Arthur Chen & Nicholas Magee

Lab 1: Introduction to Electrical Measurements

ECEN 214-519 Jan 31st
Due Feb 7th
TA: Nathan Taylor

1. Introduction

In this lab, the idea of a Portable Measurement Device is introduced, along with some of its uses. More specifically, measuring voltages, along with supplying DC current in task 1 and AC current in task 2. A combination of these methods will be used in task 3 to verify the resistance of a 10kΩ resistor.

2. Experimental Procedure

The procedure for task 1 is as follows:

Take a single 1.5V battery and connect it to the breadboard. After installing the waveform program on the laptop, connect the laptop, discovery 2, breadboard, and the battery. The battery is assumed to be 1.5 V, but could reasonably be not exactly that figure. Make sure the polarities are connected accordingly. Then use voltmeter in waveform to measure the voltage and record it. Then use both channels to measure again and note the difference (recorded in task 1 section of data and calculations.).

Task 2:

Use the waveform generator to set up a 3000Hz sinusoidal wave with 1V amplitude, or a 2V peak-to-peak voltage. Measure the AC voltage with the PMD. Double the amplitude and measure again. Change waveform to square wave, measure and take note.

Task 3:

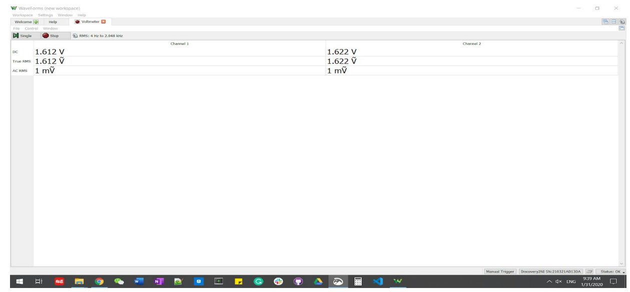
Use waveform generator to produce a DC voltage, and set offset to 1 V. After applying 10 kΩ resistor on the breadboard, connect a resistor of unknown value. Calculate the resistance of an unknown resistor using a standard voltage divider equation. Then, verify the resistance by looking at the striped on the unknown resistor.

3. Data and Calculations

Task 1:

Channel 1	Channel 2
1.612 V	1.622 V

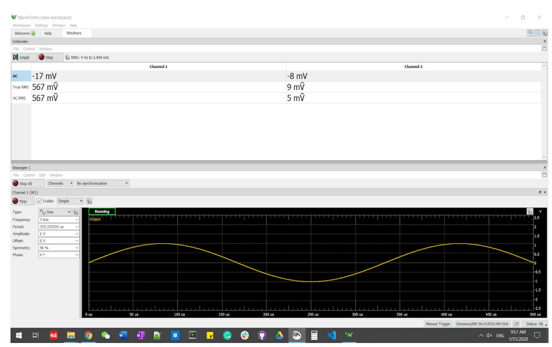
The DC voltage of the battery was measured to be 1.612 V on channel 1, and 1.622 V using channel 2. $\frac{(1.612 + 1.622)}{2} = 1.617$ V is the average of the two measurements. $\frac{(|(1.617 - 1.612)| + |(1.617 - 1.622)|)}{2} = 0.005$ V is the calculated standard deviation. So, the average voltage of the channels along with the expected deviation is: $1.617\ V \pm 5\ mV$. Errors are impossible to avoid in all experiments. This deviation could be due to the internal resistance of the wires differing, or a systematic error in the PMD. The more measurements taken, the more precise the answer will be.



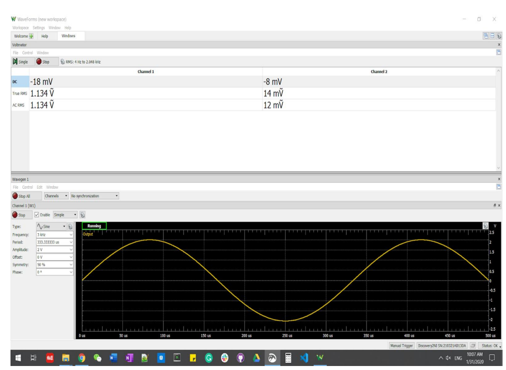
picture 1: measurement of 1.5V battery with two channels. (larger version on final page)

