Laboratory Session Log

Date: 2026-02-17 **Time:** 3:00–6:00 PM **Notebook:** pp. 3–5 **Session:** #2

OBJECTIVES

Restore LLE to default state, display amplified Johnson noise on oscilloscope, verify data export workflow, initialize GitHub repository.

SETUP & CONDITIONS

Equipment same as Session #1 (see Log 1). No SR1 used this session.

Signal chain: $R_{\text{in}} = 100$ kΩ $\rightarrow$ Pre-amp $G_1 = 600$ $\rightarrow$ HP filter 0.1 kHz $\rightarrow$ LP filter 100 kHz $\rightarrow$ Main amp $G_2 = 300$ $\rightarrow$ Oscilloscope.

Scope settings: 2 V/div, 10 μs/div, trigger on positive-going zero crossings.

Room temp: Not recorded. Still need thermometer.

PROCEDURE

1. Opened LLE. Found missing internal connections. Wired to default state per lab manual schematic. Annotated photo in notebook p. 3 and below (Figure 1).
2. Powered on. Three green LEDs confirmed.
3. Set $R_{\text{in}} = 100$ kΩ, $R_f = 1$ kΩ (pre-amp gain 600). HLE filters: HP at 0.1 kHz, LP at 100 kHz, both AC coupled. Main amp: $\times 1 \times 10 \times 30 = 300$. Total gain: 180,000.
4. Connected HLE output to scope Ch1. Observed Johnson noise: random fluctuations within ± 5 V, consistent with expectations (Figure 2).
5. Switched to $R_{\text{in}} = 10$ kΩ: noise amplitude dropped $\sim 3\times$, consistent with $V_J \propto \sqrt{R}$.
6. Dummy CSV export via USB. Confirmed 4,000-point files, compatible with `calc_moments.py`.
7. Initialized GitHub repo: `https://github.com/ozzy-mandias/noise-statistics`. Directory structure, README, `.gitignore`, LICENSE done. Git tracking active.

RESULTS

No quantitative data. Qualitative:

- Johnson noise displayed at expected amplitude (± 5 V after $G = 180{,}000$).
- $\sqrt{R}$ dependence confirmed: $\sqrt{100\text{k}/10\text{k}} = \sqrt{10} \approx 3.16$, observed $\sim 3\times$ drop.
- Data pipeline verified: scope $\rightarrow$ USB $\rightarrow$ CSV $\rightarrow$ Python.

INTERPRETATION

Expected: $V_J(\text{rms}) = \sqrt{4k_B T R \Delta f} \approx 12.8\ \mu$V for 100 kΩ at $\sim$295 K, 100 kHz BW. After gain of 180,000 $\rightarrow$ $\sim$2.3 V rms, consistent with observed ± 5 V peaks (Gaussian: peak $\approx$ 2–3$\times$ rms). Cannot do meaningful moment analysis until amplifier noise baseline is measured and subtracted.

OPEN QUESTIONS

- ? Need thermometer. T enters Nyquist formula directly.
- ? How many traces per resistor value for reliable moments at 4,000 pts/trace?
- ? Amp noise must be remeasured whenever BW or gain changes (confirmed from manual).

NEXT SESSION

Goal: Amplifier noise baseline + begin systematic data collection.

- Get thermometer. Record T at session start.
- Amp noise: multiple traces at $R_{\text{in}} = 10\ \Omega$, same gain/BW as signal runs.
- Collect data across source resistors. Log R_{in}, G_1, G_2, f_1, f_2, T for each.

SCRATCH/NOTES

Analog squarer not needed. `calc_moments.py` computes all four moments digitally. Amp noise correction still applies: $\langle V_J^2 \rangle = \langle V_{\text{total}}^2 \rangle - \langle V_N^2 \rangle$.

LLE wiring photo: notebook p. 3. Keep for reference if reconfiguration needed later.

