Laboratory No 1.

Measurements using the NI Elvis-II+ Test Instrument

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***Abstract*—This laboratory experiment aimed to explore the measurement capabilities of the National Instruments ELVIS-II+ test instrument, a platform used for various electronic measurements. The experiment involved the construction and analysis of simple circuits, including a DC voltage divider and an AC signal circuit, to assess the functionality of the digital multimeter, oscilloscope, function generator, and Bode analyzer within the ELVIS-II+ system. The experimental results were compared with theoretical predictions obtained through SPICE simulations, highlighting the accuracy and limitations of the measurements. The data collected demonstrated the ELVIS-II+ platform's effectiveness in providing reliable and precise measurements essential for circuit analysis and design.**

Keywords— NI Elvis-II+, Electronics

I. INTRODUCTION

The National Instruments Educational Laboratory Virtual Instrumentation Suite (NI ELVIS-II+) is a comprehensive platform designed to facilitate hands-on learning in electrical and computer engineering. It integrates multiple commonly used instruments, such as oscilloscopes, digital multimeters, function generators, and Bode analyzers, into a single interface. This laboratory exercise, part of the ECSE-331 course, aimed to familiarize students with the diverse capabilities of the NI ELVIS-II+ system through a series of structured experiments focusing on both DC and AC measurements.

The lab was divided into four distinct sections, each targeting a specific aspect of electronic circuit analysis:

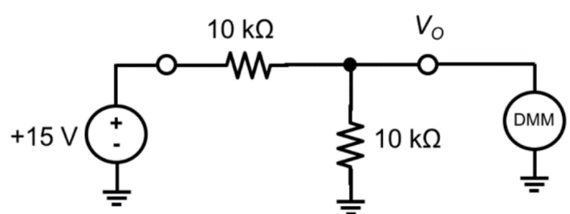
1. **DC Measurements**: The initial experiment involved constructing a voltage divider circuit using two resistors. The digital multimeter (DMM) feature of the NI ELVIS-II+ was used to measure the DC voltage at different nodes of the circuit. These measurements were then verified using the oscilloscope to ensure consistency and accuracy between the two instruments in DC voltage measurement.
2. **AC Measurements**: In the second section, the DC voltage source was replaced with a 1 V peak, 1 kHz sinusoidal signal generated by the function generator. The output waveform was observed using the oscilloscope, and the circuit's gain was investigated at different frequencies. This experiment provided insight into the behavior of the circuit under alternating current (AC) conditions and highlighted signal variations and amplitude response.
3. **Bode Analyzer**: The third section focused on using the Bode Analyzer feature to evaluate the frequency response of the circuit. By sweeping the frequency range, the gain of the circuit as a function of frequency was plotted. The results obtained from the Bode Analyzer were compared to those from the oscilloscope measurements in the previous section, demonstrating the practical application of different tools in frequency domain analysis.
4. **DC Transfer Curve**: The final experiment involved measuring the i-v characteristics of a resistor using the 2-wire i-v analyzer. By sweeping the voltage across the resistor and recording the resulting current, the i-v curve was plotted, and its slope and intercept were analyzed. This exercise introduced the concept of transfer curves and provided a deeper understanding of the linear and nonlinear behavior of electronic components.

II. EXPERIMENT PROCEDURES AND ANALYSIS

This section outlines the detailed procedures and analysis for each experiment conducted using the NI ELVIS-II+ test instrument. Each experiment was designed to explore a specific functionality of the instrument, including DC and AC measurements, frequency response analysis, and i-v characteristics. The experiments were carried out sequentially, with the results of each phase providing insights into the electrical properties of the circuits tested. The procedures for each experiment are described below, followed by an analysis of the observed results and their comparison to theoretical expectations.

A. Part 1: DC Measurements of Vo using DMM

The output voltage, Vo, was measured using a DMM as shown in the figure below.



