Winter 2023 ECSE 331: Electronics

Laboratory 1: Measurements Using The NI-Elvis-II+ Test Instrument

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Measurements Using The NI-Elvis-II+ Test Instrument

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***Abstract*— The purpose of this laboratory is to explore various measurement capabilities of NI-ElvisII+ test instrument. In this laboratory session, the DMM, Oscilloscope, Function Generator, Bode Analyzer, and 2-Wire i-v were used to explore the behavior of DC circuits and AC signals in parallel RC circuits. AC signals that were under examination were sinusoidal and square signals.**

Keywords- Electronics, NI-ElvisII+, Parallel RC Circuits, AC signals, Voltage Gain

I. INTRODUCTION

The laboratory was divided into four parts. In the first part, DC voltage at the output terminal of the voltage divider circuit was measured using the Digital Multi Meter (DMM). Next, the DMM was replaced with the Oscilloscope tool to verify that RMS value of the signal agreed with the previously measured value.

In the second part, a sinusoidal signal was generated and applied to the circuit under examination. Then, that circuit was modified as an RC circuit to measure its gain at varying frequencies. The sinusoidal waves were then replaced by square waves and the output signals were observed.

In the third part, the aim was to test the accuracy of the measurements that were done in part two. This was done by using bode plot analyzer instead of the function generator and the scope.

Lastly, the aim was to test I-V characteristics of a 10kΩ resistor. This was done by using 2 wire I-V analyzer feature of NI-ElvisII+ instrument.

Required equipment: NI-ElvisII+ test instrument, PC with Elvis-II+ software, two 10k Ohm resistors, a single 1 µF capacitor and connecting wires.

II. METHODOLOGY AND ANALYSIS

A. DC Measurements – Using the DMM Feature

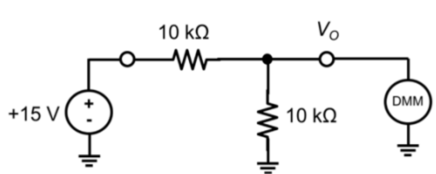

Figure 1A - Voltage Divider Circuit (DMM)

Within this section of the investigation, we are asked to perform circuit analysis on a voltage divider circuit using firstly, the Digital Multi Meter (DMM), and then using the Oscilloscope instrument provided by the NI Elvis-II+ test instrument. The voltage divider circuit under examination can be seen in figure 1A. After connecting the relevant nodes on the Elvis-II+ prototyping area to resemble the circuit; we connected the DMM across the circuit to measure the output voltage of this voltage divider. Figure 1B shows a screenshot of the attained reading of 7.8071 V. This closely follows from the expected value that is calculated according to the output voltage of a voltage divider formula; 7.5 V (Equation 1). The inconsistency between the theoretical value and the experimental value is believed to be from component inconsistencies (calibration or manufacturing error); and the overall noise experienced by the circuit.

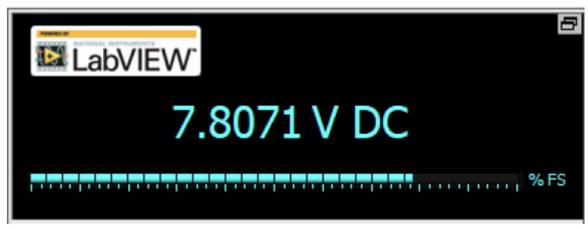

Figure 1B - DMM Reading of Voltage Divider Output

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

Equation 1 – Output Voltage of a Voltage Divider Circuit

We then replaced the DMM with the oscilloscope instrument; as seen in figure 1C. Then, we proceeded to view the reading of the output signal which is presented in figure 1D. The plot shows the output signal as a straight line with a V_{RMS} value of 7.807 V, and a peak-to-peak value of 1.93 mV. We observe that the RMS voltage value indeed matches our measured value from before, however, as this is a DC signal; we did not expect to get any reading for the peak-to-peak measurements. It is concluded then, that the peak-to-peak value that the oscilloscope is picking up is due to some sort of noise within the circuit or the instrument itself.

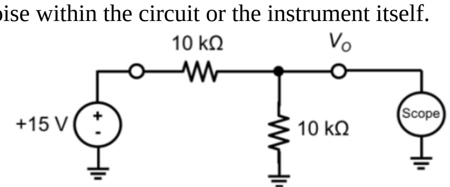

Figure 1C – Voltage Divider Circuit (Oscilloscope)

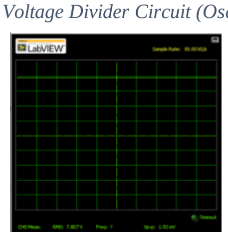

Figure 1D – Oscilloscope Signal Plot of DC

B. AC Measurements - Using the Function Generator and Oscilloscope Features

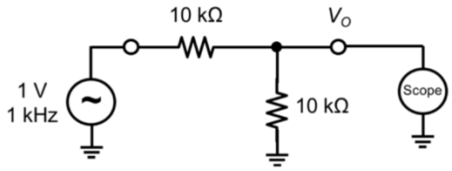

Figure 2A - Voltage Divider Circuit with AC Source

For this part of the investigation, we performed circuit analysis on the same circuit, but using an AC source, instead of the DC source we were using in the preceding section. This was possible by way of the Function Generator tool available within the NI Elvis-II+ software toolbox. The circuit under analysis can be found in figure 2A. The function generator was set up as a 1 V peak, 1 kHz sinusoidal signal and the oscilloscope was connected to the output node as seen in figure 2A. By way of the oscilloscope, we verified that the input signal was indeed set to 1 kHz, and that the amplitude of the output signal is 0.501 V, this is observed in figure 2B.

