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Dual PD Amp Circuit Board Test Results

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LIGO Scientific Collaboration

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1 Introduction

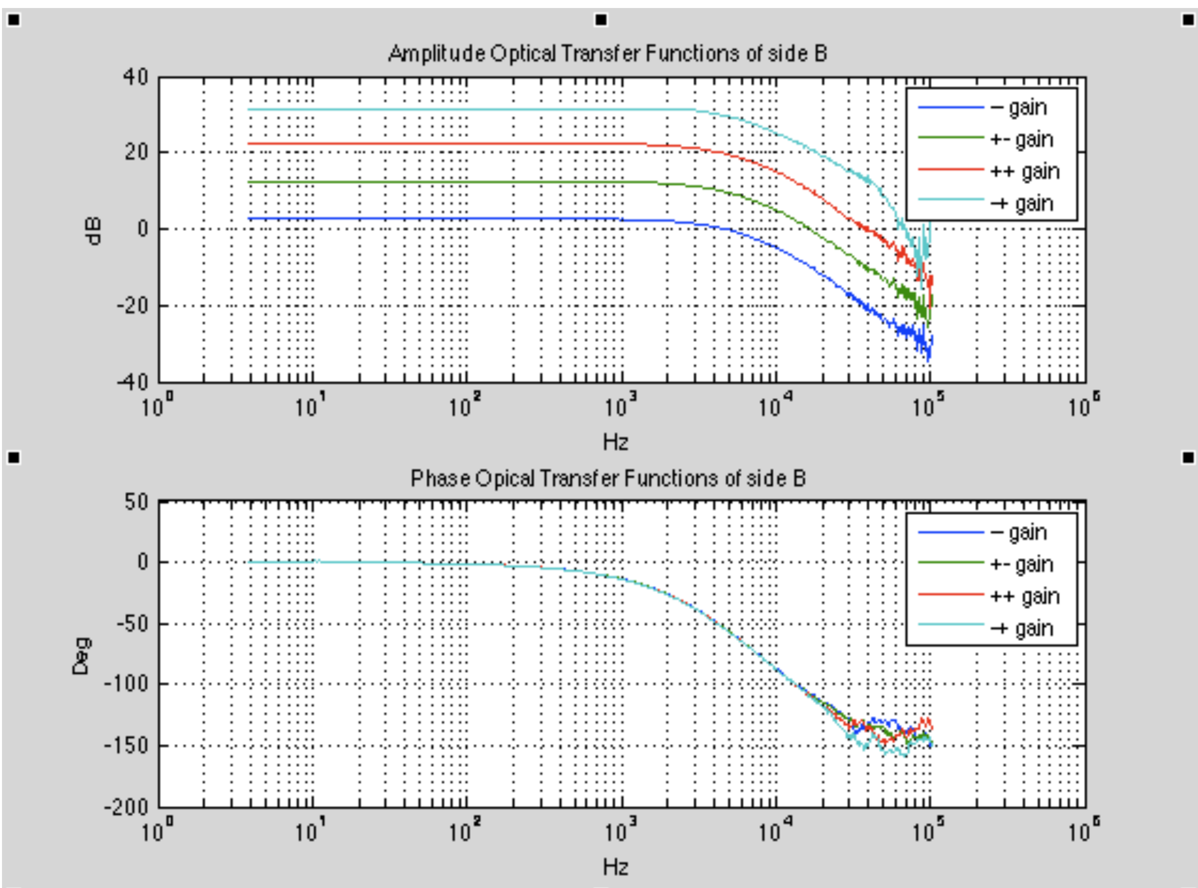
This document contains test results for the Dual PD Amp circuit board proto-type that was put together by Alexa. Ultimately, five of these boards will be made and placed inside the ALS Fiber Distribution box (wiki). One can find the test procedure and data collected for the board HERE and HERE respectively.

