ECSE331 Lab 1

Measurements Using The NI Elvis-II++ Test Instrument

ECSE331

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ECSE331 Lab-1 Report

***Abstract* — The purpose of this lab is to explore the various measure capabilities of the NI Elvis-II+ Test Instrument. This report provides the process of experiments conducted with AC and DC sources in both the time and frequency domains. It gives the results using NI Elvis-II+ digital multimeter, function generator, oscilloscope tool, two-wire I-V analyzer, and bode analyzer.**

I. INTRODUCTION

The goal of this lab was to get familiar with the utilization of the NI Elvis-II+ Test Instrument. This lab consisted of four parts. The first part measured the DC output voltage using the DMM feature on the instrument first and then replaced the DMM feature with the oscilloscope to measure the same voltage and the peak-to-peak value.

The second part added a 1μF capacitor to the circuit and measured the signal amplitude at the output with different frequencies. It generated a sinusoidal signal and a square wave signal using the function generator and the oscilloscope.

In the third part, procedures in the second part were repeated except for using the bode analyzer instead of using the function generator and the oscilloscope.

In the last part, the I-V characteristic of a 10kΩ resistor was measured using the 2-wire I-V analyzer.

II. EXPERIMENT RESULTS

A. DC Measurements

A voltage divider circuit was created according to Fig. 1. It involved two 10KΩ resistors connected in series; one of its ends was connected to a +15V power supply, and the other end to the ground. The terminals of the digital multi-meter were connected in the circuit to measure the voltage at V_O (the shared common node of two 10KΩ resistors).

From the voltage (V) division formula (1)

$$V_O = V_{in} \frac{R_1}{R_1 + R_2} \quad (1)$$

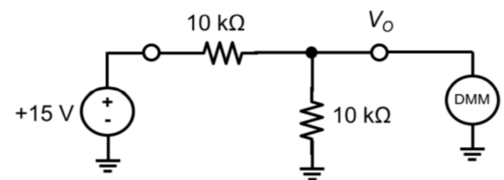

Fig. 1. Circuit

the expected voltage value at V_O should be around 7.5V. The measurement result of the DMM feature on the NI Elvis-II+ Test Instrument, as shown in Fig. 2, was 7.7785V. Thus, it was confirmed that the voltage at node V_O was close to its expected level (7.5V).

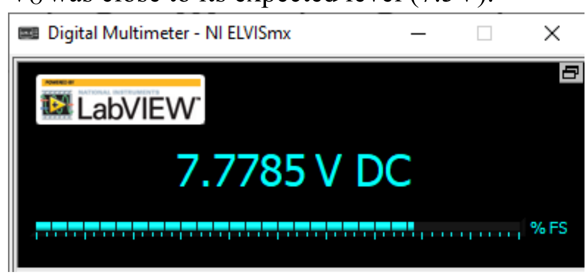

Fig. 2. V_O voltage measured result from DMM

Replacing the DMM with an oscilloscope showed that the average signal value was 7.863V. The result from DMM was 7.7785V; the signal's average was indeed in agreement with the result measured by the DMM. The peak-to-peak value seen by the scope was 2.25 mV. The peak-to-peak value should be approximately 0 since the output voltage is theoretically constant. The signal is constant since the voltage source is a constant DC voltage supply.

TABLE I

Oscilloscope Measurement Result

V_O	V_{rms}	V_{P-P}
7.836V	7.836V	2.25mV

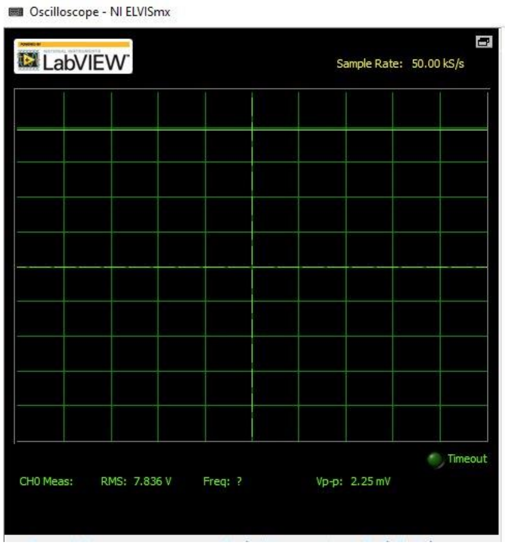

Fig. 3. Output voltage signal measured by the oscilloscope for a DC input voltage of 15V.

