PN Junction Diodes and Applications

Lab 3

EEE 334

Circuits II

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Student ID: **************

Report Completed on: **10/19/2023**

Arizona State University

INTRODUCTION

This labs' main focus is to allow the student to become more comfortable with analyzing various junction diodes. This allows for a fundamental better understanding of the basics of junction diodes and how to analyze their current and voltage properties by utilizing LTSpice Software, physically building the circuits, and further practice with a handheld multimeter.

Figure 1 was removed due to it only being a photo of myself

Figure 1 Lab Set-Up Selfie Photo

EQUIPMENT and COMPONENTS USED

For this lab the following items were used to conduct the experiments and findings:

- *Digital Multimeter*
- *ADK (Analog Discovery 2)*
- *Large Breadboard*
- *Analog Parts Kit*
- *TI-nspire CX II Calculator*
- *Wire Kit*
- *Resistors used: 1x100Ω, 2x1kΩ, 1x10kΩ*
- *Capacitors used: 1x0.1µF, 2x47µF*
- *Diodes used: 4x1N914, 1x1N4001*

Course of Action

This section covers the processes that need to be done for each part. There will be a detailed description of what needs to be found and accomplished. The completed results mentioned in this section will be found in the results section.

3.1 Current-Voltage characteristics of PN junction diodes

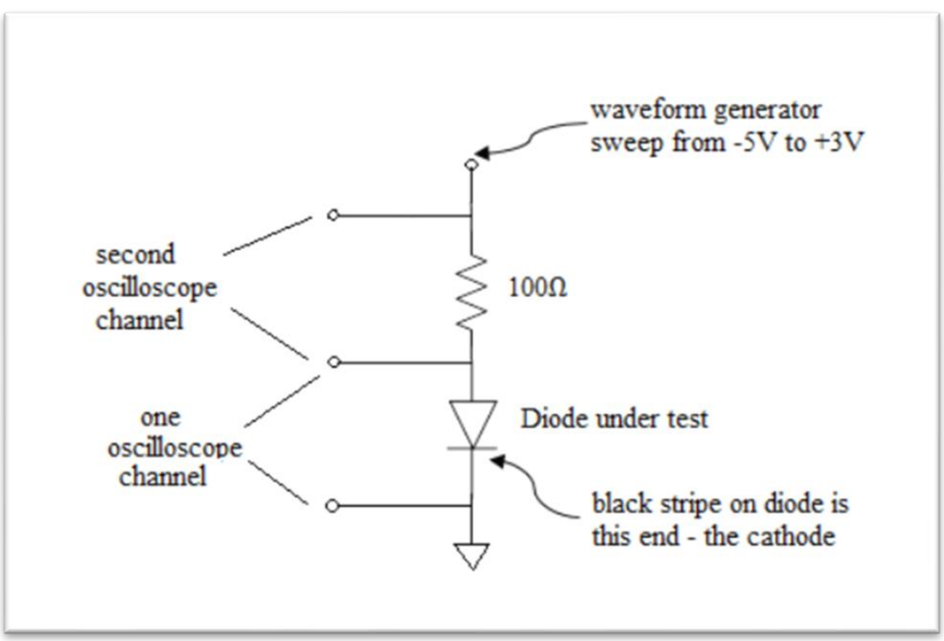

Figure 2 Physical Build Diagram for Section 3.1

For the first section of the lab section 3.1 focuses on physical building the circuit that is displayed in figure 2. This will be done with the breadboard and utilizing the 1N4001 diode along with a 100Ω resistor. Once the circuit is built the waveform software will be used to apply a sweep voltage from -5V to 3V. Once this is completed, the ADK oscilloscope will be used to determine the voltage/current values across the resistor and diode in the physical built circuit. With this information a current/voltage graph will be made with the diode's voltage values along the x-axis and the current values along the y-axis. This plot will be made by taking the data from the waveform software via a CSV file and importing it into excel. Making sure once the data is imported to divide the current through the resistor by the actual measured value on the circuit to determine the current. With all of this data a plot will be made, and this plot will allow the ability to determine the turn on voltage of the circuit. Once this is all completed, everything mentioned above will be done with the 1N914 diode.

