EY 2024/05/28 New Standard

LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
- LIGO -
CALIFORNIA INSTITUTE OF TECHNOLOGY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Technical Note	LIGO-T1500062-v17	2024/05/16

Pcal End Station Power Sensor Responsivity Ratio Measurements: Procedures and Log

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End Station: EY Date: 2024/05/28
Sphere Name and Number: R4
Measurements Performed By: Tony S. Dr Matt B.

Items to take to the end station for the measurements:

- Working Standard (in protective case)
- CDS Laptop including the power chord
- PD Satellite Box (blue box), D1300368
- Long (25') DB9 cable
- DB9/BNC male to DB9 female temperature cable
- BNC cable
- A Fluke handheld digital voltmeter
- Martel calibrated voltage source, banana-to-BNC adapter cable, and charger/AC adapter
- IR-only laser glasses (for use ONLY if work in the ALS laser enclosure, which could expose the VEA to green laser light, will not be ongoing in parallel)
- IR viewing cards: high-power (white) and low power (orange)
- 1.5 mm allen key to remove input aperture cover from Working Standard
- Handheld IR Viewer

Before (or after) going to the End Station

- Check the calibration of the Keithley Model 2100 voltmeter using the Martel Calibrated Voltage source at following three different voltages (the same one that will be taken to the end station). Note: use negative polarity.
  1. (**-4 V**): with Martel = -4.0001 V ..... V on Keithley 2100 DVM
  2. (**-2 V**): with Martel = -2.00000 V ..... V on Keithley 2100 DVM
  3. (**0 V**):with Martel = -0.00014 V ..... V on Keithley 2100 DVM

1 Before starting Pcal work in VEA

- Call the Control Room (ext. 202) to notify them of the laser status change.
- Transition VEA to **LASER HAZARD** status.

- Plug in the Blue Satelite Box to the WS_PD connector on the PCAL Chassis, using the DB9/BNC male to DB9 female to power the Blue box. Ensure the Power Source switch on the back is in the proper setting. Plug the BNC cable into the FLuke Voltmeter for now. Plug in the integrating sphere while it is sitting in a safe location. Power on the power sensor and take note of the current temperature of the on-board AD590 using the Fluke Voltmeter.
  WS on-board temperature: 299.9 K

- Make sure that the IFO's ISC LOCK Gaurdian is in a down or idle state, and that it will not try to auto lock. (sitemap / GRD / ISC OVERVIEW)
  DO NOT CHANGE STATE OF GUARDIAN UNLESS APPROVED BY THE ON-SHIFT OPERATOR

Red this safety Item

- Close the ALS laser shutter via the MEDM screen (sitemap/LSC/Shutters/ISCTX(Y) green beam.)

- Check that SEI ENV is set to Maintenance Mode to Shut Off Sensor correction (The Operator should have done this for Tuesday Maintenance but check anyways.) (sitemap/SEI/ISI SENSOR CONFIG)

1.1 Before starting the measurements

- Record Rx enclosure Digital Thermometer ("Outside" display) = 19.2 deg. C
- Record Rx enclosure Digital Thermometer (" Inside" display) = 18.5 deg. C

- Turn PCAL Interlock bypass to the ON position.

- Set shutter to local

- Disable all three excitations on the Pcal MEDM screen (sitemap/Cal/PcalX(Y)/Excitation):
  1. H(L)1:CAL-PCALX(Y)_SWEPT_SINE
  2. H(L)1:CAL-PCALX(Y)_OSC_SUM
  3. H(L)1:CAL-INJ_MASTER_SW

- Ensure that the ETM pointing is in the "aligned" state.

- Remove cover from Rx enclosure and verify that Pcal beam spots are close to their nominal locations (centered on the Rx sensor input aperture). If they are not, adjust their positions using the final steering mirrors inside the output section of the Tx module enclosure.

- Open a GPS Clock window (type `gpsclock &` in a terminal window).

- Open **StripTool** (type `StripTool &` in a terminal window) and display the following four sensor outputs. Always verify that signals are stable before recording time series.

1. **H(L)1:CAL-PCALX(Y)_TX_PD_WATTS_OUTMON**
2. **H(L)1:CAL-PCALX(Y)_RX_PD_WATTS_OUTMON**
3. **H(L)1:CAL-PCALX(Y)_WS_PD_OUTMON**
4. **H(L)1:CAL-PCALX(Y)_OFS_PD_OUTMON**

- Make sure the OFS is not railed, if it is turn the loop off and back on.

