

Experiment 6: The Oscillator Circuit

Laboratory Outline:

Now that we have conquered basic use of the oscilloscope and function generator, we'll build and analyze a time-varying circuit that oscillates periodically. While analyzing this oscillator, we'll employ methods that are necessary for analyzing any periodic voltages.

Learning Objectives

- Control the input/output voltage response of an inverter to understand its functionality.
- Use the inverter, a capacitor, and a feedback resistor to create a square-wave oscillator.
- Measure the frequency, amplitude, and offset of the square-wave using the oscilloscope.
- Validate the formula for frequency using the measurement.
- Use the flex sensor to create an oscillator with a frequency controlled by the user.
- **Explore More! The Relaxation Oscillator** is highly recommended as a follow-up to this lab!

Name/NetID:

Teammate/NetID:

Section AB/BB:

0 1 2 3 4 5 6 7

8 9 A B C D E F

(circle one)

Build your Own Oscillator Circuit

For this lab you will build a simple circuit using a resistor, capacitor and inverter as shown in the diagram below. Detailed instructions will follow on the next page...

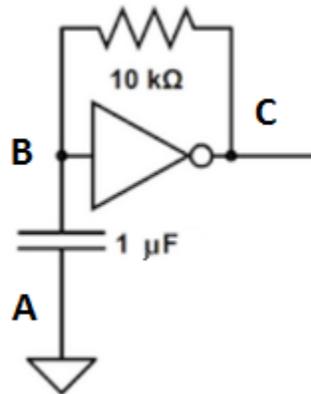


Figure 1: Circuit schematic of a simple oscillator.

Since this is our first encounter with integrated circuits (ICs) in the lab, we'll be guided through the construction of this circuit in a much more detailed manner than usual. Let's begin by examining the behavior of the inverter chip – you should already have an idea of how it works based on your examination of the datasheet.

Notes:

The triangle with a circle on one vertex  is the common symbol for (logic) voltage inverter.

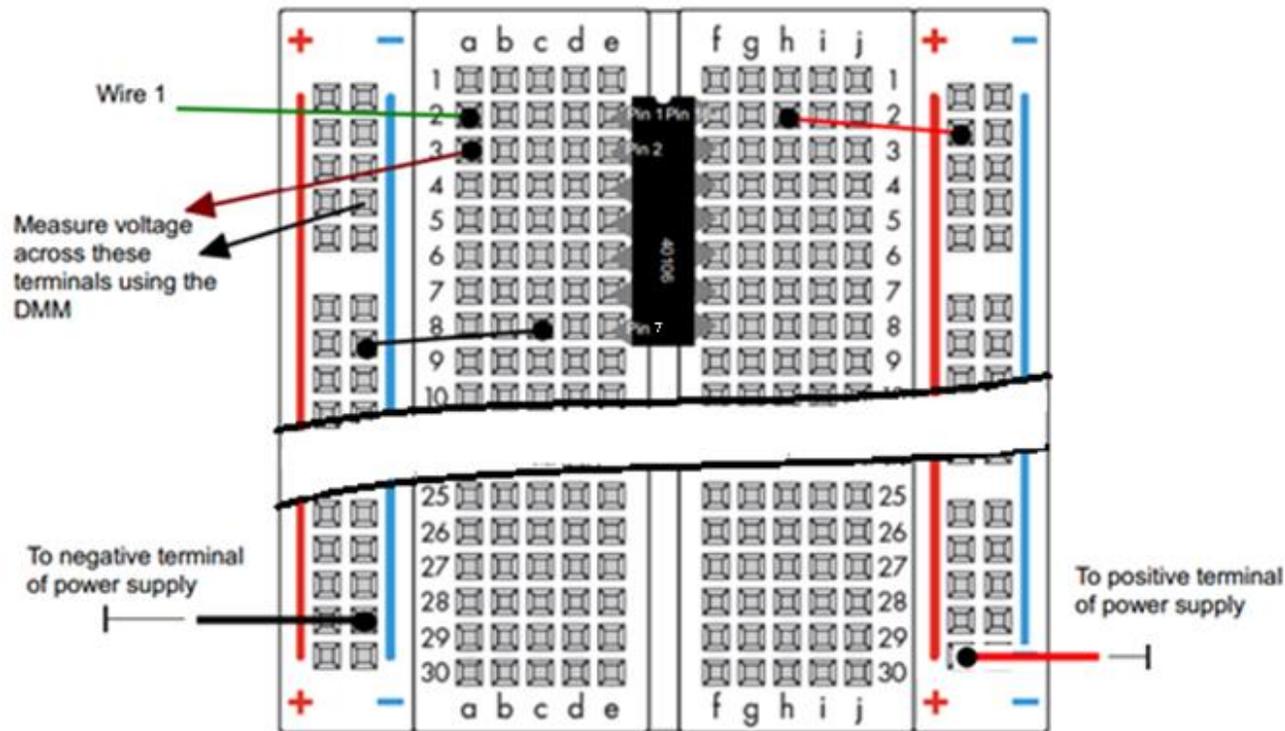


Figure 2: Physical diagram for the testing of an inverter chip.

