Electronic Measurements

Idea to remember

As electric flow can't be detected with the naked eye, electronic measuring instruments are used as fetal tools to have more insights into the electronic flow.

Objective

This experiment is designed as training for you to become more familiar with the types of measurements that can be made using the digital oscilloscope and a digital multimeter, two of the most versatile electronic instruments.

Materials

1. Large aluminum component box
2. Rheostat
3. Pasco 850 Interface
4. Fluke digital multimeter
5. Banana-to-banana wires
6. Alligator clips
7. Alligator-to-alligator wires

Concept

Measurement of electrical parameters like current and voltage are crucial in the field of measurement. Frequency indicates the state of rhythmic behavior of signal and proper change in the system with respect to time. Electronic measuring instruments are widely used for measuring the electrical charge quantity and amount of flow of electricity through different electronic elements. As electric flow can't be detected with the naked eye, electronic measuring instruments are used to check the flow of electricity. These instruments are important to understand the nature and voltage of electric charges flowing in any electronic device, electronic circuits, and electronic elements, including resistors, inductors, capacitors, and diodes.
In this lab, you will learn how to use two of the most frequently used to study electronic circuits, which are: The digital multimeter and the digital oscilloscope.

The digital oscilloscope:

In general, the oscilloscope is an instrument that graphically displays electrical signals and shows how those signals change over time. Scopes are often used when designing, manufacturing or repairing electronic equipment. Engineers use an oscilloscope to measure electrical phenomena and solve measurement challenges quickly and accurately to verify their designs or confirm that a sensor is working properly.

A Cathode Ray Oscilloscope (CRO) and a Digital Storage Oscilloscope (DSO) are two types of oscilloscopes used to measure and display electrical signals. The main difference is that a CRO uses a CRO to display electrical signals, while a DSO uses digital technology to store and display signals. In this lab, you will learn how to use the digital oscilloscope, which is integrated into the Pasco Capstone 850 interface as shown in the Figure (Add figure)

The Pasco 850 Interface.

As you can see from fig (Add figure of Pasco). The arrow on the left indicates the portion of the Interface that will serve as the oscilloscope; in this case we'll use Analog Channels A and B. The arrow on the right indicates the portion of the Interface that will serve as the signal generator ("OUTPUT 1").

Why do we need the signal generator?

It generates simple repetitive waveforms of varying magnitudes and frequencies. It uses a signal generator circuit and an electronic oscillator to generate signals, which act as stimuli for testing and designing purposes.

The digital multimeter:

The multimeter is a device used to measure various electrical parameters, including resistance, capacitance, and inductance. digital multimeter provides a high-precision measurement for the electrical parameters in under a particular range with a specified resolution.

What you need to test and measure?

The electronic elements you will be tested in this lab are the resistor, and diode which are integrated in large aluminum component box and the rheostat which is a variable resistor.

In this lab, you are dealing with alternating current and voltage. This kind of voltage can be visualized in the sinusoidal waveform (sine wave). See Figs (1a, and 1b). Some of the properties related to the sinusoidal voltage wavefunction can be measured as follows:

The time required for a given sine wave to complete one full cycle is called the period (T) in seconds. There is two different ways to measure the period from the graph.

1. The time difference between two successive peaks, as shown in Fig. (1a)

$$T = t_2 - t_1$$

2. The time required for a given sine wave to complete one full cycle as shown in Fig (1b)

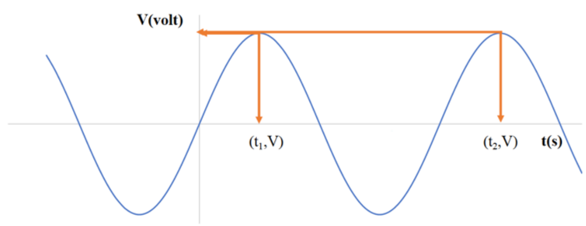


Figure (1a)

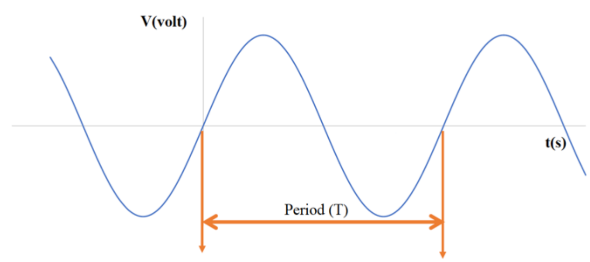
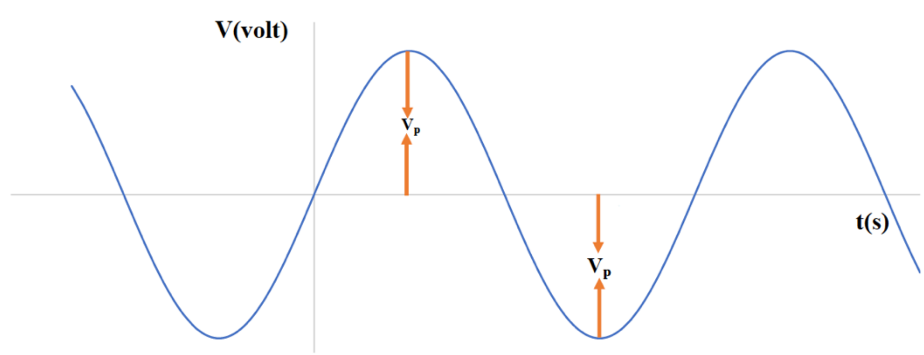