The expected output voltage, Vo, for the given voltage divider circuit is calculated using the formula:

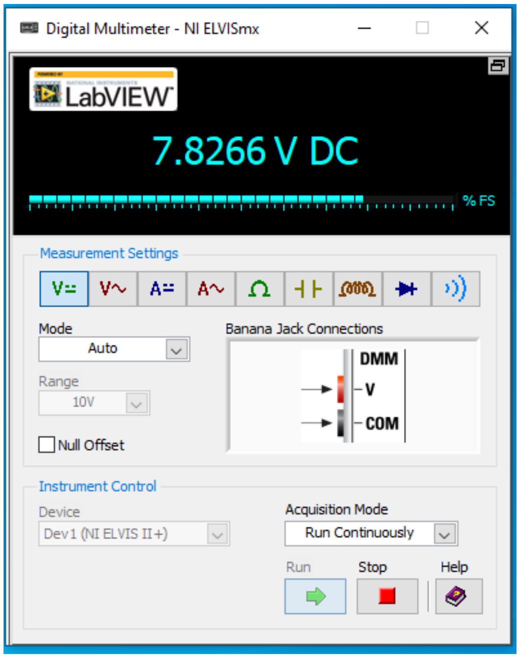
$$V_o = V_{in} \times \frac{R_2}{R_1 + R_2}$$

where $V_{in} = 15V$, $R_1 = 10k\Omega$, $R_2 = 10k\Omega$.

Substituting the values:

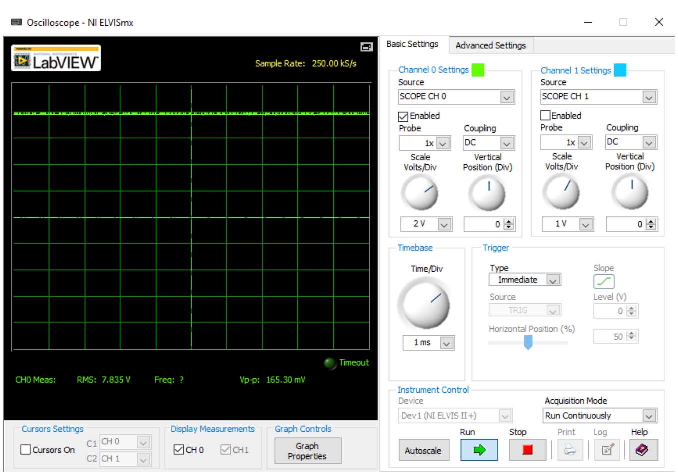
$$V_o = 15V \times \frac{10k\Omega}{10k\Omega + 10k\Omega} = 15V \times 0.5 = 7.5V$$

However, the observed voltage as seen in the figure below was 7.83 V, which is slightly higher than the expected theoretical value.



This discrepancy can be due to several factors, such as resistor tolerances, the contact resistance and the noise introduced in the circuit. The resistors used in the circuit had manufacturing tolerances of 5%, which means the actual resistance values could be slightly different from 10 k Ohms. If the resistance of R1 is slightly lower or R2 is slightly higher than their stated values, the output voltage Vo would be higher than expected. Also, the physical connections between the components and the prototyping board can introduce additional resistance, altering the voltage drop across the resistors. This could cause a slight increase in the measured output voltage.

Additionally, the DMM in the circuit was replaced by the oscilloscope as shown in the figure below.



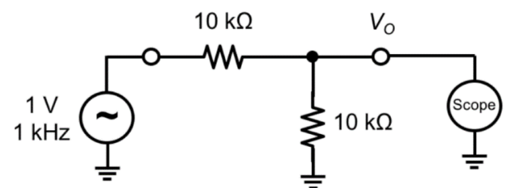
The results obtained from the oscilloscope are as follows:

Vo	7.835 V
Vrms	7.835 V
Vp-p	165.30 mV

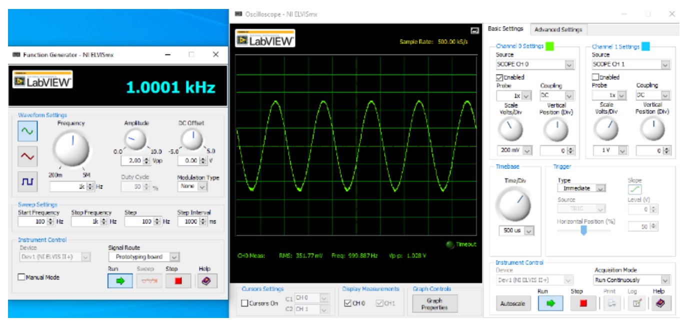
Again, the difference in the theoretical and experimental values may be explained by factors such as resistor tolerances of 5%, the contact resistance and the noise introduced in the circuit. The Vp-p value of 165.30 mV is due to internal electronic noise. This can be attributed to factors like power supply ripple, environmental electromagnetic interference, or issues with the circuit's grounding.

