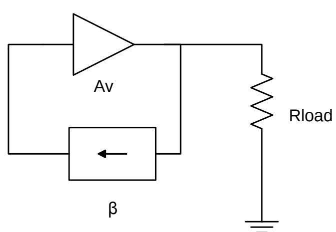
Project – Sinusoidal Oscillator

Objective: This project will demonstrate the basic operation and design of a Wien bridge RC oscillator.

Components: 741 op-amp, 1N4001 diode (2), 2N7000 MOSFET

Introduction: An oscillator is a circuit that converts a dc input to an ac output. This project investigates sinusoidal, output oscillators. Sinusoidal oscillators consist of an amplifier with a positive feedback loop of a frequency selective network. The amplifier can be a transistor amplifier or an operational amplifier. The frequency of the oscillator is determined by the frequency selective network. The criteria for an oscillator to produce sinusoidal oscillations are that the magnitude of the loop gain equal unity and the phase of the loop gain equal zero at the frequency selected for oscillations.



Av = Non-inverting amplifier
β = positive feedback transfer function
I Loop gain I = I (Av)(β) I = 1

An oscillator with a loop gain of exactly unity is unrealizable because of varying component values, parameters, and temperatures. To keep the oscillations from ceasing or increasing, a nonlinear circuit can be used to control the gain and force the loop gain to remain at unity. The Wien bridge oscillator of Figure 2 uses two diodes in the circuit to limit the amplitude of the oscillations.

The Wien bridge oscillator without amplitude stabilization is shown in Figure 1. Wien bridge oscillators are noted for high stability and low distortion. This oscillator will oscillate at the frequency:

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

When:

$$\frac{R_2}{R_1} \geq 2$$

For oscillations to start, the value R_2/R_1 should be made slightly greater than 2. These relations also hold for the Wien bridge oscillator with amplitude stabilization shown in Figure 2.