3.2 DC Analysis of a Diode

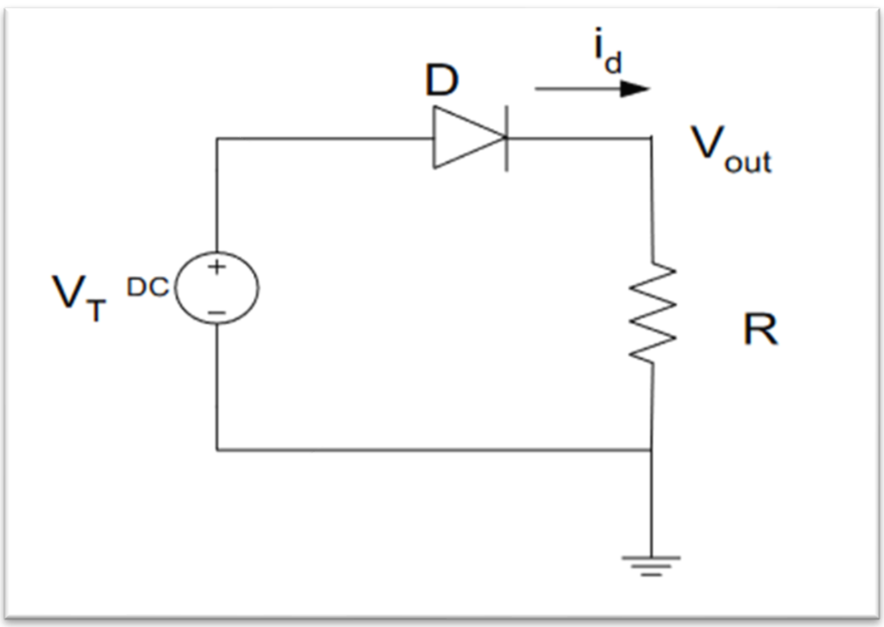

Figure 3 Diagram for DC analysis of a Diode for Section 3.2

For section 3.2, this section focuses more on the DC analysis of a diode. At the start of this analysis hand calculations will be run to find Vout and Id. This will be found by assuming that the diode is at its threshold voltage of 0.7V. This will then be the baseline for the following calculations, however it should be noted that this calculation will not be very accurate to the real reading to due physical issues such as noise. Next the circuit will be built on the bread board and the 1k resistor reading will be taken with the handheld multimeter. This value will be logged at the beginning of the results section. The multimeter will also be used to measure the Vout and Id values in the circuit and the Vd across the diode will also be taken. Once all these values have been logged the circuit will be simulated in LTSpice. A DC sweep from -1V to 5V will be accomplished, the plot will be analyzed to find the current at 4V. Finishing up this section this gathered data will be compared to each calculation to determine the percentage error if there is any.

3.3 Small Signal (AC) Analysis of a Diode

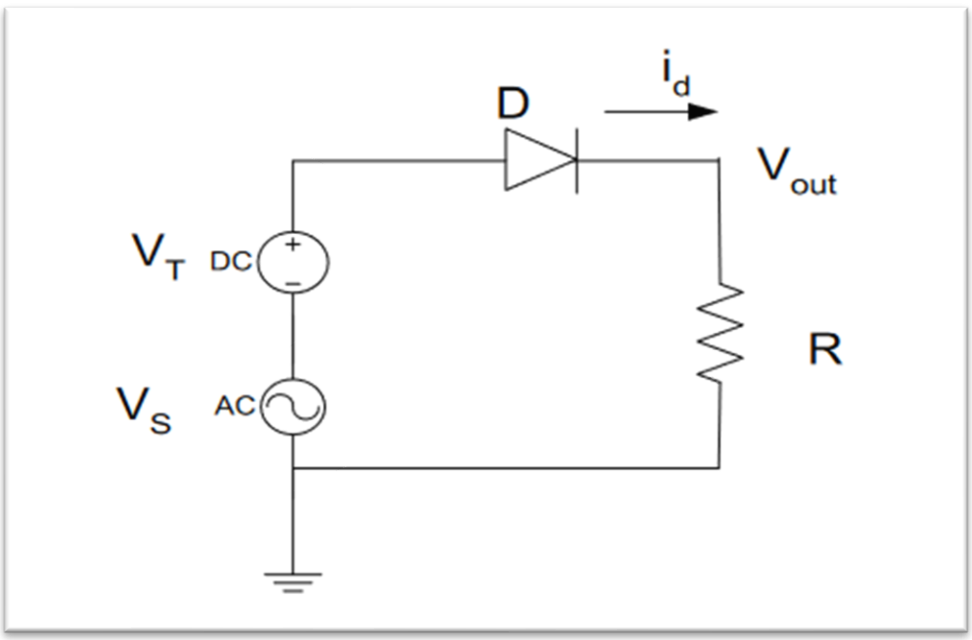

Figure 4 Small Signal (AC) Analysis Circuit

For section 3.3, this section will be a little longer than the last two. Firstly, the focus will be on obtaining the theoretical values of Vout and Id. This will be done by hand calculating Vout by setting the Vt signal to 4V and will be assuming that the diode voltage is 0.7V. With this information hand calculation of Vout and Id is possible and will be the baseline for the theoretical values. Next, the physical circuit will be built that will model figure 4 above. Now this circuit looks a little different than the past with the two voltage sources. This will be accomplished by setting Vs to 1V peak to peak with a 1k Hz frequency. Now to account for the Vt an offset voltage of 4V Dc will be implemented to factor in the 4V DC for Vt. Now that the physical circuit is built the Vpp and Vout will be measured to calculate the Vrms, and this value will then be compared to the readings from the Waveforms software for verification. This will be accomplished for Ipp and Irms as well. Another analysis will be done by setting the ADK oscilloscope to 200mV/div and the waveform of Vd across the diode will be taken along with documenting why this offset occurs also documenting the Vpp and Vrms. Now the multimeter will be used to take the Ac and DC values of Vd and Vout, also taking Vout to be used to find the RMS and DC values of Id. With all of this will be done the circuit will be simulated in LTSpice software where a transient analysis will be done to log the values of Id, Vd, and Vout. Finally, the last step is to take all the values obtained and compare them with percent error calculations to see how close or far of they were.

