



# AC Power and Grounding Observations During the Nov'09 Electronics Run

DARK ENERGY  
SURVEY

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- An initial assessment of the AC power available and the grounding was done at the 1-meter Telescope building on Tuesday, 11-03-2009.
  - This presentation expands on the information and initial observations contained in Tom Diehl's presentation, docdb #3790-v3.
  - There exist three "sets" of AC power available at the Telescope area: building utility power located at outlets around the platform boarder, a UPS equipment strip mounted on the telescope metal (but isolated from the telescope metal) , and UPS powered outlets (orange) mounted around the platform boarder.
  - There is a bonding strap between the platform metal and the telescope support metal; visually verified and checked with an ohmmeter.



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- Initial assessment continued:
  - There is an instrument grounding block that is isolated from the telescope and platform metal and is connected solely to a long buried earth ground cable outside of the building. This is currently not used.





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- Initial assessment continued:
  - The safety ground conductors' resistance reading between the building power outlets and the UPS outlets measured at a very high resistance and was varying, indicating no metal-to-metal bond or wire connection between these two safety grounds. Thus, the building AC power and grounding is completely separate from the UPS system and should NEVER be used for reference grounding or for electronic equipment grounding and power.
  - The safety ground conductor's resistance reading between the UPS powered platform outlets and the UPS power strip on the telescope metal measured at 1.5 ohms; indicating a wire conductor connection, probably back at the UPS subpanel.



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- Initial assessment continued:
  - The safety ground conductor's resistance reading between the UPS powered equipment strip and the telescope's metal measured at 0.5 ohms indicating a very hard (metal-to-metal or short wire) bond even though the strip's metal body is not directly bonded to the telescope metal.

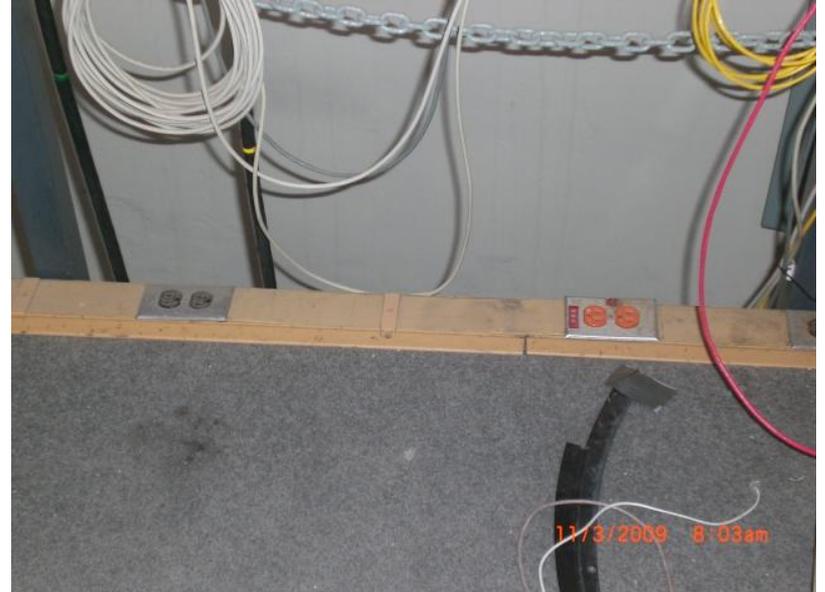




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- Initial assessment continued:
  - Using a line viewer for observing the UPS power, both on the telescope and the platform, indicated a very clean voltage waveform and no detectable power to neutral (DM) or neutral to GND (CM) noise (less than 200 mV). These readings were NOT affected by platform operation.
  - The line viewer indicated a distorted voltage waveform and DM and CM noise spikes on the building power, further verifying that this AC is NOT to be used for scope or instrument power.





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- Initial assessment conclusions:
  - The UPS power located on the telescope appeared to be OK. I did not observe any potential noise problems. This assessment was done during the morning hours.
  - The grounding of the telescope and the UPS power available, appeared to be adequate electrically (safety grounds). However, there were uncertainties about the quality of this ground for signal reference purposes and about what is actually connected to what.



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- After installation and initial power on:
  - The initial noise count (Thursday afternoon) was between 8 and 9.
  - Seemingly, everything worked well and the noise count stayed low.
  - During the first night's operation, the noise count abruptly changed and increased to around 25 counts. At times it got a lot higher.
  - On Friday morning, started the investigation.