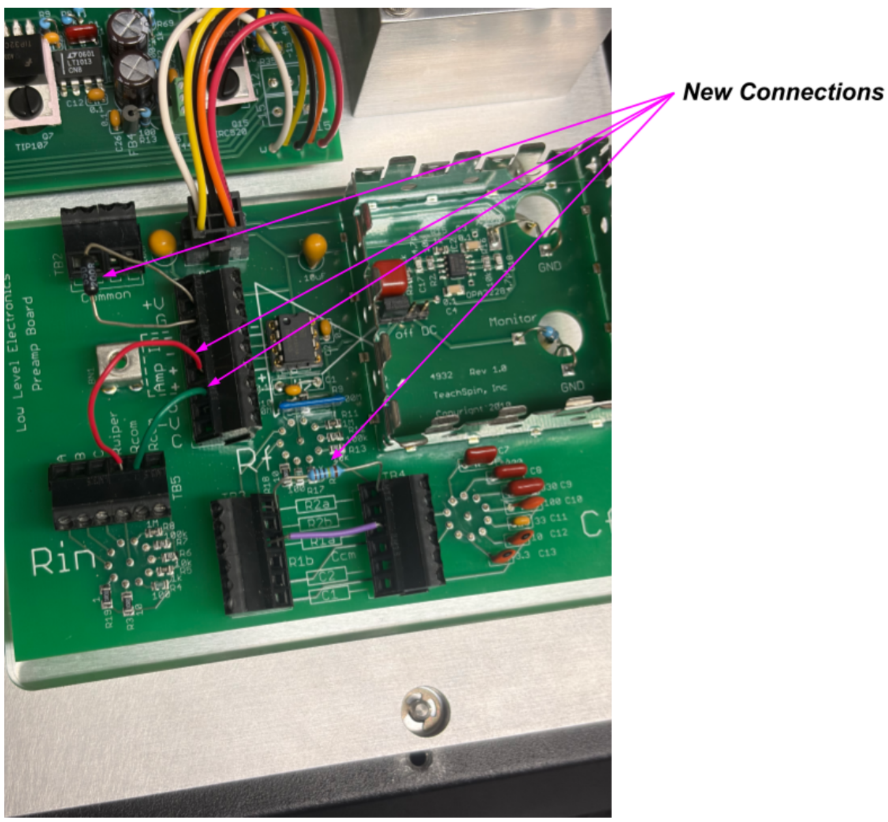

Figure 1: LLE pre-amplifier board after restoring default connections. New connections annotated in pink.

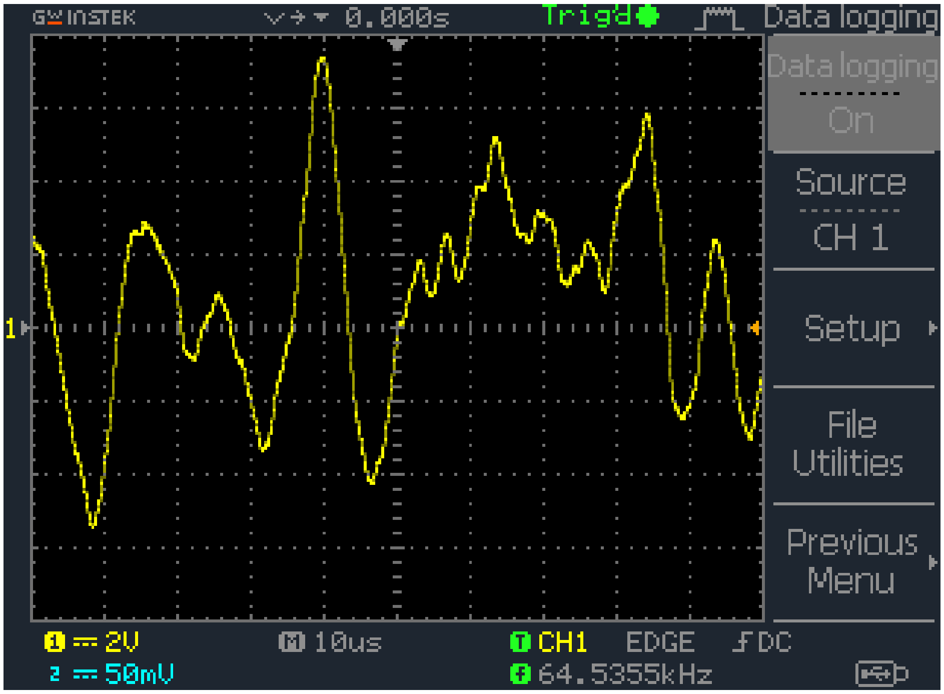

Figure 2: Amplified Johnson noise from $R_{\text{in}} = 100\ \text{k}\Omega$. Pre-amp gain 600, bandwidth 0.1–100 kHz, main-amp gain 300. Scope: 2 V/div vertical, 10 μs/div horizontal, triggering on positive-going zero crossings.

ADVISOR FEEDBACK

[Space for comments if reviewing.]