3.4 Half-Wave Rectifier

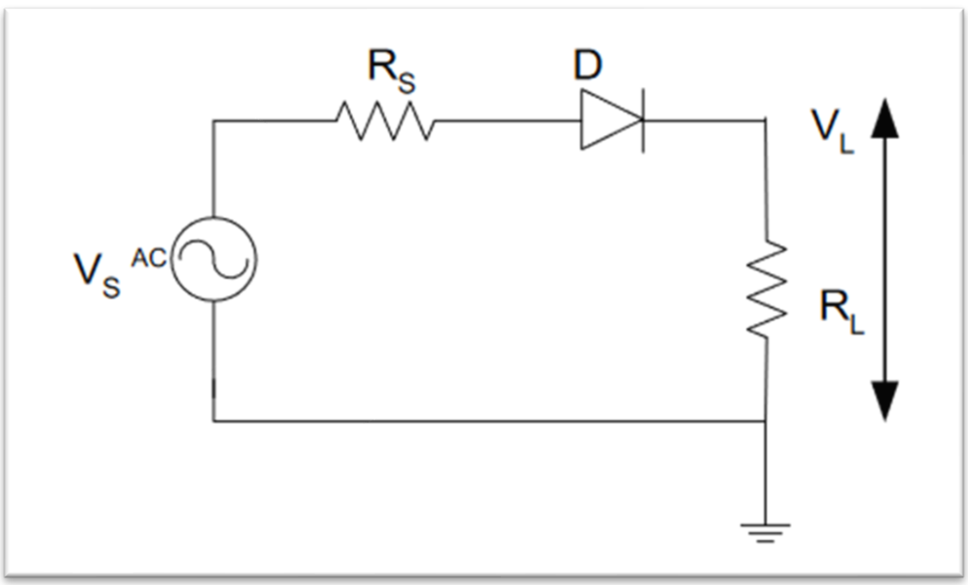

Figure 5 Half-Wave Rectifier

For this next section the circuit that will be built and analyzed is the Half-Wave Rectifier. Firstly, the circuit will be built, and the resistor being used will be measured for accuracy. Once complete, the circuit will be powered by the ADK to 4Vpp at 1k Hz. Then the waveforms oscilloscope will be used to take the values of Vs and V_L while also taking the parameters from them.

3.5 Full-Wave Rectifier

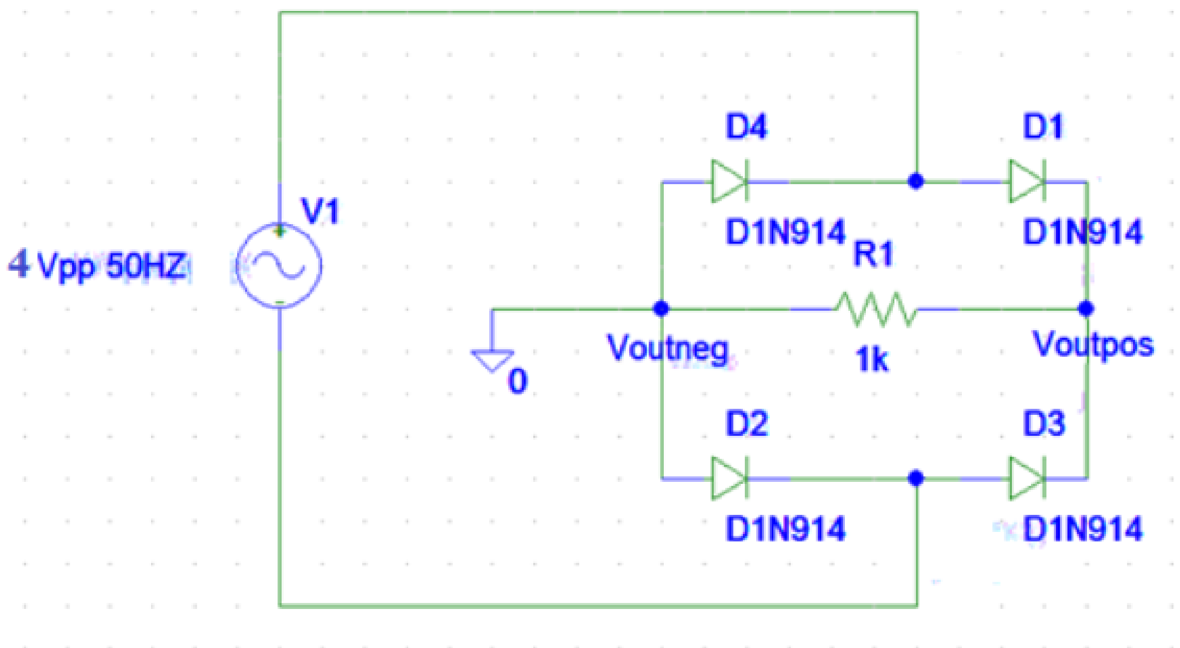

Figure 6 Full-Wave Rectifier

For this next section the circuit that will be built and analyzed is the Full-Wave Rectifier. Firstly, the circuit will be built, and the resistor being used will be measured for accuracy. Once complete, the circuit will be powered by the ADK to 4Vpp at 50 Hz. Then the waveforms oscilloscope will be used to take the values of Vo and the relevant parameters.