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- Started the Investigation:
  - Friday morning, the noise count was low and again between 8 and 9. The platform was raised and everything was off.
  - Lowered the platform. The noise stayed low. Concluded that the platform's position did not directly affect the noise count.
  - Turned on the controllers and drivers for the tracking motors. Now, the noise jumped up to 20-30 counts. Viewed the AC power coming from the UPS power strip. The DM and CM noise was directly observed using the line viewer.
  - Repeated the process of tuning on and off the tracking motors/controllers. Each time, there was a direct correlation between the increase of noise counts, the noise viewed on the oscilloscope when the motors/controllers were turned on.



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Scope is looking at the common-mode (CM) noise seen by the line viewer (LV) with the tracker controllers/motors on.

Large spikes seen are between 15 and 20 volts peak.



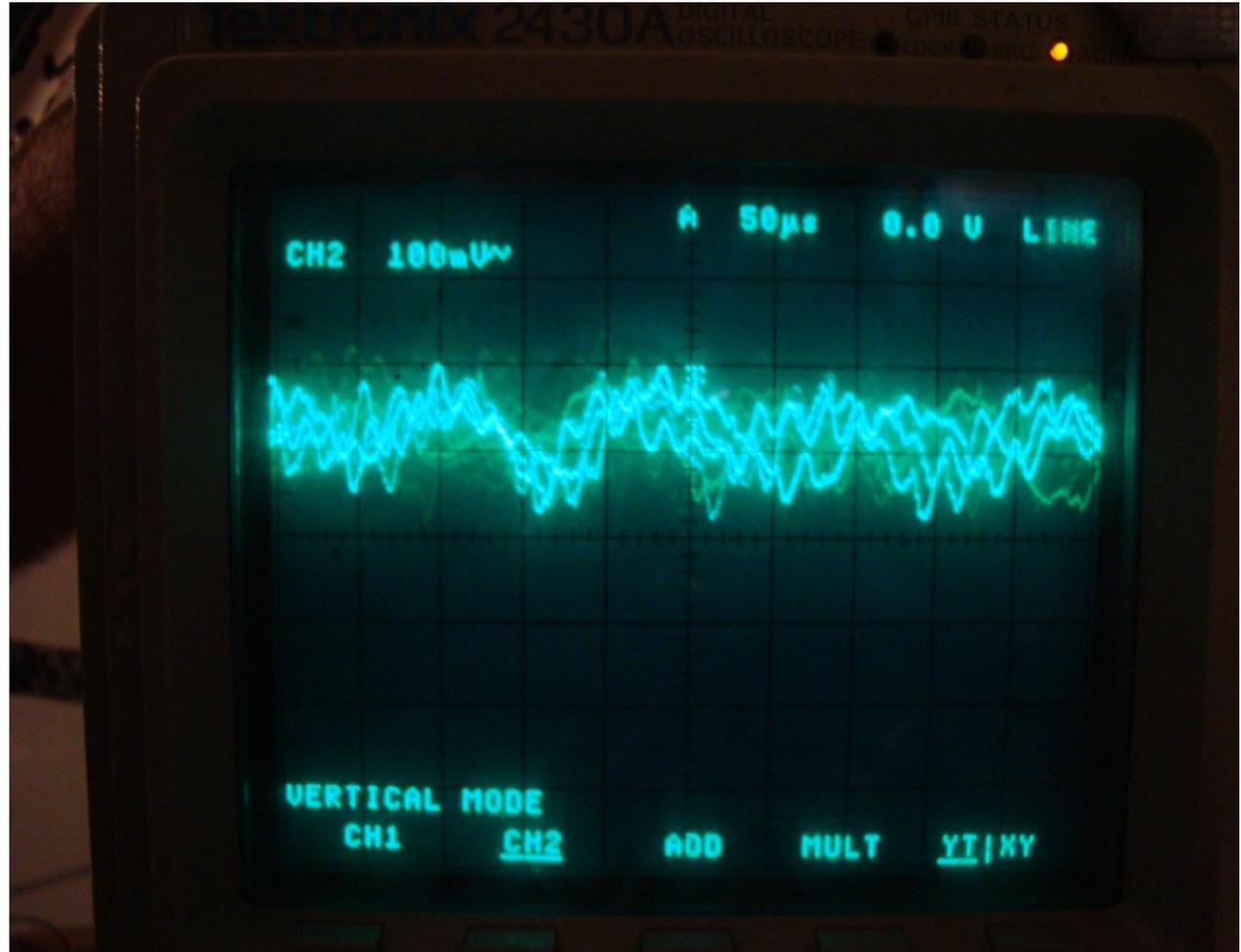


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Scope is looking at the differential-mode (DM) noise seen by the line viewer (LV) with the tracker controllers/motors on.