B. Part 2: AC Measurements of Vo using the Oscilloscope with resistors and capacitor

The output voltage, Vo, was measured using a DMM as shown in the figure below. The AC function generator was introduced to the voltage circuit, with 1 V amplitude and 1 kHz sinusoidal signal.



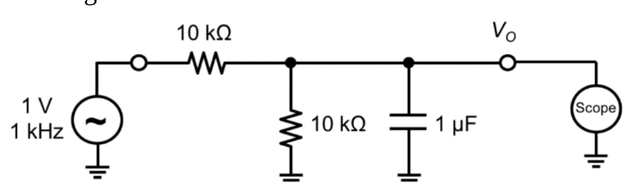
The measurements taken of the sinusoidal output voltage graph are shown in the figure below.

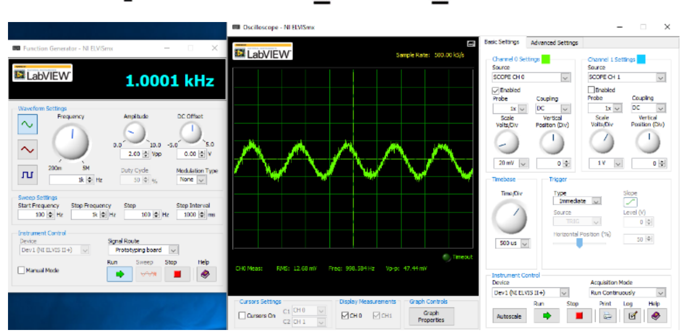


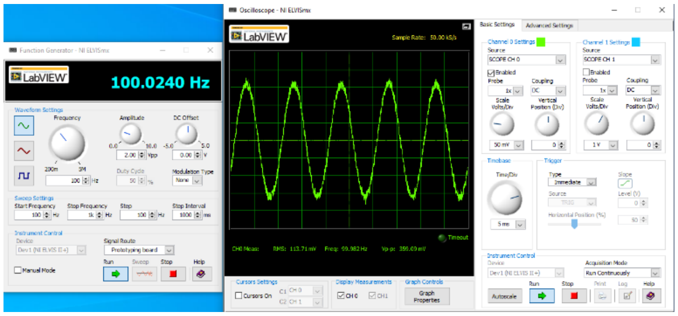
The results obtained from the oscilloscope are as follows:

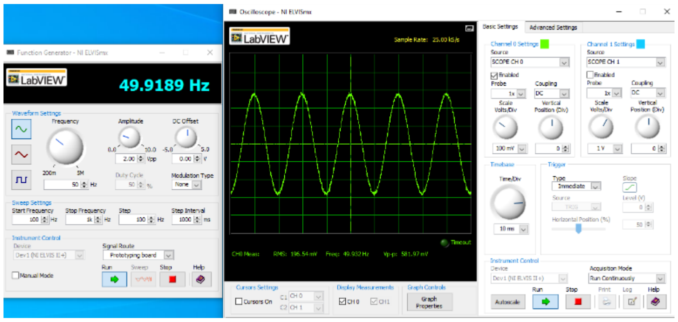
Vrms	351.77 mV
Amplitude	514 mV

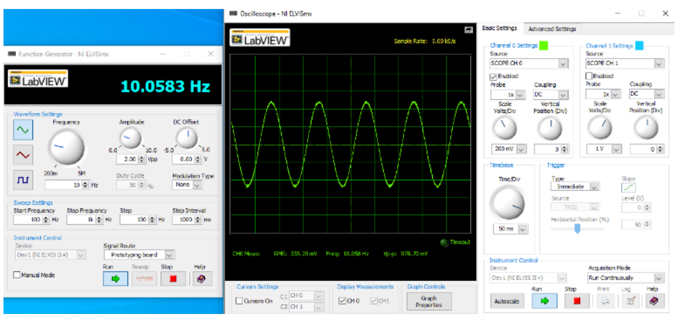
For the next step, a 1μF capacitor was introduced to the circuit on parallel to the ground 10 kΩ resistor, as shown in the circuit diagram below.