Task 2

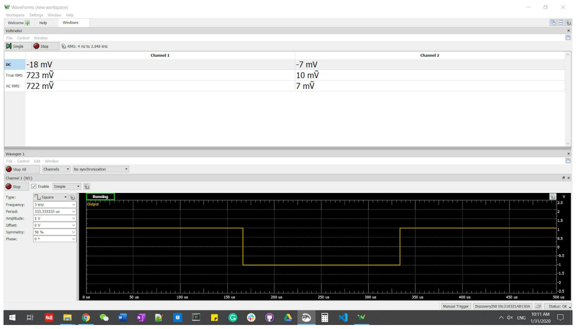
peak to peak value	2V	4V	2V(square waveform)
voltage measurem ent	567mV	1.134mV	722mV



picture 2: 2V peak to peak value



picture 3: 4V peak to peak value



picture 4: square waveform

The reason the 2V peak to peak voltage is read as much lower than 2V is because peak-to-peak voltage describes the distance between peaks of a sine oscillation. On the waveform, it is correct that the wave has a difference of 2V between the peaks. The voltmeter measures voltage of an AC current by summing the square of multiple voltages at multiple times, then dividing by the number of samples and taking the square root. This is because the average of an AC current does not give a good idea of the DC current result because heat given off by voltage is proportional to the square of the voltage. This is referred to as root-mean-square values, and the formula for an RMS value at time t is

$$v_{rms} = \sqrt{\frac{1}{T_0}\int_0^{T_0} v^2(t)dt}$$

The square oscillation RMS value is larger than the sine wave because of the RMS method just discussed. While the average for both oscillation voltages is 0, when taking the sum of the squares of the square voltages, since the square waves remain at the peaks, the sum is larger, this the square root of the sum is larger. The average of the squares of the sine voltages is much smaller, making the square root smaller.

Task 3

picture 5 missing: measurement of DC with unknown resistor. The voltmeter read exactly 0.9 V. Forgot to take this screenshot.

Using the standard voltage divider equation $V_2 = \frac{V_1 R_2}{R_1 + R_2}$, substituting the known values $V_1 = 1V$, $R_1 = 1k\Omega$ and the measured value of $V_2 = 0.9V$, we can solve for R_2 as follows:

$$0.9 = \frac{R_2}{1000 + R_2} \rightarrow 900 = 0.1R_2 \rightarrow R_2 = 9000\Omega$$

After looking at the stripes, the unknown resistor was found to have a labelled value of $1k\Omega$. This is a 100 Ω difference. From the prelab, it states the tolerance of a $1k\Omega$ resistor is $\pm 5\%$. Assuming this is the possible error of R_1, and using the deviation found in the channels from task 1 of 0.005 V, we can derive the possible propogated error in R_2. In addition, absolute error is added, while in multiplication, percent error is added. Rearranging the voltage divider equation,

$$R_2 = \frac{V_2 R_1}{V_1 - V_2}$$

then solving while carrying the errors appropriately,

$$R_2 = \frac{(0.9V \pm 5\,mV \text{ or } 0.6\%)(1k\Omega \pm 5\%)}{1V - 0.9V \pm 5mV},$$