3.6 Peak Detector (Rectifier)

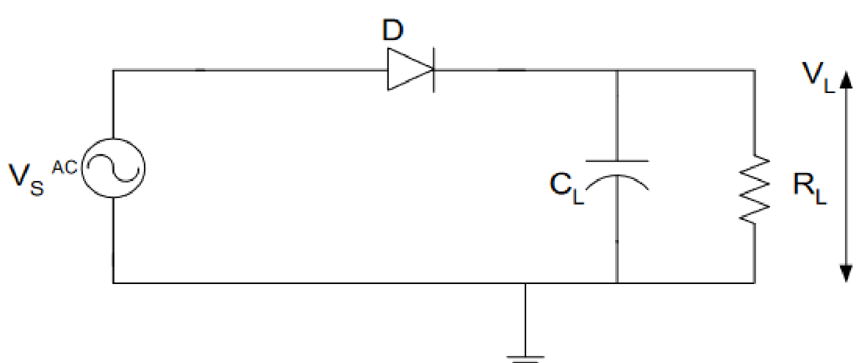

Figure 7 Peak Detector (Rectifier)

This section focuses on a circuit called the Peak Detector. First the focus is on building the physical circuit on the breadboard. This is the first circuit of the lab that now introduces capacitors with the diodes. The resistor and capacitor will be measured, and the values will be logged. Once the circuit is built the ADK will induce a 4Vpp sine wave at 1kHz into the circuit. After the voltage is induced, the waveforms oscilloscope will be used to read Vs and V_L. Lastly, the circuit will be simulated in LTSpice software, and the simulated circuit will be analyzed to verify the Vs and V_L waveforms. Once all this data is gathered it will be compared and a percent error will be calculated to see how close or how far off the values are.

3.7 Diode Clamper

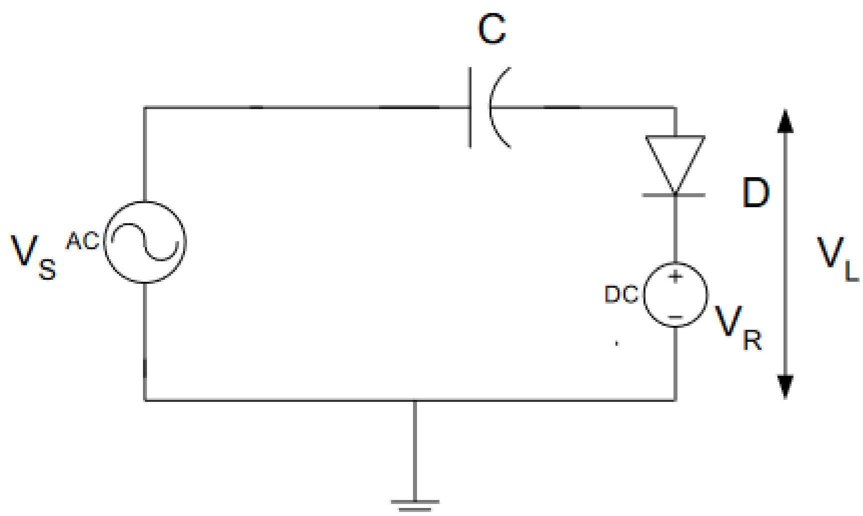

Figure 8 Diode Clamper

This section will be focused on the Diode Clamper circuit. Firstly, measurements will be taken to check to make sure the capacitor is within tolerance. These measurements will be logged into the results section. Once this is completed the physical circuit from the figure above will be built on the breadboard. Once the built circuit is complete the ADK will be used with the waveform software to induce a 6Vpp sine wave at 1kHz along with a 2V signal from the DC source. Then the oscilloscope will be used to log the Vs and V_L waveforms. The next step is simulating the circuit in LTSpice, and a transient analysis will be done to get the waveforms of Vs and V_L. Lastly, a percent error will be done to check the physical results against the simulated.

3.8 Diode Limiter (Clipper)

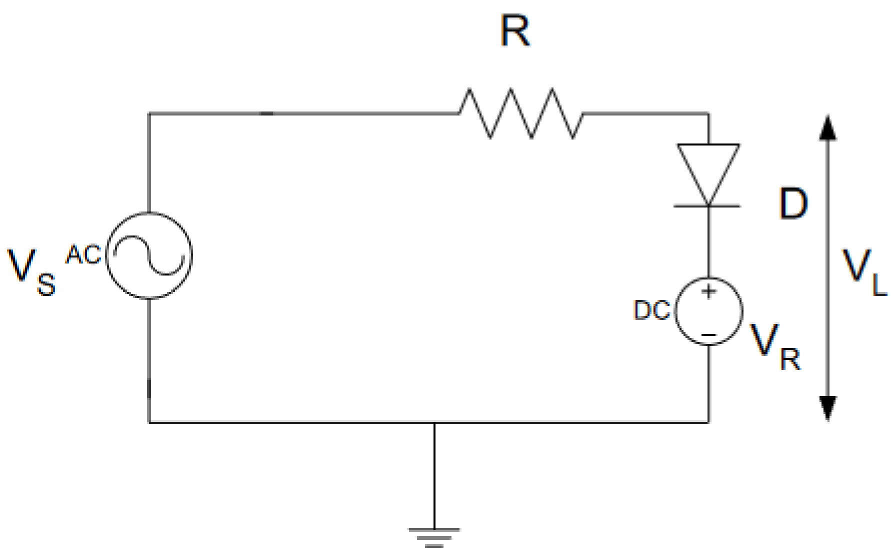

Figure 9 Diode Limiter (Clipper)

This section focuses on building and analyzing a diode limiter (Clipper). First the resistor will be measured for accuracy and the measured result will be posted. Once this is complete the circuit will be built on the bread board. Once this is complete a sine wave signal of 6Vpp at 1kHz will be induced for Vs while a 3V dc signal will be induced for Vr. After these signals are induced measurements will be taken with the ADK oscilloscope and the waveforms for Vs and V_L will be logged. After that, the circuit will be simulated in LTSpice where a transient analysis will be performed to determine the waveforms for Vs and V_L. Lastly, the simulated results will be checked against the physical circuit results for error.

