LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

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LIGO Laboratory / LIGO Scientific Collaboration

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Photon Calibrator Transmitter Module Maintenance Procedure

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Remember to revert:

- exc. off. (3)
- Sens. corr. off. (maintenance mode)
- Hs. Shutter close.

1 Introduction

The purpose of this document is to describe a procedure for periodic maintenance measurements and checks to be done on the Photon Calibrator Transmitter (Tx) Module (D1201072) at both end stations. Currently, we plan on performing this procedure on a bi-annual basis, but this could become more frequent if there are known issues with a particular system or if statistics dictate that it should be performed more often.

2 Equipment required for this procedure

- Gentec-EO Maestro laser power meter with high-power (UP17P-6S-H5) and low-power (PH100-Si-HA-OD1) heads.
- Stanford Research Systems SR785 Dynamic Signal Analyzer with three BNC cables (~4-6 feet in length) and a USB flash drive or floppy disk depending on the SR785 capability.
- CDS computer with PCal MEDM screen for the end station at which you are working.
- Infrared (laser) sensor card for aligning power meter heads to the laser beam.
- A copy of this procedure.
- A downloaded copy of the "PCal TX maintenance logbook.xlsx" Excel spreadsheet to record values.

3 Shutter check

- On the PCal Interface Chassis (D1400153), set the toggle switch to LOCAL.
- Press the shutter close button on the shutter itself inside the TX module. You should hear an audible "click" when the shutter closes. Also, check with a laser card that the beam has been blocked.
- If this test fails, the shutter or the controls need repair.
- Set the toggle switch on the Interface Chassis to REMOTE and make sure shutter is open.

4 OFS offset adjustment

- Disable the Pcal excitations on the Pcal MEDM screen.
- With the OFS (Optical Follower Servo) enabled on the MEDM screen, increase the servo OFFSET level while monitoring the OFS PD output.
- If OFS servo loses lock, disconnecting and reconnecting the AOM cable at the OFS chassis should relock the servo.
- Increase the OFFSET to the point where the OFS loses stability or lock.

  Note this **MAX OFS OFFSET**: as found 3.33 7.7 (ofs pd. -7.60)

- **Set the OFFSET such that the laser power is 95% of the maximum stable level.**

  Note this **95% OFS OFFSET**: 7.3

  The operating level will be half of this 95% power level.

