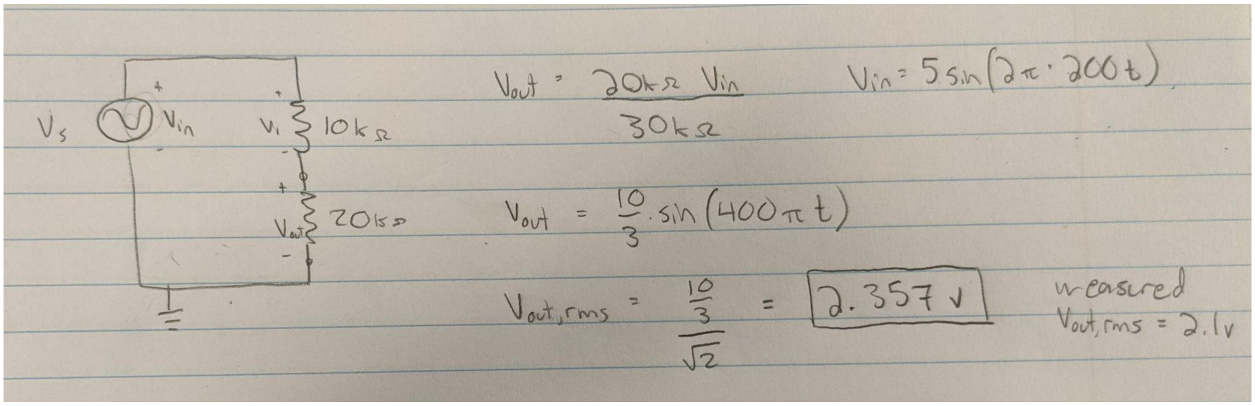
Julia Frothingham

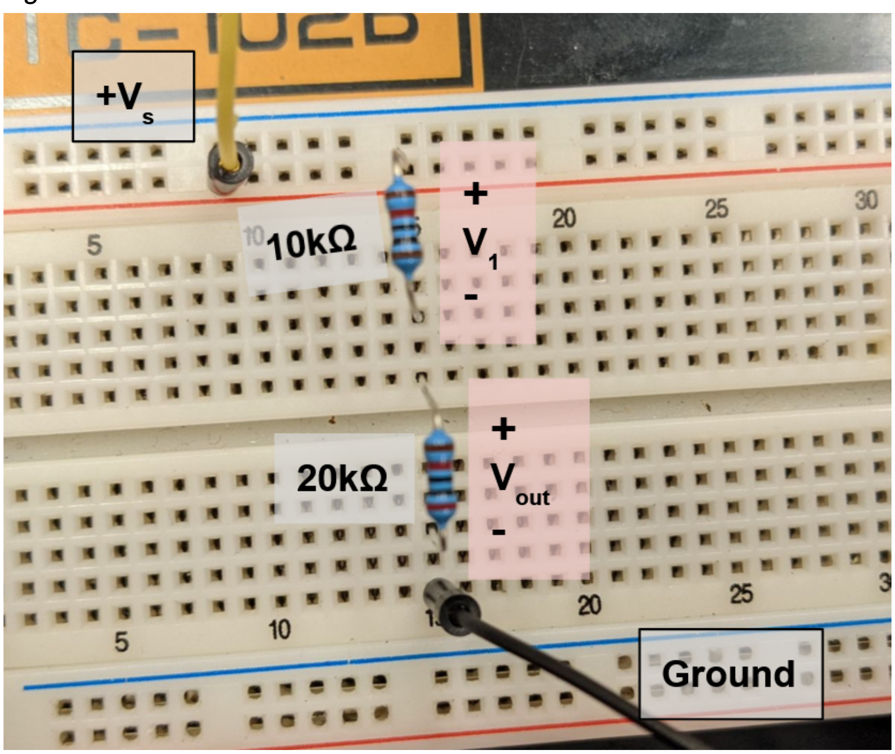
Lab 5 - Intro to AC circuits - Scopy's signal generator