$$R_2 = \frac{900 \pm 5.6\%}{0.1 \pm 5\,mV \text{ or } 5\%},$$

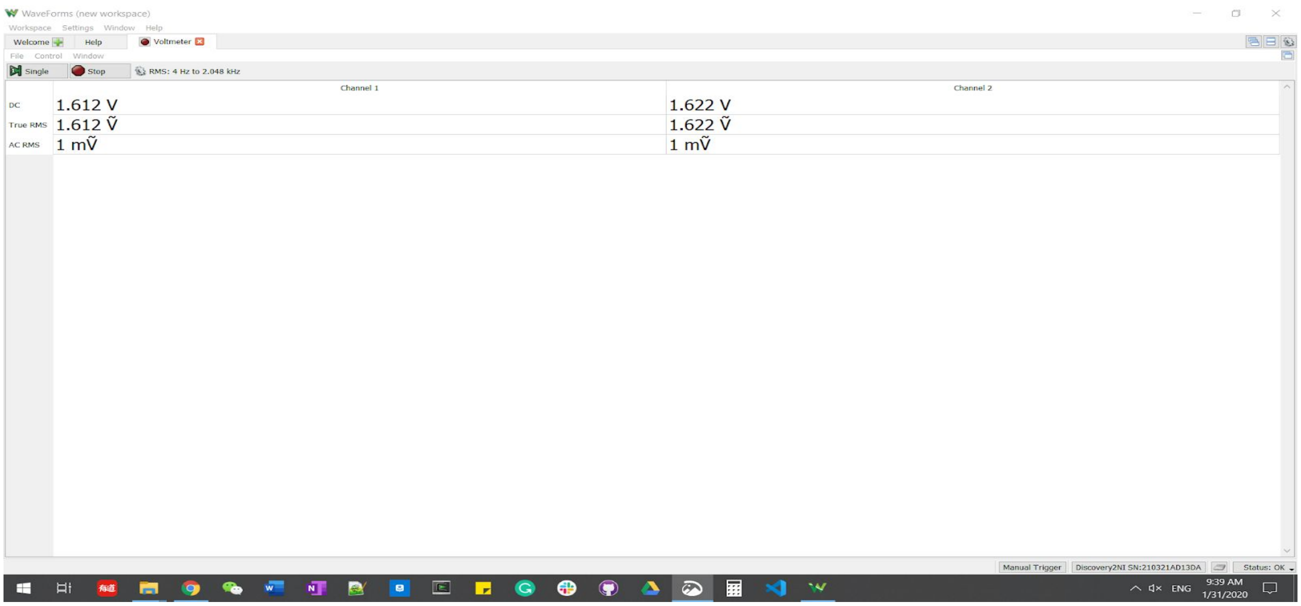
$$R_2 = 9000\,\Omega \pm 10.6\% \text{ or } R_2 = 9\,k\Omega \pm 954\,\Omega$$

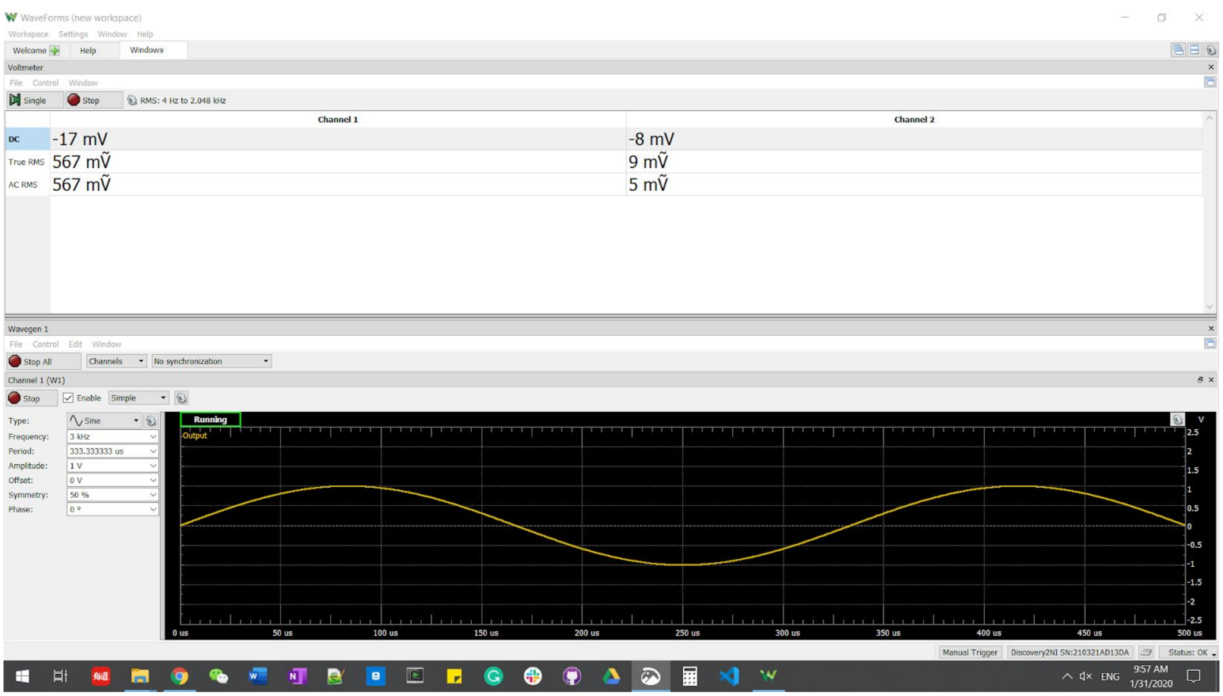
The error of the produced 1-V source was never calculated or given, so it is assumed to be $\pm 0\,mV$. From the combined propagation of errors, R_2 could have a maximum value of 9954 Ω and a minimum value of 8046 Ω. This is due to the combination of all the errors we previously calculated.