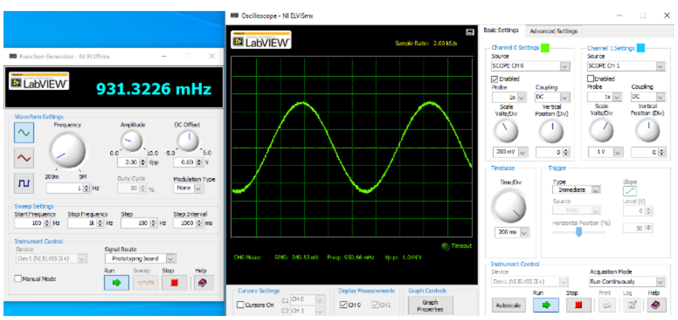






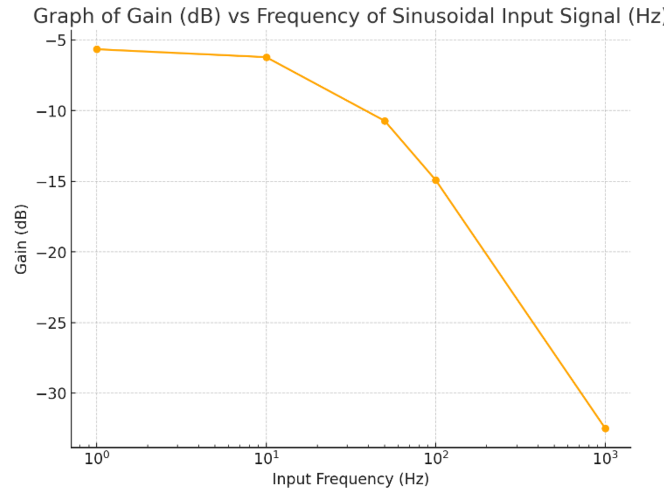






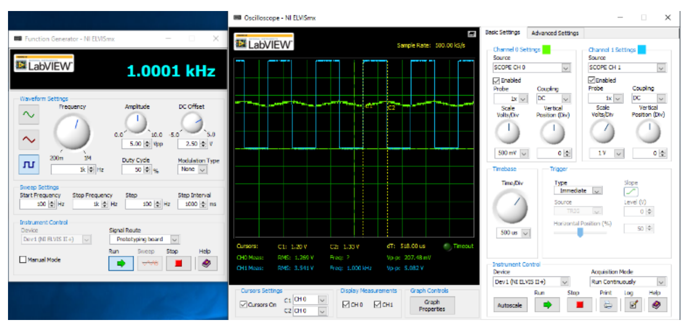
The input frequency was decremented from 1 kHz to 1Hz with a decrease by a factor of 10 each time. The measurement for input frequency of 50 Hz was added as well. The results are as follows:

Frequency of Input Signal (Hz)	Vrms (mV)	Vp-p (mV)	$Gain\ (dB) = 20 \log \frac{V_o}{V_{in}}$
1000	12.68	47.44	−32.50
100	113.71	359.09	-14.92
50	196.54	581.97	-10.72
10	335.20	978.70	-6.21
1	349.53	1044	-5.65



The graph shows the relationship between Gain (in dB) and Input Frequency (in Hz) of a sinusoidal signal. The gain decreases as the frequency increases, indicating significant attenuation of higher frequencies. A sharp decline in gain is observed from 10 Hz to 100 Hz, suggesting a low-pass filter characteristic that reduces the amplitude of high-frequency components. At lower frequencies (1 Hz to 10 Hz), the gain remains relatively stable, while at 1000 Hz, it drops significantly to around -32.50 dB, indicating weaker transmission of high-frequency signals. This behavior suggests the system is effective at suppressing high-frequency noise while maintaining consistent performance at low frequencies.

The following graph is the result of a square signal with a peak of 5 V as input.



