Lab Guide

This guide applies to all three labs. Labs 1 and 2 are **formative**: they prepare you, and the measurements you make in them, for the final **summative** Signals Lab, which is assessed by a lab report.

L0.1 General instructions

Bring a notebook to every lab and keep careful, organized records of all measured quantities, settings and error estimates. No measurement is meaningful without an estimate of its error! Keep detailed notes of any computed quantities and of the qualitative observations you make during the experiment: they may be important during your analysis.

Each lab handout contains grey **data-entry boxes**. Fill them in on the printed handout (*Download lab PDF* on the website) as you go.

L0.2 Error propagation

When you calculate with measured quantities that have uncertainties (errors), you need to propagate these errors through the calculation. Suppose two random variables A and B have standard deviations (errors) σ_A and σ_B. The error in a function of these variables is then calculated as follows.

Addition and subtraction

If $C = A \pm B$, the error in C is

$$\sigma_C = \sqrt{\sigma_A^2 + \sigma_B^2} \tag{L0.1}$$

This formula applies to both addition and subtraction: errors *always add in quadrature*, even for subtraction.

Multiplication and division

If $C = A \times B$ or $C = A/B$, the *relative* error in C is

$$\frac{\sigma_C}{C} = \sqrt{\left(\frac{\sigma_A}{A}\right)^2 + \left(\frac{\sigma_B}{B}\right)^2} \tag{L0.2}$$

To find the absolute error σ_C, multiply both sides by C:

$$\sigma_C = |C|\sqrt{\left(\frac{\sigma_A}{A}\right)^2 + \left(\frac{\sigma_B}{B}\right)^2}.$$

Example

Suppose we measure $R_R = (100.5 \pm 0.5)\,\Omega$ and $R_L = (12.3 \pm 0.3)\,\Omega$, and we want the total resistance $R = R_R + R_L + R_{\text{int}}$, where $R_{\text{int}} = (600 \pm 50)\,\Omega$. Using the addition rule (L0.1),

$$\begin{aligned} R &= 100.5 + 12.3 + 600 = 712.8\,\Omega, \\ \sigma_R &= \sqrt{0.5^2 + 0.3^2 + 50^2} = \sqrt{0.25 + 0.09 + 2500} \approx 50.0\,\Omega. \end{aligned}$$

Therefore $R = (712.8 \pm 50.0)\,\Omega \approx (710 \pm 50)\,\Omega$ (rounded appropriately).