Activity 1.2.2

Analog and Digital Signals

Distance Learning Support

Check with your teacher about:

- ☐ Using **Multisim Live** as your Circuit Design Software
- ☐ What work you need to turn in and how to submit it
- ☐ Collaboration strategies

INTRODUCTION

Even though this is a course in digital electronics, it is important to understand that the world around you is analog. Virtually everything that can be designed with digital electronics is used to either control or monitor something in the world around you, and this world is analog. Thus, to be an effective designer of digital electronics, you need to understand the characteristics of both analog and digital signals.

In this activity, you will examine several analog and digital signals to determine their **amplitude**, **period**, and frequency. Additionally, you will gain experience using the **oscilloscope** within the Circuit Design Software (CDS).

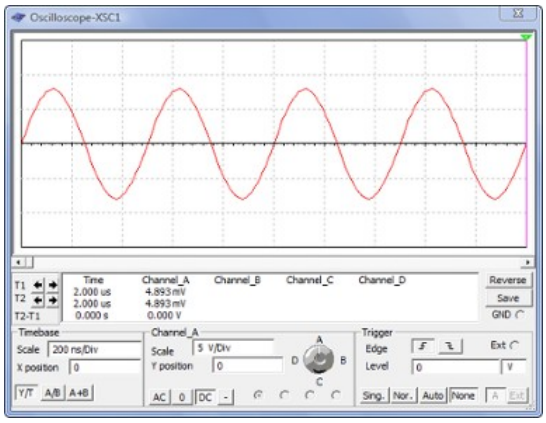


Figure 1. Analog Signal

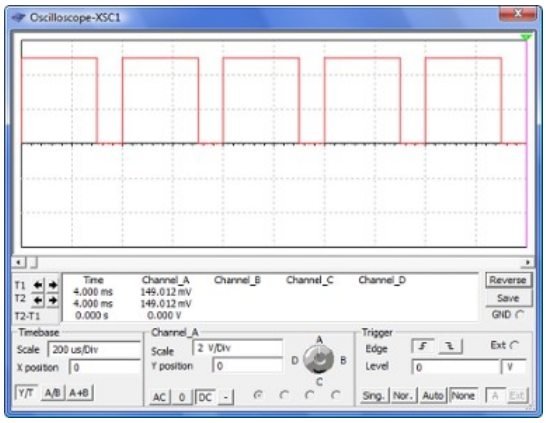


Figure 2. Digital Signal

EQUIPMENT

- Computer with Circuit Design Software (CDS)
- Calculator

RESOURCES

Analog Digital Signals presentation

Procedure

Presentation: Review **Analog Digital Signals**

1. For each of the two analog signals shown below, determine their amplitude (peak), amplitude (peak-peak), period (T), and frequency (*f*). Be sure to put your answer in proper engineering notation and use the correct units.

   a. Signal 1.

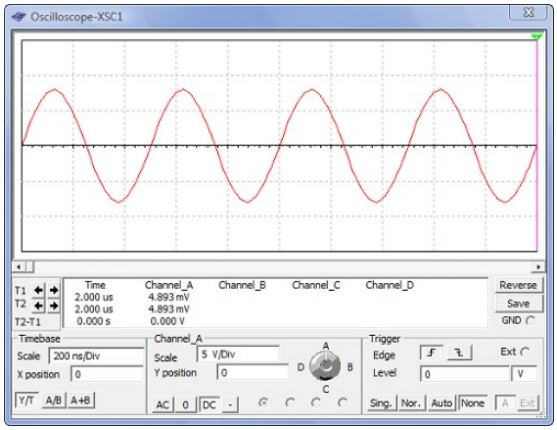


Figure 3. Oscilloscope Signal

Amp(peak): 7.5V

Amp (peak-peak): 15V

Period: 500ns? if the big sectic

Frequency: 2MHz

   b. Signal 2.

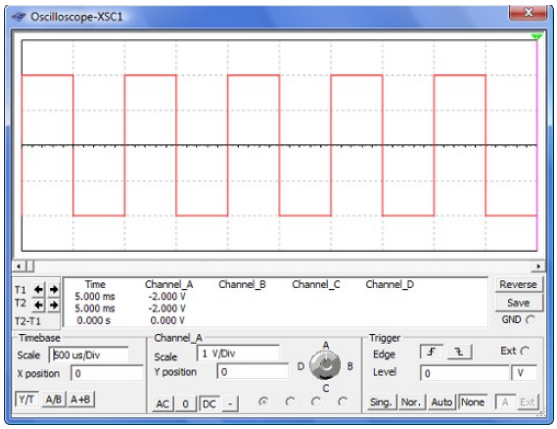


Figure 4. Oscilloscope Signal

Amp(peak): 2V

Amp (peak-peak): 4V

Period:

Frequency

Note: Why is signal 2 **NOT** considered a digital signal?

Hint

2

For each of the two digital signals shown below, determine the amplitude, period (T), frequency (*f*), time high (t_H), time low (t_L), and **duty cycle** (DC). Be sure to put your answer in proper engineering notation and use the correct units.

