

Lab 1 Report

R-1 Soldered Connector Joints

The soldered connector joints were created using standard soldering techniques, ensuring secure electrical connections and mechanical stability:

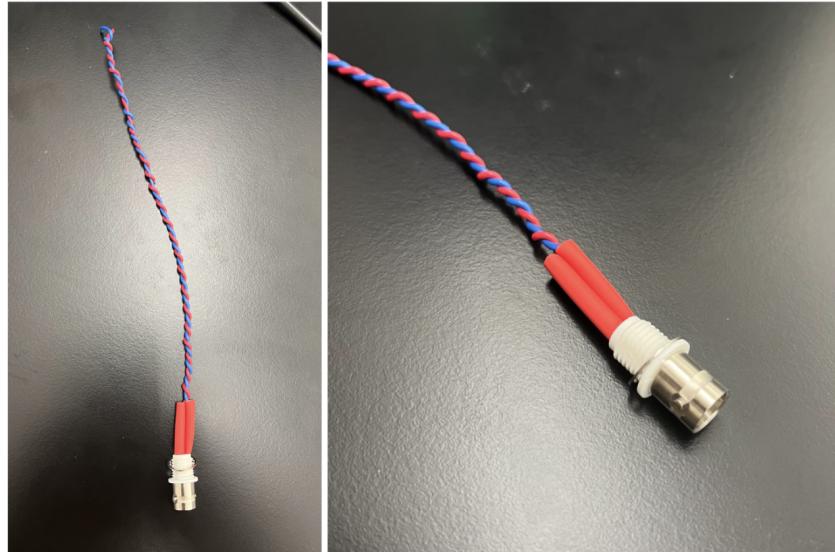


Figure 1: Soldered connector joints.

R-2 Oscilloscope and Multimeter Voltage Comparison

The oscilloscope wavegen settings and the corresponding multimeter RMS voltage measurements were recorded. The following table summarizes the results:

Oscilloscope Settings	Multimeter Reading (VAC)
Frequency: 1.642 kHz, Amplitude: 1.00 V (2.00 Vpp)	0.9977 VAC

Table 1: Comparison of oscilloscope and multimeter voltage readings.

The results show good agreement between the oscilloscope and multimeter measurements, within their specified accuracies. Specifically, the Keysight 34461A multimeter specifies an uncertainty of $(0.07\% \text{ of reading}) + (0.03\% \text{ of range})$ for AC voltage measurements in the frequency range of 10 Hz to 20 kHz. These specifications align with the observed measurements.

R-3 Multimeter Frequency Response

The frequency response of the multimeter was recorded by measuring AC voltage readings against log frequency. The results are consistent with the multimeter's technical specifications, as the voltage drops significantly beyond 300 kHz, which matches the bandwidth limitation specified for the True RMS AC voltage measurement mode.