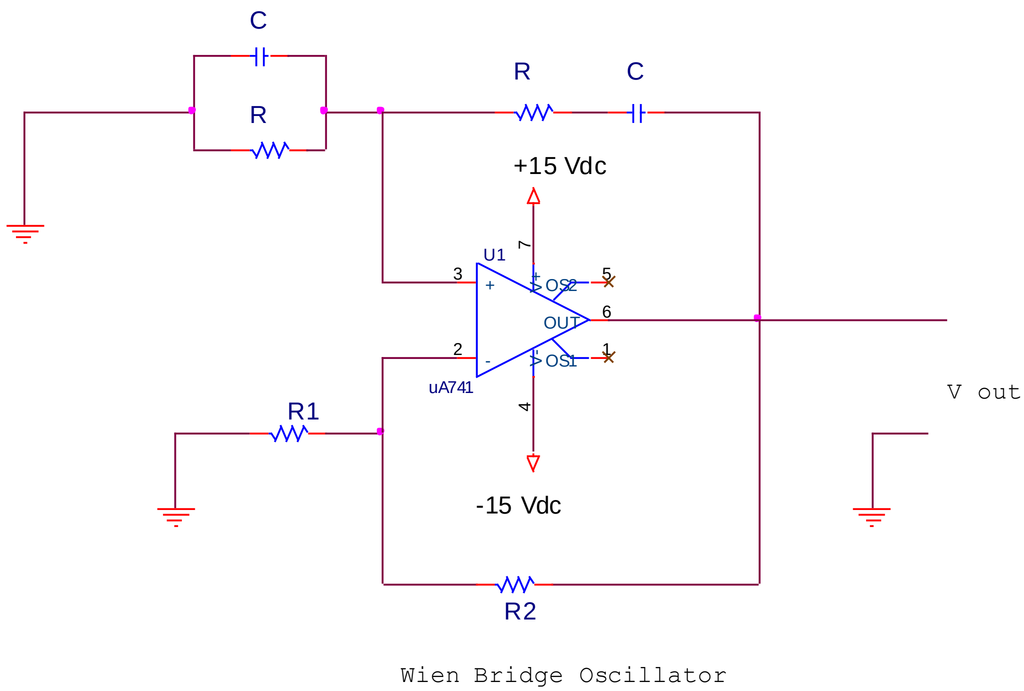


Figure 1: Wien Bridge Oscillator

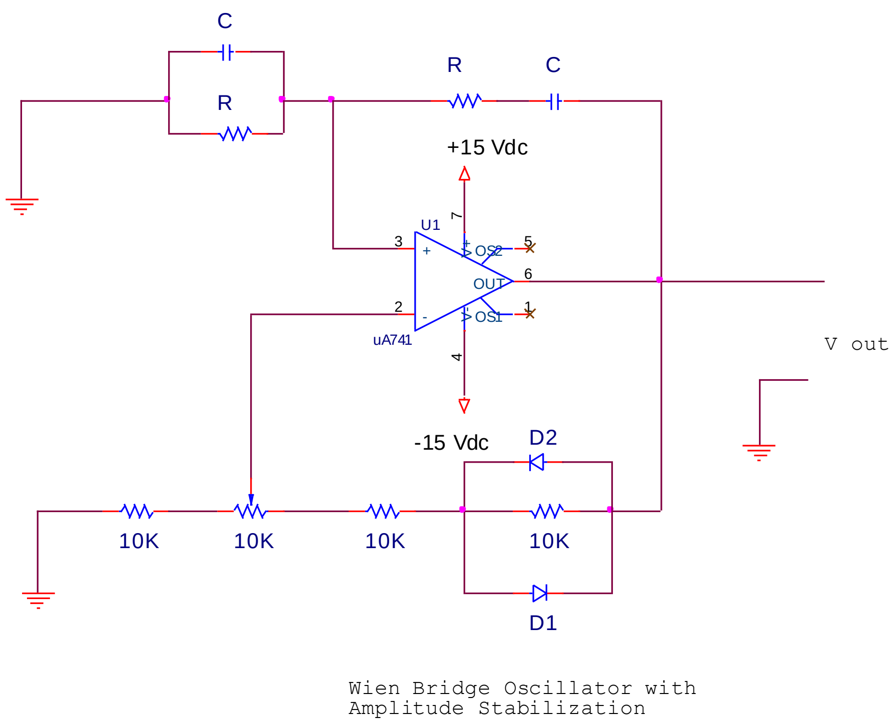


Figure 2: Wien Bridge Oscillator with Amplitude Stabilization

Design and Prelab: Oscillator, show all work, include schematics and calculations.

1. Design the Wien bridge oscillator shown in Figure 1 with an oscillation frequency in the range of 1.8 kHz to 2.2 kHz. Use ±15 V supplies for the op-amp. Verify your design with PSICE®. Use Time domain to plot the output waveform, also use FFT plot to find $f_{0.}$ Include the Pspice output waveform and FFT plot along with the circuit drawing.

2. Write the nodal equations for the oscillator circuit of Figure 1. Derive the equation to determine the oscillation frequency. What is the gain Av of the amplifier required to be so the loop gain $A_V\ \beta = 1$ at the f_o? Where A_V is the gain of the amplifier network and β is the transfer function of the positive feedback network.

3. For the Wien bridge oscillator with amplitude stabilization. How do the diodes in the amplifier negative feedback network stabilize the output? Justify your answers.

Design and Prelab: sawtooth generator.

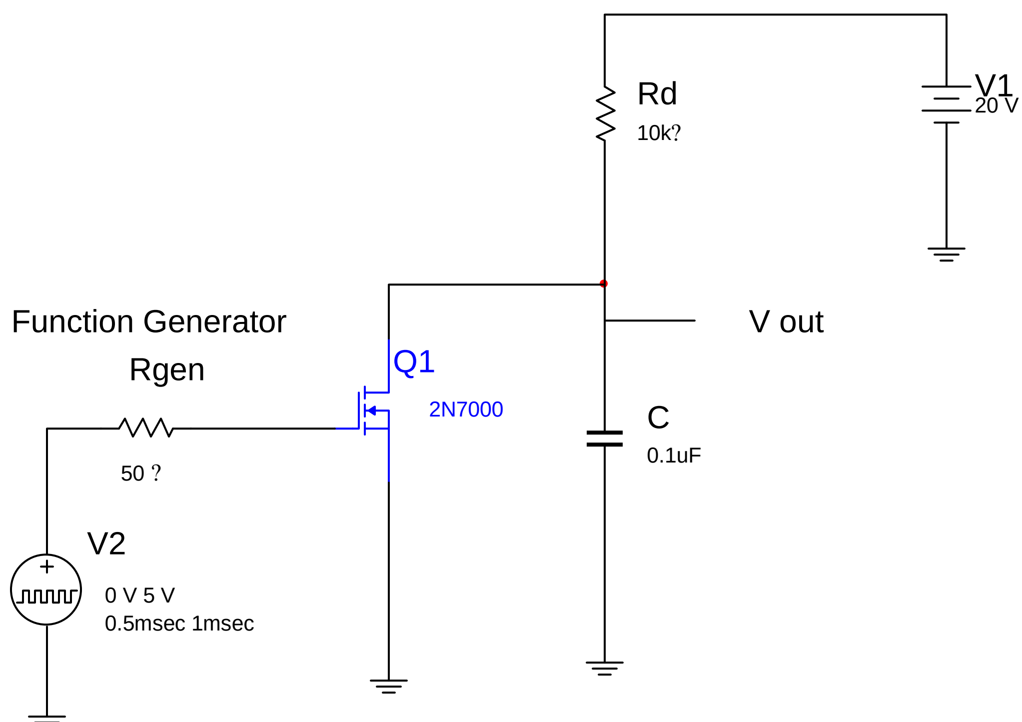


Figure 3: Sawtooth Waveform Generator

4. What effect will the values of C and R in the sawtooth circuit in figure 3 have on the output waveform? Why does this change the output? What affect does the input square have on the output? **Calculate** the time constant, and the voltage that the output will reach in 500uS. Run the circuit in PSPICE. Use R_D=10K, C=100 nF, V_{DD}=20Vdc, and Vs= 0V to 5V Square wave at 1kHz, use VPULSE for Vs. Use **IRF150** for the PSPICE MOSFET device.

