LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

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AOSEM Electronic Noise Test Procedure

Mark Barton

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California Institute of Technology
LIGO Project – MS 18-34
1200 E. California Blvd.
Pasadena, CA 91125
Phone (626) 395-2129
Fax (626) 304-9834
E-mail: info@ligo.caltech.edu

Massachusetts Institute of Technology
LIGO Project – NW22-295
185 Albany St
Cambridge, MA 02139
Phone (617) 253-4824
Fax (617) 253-7014
E-mail: info@ligo.mit.edu

LIGO Hanford Observatory
P.O. Box 1970
Mail Stop S9-02
Richland WA 99352
Phone 509-372-8106
Fax 509-372-8137

LIGO Livingston Observatory
P.O. Box 940
Livingston, LA 70754
Phone 225-686-3100
Fax 225-686-7189

http://www.ligo.caltech.edu/

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1 Introduction

1.1 Purpose and Scope

Describes how to test a batch of AOSEMs for electronic noise using the LHO BSC test stand. Could be used with minor modifications to test AOSEMs on any other other test stand or production system.

1.2 References

E1101030: AOSEM Noise Test Data

S1106179: Template for more AOSEM S-number documents.

T1000100: Parametric Study of AOSEM Sensor Noise

G1100856: bOSEM Satellite Amp Saturation

https://awiki.ligo-wa.caltech.edu/aLIGO/Suspensions/TestStands: Wiki page with additional information about the computers at the test stand.

1.3 Version history

10/10/11: Pre-rev-v1 draft.

10/16/11: -v1. Near-final version for trying out with Jeff Bartlett.

10/24/11: -v2. Refined version with new open light measurement procedure, corrected SVN procedure, more computing details, max and min open light requirements.

2 Theory

2.1.1 Noise

The noise requirement for AOSEMs was set by their use in the IO suspensions and derived by David Reitze (email to Norna Robertson, 2/8/10). It is plotted in Figure 1, and the data file for the plot is in the associated documents for this report, as well as on the SUS SVN at `^/trunk/electronicstesting/AOSEM/noise/HA_sense_noise.txt`.

To relate this displacement noise requirement to a measurement in counts/√Hz on the test stand requires chasing the chain of mechanical and electrical calibration factors.

Per T1000100, a typical AOSEM had a open light (maximum) photocurrent of 30 μA, and mechanical conversion factor of 0.05 A/m. If we assume that the shape of the curve in Figure 2 of T1000100 is representative but that different AOSEMs have different open light currents, this is conveniently expressed as a conversion factor scaled to open light of 1666 m^{-1}.

Per G1100856, satellite amplifiers will be retrofitted to have gain resistors of 120 kΩ. Thus the transresistance from the photocurrent to the two-sided differential output signal will be 240000 V/A.

The whitening filter has non-unity gain at higher frequencies, but if the software dewhitening filter is engaged, this is cancelled accurately enough for the present purposes.

The 16-bit ADC takes a 40 Vpp two-sided differential input and maps it onto 2^16 values, for a response of 1638.4 counts per V.

The average open light counts for the 12 AOSEMs in batch 2011-10-13-01 was 20926. This implies an average open light photocurrent of 20926/1638.4/24000 = 53.2 μA or multiplying by 1667 m^{-1}, a mechanical sensitivity of 0.0887 A/m. However we choose a nearby round number and define a nominal AOSEM as having 20000 counts or 50.9 μA at open light, and a mechanical sensitivity of 0.0848 A/m.

Finally, the scaling factor to metres from counts for any AOSEM is 1/1667/(open light counts), which is 3.00×10^{-11} m/count for a nominal AOSEM.

The above is implemented in the Matlab function `processbatchdirectory.m` described in the procedure section below. The function is intended to be run in the `^/trunk/electronicstesting/AOSEM/noise` directory of the working copy of the SUS SVN on the test stand. It looks in a subdirectory specified by a string argument for a noise data file saved from DTT, and generates noise plots for each of the AOSEMs in the batch with the requirements curve superimposed.