Figure 1. Circuit diagram and calculation of $V_{out,rms}$



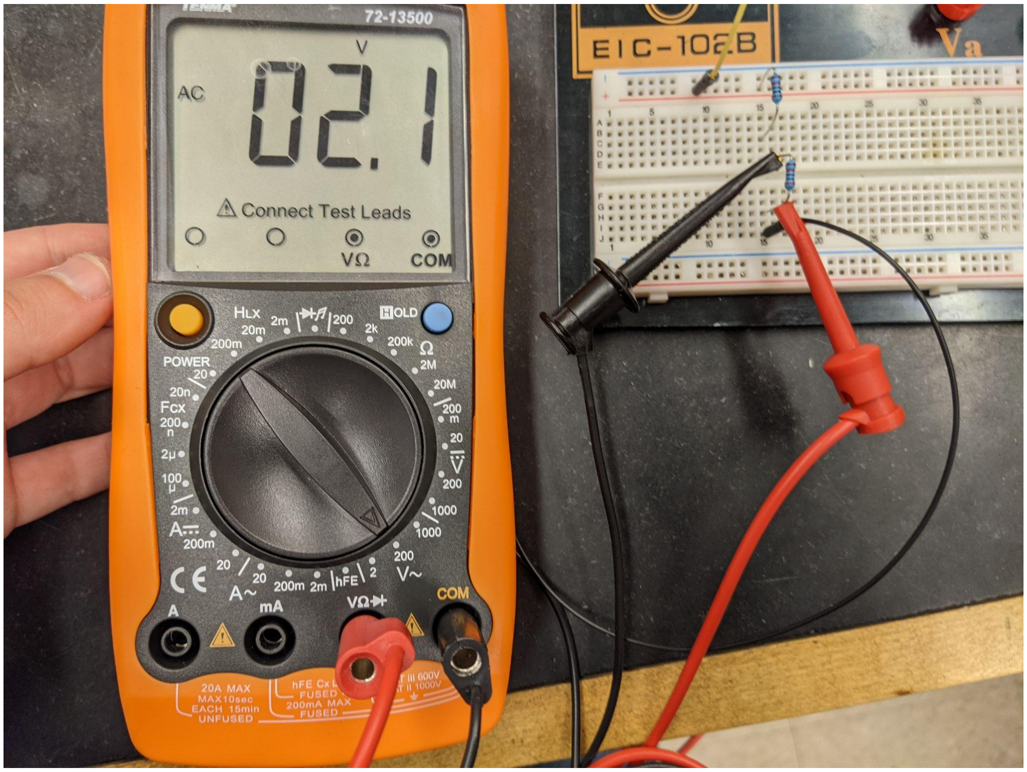
The circuit was built using Scopy's signal generator functions and the ADALM2000 as a voltage source to supply an AC signal with peak amplitude of 5V and frequency of 200Hz.

Figure 2. Built circuit.



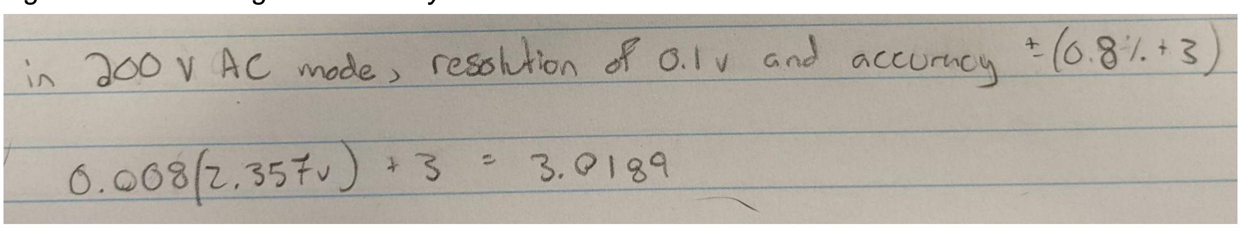
The voltage V_{out} was measured by connecting a DMM in parallel with the 20kΩ resistor. The DMM can only measure the RMS voltage for AC voltages, so it was actually measuring $V_{out,rms}$.

Figure 3. Measuring $V_{out,rms}$ with the DMM.



The calculated $V_{out,rms}$ value was 2.357 volts. The measured $V_{out,rms}$ value was 2.1 volts. Just by rough comparison, the two values aren't too far off from each other.

Figure 4. Calculating the accuracy of the DMM measurement.