Set up and test the inverter chip.

- ✓ Build the circuit shown in Figure 2 but do **not** connect to the power supply yet.
- ✓ Set the power supply to 5V and turn the OUTPUT OFF.
- ✓ Connect cables to the + and – terminal of the power supply to the breadboard and turn the power supply OUTPUT ON.

Question 1: Using wire 1, connect pin 1 of the HEF40106B chip to 5 V. This pin the input of the inverter. Using the DMM measure the voltage at the output of the inverter (relative to ground) and record the value and record it

here.

Hint: Use the datasheet if you aren't sure which pin is the output of the inverter.

Question 2: Disconnect pin 1 from 5 V and connect it 0 V and measure the voltage at the output. Record it here.

A binary digital circuit is one that uses only two voltage values at any point in the circuit. For the purposes of this lab course, we'll only use binary digital circuits that use either 5 V or 0 V (sometimes 3.3 V is used instead of 5 V but we won't deal with this in ECE 110 Lab). These voltages are then used to represent logical values of TRUE (5 V) and FALSE (0 V).

Question 3: Based on your measurements, what does an inverter do in terms of a logical operation?

Notes:

Capacitors often provide three or more numbers to indicate the capacitance in picoFarads (pF). The first digits are precision while the last digit represents a power of 10. For example, 105 means a capacitance of 10×10^5 pF or, equivalently, $1.0 \mu F$.

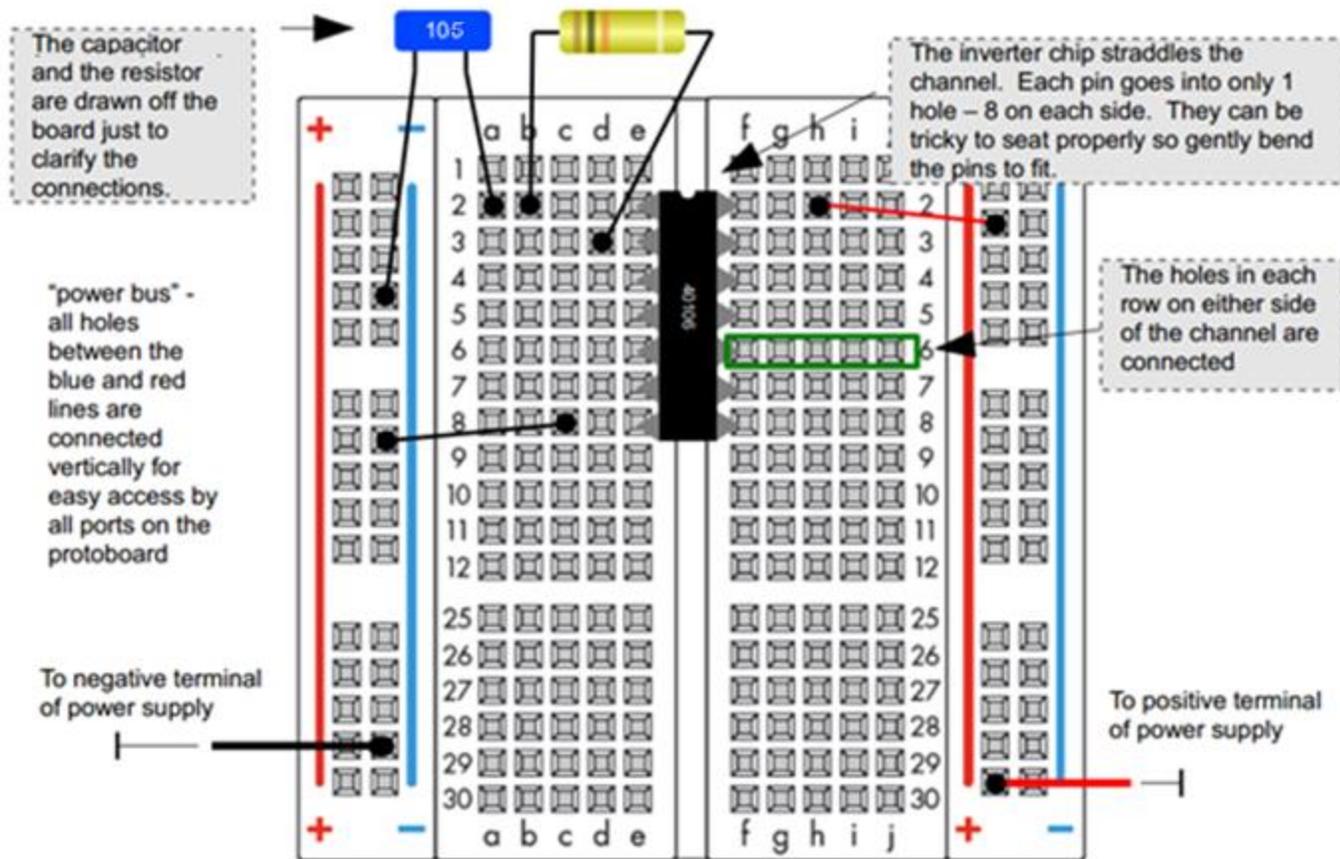


Figure 3: Physical diagram of a prototype oscillator circuit.