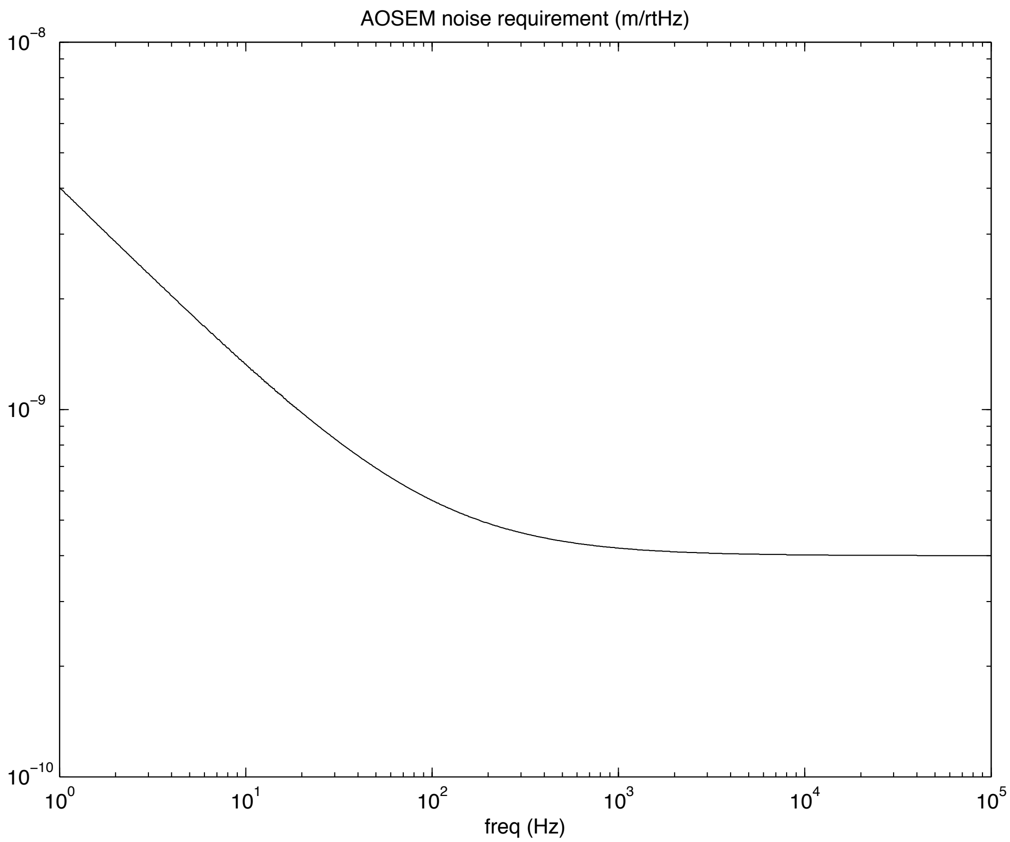

Figure 1: AOSEM noise requirement

2.1.2 Open light voltage

The test stand electronics has a component (probably the AA chassis) that saturates at around 30000 counts, so that AOSEMs that give more output that that cannot be tested for noise. Also some AOSEMs have inconveniently low output. We set provisional minimum and maximum open light count values of 15000 to 30000.

3 Procedure

3.1 Set-up for one or more batches

Most of the computing steps in this section affect the workstation and could be done most simply sitting in front it. However they are probably best done indirectly from the iMac, to save garbing and ungarbing, and this is how the instructions are written. See the wiki for more information on computing tips and techniques.

1. Open a Terminal window (click on the Terminal icon in the Dock and choose Shell->New Window->Basic) and log in to the front end with the following command (there should also be a Dock icon called "Terminal (Front End)" or the like to do both of these in one click):

```
> ssh -X controls@bscteststand2
```

2. Check what modules are running:

```
> lsmod
```

3. Check that the module `x1susquadfe` is in the resulting list. If not, continue at Step 7.
4. Check if `x1susbsfmfe` is in the list – if so kill it:

```
> killx1susbsfm
```

5. Start the quad model:

```
> startx1susquad
```

6. In the front end directory `/opt/rtcds/tst/x1/chans/daq/`, backup the file `X1SUSQUAD.ini` by renaming it to something appropriate (perhaps to include the date) and make a copy of `X1SUSQUADminimal.ini` as `X1SUSQUAD.ini`.
7. Log into the `daqd` command line:

```
> telnet localhost 8087
```

8. Check that you get a prompt `daqd>`
9. Kill the `daqd` process:

```
daqd> shutdown
```

10. The `daqd` process should quit, the telnet session will be terminated, and the `daqd` process should be automatically restarted.
11. Open a second Terminal window (again, click on the Terminal icon in the Dock and choose Shell->New Window->Basic) and log in to the workstation with the following command