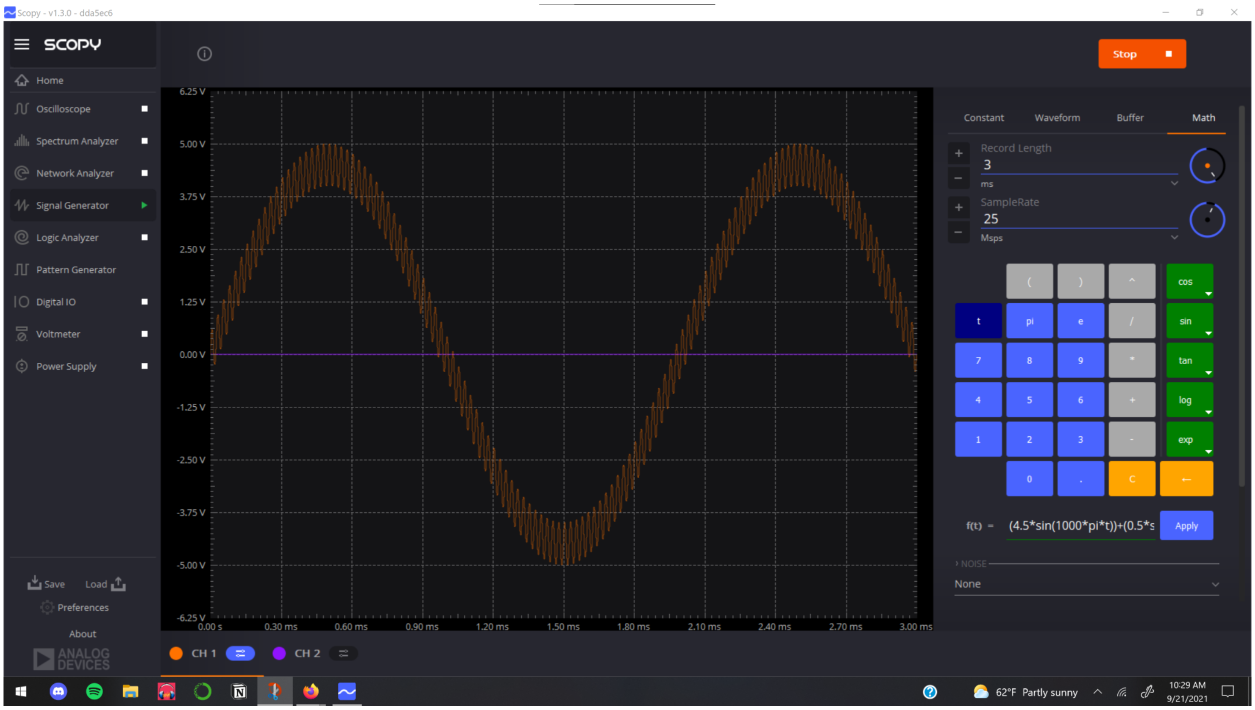


in 200 V AC mode, resolution of 0.1 v and accuracy ±(0.8% + 3)

$0.008(2.357\text{v}) + 3 = 3.0189$

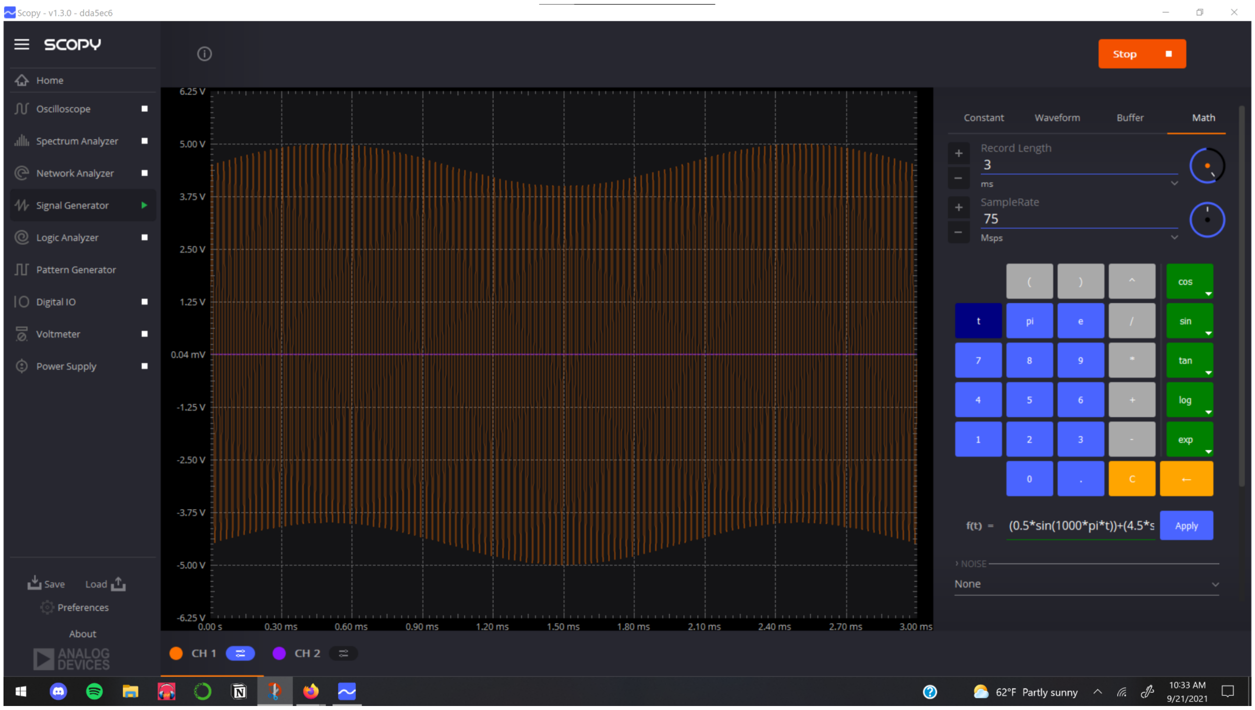
The DMM's AC voltage measurement is accurate to +/- 3.0189 volts of the calculated RMS output voltage. The measured value, 2.1 volts, is certainly within that range. However, measurements of -1V and 5V would also be within range. So it seems that the DMM is not very accurate for measuring small RMS voltages.

