COLLEGE OF ENGINEERING
SUNY POLYTECHNIC INSTITUTE

ECE 260

Name:____

Date:____

Laboratory 9 – Wien Bridge Oscillator using an LM741 Op-Amp

Purpose: In this lab, you will learn about and build a Wien Bridge Oscillator Circuit.

Equipment Required

- LM 741 Op Amp
- 10kΩ resistor
- 2 1.5Ω resistors
- 2 10nF ceramic capacitors
- 50kΩ potentionmeter
- Oscilloscope
- MultiSim Live Version is the best to use

Learning Objectives

1. Discuss the use and behavior of a Wein Bridge Oscillator circuit
2. Discuss and measure the Barkhausen Criteria
3. Tune a circuit in order to sustain oscillation

Theory

An oscillator is a circuit that produces an ac waveform as output when powered by a dc input. The power supplied by the power company is a ac signal but it operates at a preset frequency of 60 Hz, whereas many applications, such as electronic circuits, communication systems and microwave devices require internally generated frequencies that range from 0 up to 10 GHz or higher. Oscillators are used for generating these frequencies.

In order for a sine wave oscillator to maintain oscillation, it must meet the Barkhausen Criteria:

- The overall gain of the oscillator must be unity or greater (need an amplifying device)
- The overall phase shift (from input to output and back to the input) must be zero

The Wein Bridge oscillator is used for generating sinusoids in the frequency range below 1MHz. It is an RC op amp circuit with few components. It can be easily tuned and easy to design. It consists of a non-inverting amplifier with two feedback paths: The positive feedback path to the noninverting inputs creates the oscillation and the negative feedback path back to the inverting input controls the gain. See Figure 1.

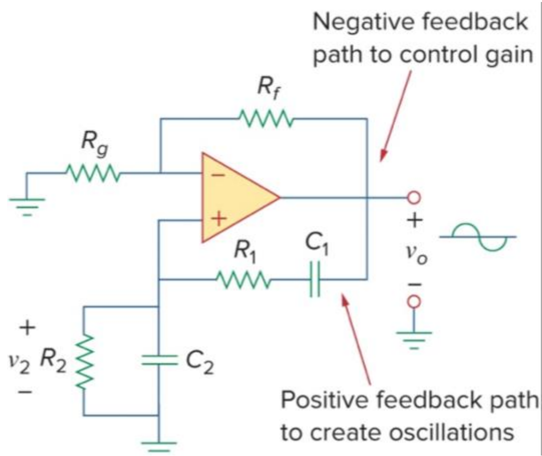


Figure 1

The frequency of oscillation can be determined if we first assume $R_1 = R_2 = R$ and $C_1 = C_2 = C$, then