Large number of HF components but low level: less than 2 volts peak-to-peak.



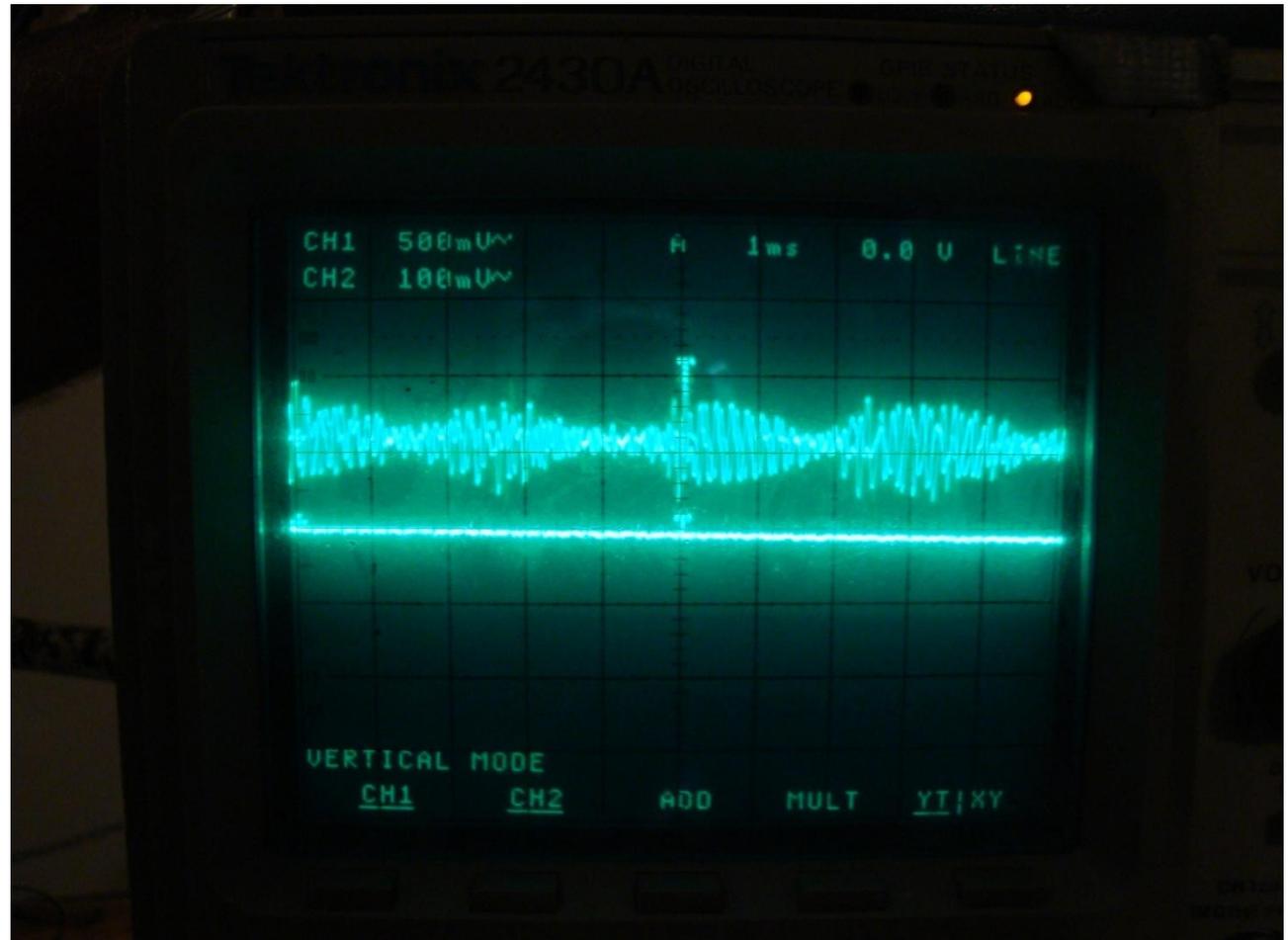


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Scope is looking at the CM and DM noise seen by the line viewer (LV) with the tracker controllers/motors off.

