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

Technical Note	LIGO-T1500062-v8	2020/01/23

Pcal End Station Power Sensors Responsivity Ratio Measurements Procedures and Log

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END STATION: X DATE: 2020/02/11

PEOPLE DOING THE WORK: Niko L, Rick S, Camilla C

Before (or after) going to the End Station

- Check the calibration of the Keithley Model 2100 voltmeter using the Martel Calibrated Voltage source (the same one that will be taken to the end station). Note: use negative polarity.
  - – 4 V with Martel = -4.00000 V on Keithley 2100 DVM
  - – 2 V with Martel = -1.9999 V on Keithley 2100 DVM
  - 0 V with Martel = -0.00013 V on Keithley 2100 DVM

Items to take to the end station for the measurements:

- Working Standard
- PD Satellite Box (blue box), D1300368
- Long (25') and short (6'-10') 9-pin D-sub cables
- BNC cable
- Martel calibrated voltage source, banana-to-BNC adapter cable, and charger/AC adapter
- IR-only laser glasses (for use ONLY if work in the green, ALS laser enclosure will not be ongoing in parallel)
- IR viewing card

Before starting the measurements

- Disable excitations on the Pcal MEDM screen.
- Check that ETM is pointed properly. Check Pcal beam locations at the Rx sensor (photograph spot locations on white card).
- Open **gpsclock**
- Open **StripTool** and display the following sensor outputs. Always verify that signals are stable before recording time series.
  - **(IFO):CAL-PCAL(END)_TX_PD_VOLTS_OUTMON**
  - **(IFO):CAL-PCAL(END)_RX_PD_VOLTS_OUTMON**
  - **(IFO):CAL-PCAL(END)_WS_PD_OUTMON**
  - **(IFO):CAL-PCAL(END)_OFS_PD_OUTMON**

Calibration measurements and log

Preliminary measurements

Calibrate the Working standard channel

- Connect **Martel Calibrated Voltage Source** to INPUT 1 on the ***BNC to DB9*** module. Note: use negative polarity.
- Record 15 seconds of data for each input voltage.
  - - 4 V = 3.9966 volts and GPS Start Time 1265 478 780
  - - 2 V = -1.9985 volts and GPS Start Time 1265 478 815
  - 0 V = -0.0005 volts and GPS Start Time 1265 478 850

Record Optical Follower Servo settings

- Offset: 3.81 volt
- Gain: 39.5 dB
- OFS PD: -3.793 volt

Record Working Standard temperature

- Measure sensor voltage at Interface Module **WS PD MON** BNC output ising a voltmeter.
  - GPS time: .....
  - WS PD MON: 2.992 volts
- Convert to degrees Celsius by dividing by 0.90909, multiplying by 100, and subtracting 273.15.
  - WS PD temperature: .....deg. Celsius.
  - WS PD temperature: .....deg. Farenheit.
- Additionally, record the reading on the temperature sensor located on the Rx support pylon.
  - Rx enclosure temperature: inside enclosure 19.6 ~~indoor~~ 19.1 .....deg. Celsius.

Time Series Measurements

- Connect Pcal Blue Box PD MON output to INPUT 1 on the ***BNC to DB9*** module.

Measurement 1:

- Block the OUTER beam with a razor blade dump in the Tx module.
- Place the WS in the INNER beam in the Tx module.

WS in the INNER beam in the Tx module.			
GPS Times		Readings from MEDM screen	
Start Time #1	1265481780	TxPD	0.518519 volt
Duration	240 seconds	WSPD	-2.3226 volt
End Time #1	1265482020	OFSPD	~~-2.32~~ -3.79248 volt

Measurement 2:

- Move the 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		Readings from MEDM screen	
Start Time #2	1265 482110	TxPD	0.518555
Duration	240 seconds	WSPD	-2.3559
End Time #2	1265 482350	OFSPD	-3.7934

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		Readings from MEDM screen	
Start Time #3	1265 482 370	TxPD	~~0.518~~ 0.000109
Duration	60 seconds	WSPD	-0.0004
End Time #3	1265 482 430	OFSPD	-0.010661

Measurement 4:

- Leave the block in the INNER beam in the Tx module.
- Open the shutter in the Tx module.
- Replace the Rx sensor with the WS in the Rx module.

WS in the Rx module. INNER beam blocked in the Tx module.			
GPS Times		Readings from MEDM screen	
Start Time #4	1265 482820	TxPD	0.518577
Duration	240 seconds	WSPD	-2.3274
End Time #4	1265 483 060	OFSPD	-3.792941

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		Readings from MEDM screen	
Start Time #5	1265 483 090	TxPD	0.518715
Duration	240 seconds	WSPD	-2.2954
End Time #5	1265 483 330	OFSPD	-3.7932

subsubsection*Measurement 6:

- CLOSE the shutter in the Tx module.

WS in the Rx module. Shutter CLOSED in the Tx module.			
GPS Times		Readings from MEDM screen	
Start Time #6	1265 483360	TxPD	5.6×10^{-5}
Duration	60 seconds	WSPD	0.010179
End Time #6	1265 483 600 420	OFSPD	-0.0001

Measurement 7:

- OPEN the shutter in the Tx module.
- Leave the beam block in the OUTER beam in the Tx module.
- Replace the WS with the Rx sensor in the Rx module.

OUTER beam blocked in the Tx module. Rx sensor in the Rx module.			
GPS Times		Readings from MEDM screen	
Start Time #7	1265 483570	TxPD	+0.518921
Duration	240 seconds	RxPD	0.254654
End Time #7	1265 483810	OFSPD	-3.79337

Measurement 8:

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

INNER beam blocked in the Tx module. Rx sensor in the Rx module.			
GPS Times		Readings from MEDM screen	
Start Time #8	1265 483850	TxPD	0.518885
Duration	240 seconds	RxPD	0.258741
End Time #8	1265 484090	OFSPD	-3.79254

Measurement 9:

- CLOSE the shutter in the Tx module.

Shutter CLOSED in the Tx module. Inner beam blocked.			
GPS Times		Readings from MEDM screen	
Start Time #9	1265 484 100	TxPD	0.000121
Duration	60 seconds	RxPD	-4.88×10^{-5}
End Time #9	1265 484 160	OFSPD	-0.0104

When measurements are finished.

- Remove the beam block from the INNER beam in the Tx module.
- OPEN shutter in the Tx module.
- Set shutter control to *Remote* on interface module.
- Re-enable excitations on the Pcal MEDM screen (if applicable).
- Check that ETM is pointed properly. Check Pcal beam locations at the Rx sensor (photograph spot locations on white card).

- Analyze the data and upload results to the SVN.
- Make aLog entry, append image of beam spots at the Rx module, add pointer to measurements results in the SVN.

Data Retrieval and Ratio and Force Coefficient calculations

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

Data Acquisition, Plots and Report

1. Make sure the SVN directory
   `/ligo/svncommon/CalSVN/aligocalibration/trunk/Projects/PhotonCalibrator/scripts/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 times series of the ratios. Make sure the plots are satisfactory.

8. If the data appears to be valid, change the name of the directory from `tDYYYYMMDD` to `DYYYYMMDD`. 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.

Force Coefficient Calculation

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/pcalTrendsPy`

2. In the command terminal run `python3 pcalPublishReports.py` with the endstation as an extra argument, e.g. `python3 pcalPublishReports.py LHO_EndY`

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

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/end_station`
   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 generated FC and PD trend plots to an alog, along with a scan of this procedure and the beam alignment photo.