$$f_0 = \frac{1}{2\pi RC}$$

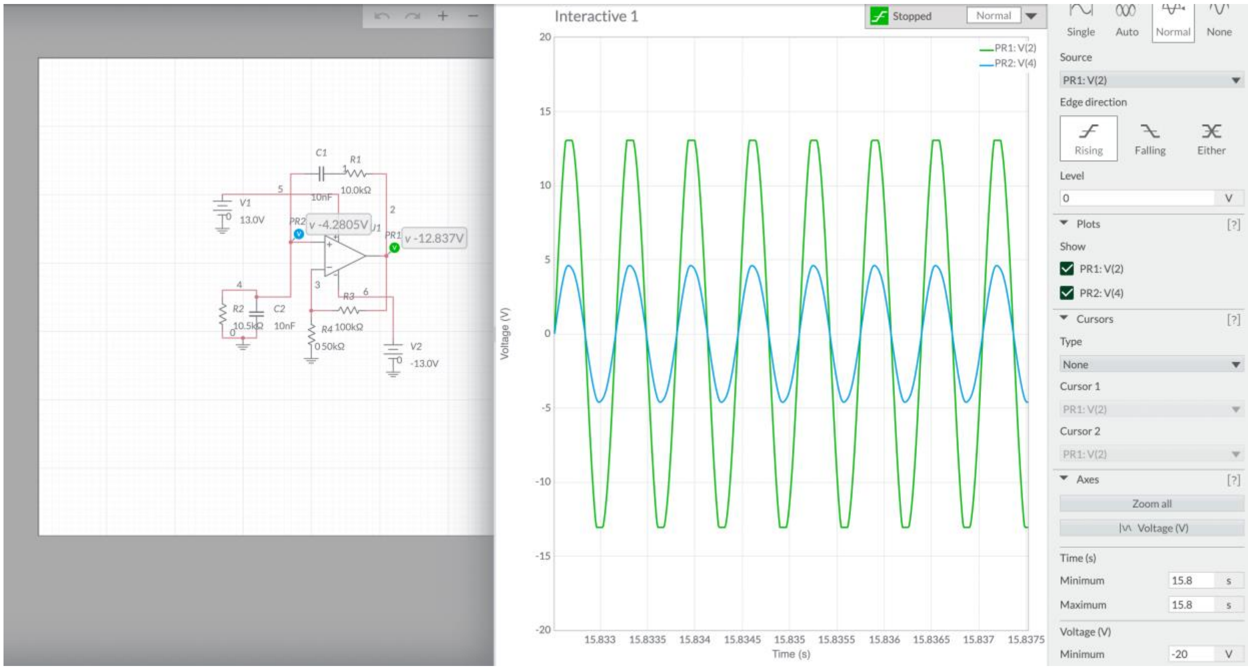
And in order to satisfy the gain constraint

$$R_f = 2R_g$$

Design

Multisim

Build the Wein Bridge oscillator shown below in Multisim. Prove the design can sustain oscillations



Experimental Lab Design

First and foremost, we use $12V_{DC}$ of power for this circuit. Refer to the circuit in Figure 2 for the actual design.

Connect +12V to $+V_{EE}$ (pin 7), and -12V to $-V_{EE}$ (pin 4). This establishes the power necessary for the LM741 chip.

This circuit is made up of several different components, all of which are composed of either resistors, capacitors, or potentiometers.

There are several formulas that we follow in order to get the frequency and gain that we desire for the circuit.

The frequency, $f= 1/2\pi RC$, where $\pi= 3.14$, R is equal to the resistance value, and C is equal to the capacitance values. These are for the R1, C1, R2, and C2 values.

The 2 RC network at the bottom of the circuit diagram determine the frequency of the output sine wave signal.

The 2 resistors should be of the same value and the 2 capacitors should be the same value.

For this circuit, we're going to create a frequency of 10KHz for the output signal.

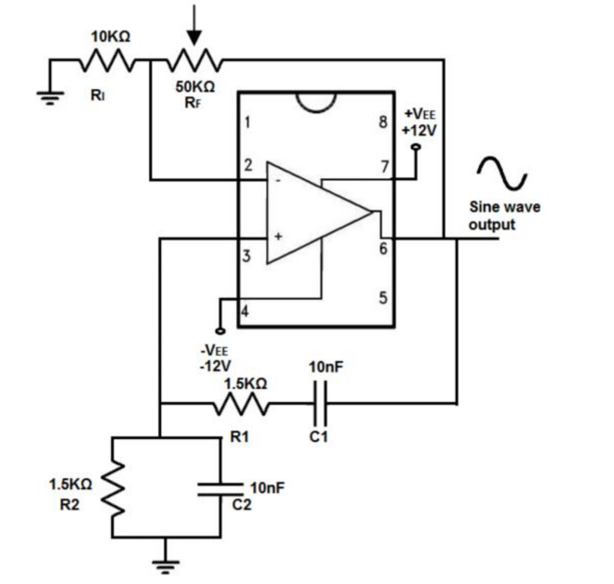


Figure 2

Choose the values of 1.5KΩ for the resistor and 10nF for the capacitor.