3.9 Voltage Multiplier Circuit

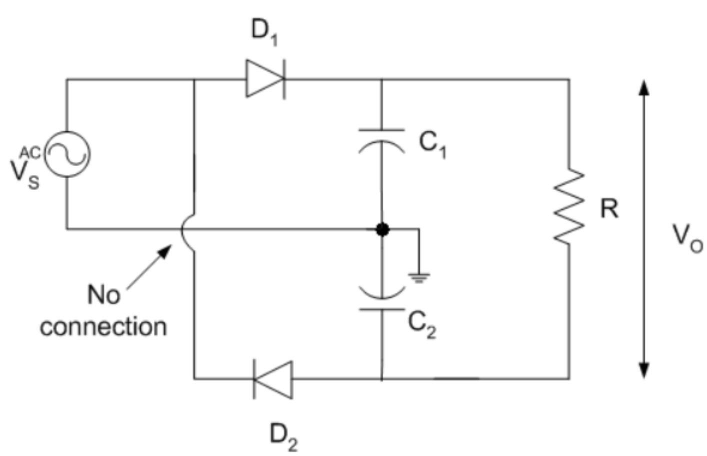

Figure 10 Voltage Multiplier Circuit

For the last section of the lab, the focus is on the voltage multiplier circuit. To start, each of the capacitors and resistor will be measured for accuracy and logged. Once this is completed the circuit will be built on the breadboard. After the circuit is built, the waveforms software will be utilized to induce a 4Vpp sine wave at 1kHz to power the circuit. Then readings will be taken with the oscilloscope to determine the waveform for Vo. After the waveform is obtained the circuit will be simulated in LTSpice where transient analysis will be run, and Vs and Vo waveforms will be logged. Once each of these parts are completed the values will be taken to determine the multiplication gain for each of the physical and simulated results. Lastly, The percent error will be calculated to determine how close or how far of the results were from each other.

