Analog Electronics

Laboratory exercise 5

Fall 2016

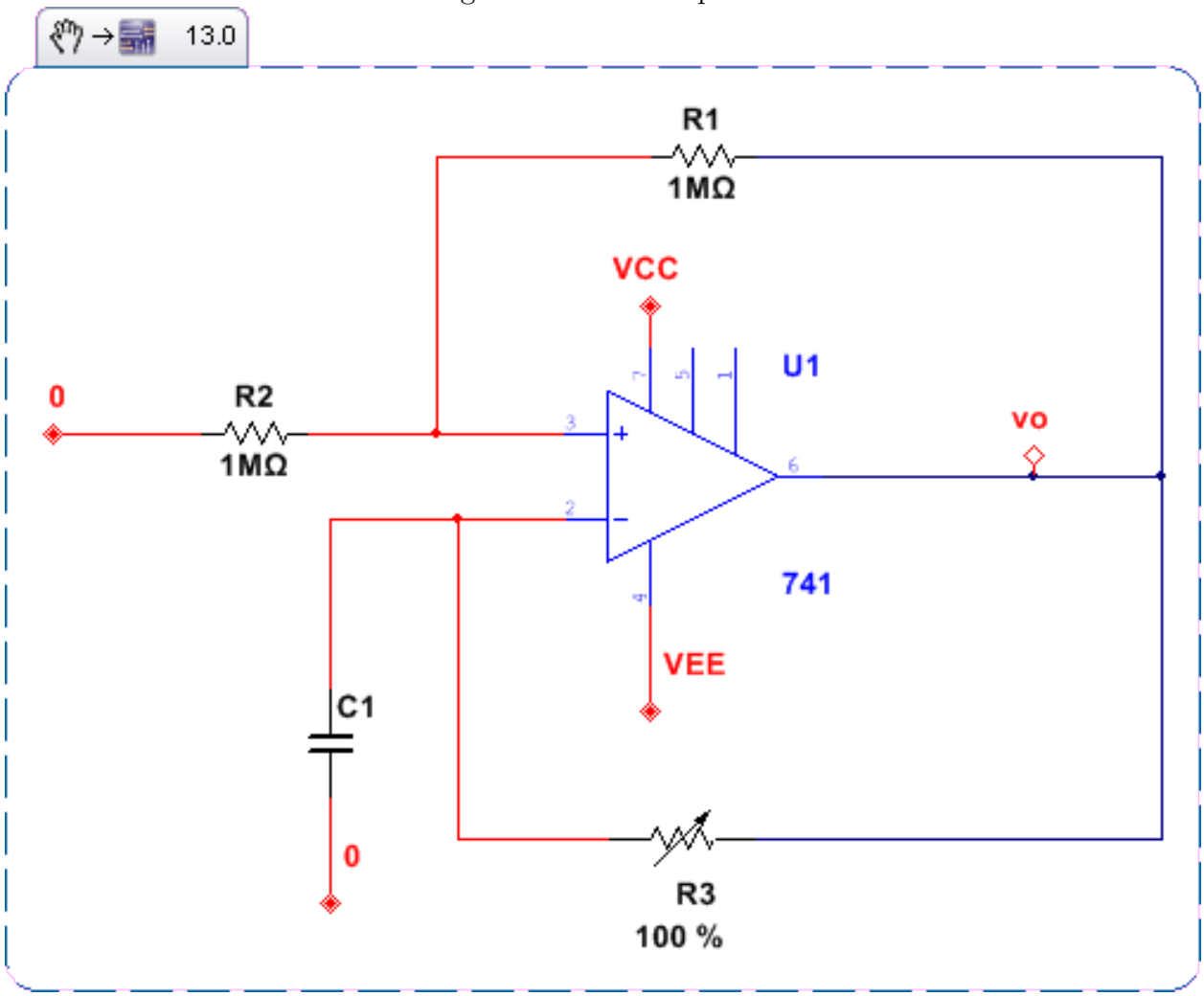
1 Abstract

In this experimentation we will be given the schematic of an Oscillating amplifier. With this and various equations, we will calculate the necessary value of R_3 using whatever capacitor we desire,to create a square wave oscillating at $500Hz$. Once we design this circuit we will then construct it ensuring that it operates as expected, and adjusting R_3 if necessary.