  Note this **OPERATING OFS OFFSET** (half of 95% level): 3.85

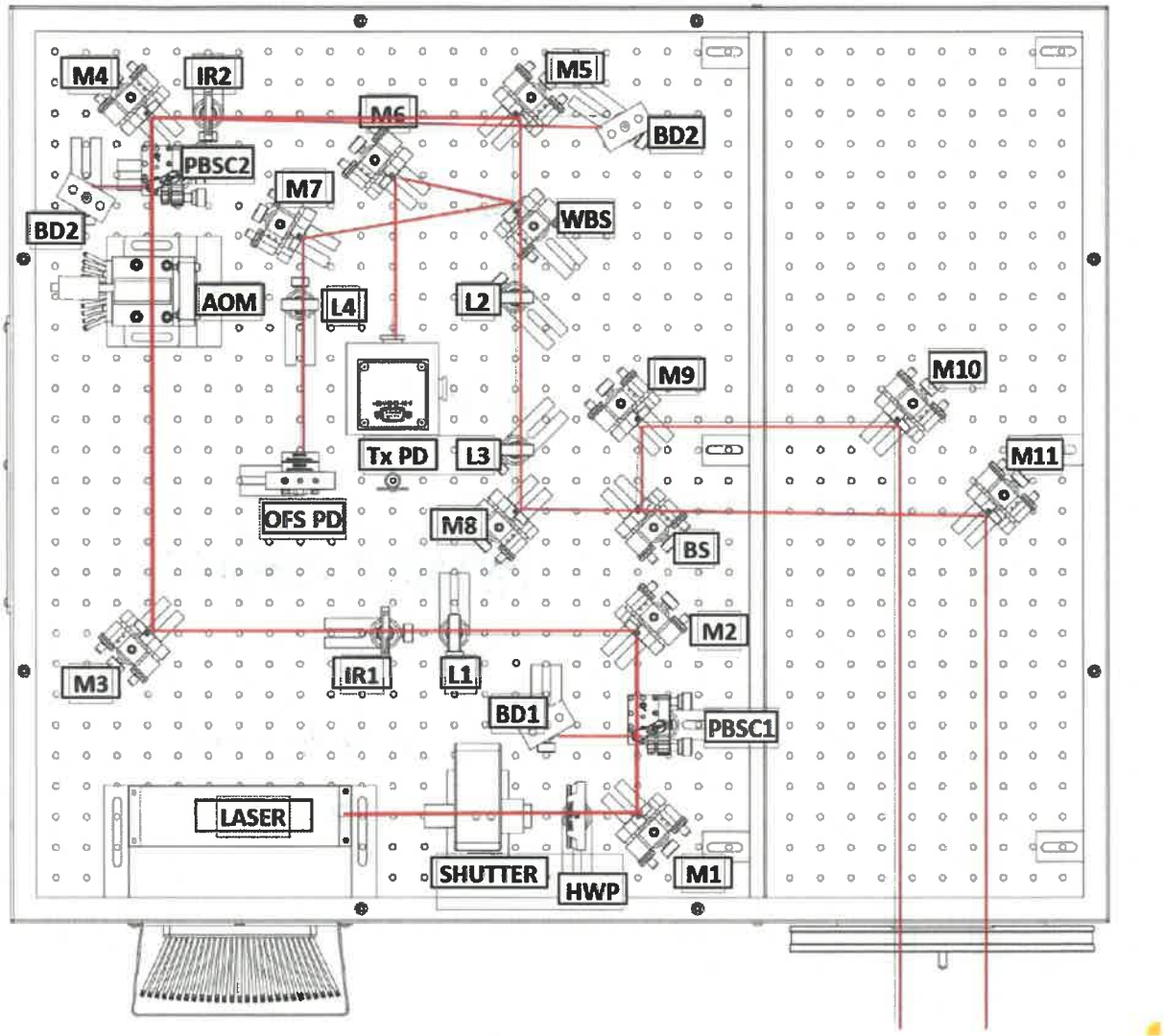


Figure 1 Transmitter module layout and component naming.

5 Laser power and polarization

- With the high-power head located between the **SHUTTER** and **HWP**, measure the laser output power.

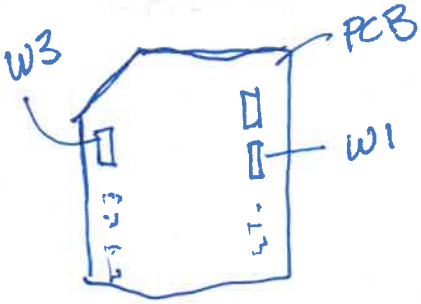
  Note the **LASER OUTPUT POWER**: 1.67W

  adjusted current & temp no significant increase

- With the low-power head located between **PBSC1** and **BD1**, measure the rejected (wrong polarization) laser power.

W1: Temp

W3: Diode Current



As Found 35 mW

Note the **REJECTED LASER POWER:** 35.6 after adj. λ/2 plate.

The rejected power should be a small fraction of the output power, less than 1-3 %.

6 AOM diffraction efficiency

- Measure the AOM input power using the high-power head located between M3 and the AOM.

  Note the **AOM INPUT POWER:** 1.59 W

- Measure the maximum diffracted power using the high-power head located between M5 and WBS.

  Note the **MAX DIFFRACTED POWER:** 1.1 W.

- Measure the un-diffracted power using the high-power head located between M5 and the adjacent BD2.

  Note the **UN-DIFFRACTED POWER:** 266 mW

- Calculate the AOM diffraction efficiency as MAX DIFFRACTED POWER divided by AOM INPUT POWER (times 100 for percent).

  Note the **AOM DIFFRACTION EFFICIENCY:** 69% as found

  The diffraction efficiency should be 70-80 %. If it is lower than 70 %, the AOM alignment likely needs to be adjusted to optimize diffraction efficiency.

- With the low-power head located between PBSC2 and the adjacent BD2, measure the rejected (wrong polarization) AOM power level. Rejected power should be <1% of the AOM Input Power.

  Note the **AOM REJECTED POWER:** 14.7 mW

7 Tx module nominal power level measurements

- **Set the OFS OFFSET at the OPERATING OFFSET level.** 3.85 V
- Using the low-power head located between M6 and Tx PD, measure the TxPD power level.

  Note the **TxPD POWER:** 6.36 mW

- Using the low-power head located between L4 and OFS PD, measure the OFSPD power level.

  Note the **OFSPD POWER:** 6.36 mW

- Using the high-power head located between downstream of M10, measure the outer beam power level.

  meas. before last turning mirror

  Note the **OUTER BEAM POWER:** 265 mW

- Using the high-power head located between downstream of M11, measure the inner beam power level.

  Note the **INNER BEAM POWER:** 260 ~~259~~ mW

- Calculate the output beam power ratio as INNER BEAM POWER divided by OUTER BEAM POWER.

  Note the **OUTPUT BEAM POWER RATIO:** 0.9811 ? ±1 ?

- The power of the both the Inner Beam and Outer Beam should be 50±2% of the sum of the Inner and Outer Beam powers. inner/total = @ 49.52%
  outer/total = 50.48%

8 Optical Follower Servo (OFS) Open Loop Transfer Function (OLTF) Measurement

- Measure the OFS open-loop transfer function (see Section 11 for instructions).
- Adjust the OFS gain on the MEDM screen to set the unity gain frequency at 100 kHz.

  Note the **OFS GAIN:** 41db → 39.6db at 100 Hz 50.1db −33.1db at 100 KHz

  Note the **OFS PHASE MARGIN:** 43°
- OFS Phase Margin should be >50° at 100 kHz.

- Capture the Bode plot of the OLTF from the SR785 so that it can be attached to an aLog entry.

9 Check of beam alignment at RX integrating sphere

- Remove both RX enclosure pieces from the RX pylon.
- Using the IR laser viewing card, take photos of the centering of both Inner and Outer beams independently by blocking one beam at a time with a razorblade beam dump.
- When complete, reinstall both enclosure pieces on the RX pylon.