RESULTS

3.1 Current-Voltage Characteristics of PN Junction Diodes

Measured value of the resistor was determined to be: **98.2Ω**

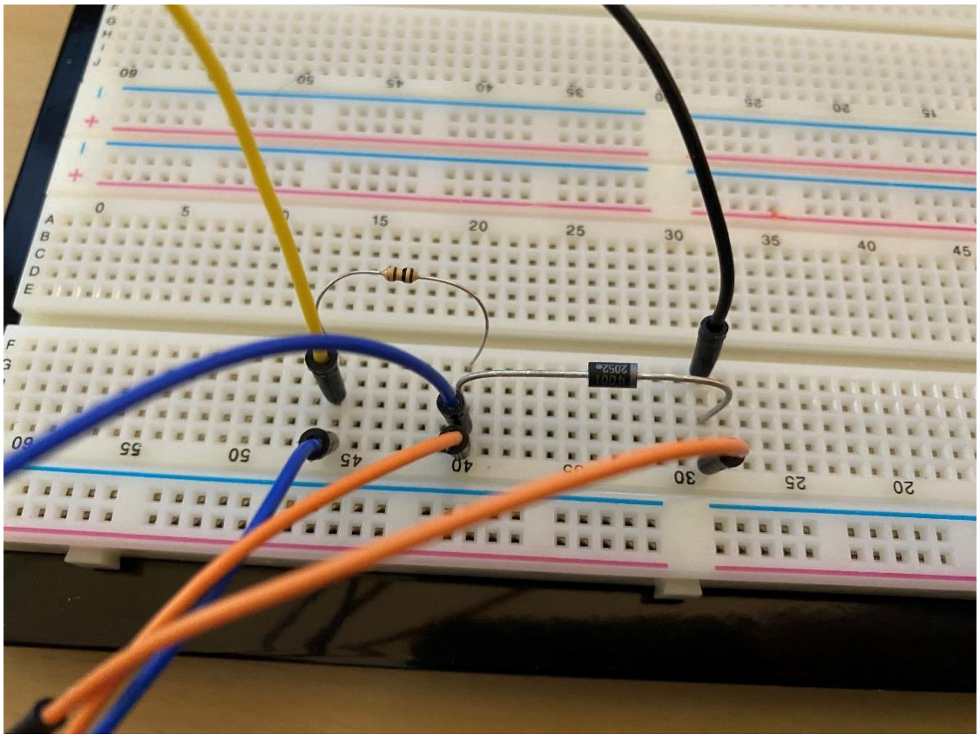

Figure 11 Built Diode Circuit Utilizing 1N4001

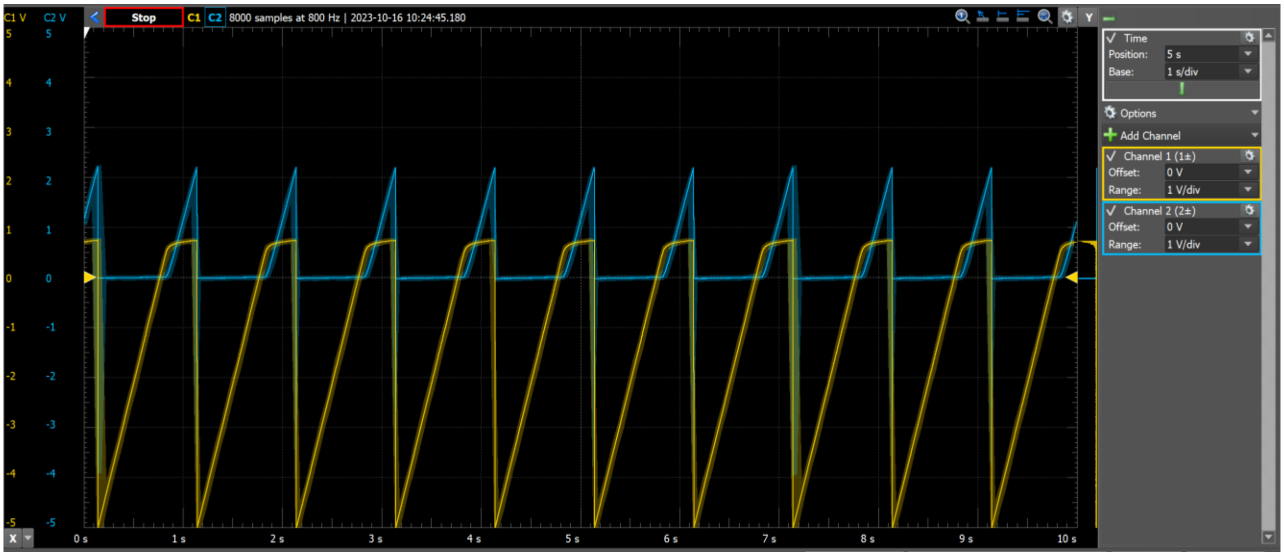

Figure 12 Waveforms Oscilloscope 1N4001 Diode -5V to 3V Sweep

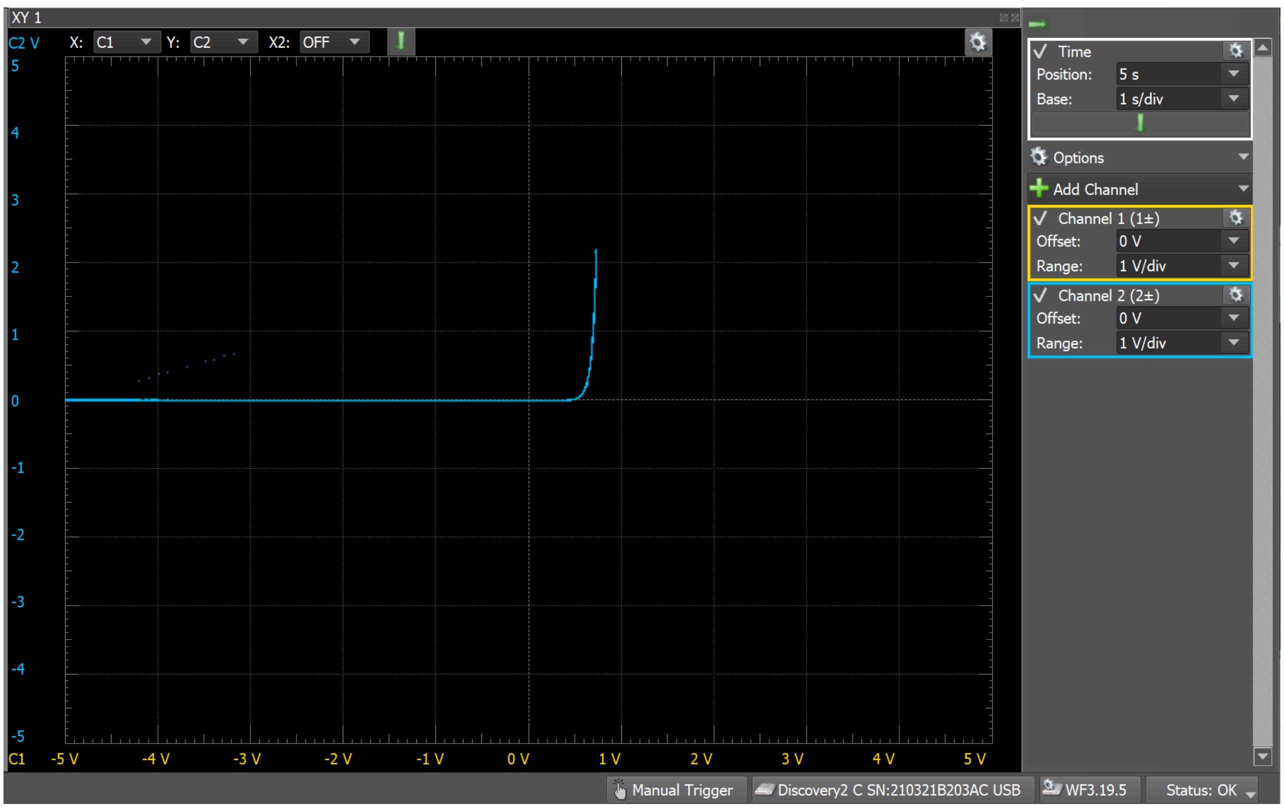

Figure 13 Waveforms Oscilloscope I-V Curve of Diode 1N4001

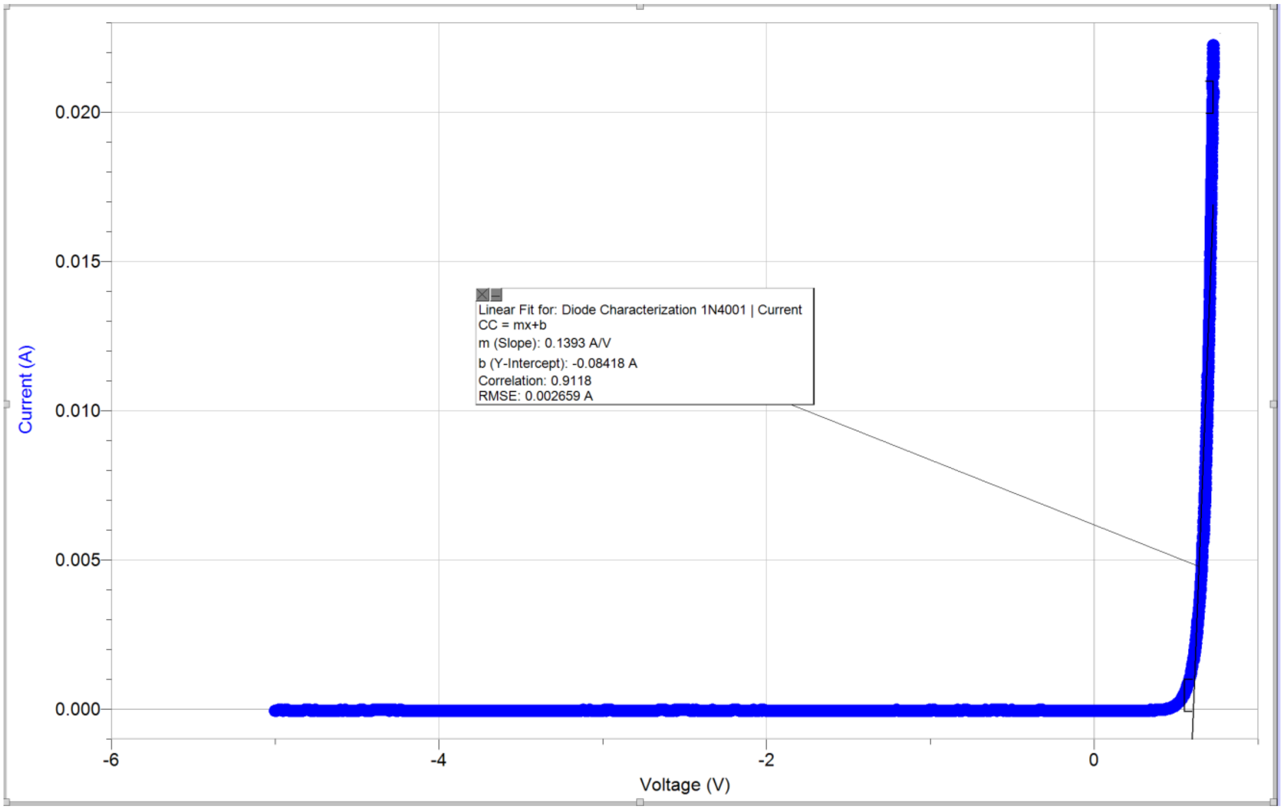

Figure 14 Graph of 1N4001 Diode Characterization