The CM noise waveform disappeared. The DM noise waveform did not change much.



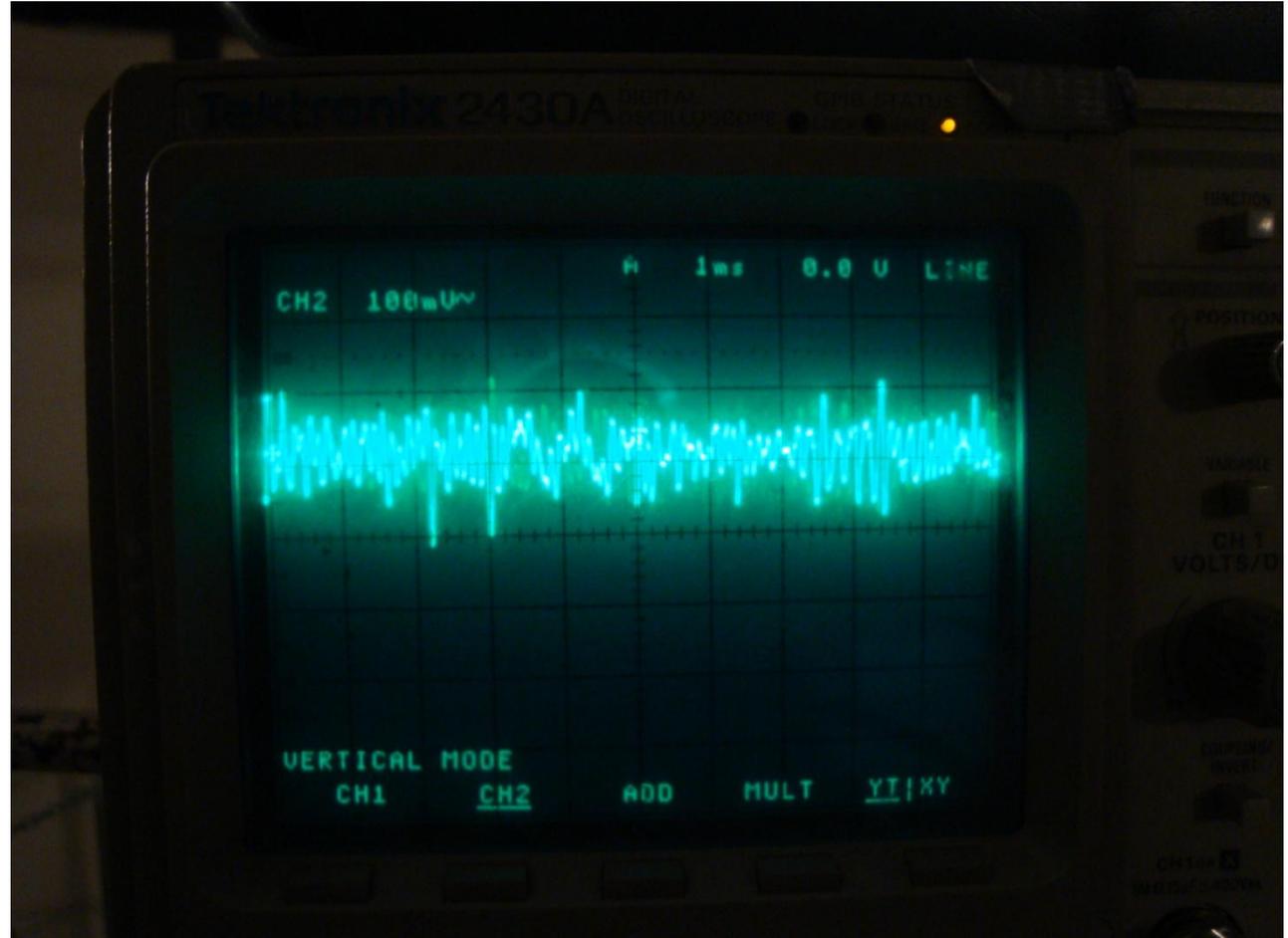


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Scope is looking at DM noise with the controllers/motors off.

The noise count increase to about 60. Then this waveform disappeared and went back to as before. It seems another source of line noise was observed.