2 Calibration measurements

2.1 Preliminary measurements

2.1.1 Record Optical Follower Servo (OFS) settings

- Offset: 3.85 V
- Gain: 38.5 dB
- OFS PD: −3833 V

2.1.2 Calibrate the Working standard channel

- Connect **Martel Calibrated Voltage Source** to INPUT 1 on the ***BNC to DB9*** interface module mounted in the Pcal transmitter pylon. Note: use negative polarity, and adjust Range to 0.000 to allow up to 4V.
- Inject the three following input voltages for 15 seconds each and record the GPS time and the output level displayed on the StripTool for each 15 second interval.
  1. (**-4 V**): GPS Start Time 1400947756; Voltage = −3.9991 V
  2. (**-2 V**): GPS Start Time 1400947821; Voltage = −1.9999 V
  3. (**0 V**): GPS Start Time 1400947885; Voltage = −0.0003 V

2.1.3 Record Working Standard temperature

- Measure the Working Standard on-board temperature using at DVM at the BNC output of the DB9/BNC to DB9 cable. Multiply the voltage by 100 to obtain the temperature in K.
  - GPS time: 1400947626
  - WS on-board temperature: 299.6 K

2.2 Power sensor measurements

- Connect the Pcal Satellite Box PD MON output to INPUT 1 on the ***BNC to DB9*** interface module mounted in the Pcal transmitter pylon.
- Record GPS start and end times and nominal StripTool output levels during the measurements.

2.2.1 Measurement 1:

- Block the OUTER beam with a razor blade beam block in the Tx module.
- Loop cable around something to ensure that the sphere doesn't fall when the cable is stepped on.
- Place the WS in the INNER beam in the Tx module.

WS in the INNER beam in the Tx module.			
GPS times		StripTool outputs	
Start Time #1	1400948422	TxPD	W
Duration	300 seconds	WSPD	V
End Time #1		OFSPD	V

2.2.2 Measurement 2:

- Move the beam block to the INNER beam in the Tx module.
- Move the WS to the OUTER beam in the Tx module.

WS in the OUTER beam in the Tx module.			
GPS times		StripTool outputs	
Start Time #2	1400948855	TxPD	W
Duration	300 seconds	WSPD	V
End Time #2		OFSPD	V

2.2.3 Measurement 3:

- Leave the WS in the OUTER beam in the Tx module with the INNER beam blocked.
- Close the shutter in the Tx module.

WS in the OUTER beam in the Tx module. Shutter CLOSED.			
GPS times		StripTool outputs	
Start Time #3	1400949270	TxPD	W
Duration	60 seconds	WSPD	V
End Time #3		OFSPD	V

2.2.4 Measurement 4:

- Leave the block in the INNER beam in the Tx module.
- Leave shutter closed in the TX module.
- Replace the Rx sensor with the WS in the Rx module.
- Open the shutter in the Tx module.
- Check if OFS is railed.

WS in the Rx module. INNER beam blocked in the Tx module.			
GPS times		StripTool outputs	
Start Time #4	1400949675	TxPD	W
Duration	300 seconds	WSPD	V
End Time #4		OFSPD	V

2.2.5 Measurement 5:

- Move the block to the OUTER beam in the Tx module.

WS in the Rx module. OUTER beam blocked in the Tx module.			
GPS times		StripTool outputs	
Start Time #5	1400950030	TxPD	W
Duration	300 seconds	WSPD	V
End Time #5		OFSPD	V

2.2.6 Measurement 6:

- CLOSE the shutter in the Tx module.

WS in the Rx module. Shutter CLOSED in the Tx module.			
GPS times		StripTool outputs	
Start Time #6	1400950342	TxPD	W
Duration	60 seconds	WSPD	V
End Time #6		OFSPD	V

2.2.7 Measurement 7:

- REMOVE the beam block from the OUTER beam in the Tx module.

WS sensor in the Rx module, both Inner and Outer beams on it			
GPS times		StripTool outputs	
Start Time #7	1400951270	TxPD	0.72346 W
Duration	300 seconds	WsPD	-3.35146 W
End Time #7	1400951570	OFSPD	-3.8330 V

REPEAT (m10): 1400953310

1400953610

TxPD	0.72375 W
WsPD	-3.3508 W
OFS	-3.8331 V

2.2.8 Measurement 8:

- CLOSE the shutter in the Tx module
- Replace WS sphere with the Rx sphere at the Rx Module.
- Open the shutter in the Tx module
- Verify that the Pcal beam spots are centered on the input aperture of the Rx sensor (photograph spot locations on white card).