2 Theory

The model for this experimentation is the following figure.

Figure 1: Given Amplifier



The following equation generates a square wave, where the time period of the square wave is given as:

$$T = 2R_3C_1 \ln \frac{1+\alpha}{1-\alpha},$$

where $\alpha = \frac{R_2}{R_1+R_2}$

By using the equation with a capacitor of our choosing we will have a equation with one unknown, R_3. Once we defined R_3 we can compare our calculated vs. our real-world measured values.

3 Finding R_3

To begin the process of find R_3 we must choose a capacitor value. The value that we will use in this experimentation is $C_1 = 1\mu F$. We will also be using the given values, $R_1 = R_2 = 1M\Omega$

We begin by taking $500Hz$ and converting it to T or time period. We can use the following equation

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

$$T = \frac{1}{500Hz} = .002$$

Now we can solve for α, with the given equation,

$$\alpha = \frac{R_2}{R_1 + R_2}$$

$$\alpha = \frac{1M\Omega}{1M\Omega + 1M\Omega}$$

$$\alpha = 0.5M\Omega$$

Finally we can use the following equation to solve for R_3

$$T = 2R_3C_1 \ln \frac{1+\alpha}{1-\alpha},$$

$$.002 = 2R_3(1\mu F)ln(\frac{1+0.5}{1-0.5})$$

$$\frac{.002}{2} = R_3(1\mu F)ln(\frac{1+0.5}{1-0.5})$$

$$0.001 = R_3(1\mu F)(1.098)$$

$$R_3 = \frac{0.001}{(1\mu F)(1.098)}$$

$$R_3 = 910.25$$

The value of R_3 that is needed to achieve a $500Hz$ square wave is 910.25Ω

4 Experimentation

4.1 Circuit Assembly

Gather the following devices for use in this experimentation.

1. 2 $1M\Omega$ Resistors
2. $1K\Omega$ 1 turn potentiometer
3. 741 Operational Amplifier
4. $1\mu F$ Capacitor

To set our potentiometer,

1. Turn on the DMM and set it to ohmmeter mode.
2. Measure between the middle pin and one of the outside pins on the potentiometer.(these will be the pins used in the experimentation)
3. Turn the screw on the potentiometer until the DMM measures a value near our calculated $R_3 = 910\Omega$

Construct the circuit as shown in Figure 1 ensuring that you use the same pins that where set on the potentiometer in the previous step.

4.2 Testing

We will now use the occiliscope to compare the waves at V_O and across our capacitor C_1

1. Begin first by powering on the occiliscope and connecting a probe to channel 1 and 2.
2. Attach the channel 1 probe to our V_0, with the reference to ground.
3. Attach the channel 2 probe across C_1.
4. The "AUTOSET" function on the occiliscope provides presentation of both waveforms.

