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***Lab #1: Introduction to Electronic Instrumentation***

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| **Course Number and Name:**  **ASE 269K Measurements and Instrumentation** | |
| **Semester and Year:**  **Fall 2013** | |
| **Name of Reporter:**  Zachary Tschirhart | **EID of Reporter:**  zst75 |
| **Unique Number and Meeting Time:**  13580 Monday 1-3pm | **Name of Lab Instructor**  **Zheng Wang** |
| **Title of Experiment:**  Introduction to Electronic Instrumentation | |
| **Date of Experiment Performed:**  September 9, 2013 | **Instructor Comments:** |
| **Date of Report Submitted:**  September 16, 2013 |
| **Names of Group Members:**  David Chang |
| **Grade:** |

**ABSTRACT**

This lab was intended to demonstrate the accuracy and precision of tools regularly used to measure numerical values in a laboratory environment. The tools used included a multimeter, DC power supply, function generator, oscilloscope, battery, and a resistor box. These tools familiarized students with different methods of acquiring measurements, and to what accuracy he or she may expect. Results indicated the multimeter measurement device delivered moderately accurate results in specific circumstances, but consistently provided unstable results with low frequency signals, while the oscilloscope measurements were more accurate overall. Conclusively, the multimeter was determined an adequate device when used to get a vague numerical range, whereas an oscilloscope could be used to visualize a signal and attain a better reading.

**OBJECTIVE AND INTRODUCTION**

The purpose of this lab is to familiarize students with instruments that will be used in many of the labs in the future.

Students must be able to use these tools in future labs without the need of a product manual and little help from the lab instructor, therefore familiarization of the tools is essential. The student must also have inherent knowledge of the accuracy in each reading on every device used, as to know the confidence of the results.

**THEORY AND EXPERIMENTAL METHODS**

Ohms law:

(1)

Where V is voltage, I is the current, and R is the resistance in a circuit.

Uncertainty calculation:

(2)

Where P is the accuracy range of the device, as a percentage, U is the value read from the device, and X is the number of digits of accuracy, and Y is the lowest possible increment available with the measured significant digits or also known as the resolution (e.g. Y is 0.001V for a measurement of 3.000V)

Root mean squared voltage for an alternating current sine wave:

(3)

Where is the maximum voltage measured, T is the time period of integration, and is the angular frequency. After the integration is carried out, only the voltage measured is needed to calculate the RMS voltage in this situation.

Any steps to reproduce this experiment can be described by the lab instructions, as it was followed step-by-step for the experiment. Any calculations made were explicitly explained and used in one of the three equations described above.

**RESULTS AND DISCUSSION**

**Section 1: Digital Multimeter**

To test the Digital Multimeter, there is a need to first understand the accuracy and what each output reading will provide. By looking into the manual for the Digital Multimeter the following questions from the lab manual can be answered and then understood:

**1.1**

Question 1 – “What is the accuracy for resistance readings? “

Accuracy for the given resistance readings for each particular measurement can be found in the chart below:

|  |  |  |
| --- | --- | --- |
| **Range** | **Resolution** | **Accuracy** |
| 500.00 Ω | 0.01 Ω | 0.05 % + 10 |
| 5.0000 kΩ | 0.0001 kΩ | 0.05 % + 2 |
| 50.000 kΩ | 0.001 kΩ | 0.05 % + 2 |
| 500.00 kΩ | 0.01 kΩ | 0.05 % + 2 |
| 5.0000 MΩ | 0.0001 MΩ | 0.15 % + 4 |
| 5.000 MΩ up to 32.000 MΩ | 0.001 MΩ | 1.0 % + 4 |
| 32.0 MΩ up to 50.0 MΩ | 0.1 MΩ | 3.0 % + 2 |
| 50.0 MΩ up to 100.0 MΩ | 0.1 MΩ | 3.0 % + 2 |
| 100.0 MΩ up to 500.0 MΩ | 0.1 MΩ | 10.0 % + 2 |

**Table 1: Range of accuracy readings from a FLUKE 187 as described in the user manual**

Question 2 – “Within what accuracy will the instrument measure a DC signal of 100 mV?”

Using the user manual and equation 2, the reading will be 0.1 ± 0.2V since the reading only had a single digit of precision.

Question 3 – “Within what accuracy will the instrument measure an AC signal of 100 mV at a frequency of 100 Hz?”

Again, using the user manual and equation 2, the reading will be 0.1 ± 4V since it only had a single digit of precision when read.