10 Recording data in aLog and DCC

It is **critical** that the results of these measurements be recorded properly. **Please** make an aLog entry and record them in the DCC.

10.1 aLog

- Make an aLog entry with the following information
  - *Pcal transmitter module maintenance* in the title
  - X-arm or Y-arm, as appropriate
  - People who made the measurements
  - All values in red caps above, listed in order (note that the list of parameters can be copied from the filecard abstract field.) or a copy of the appropriate tab from the Excel spreadsheet.
  - OLTF Bode plot attached
  - Photos of RX beam centering

10.2 Updating DCC filecard

- Add a line in the Abstract field of the metadata of the filecard of this document (https://dcc.ligo.org/LIGO-T1600436) under the appropriate end station that includes the following.
  - Date of measurements
  - Names of those involved in making the measurements
  - Link to the aLog where the measurement results are given.

11 Setting up the SR785, making the open-loop transfer function (OLTF) measurement, and saving the data.

The SR785 should be powered up and partially set up before connecting the cable from the SOURCE OUT on the SR785 because the unit comes on with the source level set at 1 V, which is too high and may knock the OFS out of lock.

Note that on the SR785, selections are made using the dial between the ENTER buttons.

11.1 SR785 setup

Two options, recalling the setup from a settings file or setting the instrument up step-by-step by hand.

11.1.1 Recalling the setup from a settings file

- Download the "PCALTF.78S" file from the DCC filecard for this document onto either a USB stick or a floppy drive depending on the storage device in the SRS785 analyzer.
- Insert the storage device into the SRS785.
- Press the DISK button
  - Select RECALL SETTINGS.
  - Select FILE NAME, turn the large knob to view the directory of files on the storage device, scroll to select the "PCALTF.78S" file, press the ENTER button.
  - Select RECALL FROM DISK
- All setting should be recalled from the file and the instrument should be ready to measure the Pcal OFS transfer function. You can now skip to Section 11.2.

11.1.2 Step-by-step setup by hand

- Power on SR785 and press the SYSTEM button, select the PRESET menu, press the ENTER button. This will clear any settings stored in the SR785.
- Press the DISPLAY SETUP button
  - Select MEASURE GROUP, select SWEPT SINE, press the ENTER button.
  - Select MEASUREMENT, select FREQ RESP, press the ENTER button.
- Press the ACTIVE DISPLAY button (to switch to the other display)
  - Select MEASUREMENT, select FREQ RESP, press the ENTER button.
- Press the SOURCE button, select AMPLITUDE, enter 10 using the number pad, select mV, press the ENTER button.
- Press the FREQ button
  - select TYPE, select LOG, press the ENTER button.
  - Select START, enter 100 using the number pad, select kHz, press the ENTER button.
  - Select STOP, enter 100 using the number pad, select Hz, press the ENTER button.
- Press 'Active Display' button so that the upper display is highlighted
- (These should be part of the "Preset" configuration, but if not, Press the DISPLAY SETUP button.
  - Press VIEW, select LOG MAG, press the ENTER button.
  - Press UNITS, select dB UNITS, select ON, press the ENTER button.
- Press the ACTIVE DISPLAY button so that the bottom display is highlighted
- Press the DISPLAY SETUP button
  - Press VIEW, select PHASE, press the ENTER button.
- Cable connections
  - From SOURCE OUT on the SR785 to CLTF IN on the Pcal Optical Follower Servo (OFS) chassis (D1300599).
  - From ERR MON on the Pcal OFS chassis to CHANNEL ONE A on the SR785.
  - From PD MON on the OFS chassis to CHANNEL TWO A on the SR785.
- Measuring the OLTF
  - Press the START/RESET button to start the measurement.
- When the sweep has finished
  - Press the AUTO SCALE A button
  - Press the AUTO SCALE B button.
- When you are satisfied with the measurement, you can press the Pause/Continue button to pause the measurement.

11.2 Setting the unity gain frequency

- Press the LINK button to link the cursors on the Upper and Lower displays
- Use the dial to move the cursor to 100 kHz.
  - Note the value on the upper plot. If it is not 0 dB, adjust the OFS gain on the upper display to set the (Unity Gain Frequency – 0 dB) at 100 kHz. Note the gain that results in an OLTF of 100 kHz. This is the OFS GAIN. Enter the value in Section 8, above.
  - Note the phase at 100 kHz on the lower display. 180 deg. minus this value is the OFS PHASE MARGIN. Enter the value in Section 8, above.

11.3 Saving data

- Insert USB stick or floppy disk into SR785.
- Press the OUTPUT button
    - Press HARD COPY BUTTON, select BITMAP/PRINT, press the ENTER button.
    - Press BITMAP/PRINTER, select GIF, press the ENTER button
- Press the PRINT SCREEN button to print the screen image to the USB stick or floppy disk.
- View the saved file on a local computer to make sure the file transferred properly.
    - NOTE: **DO NOT insert a non-CDS USB flash drive into a CDS computer** due to virus contamination concerns.