B. AC Measurements

The first AC measurement was to measure the output voltage Vo based on the circuit shown in Fig. 4. The input voltage is a sinusoidal signal $\cdot V_{in} = \sin(2000\pi t)$.

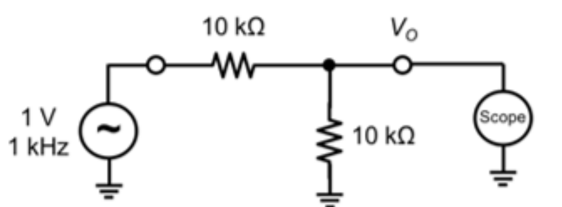

Fig. 4. R-circuit with an AC voltage signal input with an amplitude of 1V and a frequency of 1 kHz.

Using the voltage divider equation (1), we can get the expression for Vo as shown in (2):

$$V_O = \frac{V_{in}}{2} = \frac{\sin(2000\pi t)}{2} = 0.5\sin(2000\pi t)\,V. (2)$$

We can see the amplitude of the output signal should be 0.5V. Hence, as shown in Fig. 4, the output signal observed on the oscilloscope is consistent with the theoretical value. The peak-to-peak value of the measured signal is 1.072V, which means the amplitude is $\cdot \frac{1.072V}{2} = 0.536V$, which is very close to the expected 0.5V.

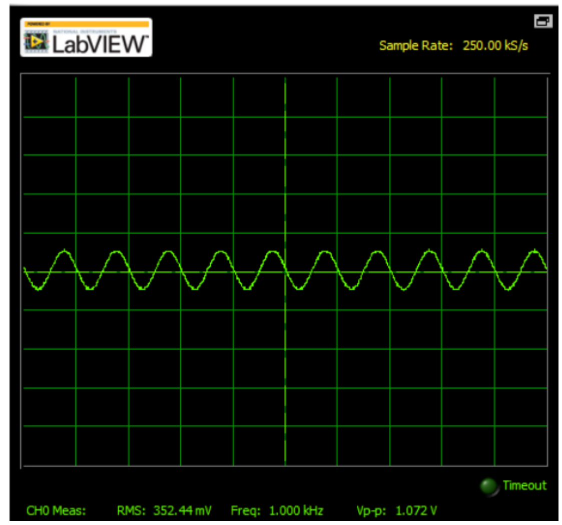

Fig. 5. Output voltage signal measured by the oscilloscope for an input voltage of sin (2000πt) in an R-circuit

The second AC measurement was to measure the voltage of a capacitor in the given RC circuit.
The circuit input is $\cdot V_{in} = \sin(2000\pi t)$ as shown in Fig.6.

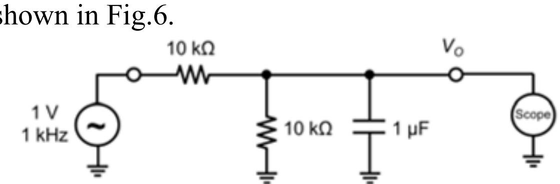

Fig. 6. RC-circuit with an AC voltage signal input.

The expected theoretical value of the output voltage can be done by using the node analysis in the frequency domain as follows:

$$\frac{V_O}{10k} + \frac{V_O - 1}{10k} + \frac{V_O}{Zc} = 0 \Rightarrow V_O = \frac{Zc}{2Zc+10k}V \ (3)$$

$$Zc = \frac{-j}{\omega C} = \frac{-500j}{\pi} \Rightarrow V_O = 15.9\angle - 91.8°V \quad (4)$$

where Z_c represents for the impedance, j for the complex number, ω for the frequency, and C for the capacitance of the capacitor.

The desired gain is $\cdot 20\log(15.9 \times 10^{-3}) = -35.97dB$.

At 1KHz, the measured amplitude is $\cdot \frac{35.03V}{2} = 17.5V$.