(there should be a Dock icon called "Terminal (Workstation)" or the like to do both of these in one click):

```
> ssh -X controls@10.11.0.96
```

12. Open the MEDM quad main screen with the following command in the Terminal window with the workstation login session from the previous step (alternatively, there should be a Dock icon called MEDM):

```
> medm -x /opt/rtcds/tst/x1/medm/x1susquad/X1SUS_CUST_QUAD_OVERVIEW.adl&
```

13. Bring up "X1SUSQUAD GDS TP" screen by clicking on the button. On that screen, click "BURT" and "Coeff Load".
14. Do a BURT backup of the MEDM state. See the wiki for detailed instructions.
15. Back at the X1SUS_CUST_QUAD_OVERVIEW screen, open all OSEM INPUT FILTER screens (for M0, R0, L1 and/or L2) that have AOSEMs connected to associated channels.
16. Check (i) that all LHS ON/OFF switches are ON, (ii) all RHS ON/OFF switches are off (for safety), (iii) all offsets are 0, (iv) all gains are 1.0, and (v) all FM1 filters are enabled (double green).
17. Leave MEDM open for recording open light counts below. Leave the front end and workstation terminal sessions open.

3.2 Procedure for each batch

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1. Select up to 20 AOSEMs for testing.
2. In the Terminal window with the workstation login session, navigate to the AOSEM directory (if you've just finished testing a prevous batch, you should have been brought back there already):

```
> cd /ligo/svncommon/SusSVN/sus/trunk/electronicstesting/AOSEM/noise
```

3. Make a copy of the subdirectory `yyyy-mm-dd-bb`, replacing `yyyy` etc by the year, month, day and batch number for the day. Hereafter this will be called the batch directory.

```
> svn copy yyyy-mm-dd-nn 2011-10-13-01
```

4. Go into the batch directory,:

```
> cd 2011-10-13-01
```

5. Open the file `AOSEM_Batch_Index.xls` with Open Office (this will be called the batch index):

```
> ooffice AOSEM_Batch_Index.xls &
```

6. Connect the AOSEMs up to the OSEM cables on the quad test stand. For each OSEM position (M0 F1 etc), record the serial number of the corresponding AOSEM in the SERNUM column in the batch index.
7. Shade the OSEMs from room light and from each other.

8. Measure the open light counts:

```
> ../readopenlight
```

9. After about 10 seconds, the open light values will appear in a `gedit` (text editor) window titled `openlightdata.txt`, from where they can be copied and pasted into the OL column of the Batch Index spreadsheet. Don't bother changing the signs to positive. Type "q" in the window or click the red close button to close it. The numbers are also available in the file `openlightdata.txt` and could be opened directly with File->Open in Open Office.

10. Enter the date and batch number in the DATE and BATCH columns of the batch index against every position that has an AOSEM connected. (This may seem redundant because the date will be the same for the whole batch, but it will prove useful when compiling the master index later.) Do not use the drag technique as for the DCCNUM column because it will increment the dates. Rather, enter the date and batch number against the first AOSEM, select all the cells and choose Edit->Fill->Fill Down.

11. Open the .xml file with DTT:

```
> diaggui AOSEM_Batch_Data.xml &
```

12. Press Start and wait a minute or two for 10 averages to be taken. Do not bump the AOSEMs or cables while data is being taken.

13. Choose File->Save.

14. In the Results pane, review the traces for all channels that have AOSEMs connected. They should all have a gentle downward slope and be fairly tightly clustered. If there are any obvious outliers, check for poor connections or circuit board screws not properly tightened and try taking data again. Consider swapping AOSEMs between positions to incriminate/exonerate the cables. Be sure to update the SERNUM column in the batch index to track any swaps, and to re-shade the AOSEMs after any adjustments. If outliers persist after reasonable efforts, then the actual AOSEMs have to be assumed to be faulty.

15. Resave if adjustments have improved the data.

16. Save the batch index and quit Open Office. Do not accept any offer to save the file in Open Office format - it needs to remain in Excel format so it can be read by Matlab.

17. Close the DTT window.

18. Return to the `noise` directory:

```
> cd ..
```

19. If there is another batch to test, repeat all the steps in this section.

3.3 Restoring test stand state

1. Restore the old MEDM values from the BURT backup generated in Section 3.1, Step 13. See the wiki for detailed instructions.