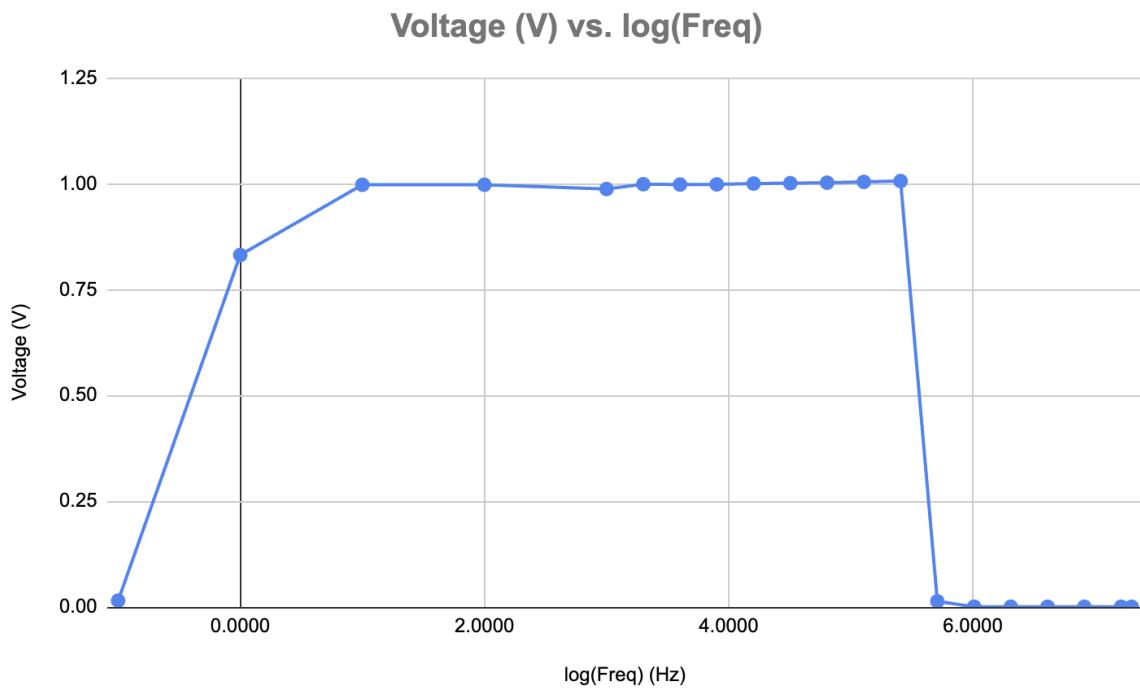


Figure 2: Frequency response of the multimeter.

Frequency (Hz)	Voltage (V)	Uncertainty (\pm V)	log(Freq) (Hz)
0.1	0.015	0.0000	-1.0000
1	0.832	0.0000	0.0000
10	0.998	0.0030	1.0000
100	0.998	0.0030	2.0000
1000	0.988	0.0030	3.0000
2000	0.9994	0.0030	3.3010
4000	0.9986	0.0030	3.6021
8000	0.9989	0.0030	3.9031
16000	1.0009	0.0030	4.2041
32000	1.0017	0.0063	4.5051
64000	1.0029	0.0138	4.8062
128000	1.0048	0.0902	5.1072
256000	1.0068	0.0903	5.4082
512000	0.0134	0.0000	5.7093
1024000	0.0005	0.0000	6.0103
2048000	0.0006	0.0000	6.3113
4096000	0.0006	0.0000	6.6124
8192000	0.0006	0.0000	6.9134
16384000	0.0006	0.0000	7.2144
20000000	0.0005	0.0000	7.3010

Table 2: Frequency response data with updated uncertainties.

Sample Calculations for Uncertainty

The uncertainty values were calculated based on the device specifications from the multimeter's user manual. Below is an example calculation for a frequency of 10 Hz:

- According to the manual, for frequencies between 10 Hz and 20 kHz, the uncertainty is specified as:

$$\text{Uncertainty} = (0.07\% \text{ of reading}) + (0.02\% \text{ of range}) \quad (1)$$

- Measured voltage: 0.998 V
- Range: 10 V
- Calculation:

$$\text{Uncertainty from reading} = 0.07\% \times 0.998 = 0.0007 \text{ V},$$

$$\text{Uncertainty from range} = 0.02\% \times 10 = 0.002 \text{ V},$$

$$\text{Total Uncertainty} = 0.0007 + 0.002 = 0.0027 \text{ V}.$$

- Final uncertainty (to 1 s.f.): $\pm 0.003 \text{ V}$.

This calculation methodology was applied to all measured frequencies and their respective readings.

R-4 Breadboard Connections

The pattern of breadboard connections is demonstrated below. The breadboard consists of:

- Power buses:** The vertically connected sections used to distribute power, as depicted by the vertical yellow lines in Figure 3.
- Terminal strips:** The horizontally connected sections, each in groups of 5, as depicted by the horizontal yellow lines in Figure 3.