2 Results

When connected to only a power source, the PD monitors read the expected vref of -5 volts. In addition, the outputs read almost zero volts. The DC offset is measured to be less than 10mV for all gain settings on both sides of the board. We also see less than 20uV for the AC offset.

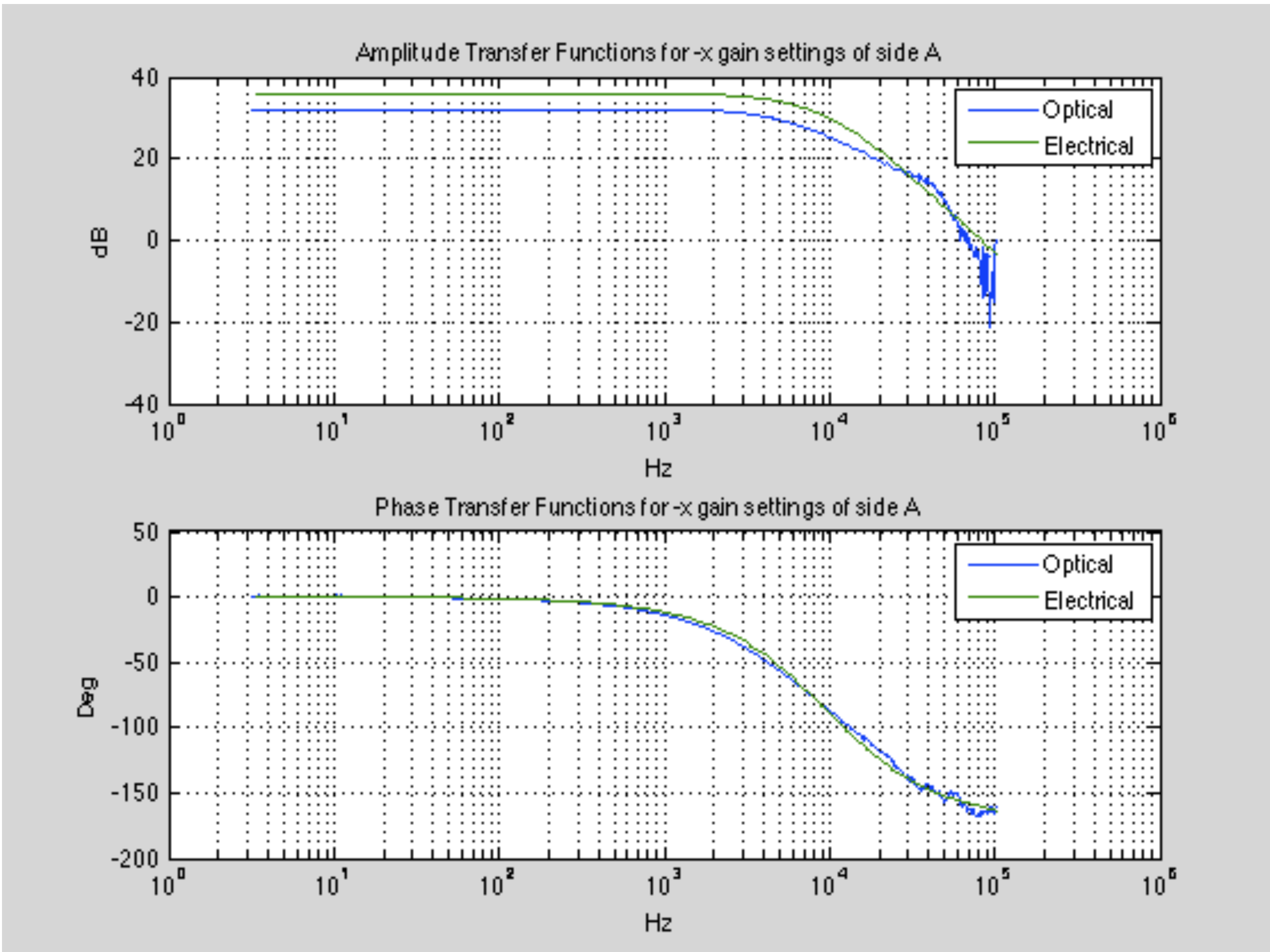
1) Transfer Function:

I computed the transfer function of the Dual PD Amp with a modulated fiber-couple laser and with the electrical source from the SR785. The modulation of the laser had its own transfer function, which I subtracted out from the transfer function of the board. Below is a graph of the amplitude and phase of the transfer function for side B of the board (A is similar) at the different gain settings. Evidently, the amplitude increases accordingly to gain. Note, that the gain settings follow the Gray Code standard. Also, one can see the bandwidth of approximately 4kHz.

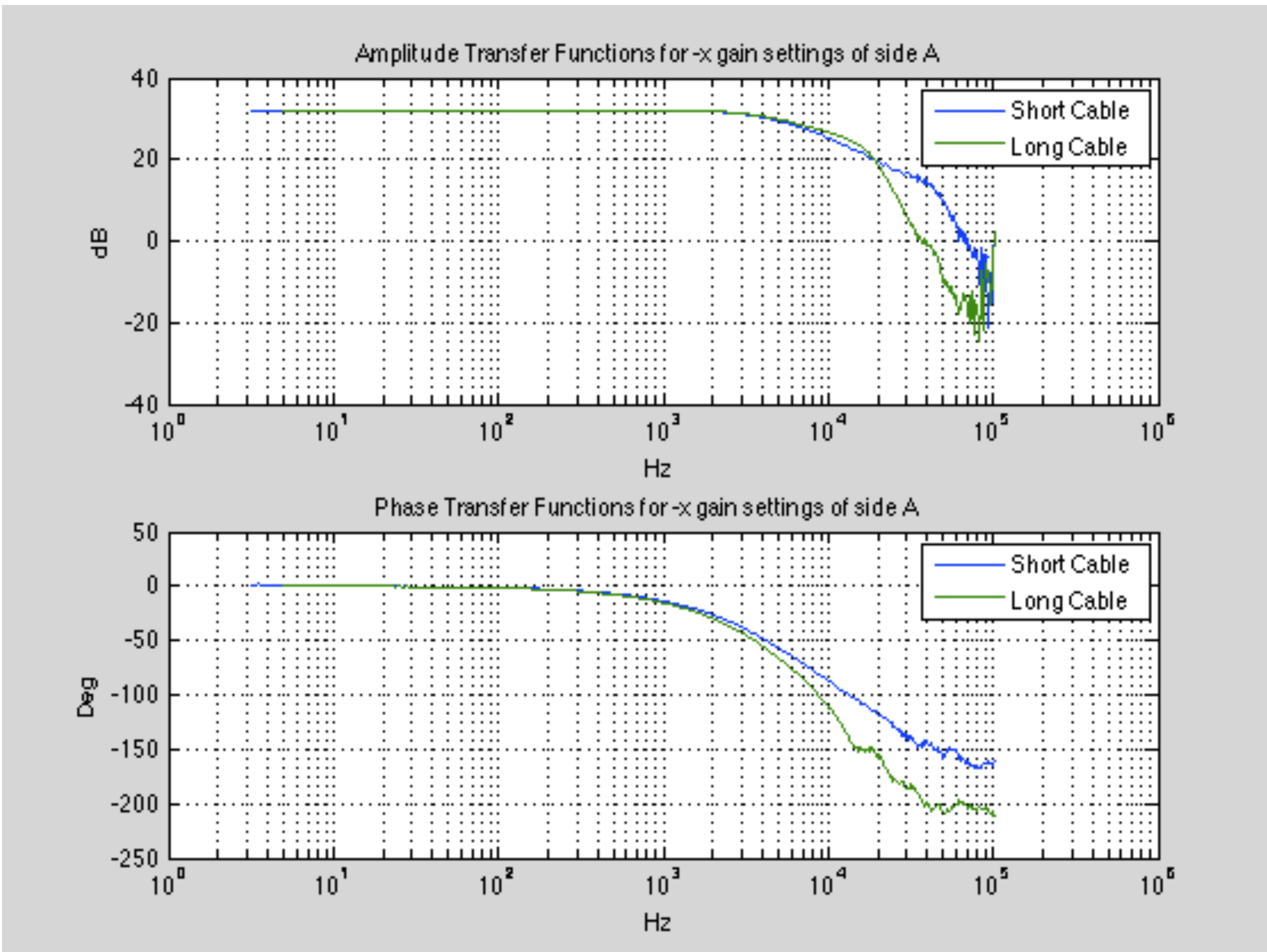


We can compare the optical transfer function with the electrical transfer. Below is a plot of this comparison for board side B at the highest gain. Evidently, they are pretty similar. However, the optical gain is a bit steeper at high frequencies and the bandwidth of the electrical gain is at approximately 6kHz.