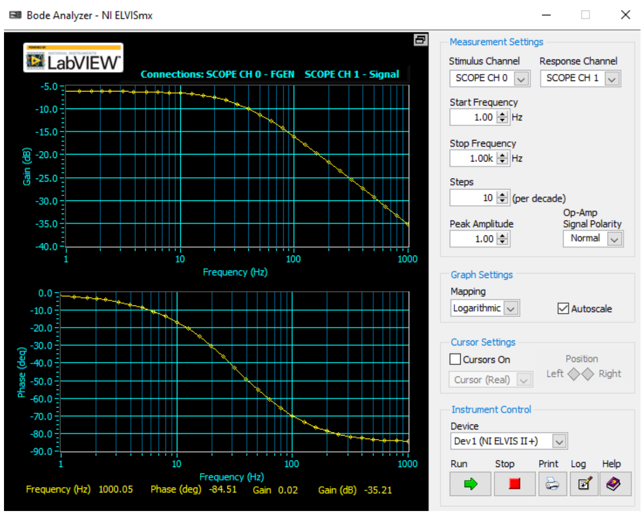
We can calculate the time constant by isolating τ in the following formula:

$$V_{min} = V_{max} e^{-\frac{\Delta t}{\tau}}$$

where τ is the time constant. On the oscilloscope, we see that the Vmin is 1.20V, the Vmax is 1.33V and the Δt value is 518.00 µs. After plugging in the values obtained from the oscilloscope, we find a time constant of 5.0361×10^{-3} seconds, or $5.0361ms$.

C. Part 4: AC Measurements using the Bode Analyzer

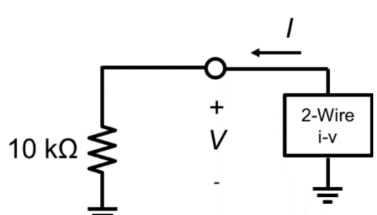
The Bode Analyzer was added to the circuit, replacing the function generator. The same steps as Part 2 were repeated. The results obtained is shown in the figure below, where the first figure was measured without the capacitor and the second figure was measured with the capacitor.



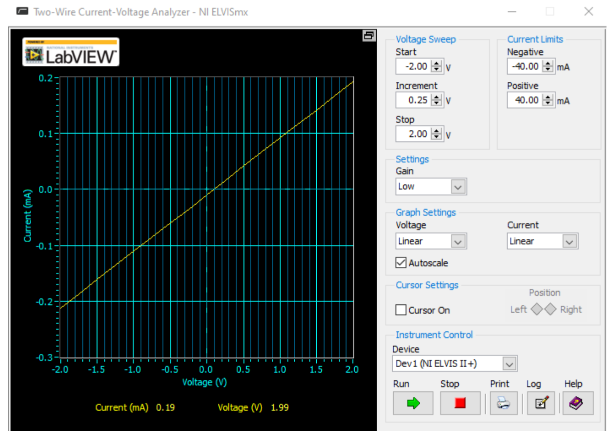
It is observed that the gain calculated over the different frequencies using the values obtained using the oscilloscope and the gain from the Bode analyzer are close to identical. The slight variations are likely attributable to the inherent measurement limits and noise sensitivity of each device, which are expected and within acceptable ranges for this type of analysis.

D. *Part 5: DC Transfer Curve Measurements using the 2-wire i-v Analyzer*

A new circuit was introduced, with a 2-wire i-v analyzer and a singular 10kΩ resistor as shown in the circuit diagram below.



By setting the voltage sweep to -2 V to 2 V, the following linear graph was observed on the 2-wire i-v analyzer.



The slope of the graph, which corresponds to the relation between the current and the voltage of the circuit, is observed to be 10 A/V. This value is equal to the value of the resistor of the circuit (10 k Ohms). Also, the linear graph intercepts the i-v axis at approximately point (0,0).

The slope of the graph represents the relationship between current (I) and voltage (V) in the circuit, defined by Ohm's Law as:

$$V = IR.$$

where R is the resistance.

Ideally, for a perfect resistor with no offset or other influences, the I-V curve should pass through the origin (0,0), indicating that at 0 volts, there is 0 current. However, in the provided graph, the I-V curve does not intercept at (0,0), which can be due to several reasons, such as the 5% tolerance in the resistor, contact resistance at connections, and offset voltage or current of the measuring device.

III. Conclusion

In conclusion, this lab successfully demonstrated the measurement capabilities of the NI ELVIS-II+ test instrument through DC and AC circuit analysis. Minor discrepancies between calculated and measured values in the DC experiment highlighted the impact of component tolerances and instrument precision. The frequency response analysis using the Bode analyzer and function generator confirmed the expected behavior of the circuit. Additionally, the i-v characteristics of a resistor were measured, reinforcing theoretical concepts. Overall, this lab provided valuable hands-on experience in circuit testing and emphasized the importance of understanding real-world factors in electronic measurements.