This will produce a frequency of:

$$f = 1/2\pi RC = 1/2\pi(1.5K\Omega)(10nF) = 1/2(3.14)(1500)(.00000001) \approx 10{,}615Hz.$$

We can easily play around with values in order to change the frequency of the output signal.

- If we swap out the 10nF capacitor for a 100nF capacitor, we get a frequency of f= 1/2(3.14)(1500)(.0000001)≈ 1061Hz, which is approximately 1KHz.
- If we swap out the capacitor for a 1nF capaictor, we get a frequency of f= 1/2(3.14)(1500)(.000000001)≈ 106,157Hz, which is approximately 100KHz.
- We can also do the same thing for the resistor. If we increase the value of the resistance, the frequency decreases. So if we increase the resistor from 1.5KΩ to 15KΩ while keeping the capacitor value unchanged, this will decrease the frequency by 10. If we change the resistor value to 150KΩ while keeping the capacitor value unchanged, this will decrease the frequency by 100.

Now we can focus on the gain, amplitude of the signal, which is how tall or loud the signal is.

The gain of the circuit is determined by the 2 top resistors, resistors R_F and R_I.

The gain of this circuit is determined by the formula, $A= 1+ R_F/R_I$, where we want $\mathbf{R_F = 2R_I}$.

Since we are using a 10KΩ resistor for R_I, the correct value for R_F is about 20KΩ.

But being that this circuit is so precise and sensitive, it's better to have a ***potentiometer*** in place for adjustment than a fixed resistor. The potentiometer allows you to fine tune the resistance just right so that you can get a good sine wave signal at the output.

If the gain is too low, you will not get a sine wave at all for the output. If the gain is too high, the peaks of sine waves will be clipped and, thus, distorted. The potentiometer has to be adjusted so that there is an undistorted, unclipped sine wave as the output.

To sum up this circuit:

- The op amp chip, in this case, an LM741 is used to create oscillations that are digital in nature, or square in nature.
- The 2 RC networks on the bottom shape these digital waveforms into sine waves and they determine the frequency of the sine wave.
- The RC networks form time constants in the circuit to determine how long one cycle is. The resistor-capacitor determines the time constant of the signal because they control the charge-discharge cycle time of the capacitor. The smaller the resistor and capacitor are, the shorter the time constant and, thus, the greater the frequency. This is because with less resistance, there is less 6mpediment to the flow of current. Thus, a greater amount of current can flow more easily through the circuit. The smaller the capacitor, the less charge it can store, so it takes a shorter period of time for the capacitor to charge up.
- All this equates into a shorter time cycle for the capacitor, which means a greater frequency. Similarly, converse, if the resistor and capacitor value are greater, this creates a longer time constant and shorter frequency. With greater resistance, there is more impedement to the flow of current, so there is less current flow for a given period of time. With a greater capacitor value, the capacitor takes a longer time to charge up. And that's why a longer time cycle exists for the signal and, thus, a shorter frequency.
- Apart from the RC networks, the 2 resistors, R_F and R_I determine the gain of the signal.
- The output sine wave signals appears at pin 6 of the op amp, which is the output pin.\
- Keep in mind again that in order to get an output at pin 6, the potentiometer must be carefully tuned. This circuit is a very precise circuit. If the potentiometer isn't tuned precisely, there either will be no signal at the output or a clipped signal. You have to turn the potentiometer, so that it's just at the right resistance value. If not, you will either get no output or a clipped output that isn't sine wave like. If the resistance falls too low, you will not get no signal output at all. If the resistance goes too high, hte signal will be distorted and clipped. Thus, proper tuning is necessary.

In the lab, we will use an oscilloscope to view the waveform. If you connect the positive lead of the oscilloscope to the output pin (pin 6) and the negative terminal to ground, you should see a sine wave, if the potentiometer is adjusted correctly.

Document and record your results.