At 2K Hz, the measured amplitude is $\cdot \frac{27.1}{2} = 13.6V$.

At 3K Hz, the measured amplitude is $\cdot \frac{25.85}{2} = 12.9V$.

At 4K Hz, the measured amplitude is $\cdot \frac{21.27}{2} = 10.6V$.

At 5K Hz, the measured amplitude is $\cdot \frac{20.85}{2} = 10.4V$.

Hence we can draw a graph showing the relationship between the frequency and the voltage gain as shown in Fig. 7. All the measured plots are provided in the appendix.

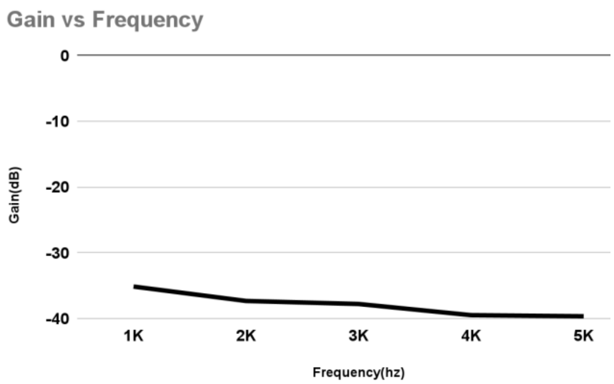

Fig. 7. Circuit gain as a function of the signal frequency

We can observe that as frequency increases, the gain of the circuit will decrease.

Next, we replace the voltage supply with a square wave and make it swing from 0V to 5V, which means the peak-to-peak value is 5V and has an offset of 2.5V. The output signal is shown in Fig.8. The time constant should be $\frac{1}{5}dT$. In our measurement, the dT is $496\mu s$, hence the time constant $\cdot \tau = \frac{1}{5} \times 496 = 99.2\mu s$.

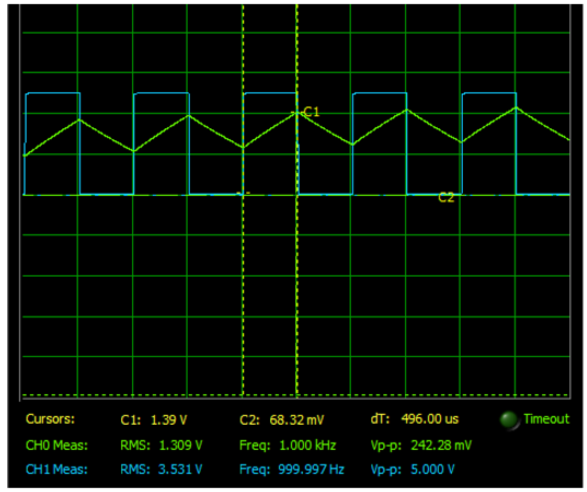

Fig. 8. Output voltage signal when input is a square wave.

However, the expected theoretical value of the time constant (τ), from its formula (3):

$$\tau = RC = (\frac{1}{R_1} + \frac{1}{R_2})^{-1}C, (3)$$

should be $\cdot \tau = 5\mathrm{k}\Omega * 1\mu\mathrm{F} = 5\mathrm{ms}$, and R represents for the resistance of the resistor.

The discrepancy between the measured and the theoretical value may be caused by the nature of the capacitor. It may not be fully charged at the time the measurement was done.

C. Bode plot

We will use a bode analyzer to redo part B in this part. Firstly, For the R-circuit, the gain is constant at around -6.53dB when we change the frequency from 10Hz to 100kHz since the output voltage and input voltage are all constant. Our measured result is shown in Fig. 9. As for the RC circuit, the measured gains by the bode analyzer from 1kHz to 5kHz are -33dB, -38dB, -44dB, -46dB, and -48dB, as shown in Figure.10. The values are generally consistent with the values that we measured by the oscilloscope.