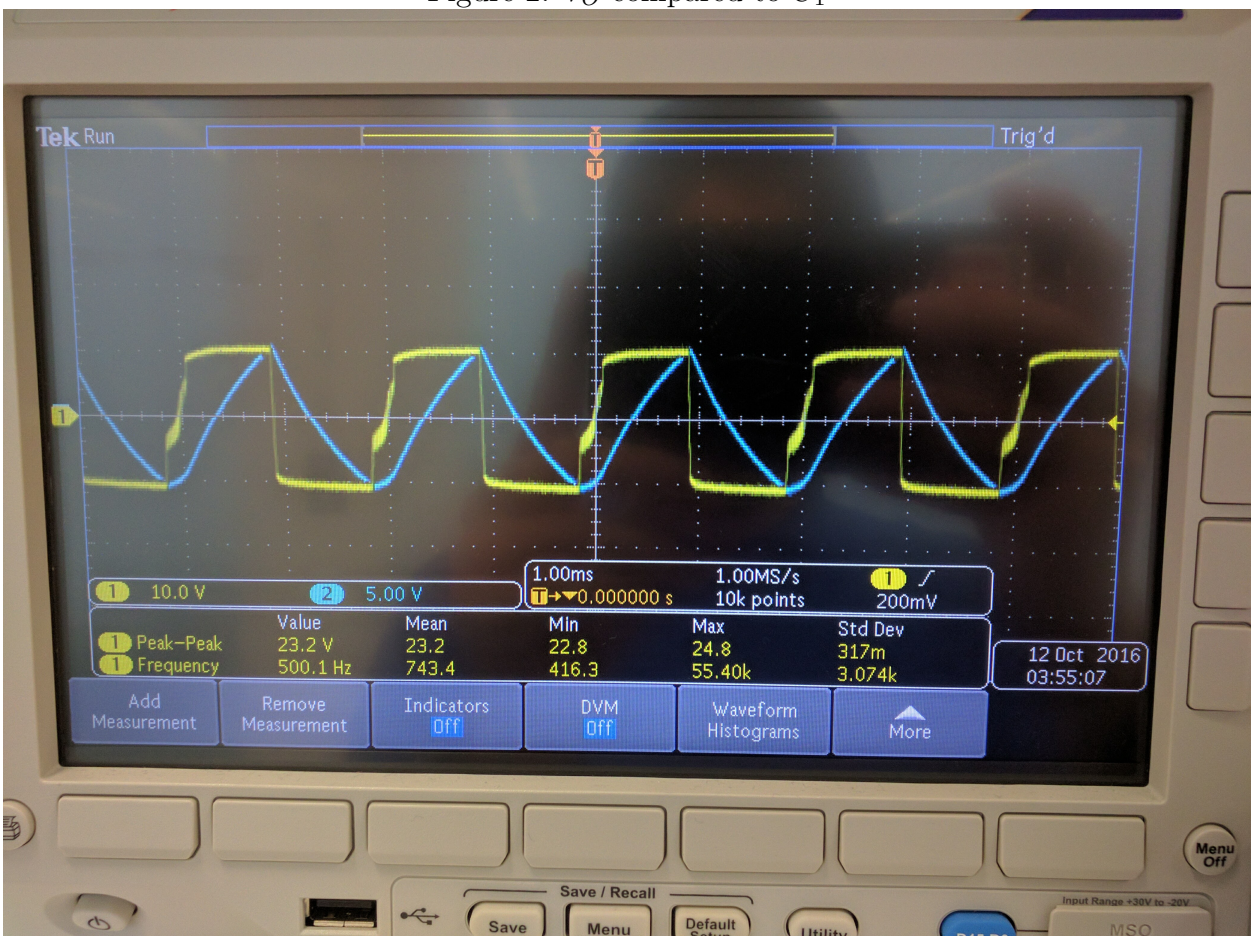
4.3 Achieving $500Hz$

The data that occiliscope displayed showed that our desired V_0 frequency of $500Hz$ was not met. We can tweak our potentiometer to finalize our experimentation.
By twisting our potentiometer screw we can vary our resistance enough to reach our final frequency of $500Hz$. Once you achieve this, power of the circuit, remove the potentiometer and measure the new R_3 value.

5 Comparing Waveforms

The following image is of the occiliscope and the waveforms that were created with the oscillating amplifier with our new R_3 value of 798.7Ω.

Figure 2: V_O compared to C_1



6 Conclusion

In this experimentation we used a variety of analysis techniques to calculate and design an amplifier that took a DC voltage and created a square waveform from it. The experimentation allowed us to visualized simulated vs. real-world values. During that we also derived a R_3 value that we then manipulated to get us our desired frequency. One problem that occurred in this experimentation was an odd artifact on the V_O square wave. It was later discovered a greater resistance value in combination with a smaller capacitor would've helped to remove the a deformity. Overall the experiment was yet another example of the usefulness of the 741 operational amplifier.