From the figures above for section 3.1 the 1N4001 diode was analyzed. It can be seen that the results are accurate from what was expected. When analyzing the graph, the turn on voltage was calculated from the linear fit. The turn on voltage came out to be **0.60V** which is pretty close to the 0.7V that has been used in the class thus far.

The experiment was repeated below now analyzing the 1N914 diode.

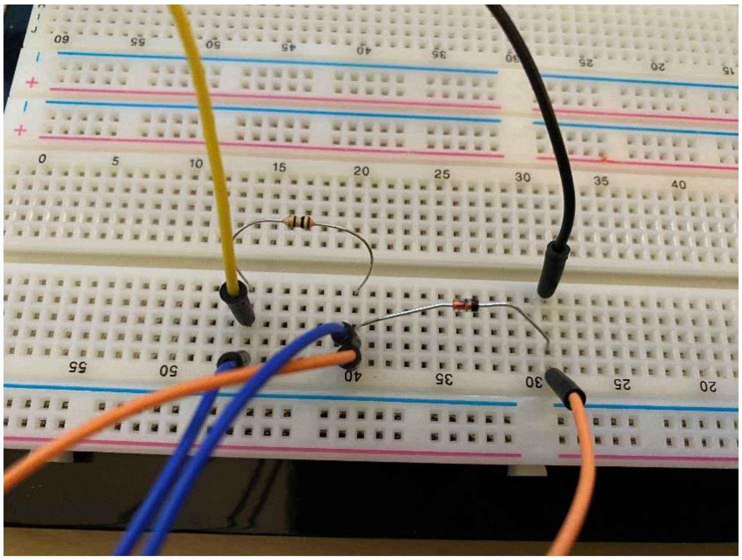
Figure 15 Built Diode Circuit Utilizing 1N941