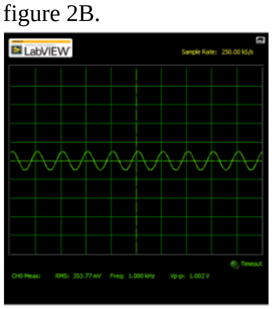

Figure 2B – Plot of Output Signal (1kHz)

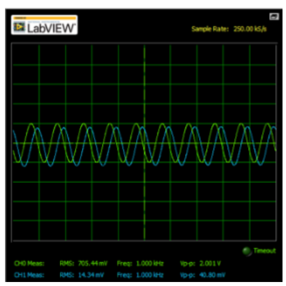

Figure 2C – Plot of Input Signal Against Output Signal (1kHz)

We then connected a 1 uF capacitor in parallel to our existing circuit to arrive at the circuit shown in figure 2D. Additionally, we connected the input signal to the oscilloscope to plot both the input and output signals as seen in figure 2C. As seen in figure 2C, we measured an output frequency of 1 kHz and an amplitude of 20.40 mV. We repeated this for a range of 1 kHz to 5 kHz and arrived at the results in figure 2E, where the gain was calculated according to equation 2. We then plotted this data to arrive at figure 2F.

$$Gain(dB) = 20\ \log_{10}\left(\frac{V_{out}}{V_{in}}\right)$$

Equation 2 – Voltage Gain Equation

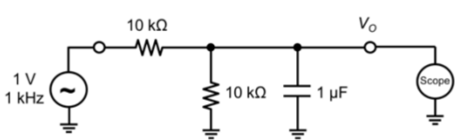

Figure 2D – RC Circuit Under Examination

Frequency (kHz)	*V_{in} (mV)*	*V_{out} (mV)*	*Voltage Gain (dB)*
1	705.440	14.340	-33.838
2	705.290	7.680	-39.260
3	704.950	5.650	-41.922
4	704.160	5.500	-42.146
5	704.030	4.970	-43.025

Figure 2E – Table of Raw Data: Voltage Gain Along Varying Frequency

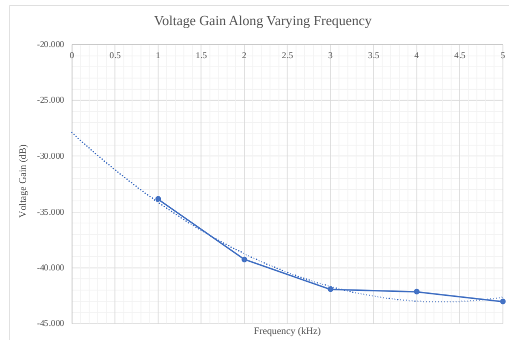

Figure 2F – Plot of Voltage Gain Against Frequency

Through our plot, it can be observed that our incremental changes of 1 kHz seem to initially cause a larger disparity (steeper slope), but their effect seems to be dampened as we reach higher frequencies. This can be observed as going from 1 kHz to 2 kHz causes a change of 5.422 dB, while going from 4 kHz to 5 kHz causes a change of 0.879 dB. So, in essence, the reactance of our system seems to decrease. This can be explained by the formulation of parasitic capacitance within the resistors that we use. Parasitic capacitance is an unwanted side-effect when dealing with high-frequency AC signals through any real resistor. This is due to the impedance of resistors decreasing as they are exposed to higher frequency signals; and so, the resistor starts to store electrical energy in the form of electrical charge [1].

We then used the function generator to change our input signal to a square wave signal with a frequency of 1 kHz and an amplitude of 2.5 V. A plot of the input signal against the output signal can be observed in figure 2G. This plot, along with the cursor features of the oscilloscope allowed us to measure the time constant associated with the output signal. We measured the time constant by observing when the signal is reduced to $\frac{1}{e}$ of the total output signal. Equivalently, it is the time that it takes to reach 63.2% of the peak of the output signal.

Using the cursors, we find that our output signal reaches 63.2% of its peak at around -1.45 mV with a trough of -10.20 mV. And so, we can conclude that the time constant associated with this output signal is 304 us. This value is much smaller than we anticipated and according to simulations on spice of a similar circuit, we did not arrive at this result. We have assumed this inconsistency is due to output impedance of our signal generator [2][3].