Both Inner and Outer beams on Rx sensor in the Rx module.			
GPS times		StripTool outputs	
Start Time #8	1400951930	TxPD	0.72362 W
Duration	300 seconds	RxPD	0.71358 W
End Time #8	1400952230	OFSPD	-3.8331 V

REPEAT (m11): 1400953885

1400954185

TxPD	0.72348 W
RxPD	0.713455 W
OFSPD	-3.83244 V

2.2.9 Measurement 9:

- CLOSE the shutter in the Tx module.

Shutter CLOSED in the Tx module.				
GPS times		StripTool outputs		
Start Time #9	1400 953 002	TxPD	-2.326e-5	W
Duration	60 seconds	RxPD	-3.939e-5	W
End Time #9	1400 953 062	OFSPD	-0.0106	V

:] Repeat #7 to #8

2.2.10 Before leaving VEA

1. OPEN the shutter in the Tx module.
2. Set the shutter control to **Remote** on interface module.
3. Replace the enclosure covers on both the Tx & Rx modules
4. Re-enable the three excitations on the Pcal MEDM screen (if applicable)
5. Make sure **ALL** covers are back on before Turning the interlock bypass to **OFF**.
6. Transition VEA back **LASER SAFE** status
7. Call the Control Room (ext. 202) to notify them of the laser status change and that they may unshutter ALS and take the SEI ENV to CALM if they wish to start Locking.

2.2.11 To complete the end station measurement effort

- Analyze the data (see Section 3) and upload results to the SVN.
- Make an aLog entry; append images of the beam spots at the Rx power sensor aperture, and add a pointer to the measurements results in the SVN.

3 Data Retrieval and calculations

For more details on how to run these calculations, refer to T1900758.

3.1 Data Acquisition, Plots and Report

1. Make sure the SVN directory
   `/ligo/svncommon/CalSVN/aligocalibration/trunk/Projects/PhotonCalibrator/scripts/04/pcalEndstationPy`
   is installed on the machine where you are working.
   Change to this directory.
   Note: A description of the Photon Calibrator SVN directory structure and instructions for checking out the whole Pcal repository can be found in LIGO-T1500095.

2. Execute the command `svn update` to make sure you have the latest versions of the scripts.

3. Execute the command `kinit albert.einstein@LIGO.ORG` to establish connection to the external data server. This will be required for obtaining data later.

4. Open the `config.py` Python script.

   (a) Enter the appropriate IFO location and arm and date code.

   (b) Enter the GPS times of the various measurements as you have listed them in this procedure.

   (c) Save `config.py`

5. In the command terminal run `python3 generate_measurement_data.py`

6. It will create a folder named `tDYYYYMMDD` in the appropriate end-station-specific directory, e.g. for LHOY
   `/ligo/svncommon/CalSVN/aligocalibration/trunk/Projects/PhotonCalibrator/measurements/LHO_EndY`

7. The data is fetched from the server and written into .json files in the `DYYYYMMDD` directory along with a config.py copy. It also generates and saves plots of the time series of the measurements and the relevant ratios. Make sure the plots are satisfactory.

8. If the data is corrupted in some way (e.g. a large glitch in the data or a data dropout), change the directory name to `xDYYYYMMDD`. This vetoes the directory from trend documents published at a later date.

3.2 Generating the trends document

1. If the data was not vetoed, then navigate to the directory containing the scripts for making force coefficient trends, in
   `/ligo/svncommon/CalSVN/aligocalibration/trunk/Projects/PhotonCalibrator/scripts/O4/pcalTrendsPy`

2. In the command terminal run `python3 pcalPublishReportsV2.py` with the end-station as an extra argument, e.g. `python3 pcalPublishReportsV2.py LHO_EndY tDDYYYYMMDD`

3. It creates a force coefficient trend document back in the measurements directory. For LHOY, there will be one named `LHO_EndY_PD_ReportV2.pdf`.

3.3 Commit the new files to the SVN

1. In the terminal window, execute the following commands (Refer to T1500095 for details) from the
   `.../PhotonCalibrator/measurements/LHO(LLO)_EndX(Y)`
   folder (Refer to T1500095 for details.)

- `svn add DYYYYMMDD`
- `svn commit -m "message, e.g.  person committing files"`
- `svn update`

2. Run the last two items on the list from `.../PhotonCalibrator/scripts/pcalTrendsPy` to add the new trend documents to the svn.

Add to alog

Add the plots of the time series of the measurements, their ratios and the generated trend plots to an alog, along with a scan of this procedure and the beam alignment photo.