Question 4 – “Within what accuracy will the instrument measure a resistance of 1000 ohms?”

The accuracy was calculated using equation 2 and the user manual with a result of 1000 ± 3 Ω. This reading again only had a single digit of precision, thus the accuracy is rounded up from 2.5 Ω to 3 Ω.

**1.2**

Question – “How much current were you drawing from the battery in #1.2?”

In order to calculate the current drawing from the battery, the impedance in the multimeter needs to be known as well as equations 1 and 2. With a volt reading of 1.4006 ± 0.01025 V, the drawing current is found to be 1.4 x 10-7 ± 0.010 Amps.

**1.3**

Question – “Turn the ‘Auto Range” off. Note what happens when the voltage exceeds 5V.”

Following the instructions in the lab manual, the multimeter displays an “overload” message

**1.4**

Question – “What is the range of fine voltage control for the power supply?”

Using equation 2 and measurement results collected from the multimeter, a range of 0.0006 ± 0.01000V to 2.9325 ± 0.01073V was obtained.

**1.5**

Question – “Are all of the resistors within the tolerance indicated by the color code?“

Comparing the measurements and calculated uncertainty (using equation 2) with the resistor color codes, the following was found:

|  |  |  |
| --- | --- | --- |
| **Identified resistor** | **Measured resistance** | **Within tolerance?** |
| 100Ω ± 5% | 107.46 ± 10.05 Ω | Yes, because of the measured uncertainty |
| 1 kΩ ± 10% | 1.0023 ± 0.0007 kΩ | Yes |
| 10 kΩ ± 10% | 10.048 ± 0.007kΩ | Yes |
| 100 kΩ ± 10% | 105.98 ± 0.07kΩ | Yes |
| 1 MΩ ± 10% | 1.0112 ± 0.0031MΩ | Yes |

**Table 2: Resistor tolerance measurements**

**Section 2: Function Generator**

The Function Generator is tested next by measuring the required outputs and following the lab instructions.

**2.1**

Question – “Determine the maximum output voltage available from the function generator by using the multimeter. How does this compare with the maximum value stated in the manual?”

The voltage measured with the multimeter was 7.489 ± 0.0112V compared to the 10 volts specified in the function generator’s user manual. The difference comes from the multimeter outputs the RMS voltage while the user manual gives the peak-to-peak voltage.

**2.2**

Question – “Switch the function generator to 10 Hz, then to 1 Hz, then to 0.2 Hz, leaving the output level fixed. What did you find?”

The three voltages found were 7.313 ± 0.095V, 3.141 ± 0.086V, and 0.098 ± 0.080V. When the measurements were taken, they were very unstable and varied quite a bit from reading to reading. This is because the multimeter is looking at the RMS value and the frequency is too low and outside of the window that is being measured.

**Section 3: Oscilloscope**

To test the Oscilloscope, the first six instructions in the lab manual need to be followed to setup the test. Once this is complete, the following questions can be answered:

**3.3**

Question – “How does the measured p-p voltage compare with the value measured on the multimeter? Explain the difference.”

The measured voltage was 2.88 V, which was different from the 0.9834 ± 0.0001 V measured from the multimeter. The difference seems to come partially from the fact that the oscilloscope is measuring peak-to-peak voltage and the multimeter is measuring the RMS of the positive side of the waveform.

**3.4**

Question – “Measure delta T for one cycle and calculate signal frequency. How does this compare with the frequency indicated on the function generator dial?”

The measured time between wave peaks was 9.600 ms which is, by definition, 104.16 Hz. Comparing this to the frequency indicated on the function generator dial, which was 104.2 Hz, this shows that the two are very closely related. The oscilloscope may even use a similar method to calculate the frequency.

**3.5**

Question – “What happen to the display when switching the SLOPE to negative?”

It can be seen that the phase of the signal is shifted by π.

**CONCLUSIONS**

The conclusions drawn from this experiment are to understand the tools needed to accurately measure the required signals and to know exactly what implicit data is being displayed to the user. The multimeter, for instance, only displays AC voltage as an RMS value, which if reading the value without knowing context, this could be interpreted wrong. Also knowing the range at which each tool is capable of displaying data is important.

**BIBLIOGRAPHY**

RAVI-CHANDAR, Krishnaswamy. *Lab #1: Introduction to Electronic Instrumentation*. Rep. no. 1. N.p.: n.p., n.d. Print.