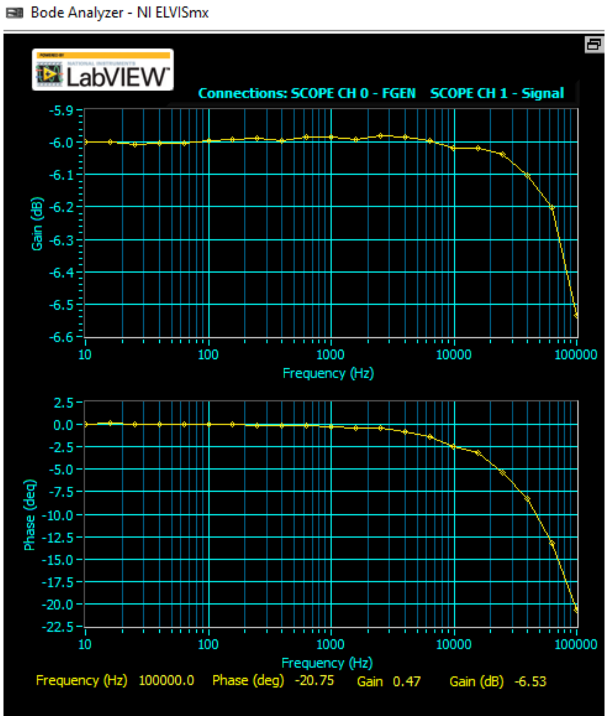

Fig. 9. Gain of R-circuit

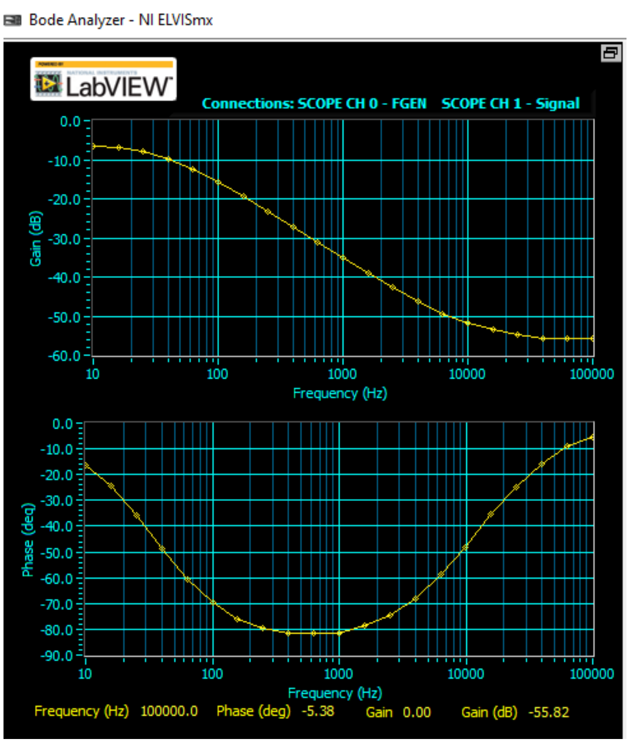

Fig. 10. Gain of RC-circuit

D. DC Transfer Curve Measurements

In this part, we obtained the I-V curve of a 10kΩ resistor using the digital 2-wire analyzer. Theoretically, the I-V curve should have a slope of $\frac{1}{R}$. Hence the R-value can be obtained from the slope of the simulated I-V curve shown in Fig.11.

$$\frac{1}{R} = \frac{0.2-(-0.2)}{2-(-2)} = 10^{-4}V. \quad (4)$$

The reciprocal of the slope is thus 10000Ω, which is the value of the resistor.

$$I(V) = 10^{-4}V + b. \quad (5)$$

Plugging in the point (0.2, 2.01) to (5), we get b = 0.199. Thus, the i-v axis is intercepted at the point (0, 0.199).

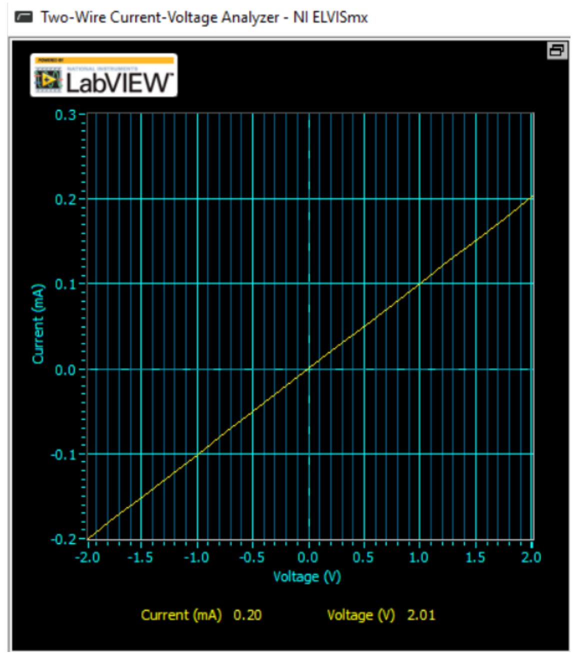

Fig. 11. I-V curve of R.