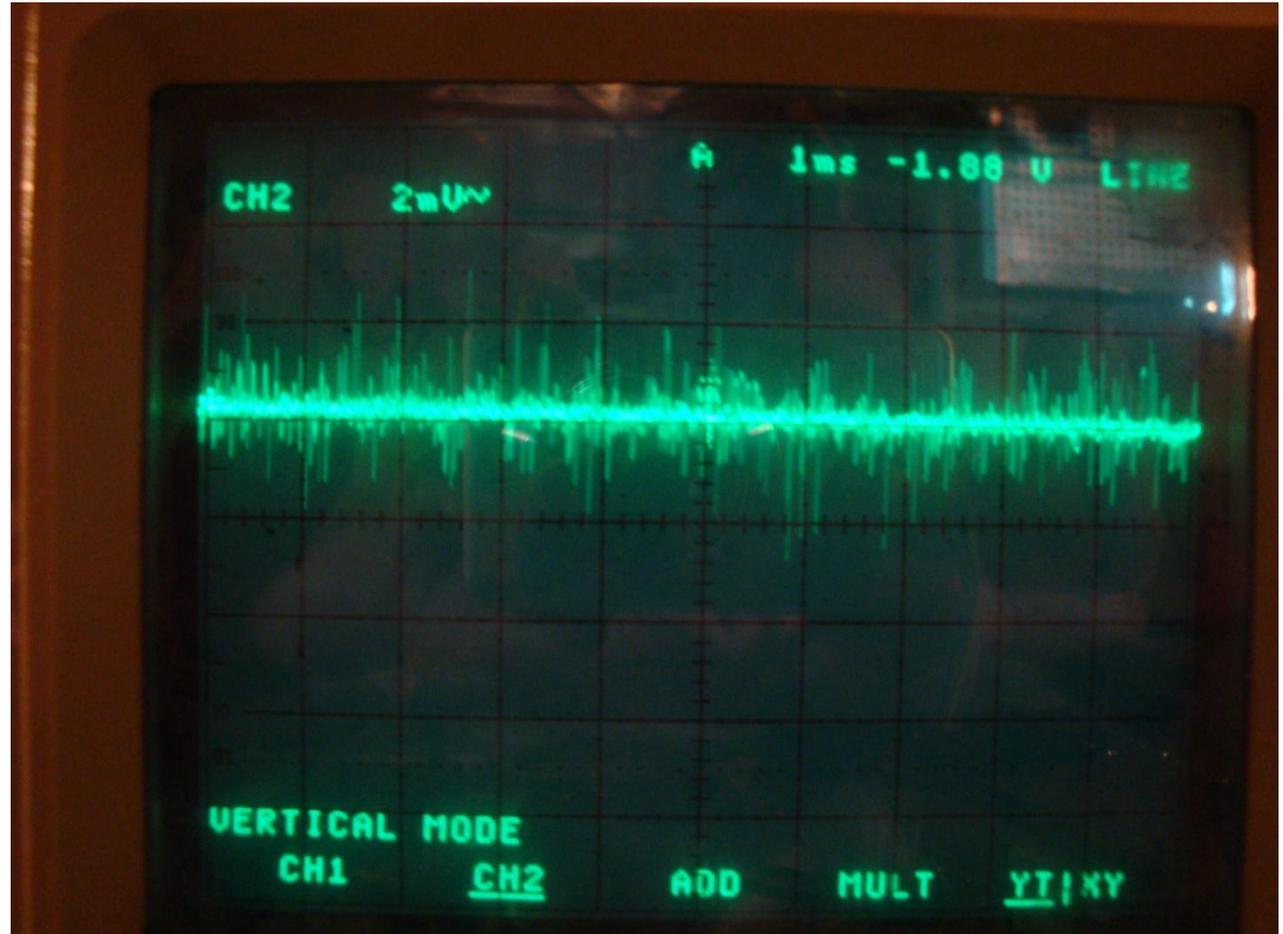




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With the tracker controllers/motors on, use a H-field probe and located this noise on the cable shield as it is terminated by the dewar's circular connectors. This noise almost exactly duplicates the pattern seen on the CM noise using the line viewer.





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- Attempted solutions:
  - Adding a ground strap from the crate to the telescope metal did not affect the noise seen with the viewer.
  - Cutting the safety ground wire to the crate and removing the ground strap greatly increased the noise count ( $>100$ ).
  - Used a portable UPS unit in series with the AC to the crate. With everything off (in the afternoon), the noise went down to 6-7.
  - Turned on the tracking controllers/motors, with the portable UPS installed and the noise count increased slightly to 9-12 counts. This was repeated to verify the portable UPS affect on the noise count.