Figure 5. The sum of two sine waves, one with amplitude 4.5V and frequency 500Hz and one with amplitude 0.5V and frequency 40,000Hz.



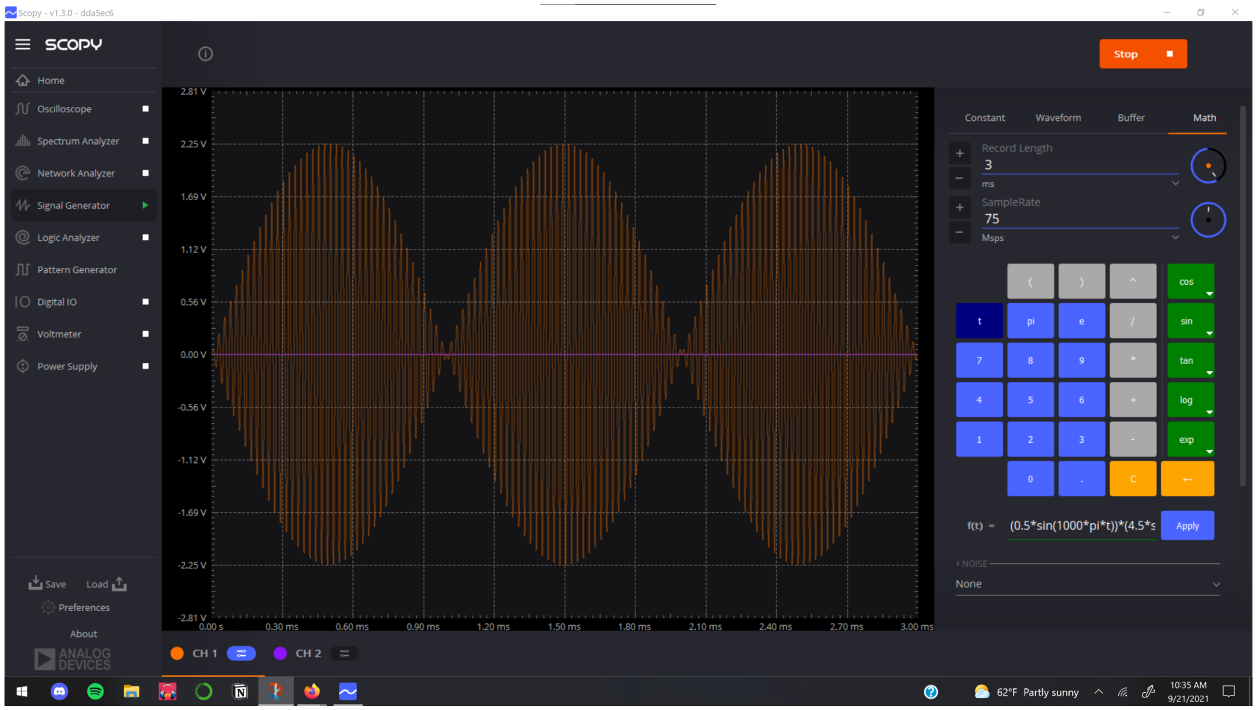
The shape of the wave makes sense. Its overall shape is that of a sine wave with a lower frequency and higher amplitude, but the lower amplitude and higher frequency component of the wave is also present in the way that the overall shape isn't "drawn" with smooth lines, but rather displays spikes and dips determined by the low-amplitude high-frequency wave.