III. CONCLUSION

By doing this lab, students explored various measurement capabilities of the NI Elvis-II+ Test Instrument. Students gained skills in analyzing DC and AC circuits using DMM, function generator, oscilloscope, bode analyzer, and 2-wire i-v analyzer. During this process, students had a better understanding of circuits and signals.

APPENDIX

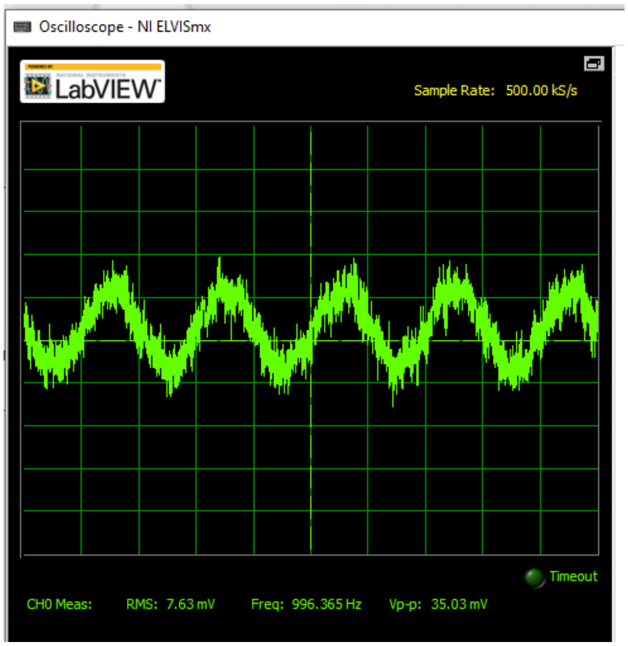