5. Change the input square wave to 750Hz. Calculate the time constant. Calculate the expected voltage peak.

6. Change the input back to 1khz and now change the C=0.047uF. Calculate the time constant. Calculate the expected peak voltage.

Lab Procedure: Wien bridge oscillator

1. Construct the Wien bridge oscillator circuit of Figure 1. Use the designed values for the resistors and capacitors: Use ±15 V supplies for the op-amp.

2. Capture the waveform output of the oscilloscope; include the plot in your report. **Note** any distortion in the output waveform or if oscillations begin to increase without bound. If oscillations do not start, try increasing the ratio R_2/R_1 to slightly greater than 2.0. This can be done easily if you use the decade resistance box for R_2. If oscillations increase without bound, try getting the ratio R_2/R_1 closer to exactly 2.0

3. Determine the frequency of the oscillations. What is the peak amplitude of the oscillations? Measure the actual values used for R_1 and R_2.

4. Now add the amplitude stabilization circuit to construct the Wien bridge oscillator of Figure 2. Be sure to connect the 10 kΩ potentiometer correctly. The 10kΩ potentiometer is located on the large proto board.

5. Before applying power to the circuit, adjust the pot to the bottom of its range. Turn the power on, and while monitoring the output waveform on the oscilloscope gradually increase the pot setting until sustained oscillations occur. Note the changes in the output waveform amplitude and shape during the pot’s adjustment.

6. Determine the frequency of the oscillations. What is the peak amplitude of the oscillations? Note any distortion in the output sine wave.

Lab Procedure: Sawtooth Waveform Generator

7. Construct the sawtooth waveform generator of Figure 3. Use a square wave with an upper limit of 5V and a lower limit of **0V** at a frequency of 1 kHz for the input signal. Use V_{DD} = 20 V. To begin with, use R_D = 10 kΩ and C = 100 nF. **Calculate** the **time constant** and the **expected Vout**. Observe the changes in the output waveform, as you change component values.

8. Change the R_D =15kΩ C= 100nF calculate the new time constant and the **expected Vout**.

9. Change the R_D =10kΩ C= 47nF calculate the new time constant and the **expected Vout.**

10. Change the R_D =10kΩ C= 100nF calculate the new time constant and the **expected Vout.** Generator frequency= 750Hz

Questions:

1. Why isn't an input signal source needed to obtain an output voltage signal?

2. For both oscillators when does the output waveform distort? Why?

3. Compare the operation of the two Wien bridge oscillator circuits. Comment on differences and similarities.

4. In the oscillator with the stabilizing circuit discuss the changes in the output waveform amplitude and shape during the pot's adjustment.

5. Compare the stabilized oscillator to the non-stabilized oscillator does the frequency change increase or decrease if the amplitude is saturated or not? Explain why it changes.

6. What effect does increasing the R have on the sawtooth output waveform? Why?

7. What effect does decreasing C have on the sawtooth output waveform? Why?

8. What effect does decreasing the frequency of the input clock have on the sawtooth output waveform? Why?

Report Project Sinusoidal Oscillator.
Name:____________________ Date_______________ Lab Bench # _________

Remember to include all of your prelab assignment.

1. Values of components used to construct the wien bridge oscillator.

   R=______________ C=______________

   R_1=_____________ R_2=______________

2. Did you change the values of R_1 or R_2 to get it to start to oscillate?

   New values R_1=___________ R_2=__________

3. Frequency=_________________ Peak amplitude=___________

   Measured values R_1=__________ R_2=____________

5. Note any changes in amplitude and wave shape while adjusting the 10k pot.

6. Frequency=_________________ Peak amplitude=___________

7. **Sawtooth generator:** Explain differences between **calculated** and **measured**
   Time constant= _____________ Vout____________________ (calculated)
   Rd= _________________ C= _______________
   Generator Frequency=___________ Vout = ______________(measured)

8. Time constant= _____________ Vout____________________(calculated)
   Rd= _________________ C= _______________
   Generator Frequency=___________ Vout = ______________(measured)

9. Time constant= _____________ Vout____________________(calculated)
   Rd= _________________ C= _______________
   Generator Frequency=___________ Vout = ______________(measured)

10. Time constant= _____________ Vout____________________ (calculated)
    Rd= _________________ C= _______________
    Generator Frequency=___________ Vout = ______________(measured)

Before you leave: Shut down Windows, return cables to racks, return parts to correct drawer bins, return adapters to container, turn off bench power, clear bench, and place seat under bench. (5 points)

Answer the questions at the end of the lab procedure and turn in with the report.