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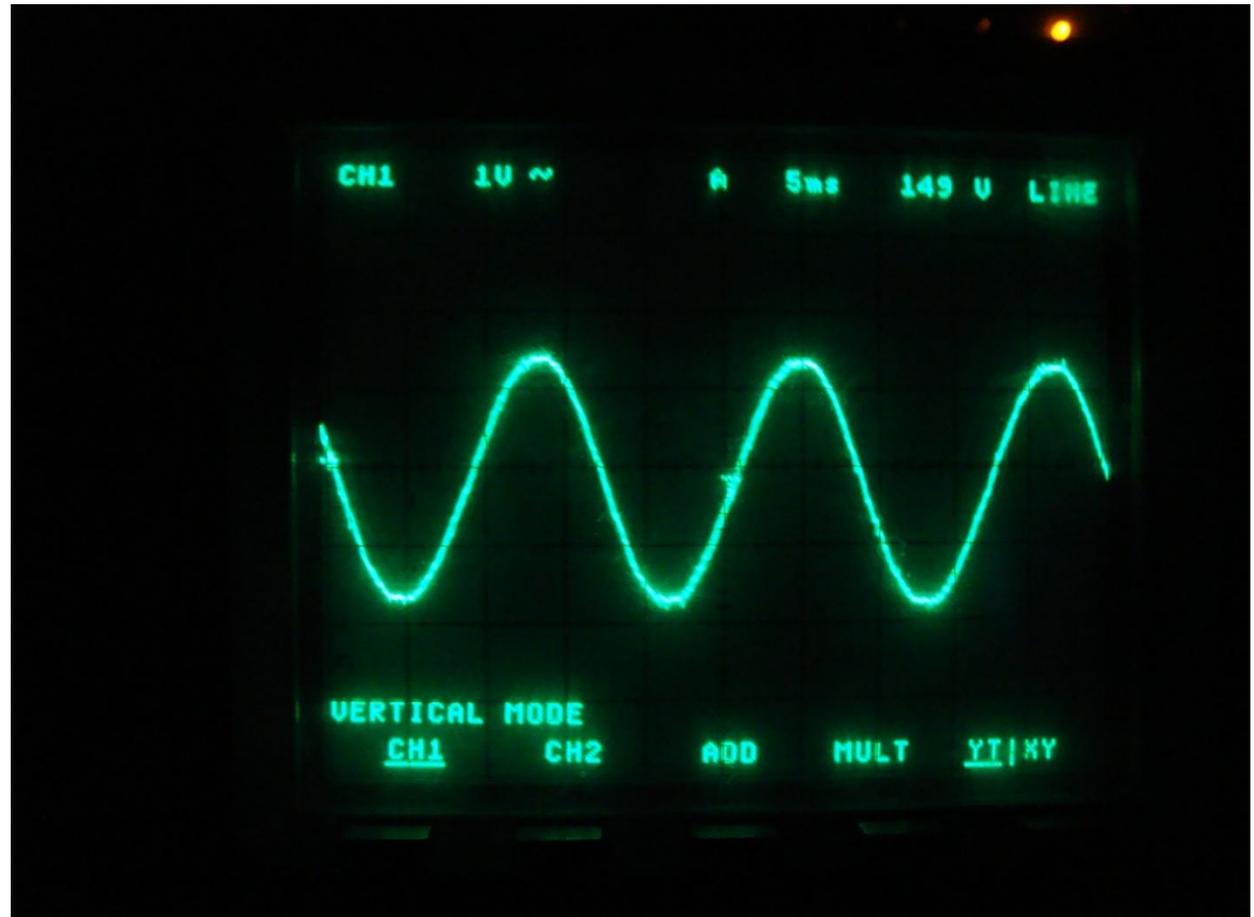
- Friday evening observations:
  - Installed a line filter for the crate's power cord. Removed portable UPS and turned controllers/motors off. Noise count was around 9-12. Turned motors on, noise count jumped to 26-46. This (the line filter) did not help much.
  - Re-installed the portable UPS and with the motors off, the noise was 7-7 counts. With them on, the noise counts was at 9-12. This seemed to be a temporary solution.
  - At 21:20, with the tracker controllers/motors on, noise still at 9-12.
  - Took out portable UPS, noise jumped to 28-48 counts (?).
  - Noise then jumped to  $>100$ , re-installed the portable UPS and noise still high at 50-30.
  - Examined the incoming UPS power on the power strip.



