**Noise Study of TetrAMM**

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I studied the noise on the TetrAMM under various conditions, including:

1. Inputs disconnected
2. Inputs connected to 4 photodiodes in light-tight box
3. Inputs connected to 4 photodiodes exposed to outside sunlight
4. Inputs connected to 4 photodiodes exposed to interior LED lights

**Study 1: TetrAMM inputs disconnected.**

This screenshot shows the main quadEM screen.

A screenshot of a computer

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These are the important settings:

|  |  |
| --- | --- |
| Range | 120 nA |
| Values per reading | 100. This means the TetrAMM is averaging 100 readings internally and sending data to EPICS at 1 kHz. |
| Averaging time | 0.1 second. This means EPICS is averaging 100 readings |
| Fast averaging time | 0.01 second. This means the fast average is 10 readings. |
| Scale | 1e12. This means the units displayed are pA. |

Note that the average value for each change is about -1 pA, and the noise (sigma of 100 readings) is about 0.8 pA.

This screenshot shows the TimeSeries plugin. The time/point is 1 ms, and the averaging time is set to 0 so it averages 1 point (no averaging). It is in Circular Buffer mode, and there are 2048 time points.

A screenshot of a computer

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This is the time series plot for the first channel. Note that the amplitude range is about ±1 pA.

A screen shot of a computer

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This is the FFT of the time series of the first channel. There are small peaks at 60Hz and 180 Hz.

A screenshot of a computer

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**Study 2: TetrAMM inputs connected to photodiodes in a closed box**

The remaining measurements were done with the photodiode box shown in the photo below. Each photodiode is connected to one of the TetrAMM inputs.

A box with wires and wires

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In this test the cover was placed on the box and the box was placed in a dark bag, so very little light reached the photodiodes.

A screenshot of a computer

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The average current is about 30 pA, and sigma is 200-500 pA.

This is the time series plot for channel 1. It shows a mean value near zero, and noise of about ±1000 pA peak to peak.

A screen shot of a computer

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This is the FFT. Note that there are strong peaks at 60 Hz and the odd harmonics (180 Hz, 300 Hz, 420 Hz).

A screenshot of a computer screen

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This is the same setup, but the Range of the TetrAMM is changed from 120 nA to 120 µA. The scale is changed from 1e12 to 1e9, so the units are nA. The mean value is less than 1 nA, and sigma is also less than 1 nA.

A screenshot of a computer

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This is the time series of channel 1.

A screen shot of a computer

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This is the FFT. The same frequencies are present as with the previous test, but the amplitudes are much smaller.

A screenshot of a computer screen

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**Study 3: TetrAMM inputs connected to photodiodes exposed to outside sunlight**

In this test the cover was removed from the photodiode box and it was positioned so that most of the light came from a window, and only a small fraction was the interior room lights. The mean value is about 110 µA, and sigma is 19 nA. The signal/noise is thus about 5800:1.

A screenshot of a computer

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This is the time series. The total amplitude range is less than 0.5%, and it is dominated by slow changes in the light.

A screen shot of a graph

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This is the FFT. There are peaks are 220 and 440 Hz. These come from the interior LED lights. The amplitude is less than 10 units.

A screen shot of a computer

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**Study 3: TetrAMM inputs connected to photodiodes exposed to interior LED lights**

In this test the cover was removed from the photodiode box and it was positioned so that most of the light came from interior LED room lights, and only a small fraction from the window. The mean value is about 27 µA, and sigma is 150 nA. The signal/noise is thus about 180:1.

A screenshot of a computer

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This is the time series. The total amplitude range is about 1.9%, and is dominated by high-frequencies.

A screen shot of a computer

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This is the FFT. There are strong peaks at ~220 and ~440 Hz. These come from the interior LED lights. The amplitude is about 100 units.

A screen shot of a computer

AI-generated content may be incorrect.

**Conclusions:**

* The intrinsic noise of the TetrAMM (inputs disconnected) is less than 1 pA.
* When illuminated with a DC source (sunlight) the signal/noise is >5000.
* When illuminated with LED lights that have an A/C component at 220 and 440 Hz, that is what is observed, and there is very little 60 Hz or 180 Hz.