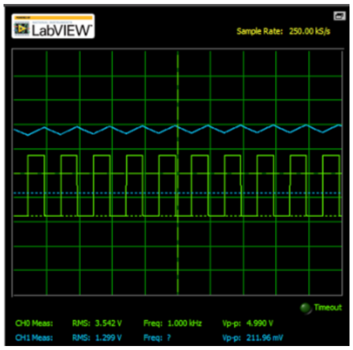

Figure 2G – Square Input Signal Plotted Against the Resulting Output Signal

C. AC Measurements – Using the Bode Analyzer

Throughout this section, we examine the same circuit as in the preceding section. However, instead of using the oscilloscope instrument, we used the Bode Analyzer software to get a plot of the gain, and further try to deduce the time constant related to the output signal. The bode analyzer allows us to specify the number of samples in a wide range of magnitudes; and so, it serves to be a more useful tool in trying to deduce reliable and valid data.

The plot that the bode analyzer produced can be observed in figure 3A with 100 samples being taken per decade. We can examine the plot of voltage gain in decibels against frequency to validate our results from section B; we see that at lower frequencies the system is more reactant to the changes in frequency and then conforms to a straight-line projection towards higher frequencies. Our measurements from the previous section are slightly larger than the plot from the bode analyzer; this can be accounted for by the fact that our measurements are based on a single sample over a range of frequencies, while the bode analyzer has taken much more samples; offering us a more reliable reading.

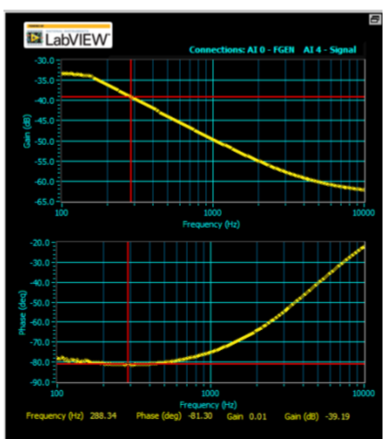

Figure 3A – Bode Analyzer Plot

Further analysis suggests that each of our measurements from the preceding section is 17 units higher than the plot from the bode analyzer; this further suggests that we had some sort of systematic error due to manufacturing error or some sort of impedance within the system. This leads us to believe that our measurements from section B are indeed reliable; however not necessarily valid.

This also applies to the time constant which is assumed to be a -3 dB drop from the initial db reading [4]. Using the cursor tool, we can deduce a cutoff frequency of 288 Hz; giving us a time constant of 3472.2 us which is closer to the magnitude that we expected. It is assumed that these discrepancies are due to the limit of samples in the procedure of section B.

D. DC Transfer Curve Measurements Using 2 Wire I-V Analyzer

In this part, we were asked to construct the circuit found in figure 4A; by connecting a single 10 kΩ resistor to a 2 wire I-V analyzer.

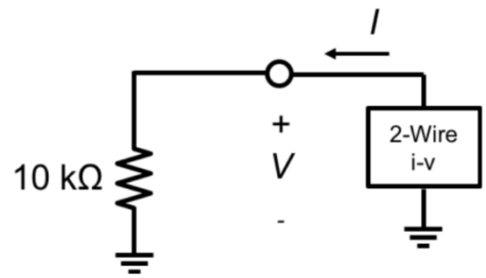

Figure 4A - 2-Wire i-v Analyzer Connected to 10 KOhm Resistor

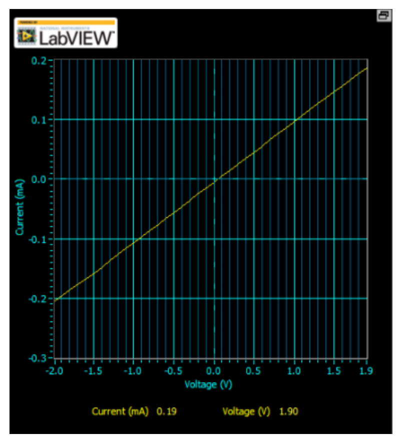

Figure 4B - I-V Curve Obtained from Two-Wire Current-Voltage Analyzer Connected to 10k Ohm Resistor

From the plot in figure 4B we can deduce that the slope of the I-V function is approximately 0.0001 A/V. This unit of operation deduces the conductance relationship between the current and the voltage. That is, the graph is the reciprocal of Ohm's law. And so, we find that the reciprocal of the slope, gives us the resistance of the resistor that is under examination; 10 kΩ. The curve intercepts i-v axis approximately at (0,0). It is not exactly (0,0) because of some negligible error. As this result corresponds to Ohm's law, we can conclude that the resistor is an Ohmic material.

III. CONCLUSION

In this laboratory various measurements and observations were conducted using NI-ElvisII+ test instrument. Specifically, instruments that were used were the DMM, oscilloscope, function generator, bode analyzer and two-wire current-voltage analyzer. The purpose of using these instruments was to investigate behaviours and properties of DC circuits and AC signals in RC circuits. We can conclude that our measured values in experiments mostly agreed with theoretical values with minor deviations or systemic errors. We assume that these deviations can be due to noise and manufacturing defects. Additionally, increasing the number of samples in each experiment will increase the reliability of obtained results.

IV. REFERENCES

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