4. Conclusion

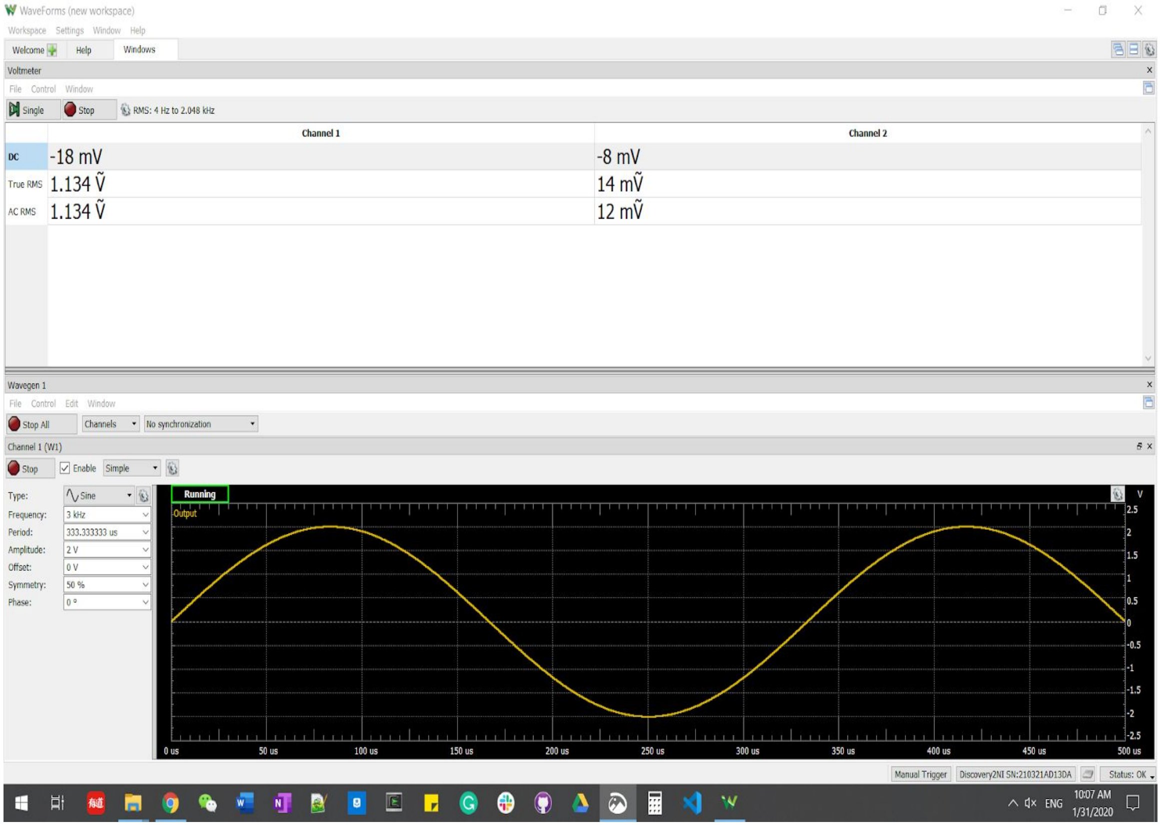
When attempting to measure voltage, resistance, or current of a circuit it is important to be wary and knowledgeable of the possible errors that can occur when measuring. In this lab, wire resistance affected voltage measurements, the Analog Discovery 2 differed in channel measurements, and resistor values always vary. All these errors propagated into a 10.% error propogation in the final result.

