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

Technical Note **LIGO-T1500062-v8** 2019/06/04

Pcal End Station Power Sensors Responsivity Ratio Measurements Procedures and Log

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END STATION: Y DATE: 11/10/2019

PEOPLE DOING THE WORK: Niko, Dripta

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 = ... V on Keithley 2100 DVM
  - − 2 V with Martel = ... V on Keithley 2100 DVM
  - 0 V with Martel = ... 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)

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 = -3.9984 volts and GPS Start Time 1254 848798
  - \- 2 V = -1.9994 volts and GPS Start Time 1254 848769
  - 0 V = -0.0003 volts and GPS Start Time 1254 848745

Record Optical Follower Servo settings

- Offset: 3.67 volt
- Gain: 38.30 dB
- OFS PD: -3.657 volt

Record Working Standard temperature

- Measure sensor voltage at Interface Module **WS PD MON** BNC output ising a voltmeter.
  - GPS time: ....
  - WS PD MON: .... 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.

Time Series Measurements

- Connect Peal 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	1254849 445	TxPD	3.007	volt
Duration	240 seconds	WSPD	-3.097	volt
End Time #1	〃 685	OFSPD	-3.656	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	〃 849 950	TxPD	3.008
Duration	240 seconds	WSPD	-3.126
End Time #2	〃 850 190	OFSPD	-3.656

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	〃 850 230	TxPD	0.011
Duration	60 seconds	WSPD	-0.0001
End Time #3	〃 〃 290	OFSPD	-0.011

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 " 850 820	Readings from MEDM screen	
Start Time #4		TxPD	3.007
Duration	240 seconds 851 060	WSPD	-3.073
End Time #4		OFSPD	-3.656

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 " 851 175	Readings from MEDM screen	
Start Time #5		TxPD	3.0059
Duration	240 seconds " " 415	WSPD	-3.071
End Time #5		OFSPD	-3.650

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	" 425	TxPD	0.011
Duration	60 seconds	WSPD	-0.0003
End Time #6	" 485	OFSPD	-0.0112

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	// 720	TxPD	3.007
Duration	240 seconds	RxPD	2.198
End Time #7	// 960	OFSPD	-3.656

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	// 852 020	TxPD	3.007
Duration	240 seconds	RxPD	2.199
End Time #8	// // 260	OFSPD	-3.656

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	// 305	TxPD	0.0112
Duration	60 seconds	RxPD	-0.0003
End Time #9	// 365	OFSPD	-0.010

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

Data Acquisition, Plots and Report

1. Make sure the SVN directory
   `/ligo/svncommon/CalSVN/aligocalibration/trunk/Projects/PhotonCalibrator/scripts/pcalEndstation`
   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. Navigate to `/ligo/svncommon/CalSVN/aligocalibration/trunk/Projects/PhotonCalibrator/scripts/pcalEndstation`

5. Open the `endstationPcalAnalysis.m` matlab script.
   (a) Enter the appropriate ifo. location and arm and date code.
   (b) Make sure the `workingcopy_location` in the Matlab file `pcalworkingcopylocation.m` has the appropriate path to the `PhotonCalibrator` directory, e.g. `/ligo/svncommon/CalSVN/aligocalibration/trunk/Projects/`
   (c) If you are running with this calibration data for the first time, make sure that the rerun parameter is set to 0.
   (d) Enter the GPS times of the various measurements between lines 40 and 60.
   (e) run `endstationPcalAnalysis.m`

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. This will also fetch the data from the server and write them into .txt files in the `DYYYYMMDD` directory.

8. It also generates plots of the times series of the ratios and saves the plots to the same directory, in addition to displaying them on the screen. Make sure the plots are satisfactory before closing them.

9. It will generate the files, `DYYYYMMDD_Ratio.mat` and `DYYYYMMDD_Results.mat`, that contain the calibration results, and save them in the same directory.

10. Finally it publishes a report LHOY_PD_trend.pdf in the output `tDYYYYMMDD` directory, and copies over the scripts used for analysis to the sub-directory `tDYYYYMMDD/scripts`

11. Use the times series plots and the trend document to assess the quality of the recently acquired results.

12. 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 Coeffcient 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/Project:`
`PhotonCalibrator/pcalCalFactor/scripts`

2. Open pcalFCPublish.m, and change to the appropriate date_code. Run the script by passing the appropriate ifo-arm arguments For example for LHOY, run
`pcalFCPublish('LHOY, '').`

3. It creates a force coefficient trend document back in the measurements directory. For LHOY, it will be named `pcalFCReport_LHOY.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: including comment on veracity of data and analysis results by person committing the directory to the SVN"`
   - `svn update`