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Now, looking at the voltage sine-wave, small hash spikes can be seen at the peaks. These were not there before. Something new is now affecting the incoming AC power.

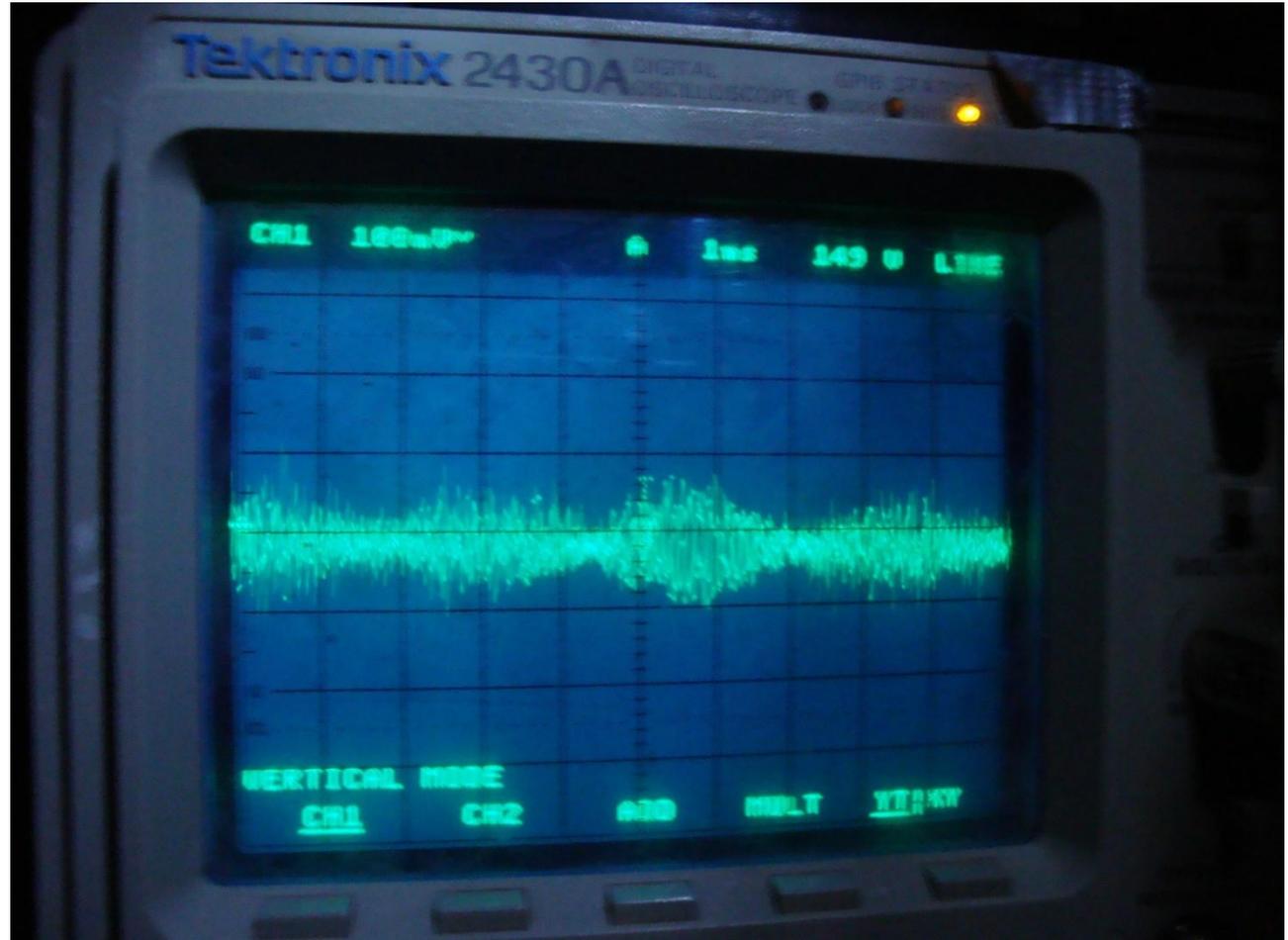




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The DM noise has not increased in amplitude ( $< 2$  volts p-p) but there appears to have been a significant increase in HF components.