- ✓ Turn the output of the power supply OFF.
- ✓ Construct circuit shown in **Figure** (the circuit schematic is in Figure 1).
- ✓ Turn the output of the power supply ON.

Question 4: Indicate on the physical diagram above, the nodes labeled A, B, and C in the schematic below.

Question 5: The triangle with a circle on one vertex  is the common symbol for inverter and the two parallel plates represent a capacitor of 1 microFarad. Label the nodes that correspond to pin 1 and pin 2 of the IC on the schematic below.

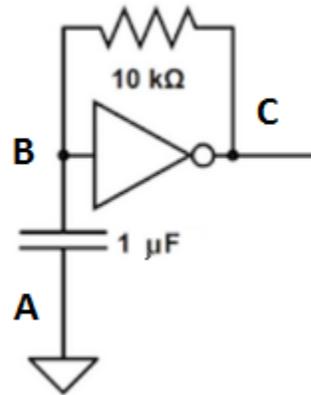


Figure 4: Circuit schematic of a simple oscillator.

Question 6: Probe the voltage across nodes A and C with the oscilloscope and plot the resulting square wave on the graph paper provided (or MATLAB).

Question 7: What are the period, frequency, amplitude, and duty cycle of the signal?

It should now be apparent that the DMM is not capable of capturing all of the circuit's behavior. In future labs we'll explore this circuit further and see how we can modify this circuit's behavior.

Question 8: The oscillating frequency of our oscillator is determined by the equation $f \approx \frac{1}{0.55RC}$ Hz, where R is the resistance in Ohms and C is the capacitance in Farads. Using the resistors and capacitors available, try to modify your oscillator to have a frequency as close to 500 Hz as possible. What choice of R and C did you use? Plot your signal (in MATLAB if available).

Question 9: Replace the $10\text{ k}\Omega$ resistor with the flex sensor from your SparkFun kit. What are the minimum and maximum frequencies that the oscillator can now produce?

Conclusion

The ECE 110 Lab is focused on learning to use sensors and actuators. Last week, we learned how to incorporate a resistive sensor (the flex sensor) into a voltage divider circuit. This week, got a chance to incorporate the flex sensor into the oscillator circuit. As the semester progresses and we learn how to use additional circuit elements, we'll refine this circuit to employ the flex sensor in a more useful way and we'll build a car that uses this circuit to automatically navigate between walls. As always, we continue to learn more about the toolbox of the practicing electronics engineer!

Question 10: Discuss why the oscilloscope is critical to the measurements made in this lab. What information was gathered that the DMM could not (easily) obtain?

What You Learned

You should now understand *how* and *when* to use all the bench equipment in the ECE 110 Lab. Unless an experiment requires a particularly-obscure capability from these devices, all future procedures will assume you understand how to take the necessary measurements using the necessary sources and meters. In addition, you have expanded your knowledge on constructing prototype circuits and will be able to build most circuits required of future experiments.

Explore More!

At the end of each regular lab procedure, as time permits, you will be provided with materials to continue to improve your mastery of the materials. There are many suggested modules (many options) for this week including ***Explore More! The Relaxation Oscillator***, ***Explore More! Build Motor Drive Circuit***, ***Explore More! Using Arduino Digital Outputs***, and ***Explore More! Analog Inputs***. You are to work on these as long as time permits. The modules will be submitted to your TA when finished and a number of them will count in your final grade.

Lab Report Rubric

The following rubric will be provided at the end of each lab procedure. As a final step in preparing your lab report, you may use this rubric to analyze your own performance.

Section	Criterion	Comments:
<i>Experimental Setup and/or Design Description</i>	Circuit Schematics are drawn neatly, accurately, and properly labeled. Decisions regarding experimental setup and design are clearly explained.	
<i>Measurements</i>	Tables include units and proper precision. Any <i>new device</i> introduced should be characterized using measurements!	
<i>Computations</i>	Computations performed on raw data are <i>explicitly</i> described and follow rules for significant figures.	
<i>Analysis</i>	Graphs have title, labels, units, scale, legend; Lines for curve-fitting appear in the graph when needed and parameters like the intercepts and the slope are labeled.	
<i>Modeling</i>	A mathematical model for the curve-fit graph allows for more abstract references to the device's behavior. The expected behavior is explained in the context of the graph.	
<i>Conclusion</i>	Conclusions are drawn from your experimental results to support the reason(s) for completing the experiment. Closes the loop on the Introduction.	
<i>General Formatting</i>	Answers to questions clearly labeled. The overall appearance of the report is professional.	
<i>Self-assessment</i>	This table has been thoughtfully completed.	