_PD_OUTMON`) on the MEDM screen.
6. Have the Calibration Log (T1500062) ready in front of you and follow the instruction in the Calibration Log to take the data.
7. For these measurements, the TxPD and RxPD are always in its original position whereas WS occupies two different positions, at TX just before the beam enters the vacuum system and at RxPD position, depending on the requirements.

5.4 Data Retrieval and Ratio calculation

5.4.1 Data Acquisition, Plots and Report

1. Make sure pcalEndstation is installed in the machine where you are trying to do the calibration calculation. You can check out the whole Pcal repository by following the instruction in T1500095.

2. From CDS computer you can access 'pcalEndStation' by going to this location:

   /ligo/svncommon/CalSVN/aligocalibration/trunk/Projects/PhotonCalibrator/.. scripts/pcalEndStation/

3. Do 'svn update' to make sure you have the latest version of the scripts.

4. Also 'kinit einstein@LIGO.ORG' to establish connection to external server. This will be required for obtaining data later

5. Open ' parametersforScript01.m ' script.

   (a) Enter appropriate calibration date, location and GPS time.
   (b) Make sure the workingcopy_location has appropriate path.
   (c) This parameter file is associated with Script01.

6. Run Script01_pcaldateandtime.m.

   (a) It will create a folder in 'DYYYYMMDD' format at appropriate location.
   (b) It also creates a matlab file named ' DYYYYMMDD_time.m ' with GPS time information within the folder.

7. Open ' parametersforScript02.m ' script.

   (a) Enter appropriate calibration date, location and GPS time (This is usually same as the one for first parameter file unless you are re-running the analysis code).
   (b) Make sure the workingcopy_location has appropriate path.
   (c) This parameter file is associated with Script02.

8. Run ' Script02_pcalDataandResults.m ' .

   (a) This will fetch the data from the server; write it as txt files into the folder.
   (b) It also plots the ratios and saves the plots to the same folder. Make sure the plots are satisfactory before closing it.
   (c) Additionally it will save a 'DYYYYMMDD_Ratio.mat' and 'DYYYYMMDD_Results.mat ' file that contains calibration results.

9. In Matlab Command window run the following command.
   pcalPublishReport(ifo_arm, outputFilename)

   (a) ifo_arm = 'LHOX' or 'LHOY' or 'LLOX' or 'LLOY'
   (b) outputFilename
       - '' (empty string will return default filename)
       - 'XXXXX.pdf'

5.5 End-station

5.6 Gold standard

5.7 Working standard

Chapter 6

Camera module

Chapter 7

Summary