Figure 6. The sum of two sine waves, one with amplitude 0.5V and frequency 500Hz and one with amplitude 4.5V and frequency 40,000Hz.



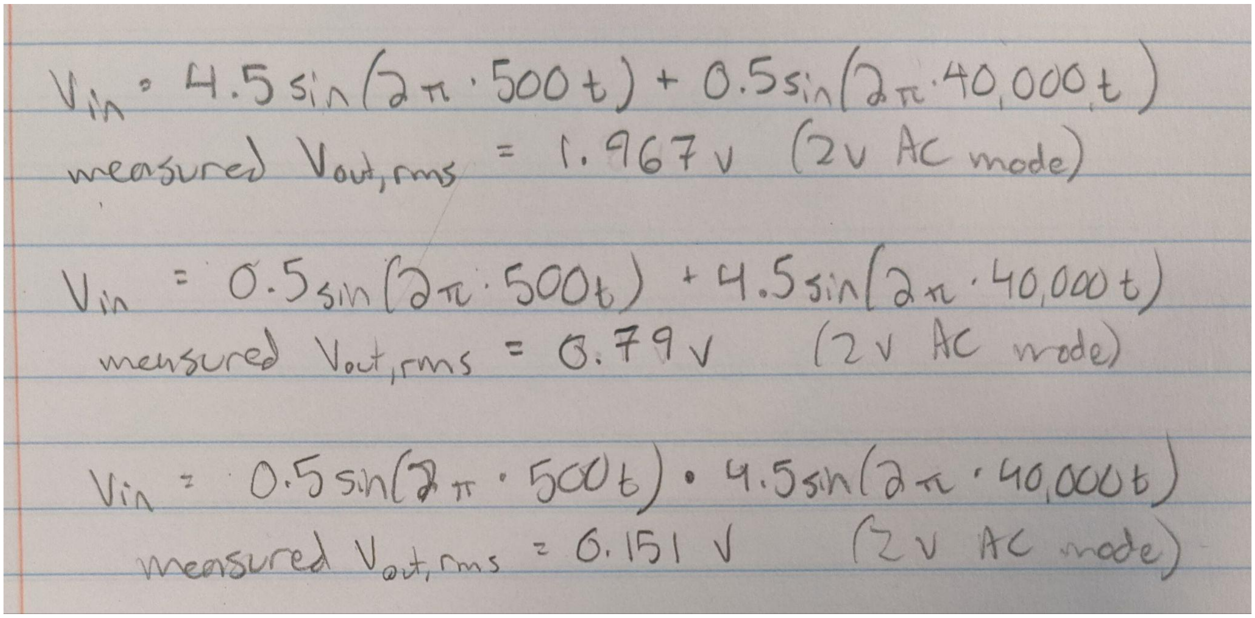
The shape of the wave makes sense. The overall amplitude of the wave is larger, determined by the high-amplitude high-frequency wave, and looking at a small time selection would show the higher frequency component. However, looking at the wave over a longer period of time shows that the lower frequency component is also present, though its effects on amplitude are much smaller, since it also has a lower amplitude.

Figure 7. The product of two sine waves, one with amplitude 4.5V and frequency 500Hz and one with amplitude 0.5V and frequency 40,000Hz.



The shape of the waves makes sense. The peak-to-peak amplitude is 2.5V, which is the product of the two amplitudes being multiplied together, 4.5V and 0.5V. Additionally, the waveform displays both a larger and smaller frequency. However, unlike the sum of two sine waves of different frequencies, the product here creates a different overall shape - in this case, it looks similar to a plot of destructive interference of two sine waves, with each “egg” shape made up of waves of a very high frequency.

Figure 8. Measured $V_{out,rms}$ for each of the three waves pictured in Figures 5-7.



$V_{in} = 4.5\sin(2\pi \cdot 500t) + 0.5\sin(2\pi \cdot 40{,}000t)$

measured $V_{out,rms} = 1.967\text{ V}$ (2V AC mode)

$V_{in} = 0.5\sin(2\pi \cdot 500t) + 4.5\sin(2\pi \cdot 40{,}000t)$

measured $V_{out,rms} = 0.79\text{ V}$ (2V AC mode)

$V_{in} = 0.5\sin(2\pi \cdot 500t) \cdot 4.5\sin(2\pi \cdot 40{,}000t)$

measured $V_{out,rms} = 0.151\text{ V}$ (2V AC mode)

The DMM is not actually measuring the RMS output voltage because the input voltage is not a sine wave with a single amplitude or frequency. Because the input voltages are sums or products of sine waves, they are more complicated to analyze.