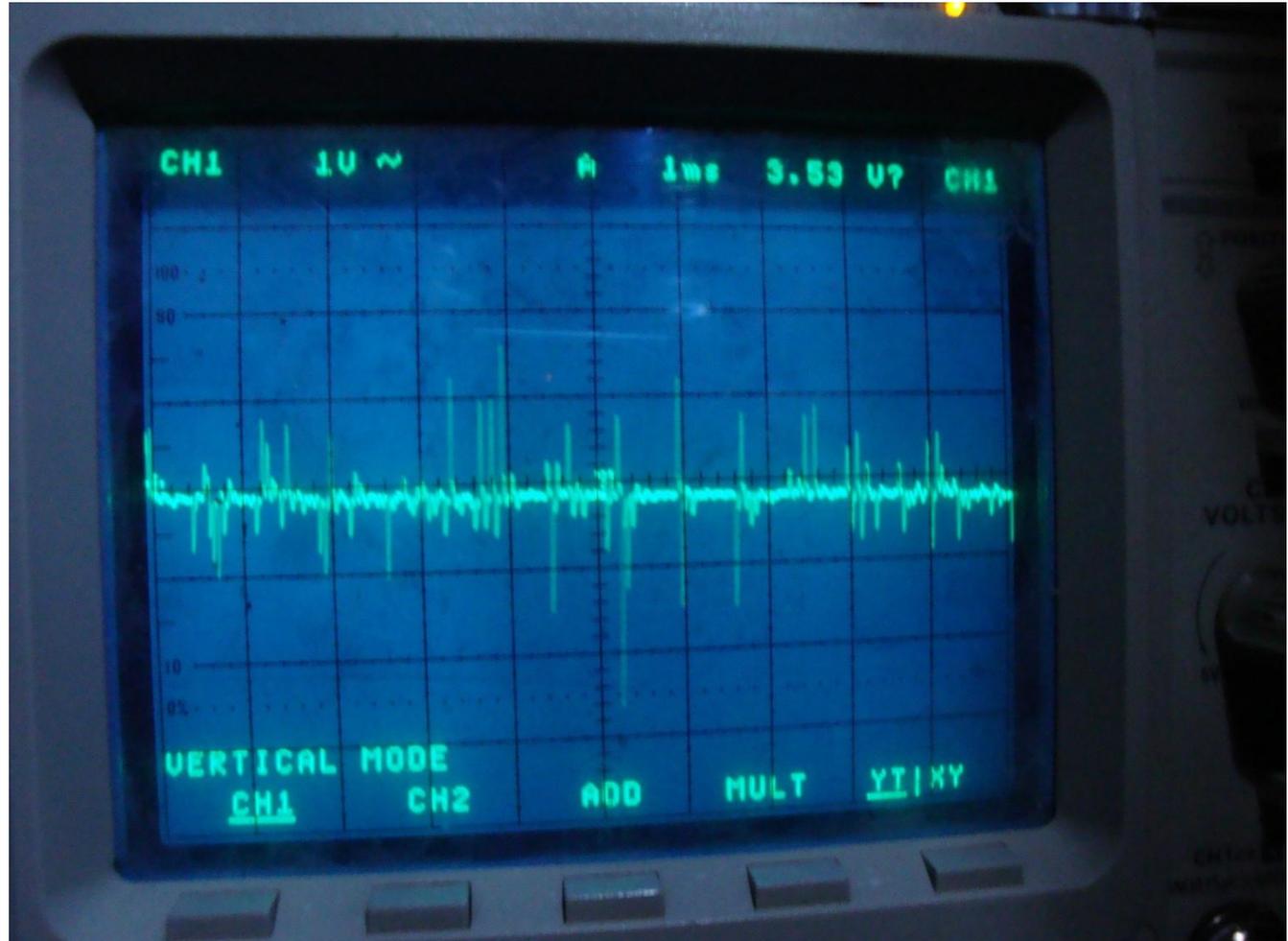




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Looking at the CM noise and triggering on the noise peaks, the amplitude of the spikes increased from 15-20 volts to now 25-30 volts.





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- Conclusions:
  - The small line filter did not help much. Even the portable UPS output filter was insufficient to filter out the CM noise seen.
  - The noise count is a direct result of conducted noise from the AC power input. The common mode noise can be seen on the cable shields and is most probably coupling into the signal path.
  - This noise on the UPS power clearly shows that as things get turned on in the 1-meter building and in other buildings as well, the line noise gets progressively worse and more unpredictable.
  - The means of filtering the AC power coming to the crate needs to be greatly enhanced, either by using a much better line filter at the crate, by using a line conditioner at the UPS panel and a dedicated branch circuit for the electronics, or by using both.