Figure (1b)

Frequency is the number of cycles that a sine wave completes in one second. The Unit is the hertz (Hz). And is given by

$$f = \frac{1}{T}$$

The voltage Peak (V_p)value of a sine wave is the value of voltage at the positive or the negative maximum (peaks) with respect to zero. Since positive and negative peak values are equal in magnitude, a sine wave is characterized by a single peak value, also known as the wave amplitude.



The peak-to-peak value of a sine wave is the voltage (or current) from the positive peak to the negative peak.

$$V_{pp} = 2\,V_p$$

The rms value (root mean square) V_{rms}, also referred to as the effective value, of a sinusoidal voltage, is actually a measure of the heating effect of the sine wave.

$$\boldsymbol{V_{rms} = 0.70\,V_p}$$

Real-World Application:

1. A digital multimeter is an incredible tool, capable of troubleshooting nearly every electrical system and fault in existence at a low cost. It can be used by ordinary people, engineers, or technicians working on any kind of electrical system.

2. Oscilloscopes are widely used by professionals such as automotive mechanics, medical researchers, television repair technicians, and physicists.

Procedure

As we mentioned previously, this lab is just a training session for you to get familiar with how to use the previously mentioned instrument and how to graph and display the data. Part A of this lab will lead you in your learning on how to use the oscilloscope and part B, will do the same but using the DMM. For this purpose, you will do some measurements. You might find the steps are lengthy. However, they are easy to follow.

Part A- using the digital Oscilloscope:

The procedure should begin with the following steps:

1. ☐ Set up the 850 Pasco interface to function as Oscilloscope using the following steps
    I. Connect the analog voltage probes to Channel A of the Pasco 850 Interface (if they aren't already connected); the connector types should serve as a clue how to connect them.

    II. Connect the other end of the voltage probe in Channel A to Output 1 (black to ground, red to sine-wave representation). See the picture (add photo)

    III. Open the Pasco Capstone program on your computer desktop. On the "Tools" windows panel on the left side of the screen, click on "Hardware Setup".

IV. Click on analog input A on the interface and select “Voltage Sensor” from the drop-down. Repeat this for analog input B.

V. On the diagram of the interface, click the yellow circle over the signal generator, then select **Output Voltage Sensor** from the menu.

VI. On the “Tools” window panel, click on “Signal Generator”, and a “Signal Generator” window panel will open.

VII. On this panel, click on “850 Output 1” and change the waveform to “Sine”, which should be selected by default, then set the Frequency to 100 Hz.

VIII. Set the voltage (“Amplitude”) to 5V, then click “On” to turn on the signal generator.

2. ☐ Next, you need to display the signal from the signal generator on your computer. To do that,

I. In the “Displays” window panel on the right side of your screen, double-click “Scope.”
II. The goal here is to monitor the voltage across channels A and B simultaneously (on the same scope). Click on it to add a new y-axis to your scope display. (A “Select Measurement” button will pop up on the right side of your scope.)
III. Click on “Select Measurement” on the left of your scope and choose “Voltage, Ch A V.”
IV. Repeat this for the right side of your scope, selecting “Voltage, Ch B” this time around.

3. ☐ On the "Controls" window panel at the bottom of your screen, change the sampling mode to "Fast Monitor,” then click “Monitor.”

4. ☐ You need to check the following point before start analyze the data

I. If you’ve done this correctly, you should see a sine wave on the graph. You’re viewing the signal generated by the signal generator function of the Interface.
II. The graph’s key (or legend) indicates which curve is which.
III. Click on the scale to fit icon  to scale the voltage axis to the best fit automatically.

IV. Use the coordinates tool to determine the coordinates of a single data point. Use the delta tool to determine the difference between two data points.
V. (Add the step related to Sig.figs(t))

5. ☐ Now use the graph you generate to measure and answer Q1 from the worksheet.

In the next step, You need to build a half-wave Rectifier circuit. A half-wave rectifier converts an AC signal to DC by passing either the negative or positive half-cycle of the waveform and blocking the other. Half-wave rectifiers can be easily constructed using only one diode, a resistor.

6. ☐ Using the circuit components in the large aluminum box, make a simple circuit with a 10 kΩ resistor in series with a diode and signal generator, as shown in Figure (add photo).