2. Find the Terminal window with the front end login session from before.

3. In the front end directory `/opt/rtcds/tst/x1/chans/daq/`, delete the minimal version of `X1SUSQUAD.ini` and rename the backup as `X1SUSQUAD.ini`.
4. Log into the `daqd` command line:

```
> telnet localhost 8087
```

5. Check that you get a prompt `daqd>` .
6. Kill the `daqd` process:

```
daqd> shutdown
```

7. The `daqd` process should quit, the telnet session will be terminated, and the `daqd` process should be automatically restarted.

3.4 Data processing

The instructions below assume the same Terminal window with the workstation login session on the iMac as used above, but with minor adaptations could be done in comfort at the actual workstation.

1. Check that you are in the `noise` directory and if not, go there:

```
> cd /ligo/svncommon/SusSVN/sus/trunk/electronicstesting/AOSEM/noise
```

2. Open the master index spreadsheet with Open Office:

```
> ooffice AOSEM_Master_Index.xls &
```

3. Open Matlab:

```
> matlab &
```

4. Open a web browser (it must be one running on the workstation, not the iMac, because otherwise it won't have access to the result files):

```
> firefox &
```

5. (Optional) Open a file browser:

```
> dolphin &
```

6. Do an SVN update to prevent problems with later SVN commits:

```
> svn update
```

7. Repeat the remaining steps for each batch that has not previously been processed.
8. Within Open Office, choose File->Open, navigate into the batch directory (`2011-10-13-01` or the like) and select the `AOSEM_Batch_Index.xls` file. Make a note of the number of AOSEMs in the batch.

20. In Firefox, go to https://dcc.ligo.org/e-traveler/ .
21. Type S1106179 in the S-Number box at the top of the e-traveler web page. A "Clone _ times" box and a "Clone!" button should appear - type the number of AOSEMs in the batch in the box and click the button. (S1106179 is a dummy document which will never be part of a batch, so enter the full number of AOSEMs rather than the number less one.)

22. The e-traveler page will report a list of new S-numbers that have been created. Enter these numbers in the DCCNUM column of `AOSEM_Batch_Index.xls`. Since the numbers will normally be sequential, the easiest way to enter all of them is to copy and paste the first one, reselect the cell, and then drag the marker at the bottom right corner downwards. Leave the e-traveler window open in Firefox.

9. Copy all the rows with valid data in `AOSEM_Batch_Index.xls` and paste them at the end of the similar list in `AOSEM_Master_Index.xls`.

10. Save and close the `AOSEM_Batch_Index.xls` file. Save the `AOSEM_Master_Index.xls` file but leave it open if there are any more batches to process.

23. Open a new window or tab within Firefox, go to the DCC page for the AOSEM Noise Test Data summary document, E1101030 and click the Change Metadata button.

11. Select and copy the list of new S-numbers from the e-traveler window and paste it at the end of the Related Documents field in the E1101030 window. Click Change Metadata again. Leave the browser window open.

12. Within Matlab, generate the result plots:

```
>> processbatchdirectory('2011-10-13-01')
```

13. Review the on-screen plots and check that all the measured curves (blue) are below the requirement curves (red). Make a note of the serial numbers of any AOSEMs that fail, and remove those AOSEMs from circulation.

14. (Optional) Within the file browser, navigate into the batch directory, and check that the right number of PDF files have been generated. Preview one or two to check that they are sensible.

15. On the browser page for the summary document E1101030, scroll to the end of the Related Documents list. Using control-click or the like (command-click on a Mac), open all the new S-documents in separate tabs/windows.

16. In each of the new S-document tabs/windows, click "Upload LIGO-S*yynnnnn*-v1" and add the corresponding PDF plot file. At the same time, adjust the title of the document to include the serial number, e.g., "AOSEM" -> "AOSEM SN123". (There should be no need to consult the batch index or master index because both the DCC S-number and the serial number are part of the PDF file name.)

17. In the Terminal window with the workstation login session, look at the contents of the batch directory and check for files called `core` (caused when program crash). If there are any, delete them to stop them wasting space in the SVN:

```
> ls 2011-10-13-01

> rm 2011-10-13-01/core
```

18. Put the new files under SVN version control. Messages that some items are already under version control (from the `svn copy` command above) can be ignored:

```
> svn add 2011-10-13-01
```

19. Upload the batch files and the updated master index to the SVN repository:

```
> svn commit -m ""
```