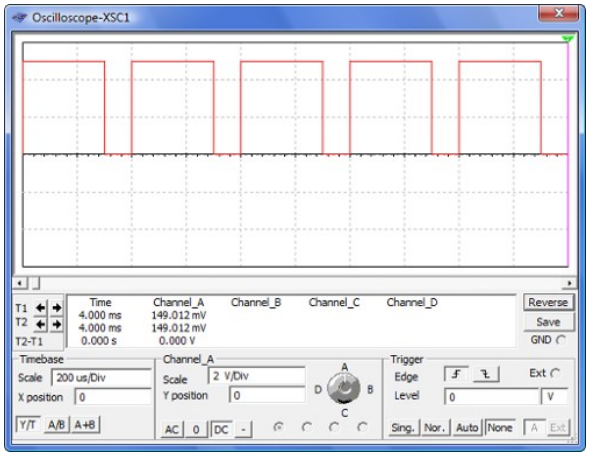


Figure 5. Oscilloscope Signal

Amplitude: 4.5V

Period: 400ns

Frequency 2.5MHz

Time High: 300ns

Time Low: 100ns

Duty Cycle: 75%

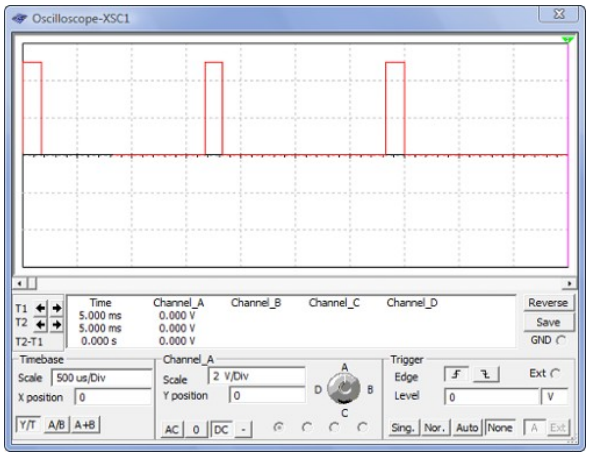


Figure 6. Oscilloscope Signal

Amplitude:	4.5V
Period:	1700us
Frequency:	588Hz
Time High:	200us
Time Low:	1500us
Duty Cycle:	11.74%

3 Using CDS, enter the test circuit shown below. This circuit consists of a CLOCK_VOLTAGE, a DC_POWER (battery), and two 5 V LAMPS. This circuit doesn't do much of anything useful other than make the two lamps flash, but you will use it to gain experience in using the oscilloscope to measure signals.

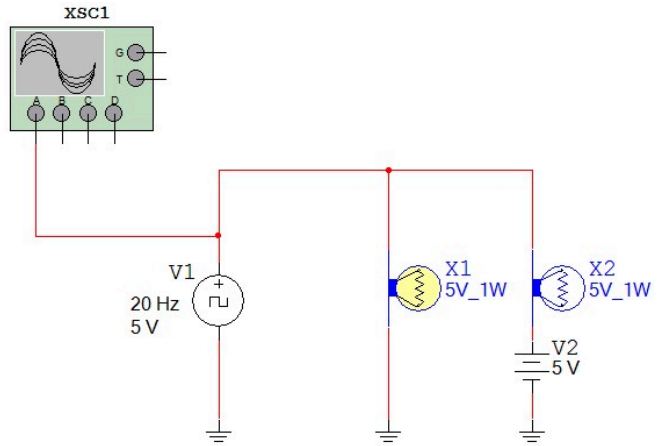


Figure 7. CDS Circuit

Distance Learning Support

Use **Multisim Live** to create your circuit.

- A **Lamp** can be found in the **Indicators** subpalette. By default, lamps have a maximum voltage of 12 V and a maximum power of 10 W so change these values to 5 V and 1 W, respectively.
- The **Clock Voltage** is in the **Sources** subpalette. Set its values as described in sub-step (a) below.
- Add a **Voltage** component (**Analysis** subpalette) to your circuit as shown.

Show circuit

a. Open the CLOCK_VOLTAGE component by double-clicking on it and set the frequency, duty cycle, and voltage to 20 **Hz**, 10%, and 5 V.
b. Open the DC_POWER and set the voltage to 5 V.

Distance Learning Support

Skip this step (b).

c. Connect the OSCILLOSCOPE to the positive side of the CLOCK_VOLTAGE component.

Distance Learning Support

Skip this step (c).

d. Start the simulation. Are the lamps flashing? Does the flashing rate make sense for the frequency and duty cycle of the CLOCK_VOLTAGE? If not, review your setup and

make any necessary corrections.

Distance Learning Support

In place of the oscilloscope, select the **Split** button at the top of the screen to observe the Grapher in split-screen mode. You can also view the Grapher in fullscreen mode using the **Grapher** button.