7. ☐ Use Ch A to monitor the voltage signal from the signal generator. Use ChB to monitor the voltage across the resistor, as shown in (add photo)

8. ☐ Set the frequency of the signal generator to 200Hz.

9. ☐ Measure the V_p using the oscilloscope across the resistor

10. ☐ Using the measurement from the previous step, answer Q2- Q4 from the worksheet.

Part B: Digital Multimeter (DMM):

For this part, you will use the DMM to measure different. electrical factors as follows:

First: Use DMM as Ohmmeter

1. ☐ Set the meter to ohms (Ω). (Be sure not to overlook the prefix k for kilo-ohms or M for mega-ohms.) (Add photo)

2. ☐ Use the ohmmeter to First measure the resistance wire-wound rheostat by connecting to one end and the terminal on the upper bar. (add photo)

3. ☐ using your measurement from the previous step, answer Q5

4. ☐ move the sliding contact at different Lengths (L) as indicated in Table 1 of the worksheet and measure and record the resistance at each one of these lengths by answering Q6.

5. ☐ What is the effect of moving the sliding contact. Use your observation to answer Q7.

6. ☐ Now use the DMM to measure the resistance of the Oscilloscope ChA lead input. You need to have the signal generator unplugged.

7. ☐ Connect the ChA led to the ohmmeter as you can see from the photo(addphoto).

8. ☐ Record your measurement in Table 2 of the worksheet.

9. ☐ Repeat steps 7-8 using ChB

10. ☐ It's also interesting to measure your body's resistance. Gently hold the metal part of one ohmmeter lead in each hand. Read and record the meter by answering Q9.

11. ☐ What happens when you squeeze more tightly (or you make your hand wet using a little amount of the tap water. Ask your TA for help)? What change occurs when you wet your fingers and squeeze tightly? Read and record the meter by answering Q9.

Second: AC Voltmeter:

1. ☐ Now set the DMM for AC volts (V~).

2. ☐ Set the frequency of the signal generator to 500 Hz sine wave and the amplitude to 5 V.

3. ☐ Using either Ch A or ChB, connect the signal generator, the oscilloscope, and the DDM, as you can see from the photo (add photo).

4. ☐ Now, using this setup, answer Q10-Q12.

5. ☐ keep the same setup of the last step and investigate the frequency response of the meter via the following.

    a. Starting with low frequencies, use the oscilloscope and the signal generator amplitude control to keep the peak-to-peak voltage constant.
    b. Measure the voltage reading (V_{rms}) from the voltmeter.
    c. Increase the frequency.
    d. Repeat steps a-c for several frequencies spanning a reasonable range, as shown in the table of the worksheet.

If the voltmeter responds ideally, it will read the same at all frequencies. Based on your observations, what is the highest frequency at which you have confidence in this meter?

Experiment Sheet for Electronic Measurements

Q1: Using the graph you generated in part A, you were supposed to measure the period of your signal. Look back at the concept and the procedure in the lab manual if you need more help.

a. What did you get for your period? ____________________

b. What frequency would this correspond to? _______________

c. What did you get for the peak-to-peak voltage? ______________

d. What amplitude did this give you? __________________

Q2: When you wired the diode and resistor, what was the maximum current (I = V/R, use the amplitude of the voltage for V)?

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Q3: Roughly sketch what your voltage looks like with and without the diode in the space below.

Q4: Based on your observations from number 5, what do you think a diode does?

Part B: Digital Multimeter (DMM):

Q5: Were your Ohmmeter readings close to the numbers printed on the rheostat? ______

Q6: What resistance do you measure for each of the following resistor length

L	0	L/4	L/2	3L/4	L
R					

Table (1)

Q7: what is the relationship between the resistor length and the resistance?

Q8: The resistance of Oscilloscope led input

R	Ch A	Ch B

Table (2)

Q9: The resistance of your body

R	Dry	Wet

Table (3)

Q10: When you were measuring AC-voltage, what did your voltmeter measure? _____________

Q11: What did your O-scope show the voltage amplitude (V_p) to be for the same voltage? _________

Q12: When testing the frequency response of your voltmeter, what should the V_{rms} have been (use $V_{rms} = V_p/\sqrt{2}$)? ______________

Please note that An AC voltmeter should read root-mean-square (rms) voltage. Check that your answer from Q10 and Q12 match.

Q13: In the table below, record the values your voltmeter reported as this rms voltage for these different frequencies. Note that for each frequency, you must adjust the signal generator's amplitude setting to maintain a constant amplitude on your O-scope.

f (Hz)	50	200	400	800	1,600	3,200	6,400	12,500	40,000
V_{rms} (V)									

Q14: Around what frequency did your voltmeter become unreliable (when did the voltage that it was reporting become noticeably different from the actual voltage)?

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