Larger Pictures

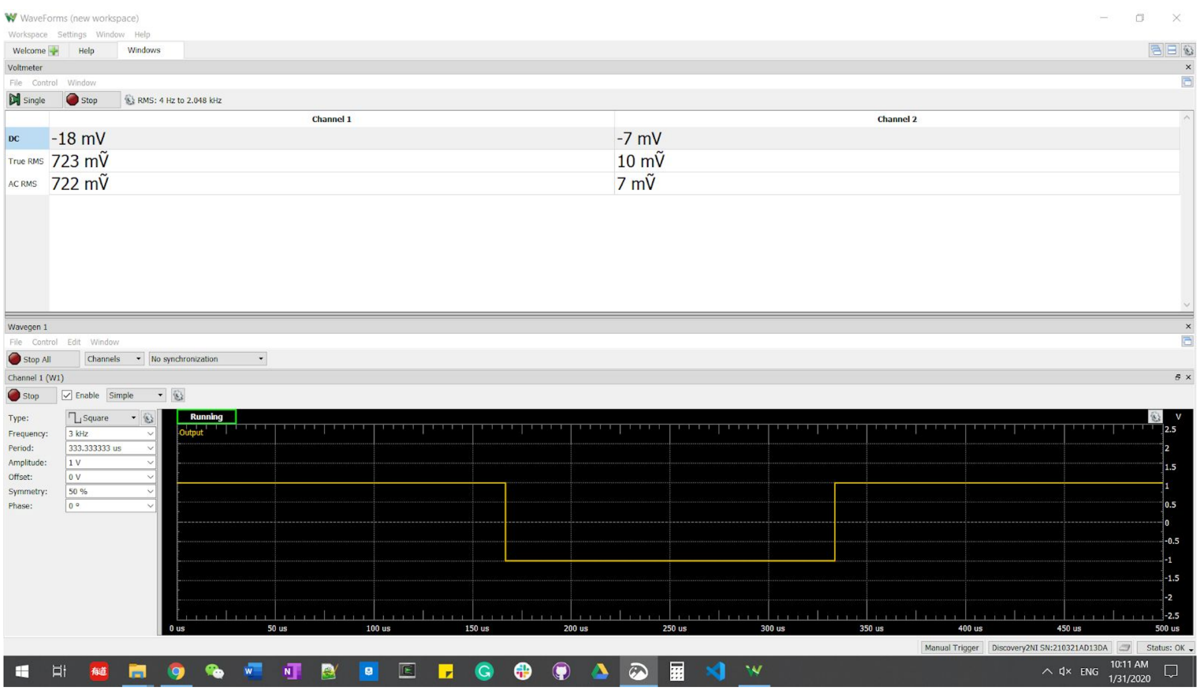
1. 

2. 

3.


WaveForms (new workspace)
Voltmeter
RMS: 4 Hz to 2.048 kHz
Channel 1
Channel 2
DC -18 mV -8 mV
True RMS 1.134 V 14 mV
AC RMS 1.134 V 12 mV
Wavegen 1
Channel 1 (W1)
Type: Sine
Frequency: 3 kHz
Period: 333.333333 us
Amplitude: 2 V
Offset: 0 V
Symmetry: 50 %
Phase: 0 °
Running
Output
1/31/2020

4.


WaveForms (new workspace)
Voltmeter
RMS: 4 Hz to 2.048 kHz
Channel 1
Channel 2
DC -18 mV -7 mV
True RMS 723 mV 10 mV
AC RMS 722 mV 7 mV
Wavegen 1
Channel 1 (W1)
Type: Square
Frequency: 3 kHz
Period: 333.333333 us
Amplitude: 1 V
Offset: 0 V
Symmetry: 50 %
Phase: 0 °
Running
Output
1/31/2020

Prelab with signature (me and Arthur both submitted because we were not sure if the signed pre lab was needed)

ECEN 214 Lab 1

Magee

Task 1

DC voltage - 1.608 V channel 1

1.621 V channel 2

Task 2

AC → 0.567 V

When pp is 4V: AC = 1.134 V

Square: 0.722 V

Task 3

V1: 1V

R1: 1kΩ

V2: 0.9V

R2: 10kΩ

Calculated: 9kΩ

$$V_2 = \frac{V_1 R_2}{R_1 + R_2}$$

$$0.9 = \frac{R_2}{1000 + R_2}$$

$$900 + 0.9R_2 = R_2$$

$$900 = 0.1R_2$$

1/31