c

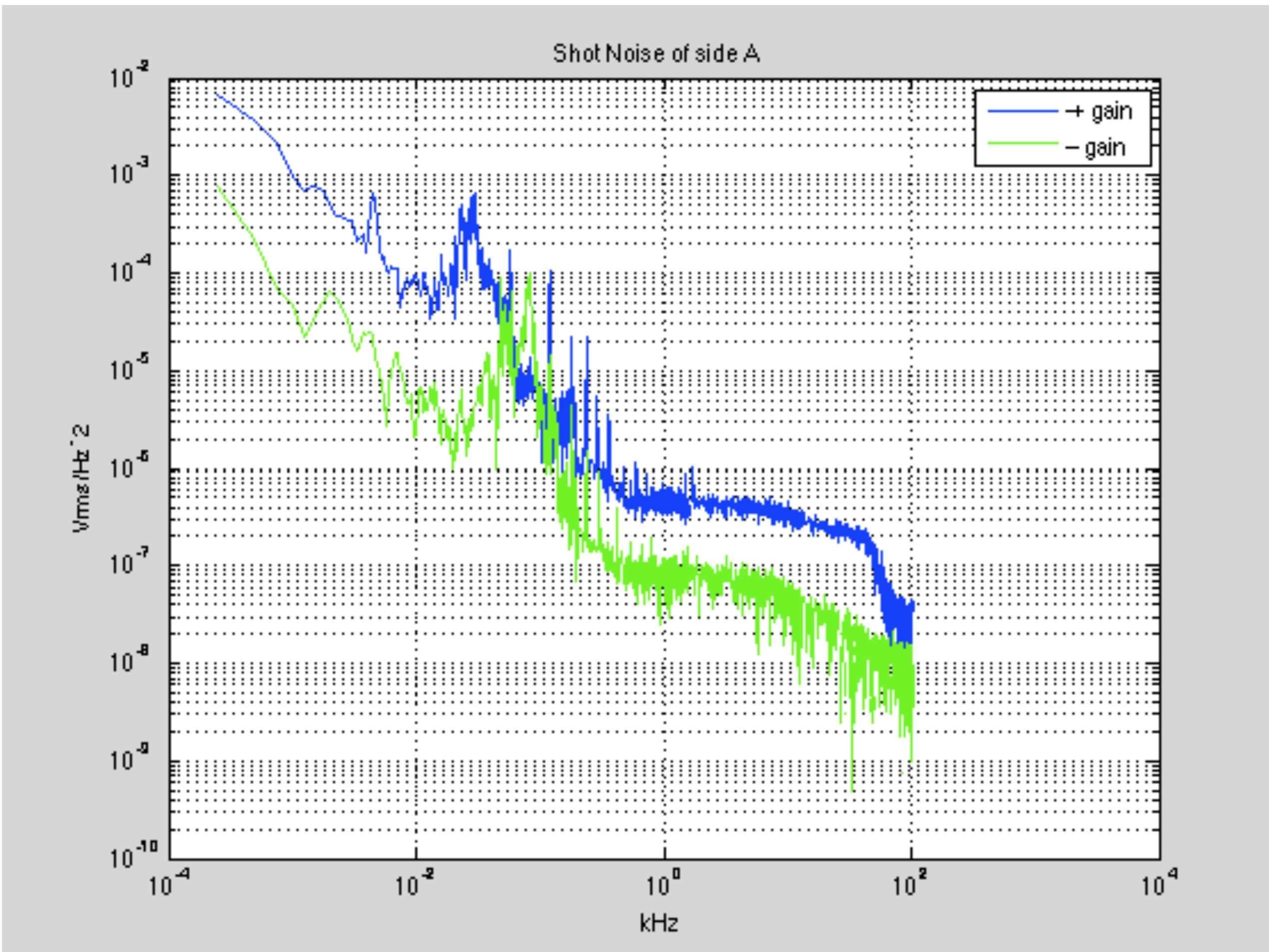


I repeated the measurements of the optical transfer function using a long cable (100ft). The results were consistent. Below is a plot comparing the two transfer functions from board side A at the highest gain.