Fig. 12. Output voltage of the circuit at 1kHz

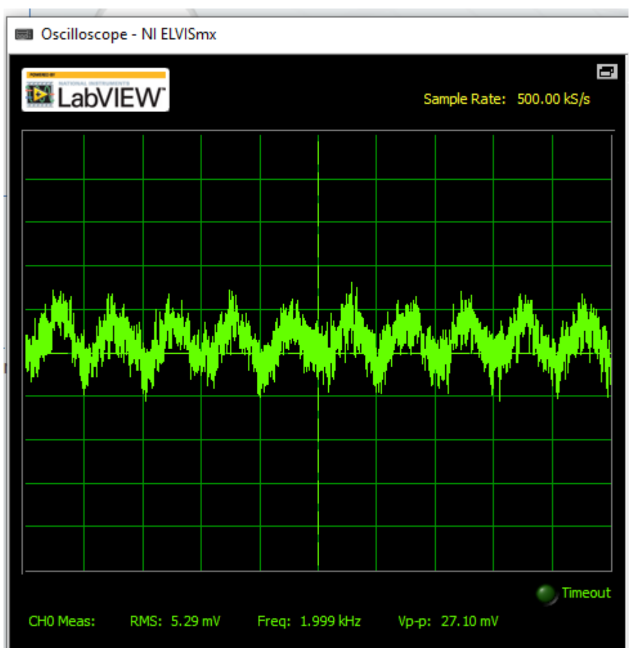

Fig. 13. Output voltage of the circuit at 2kHz

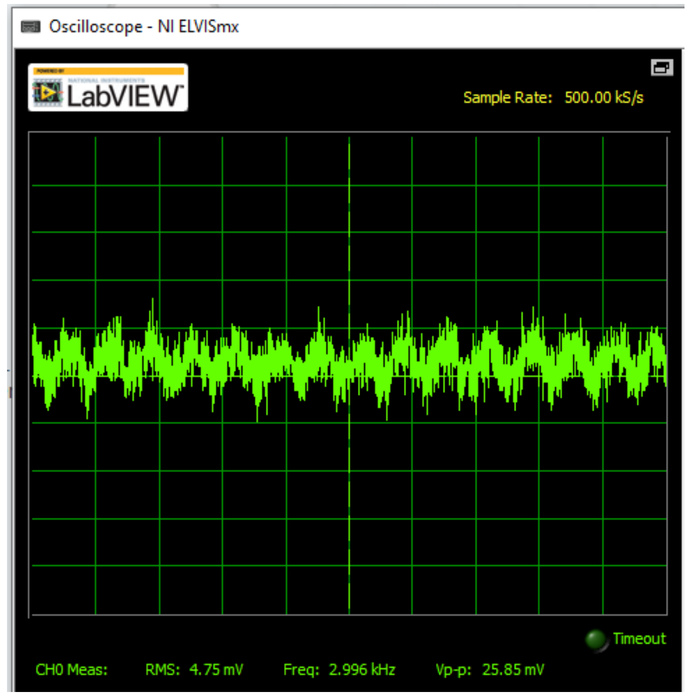

Fig. 14. Output voltage of the circuit at 3kHz

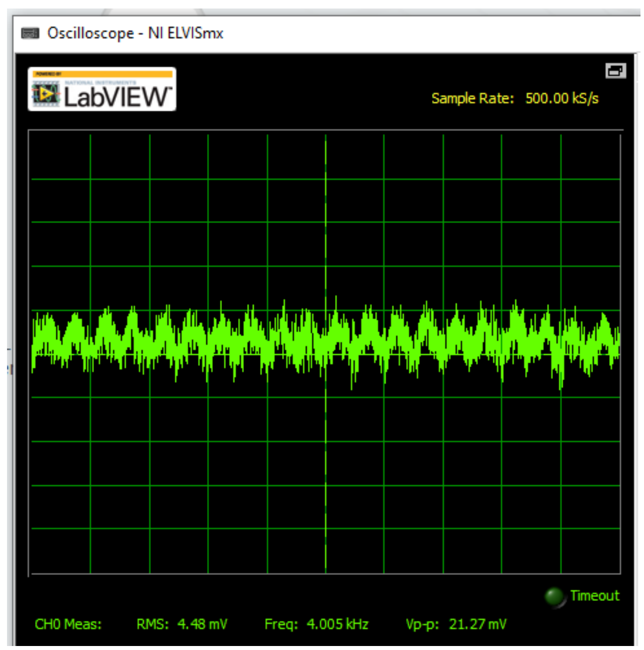

Fig. 15. Output voltage of the circuit at 4kHz

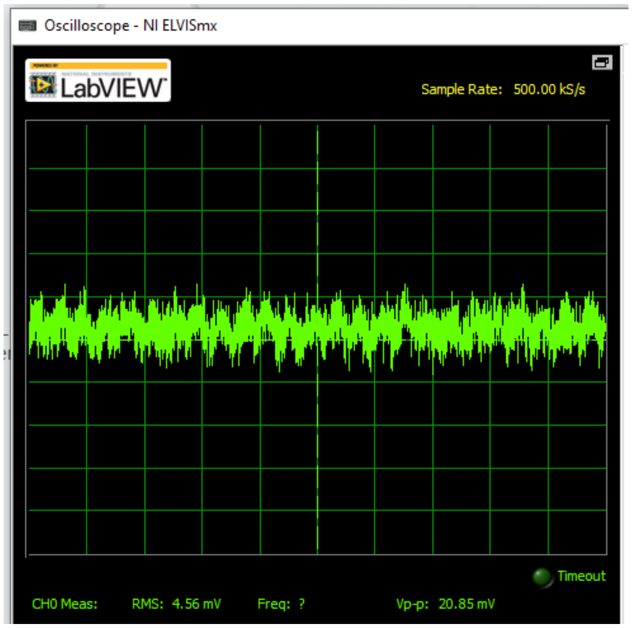

Fig. 16. Output voltage of the circuit at 5kHz