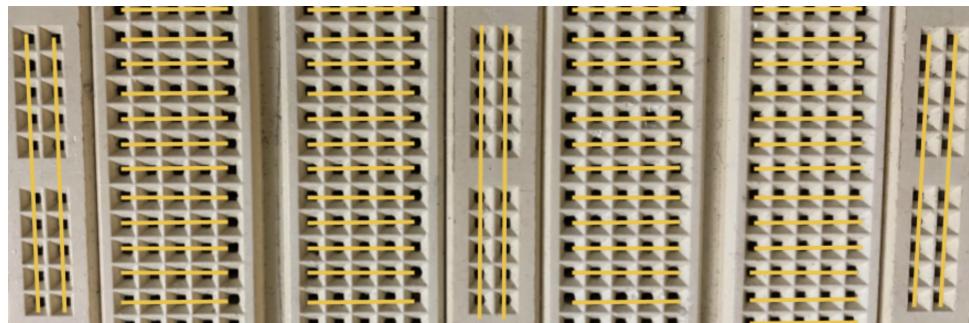


Figure 3: Annotated breadboard connections.

R-5 LED Voltage Thresholds

The minimum peak voltage required to make the LEDs glow visibly was measured as follows. The uncertainties were estimated to be around $\pm 0.1\text{V}$ based on the visible fluctuations in the multimeter readings during the measurements.

LED Color	Condition	Voltage (V)
Blue	Proper brightness	2.585 ± 0.1
Blue	Dim light	2.414 ± 0.1
Red	Proper brightness	2.147 ± 0.1
Red	Dim light	1.703 ± 0.1

Table 3: Measured LED voltage thresholds.

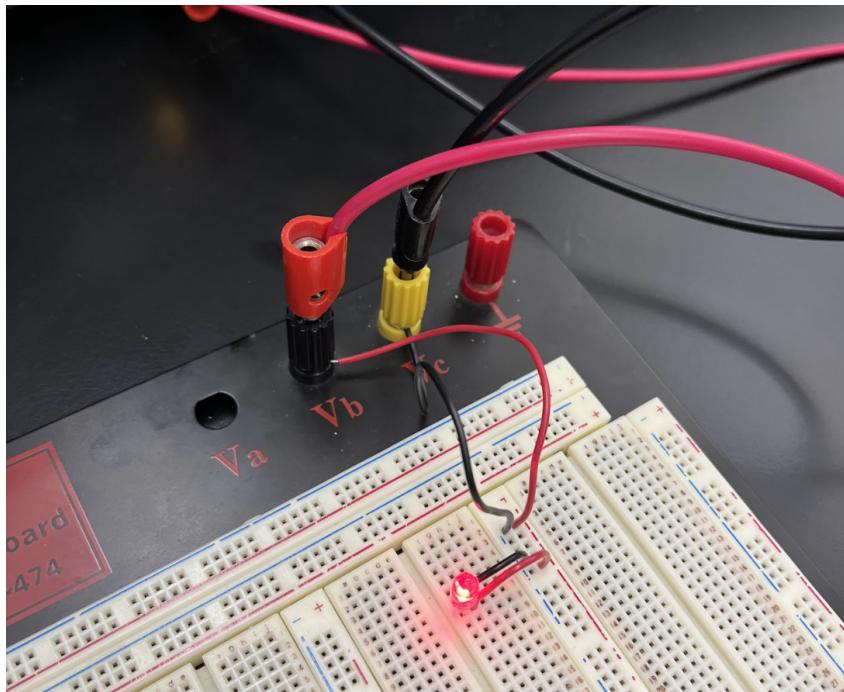


Figure 4: R5 Circuit with Red LED

R-6 LED Circuit Video

A short video demonstrating the circuit with LEDs flashing has been submitted via Quercus. The circuit was driven using a square waveform with a frequency of 2 Hz, an amplitude of 10.0 Vpp, an offset of 0.0 V, and a 2.2 k Ω resistor.