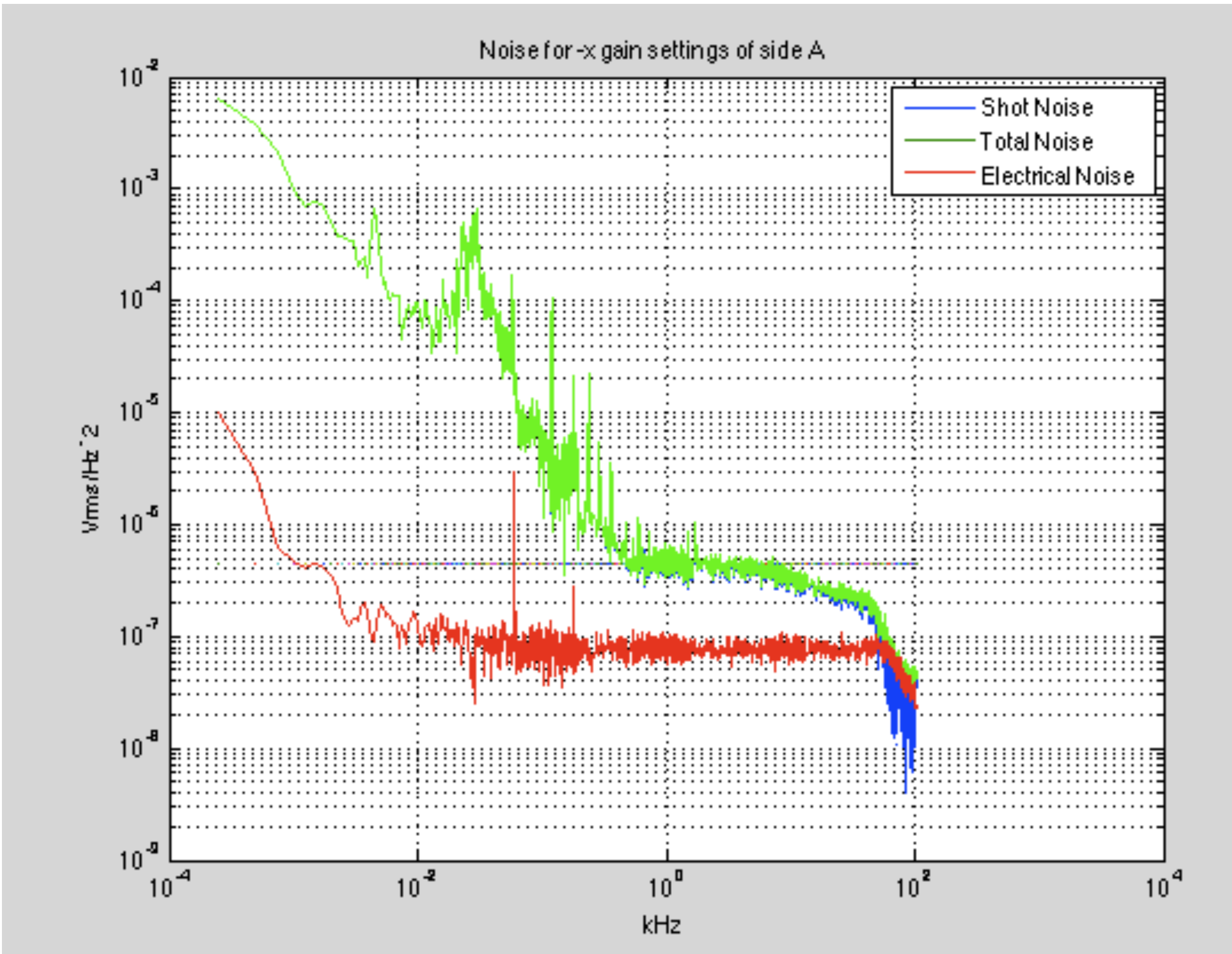


2) Noise:

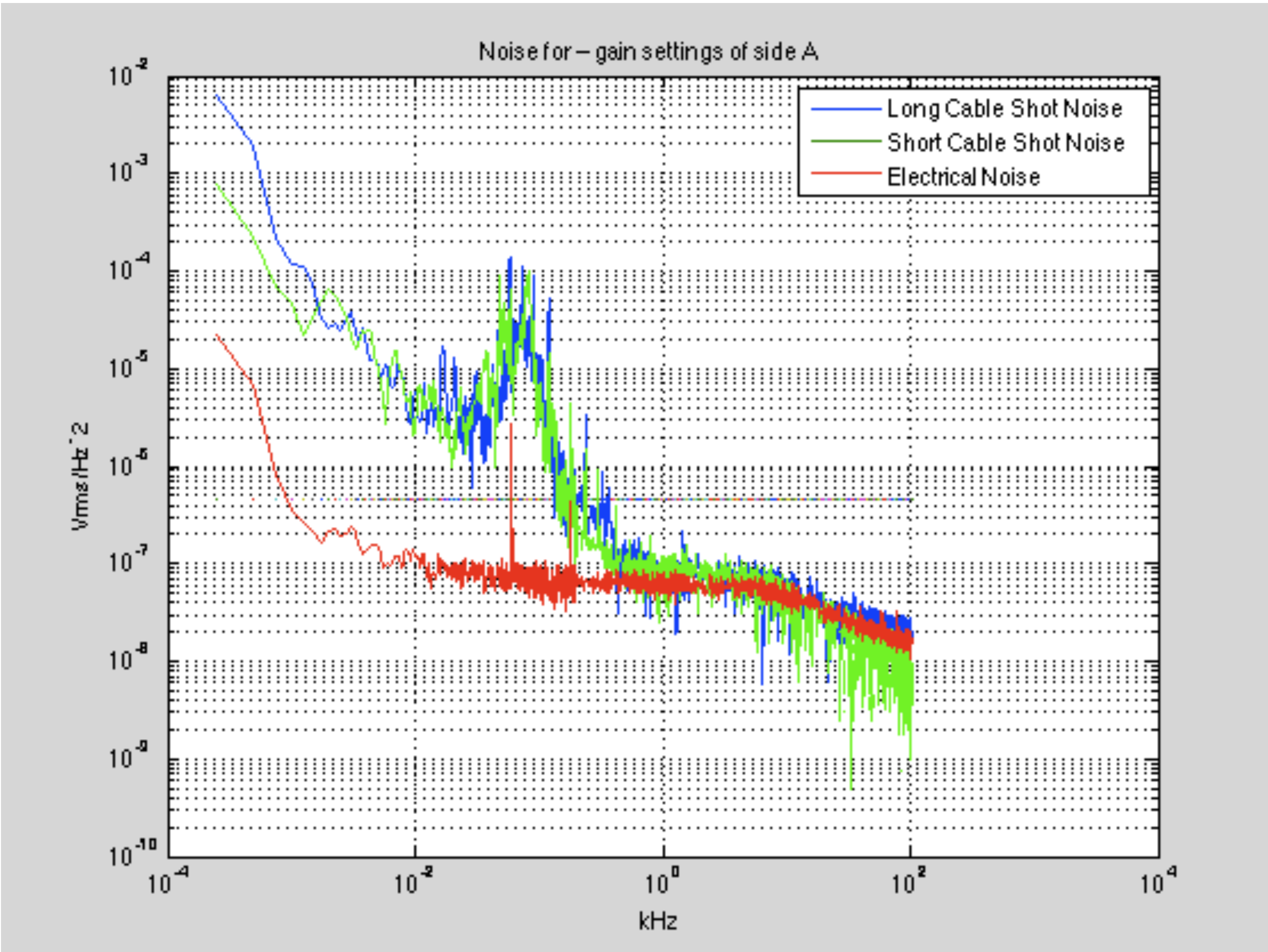
I also computed the total noise, electrical noise, and shot noise of the board. Using a halogen light source, I found the shot noise for both sides of the board for all the gain settings. Below is a plot of side A at the highest and lowest gain settings. One can see that the shot noise increases for higher gain. Both measurements have a sharp increase at around 400Hz; this is not shot noise, but comes from the noise of the source. This measurement should ultimately be done with a more stable source connected to a battery and not a power supply.