Figure 8. Grapher

e. Now that the circuit is working, use the oscilloscope to measure the signal being generated by the CLOCK_VOLTAGE. Use the markers to measure the period, time high, and time low. Use this data to calculate the frequency and duty cycle of the signal.

Distance Learning Support

Customize your Grapher in Multisim Live to view the signal output. Important: The simulation must be running to make these changes.

- Select the **Grapher** and if necessary, open its configuration pane.
- Expand the **Axes** drop-down menu and change the scale of the Y axis: change **Voltage** Minimum to 0 and Maximum to 6.
- In the **Axes** drop-down menu, change the scale of the X axis: Change **Time/Div** using the arrow buttons until you can see multiple signals.

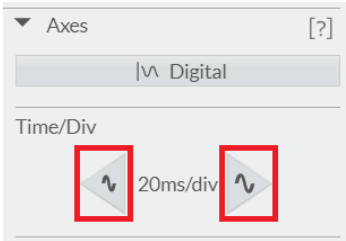


Figure 9. Axes Dropdown

- Expand the Cursors drop-down menu. Under **Type**, select **X Axis**. Two movable markers appear with their values shown below the graph.
- Stop the simulation.
- Move the cursors to the rising edges of two consecutive signals and note the ΔX value below the graph for the period.
- Move the C2 cursor to the falling edge of the first signal and note ΔX values below for the duty cycle.

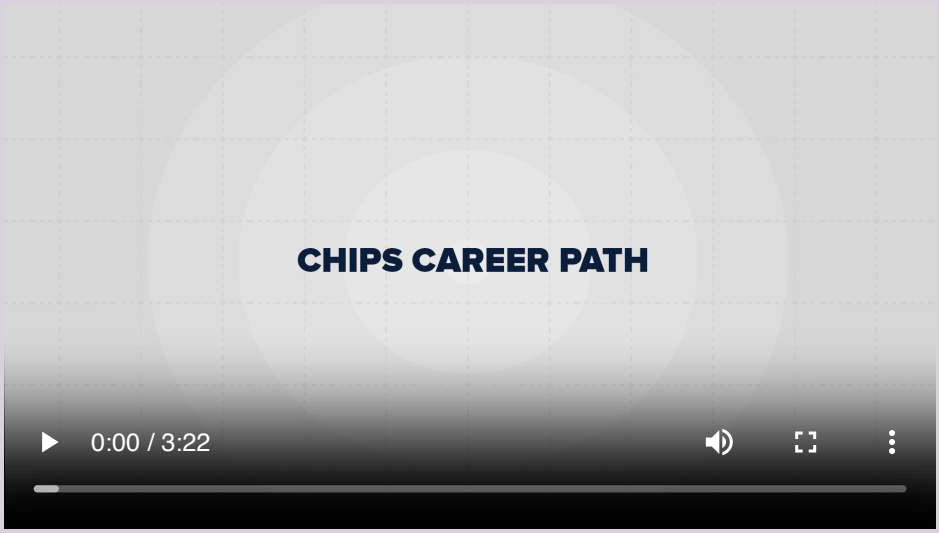
f. Do the measured (and calculated) values match those set up in the CLOCK_VOLTAGE device? If not, review your measurements and make any necessary corrections.

CHIPS and Science Act of 2022

Ever wonder what it might be like to work in the semiconductor industry? As an engineer, what does a typical day look like? What problems are you trying to solve? Who works with you?

What about a semiconductor technician? How do they work together with engineers to solve problems? What is their day-to-day work like?

View the Chips Career Paths video to learn more about these careers.



Chips Career Paths video

Reflection Question: What resonates with you most about Julia and Jeremy's workdays? To what extent do either of these seem like viable careers for you?

CONCLUSION

1. List the characteristic that makes a digital signal different from an analog signal.

2. In the diagram shown, label the parts of the analog signal.

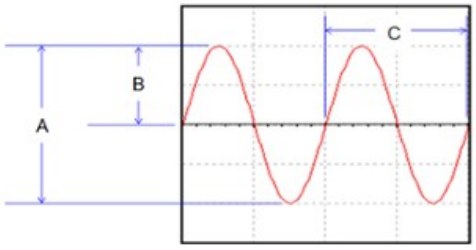


Figure 10. Analog Signal

3. In the diagram shown, label the parts of the digital signal.

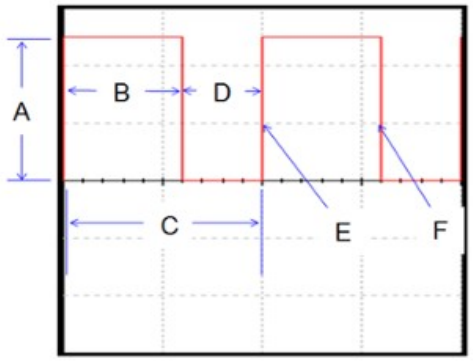


Figure 11. Digital Signal

4. What are the two standard voltage levels that are acceptable for a digital signal?

Proceed to next activity