Below is a plot of the total noise, shot noise, and electrical noise all plotted together. The electrical noise is about 60nVrms/SqrtHz. The electrical noise was consistent for both sides of the board and for all gain settings – this is expected given that the noise is dominated by the op-amp that is not connected to the gain switches. The graph below also includes a dashed line, which represents the expected shot noise. Our measurement matches this expectation nicely between 500Hz and 7kHz.



Again, these noise measurements were repeated using a long cable (100ft). Below is a graph of the electrical noise, and the shot noise of side A at the lowest gain setting for both the long and short cable. Evidently, there isn't much of a difference between the two cables in terms of noise.



Lastly, here is a table for boards A and B averaging the noise measurements in the span of 1kHz to 2kHz. The table includes the electric noise, shot noise, and total noise for the short cable, the shot noise for the long cable, and the expected shot noise. Note that the expected shot noise is only an approximate value given that this calculation assumed an output voltage of 10V through each channel of the board. However, it was not possible to obtain exactly 10V out of the board with the LED for each gain setting, and as the data was collected there was some saturation. Another thing to note; the 10 and 11 gain settings are less accurate because less data points were collected due to time constraints. However, I feel we can conclude that the board is behaving as we expect/designed it to.

Board Side B Average nVrms/SqrtHz from 1kHz to 2kHz

Gain	Electric Noise	Shot Noise	Total Noise	Long Cable Shot Noise	Expected Shot Noise (Approx)
00	63.23	121.56	137.15	107.51	80
10	64.15	182.13	193.03	152.29	142
11	68.85	180.77	240.85	298.38	253
01	80.00	427.67	435.44	443.61	449

Board Side A Average nVrms/SqrtHz from 1kHz to 2kHz

Gain	Electric Noise	Shot Noise	Total Noise	Long Cable Noise	Expected Shot Noise (Approx)
00	63.04	85.82	107.69	104.93	80
10	74.26	187.53	168.02	194.74	142
11	66.55	257.59	304.27	257.35	253
01	78.00	486.10	492.59	473.39	449