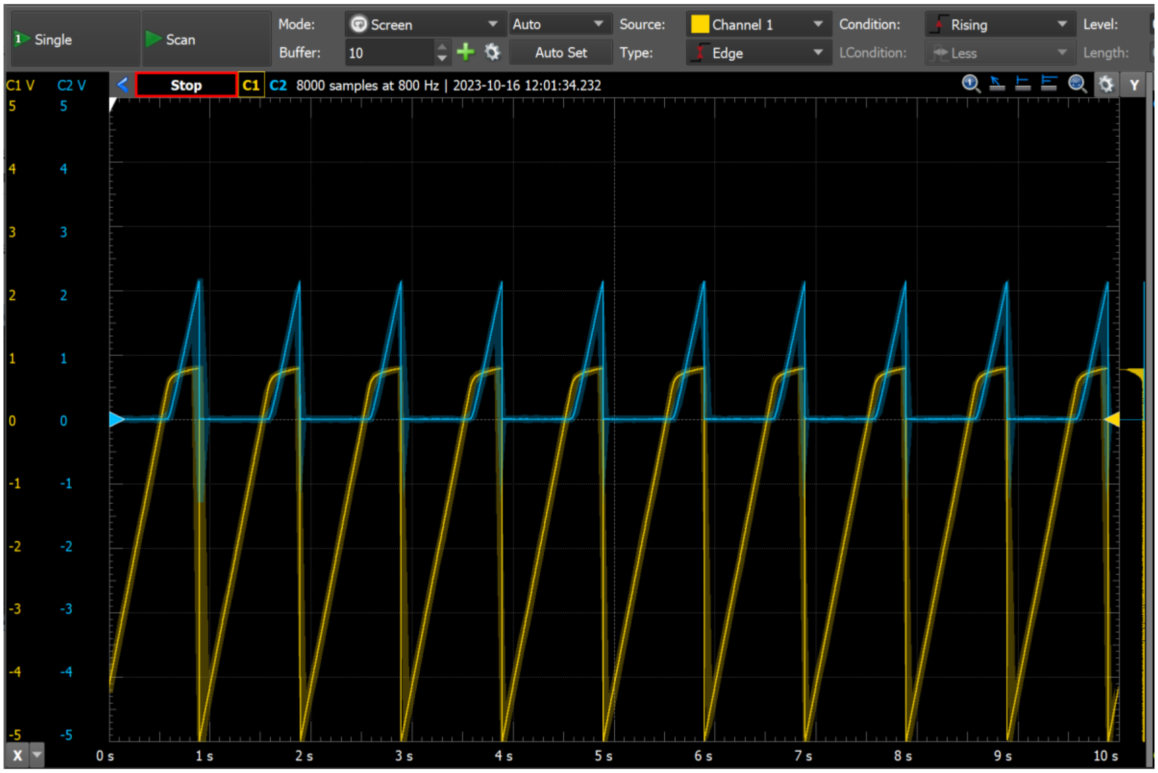

Figure 16 Waveforms Oscilloscope 1N941 Diode -5V to 3V Sweep

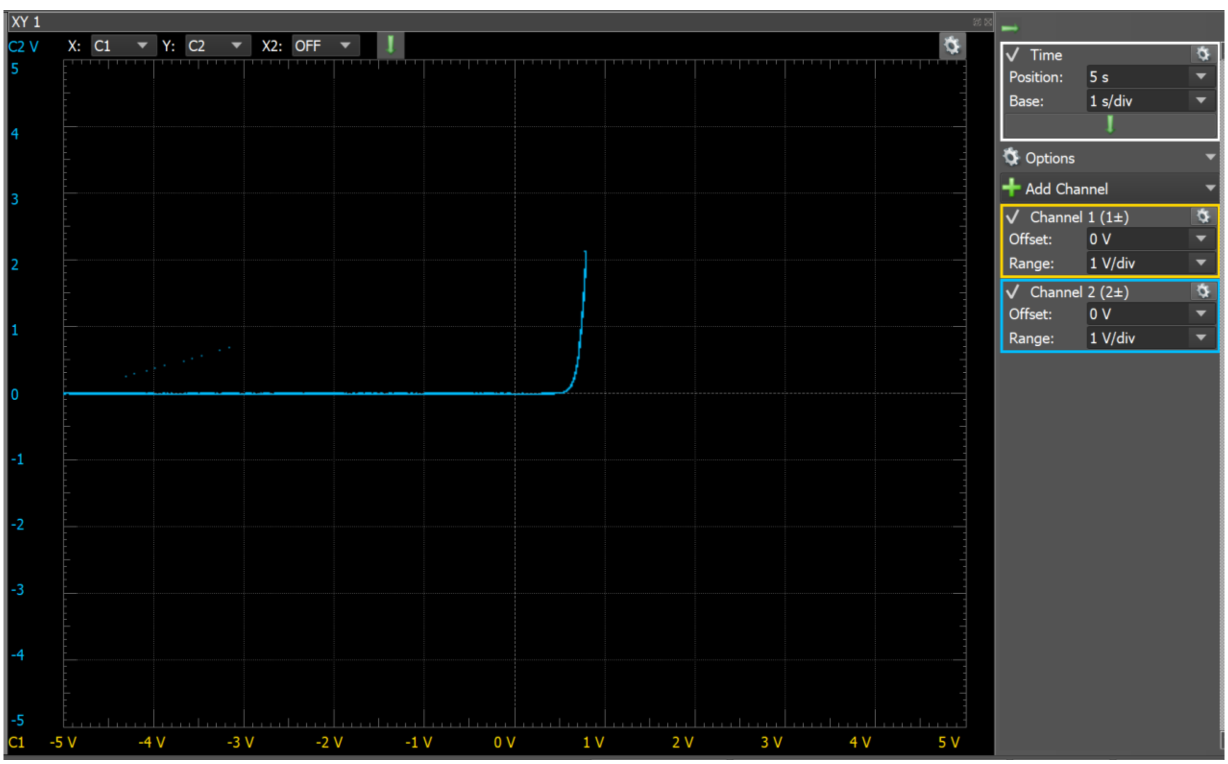

Figure 17 Waveforms Oscilloscope I-V Curve of Diode 1N941

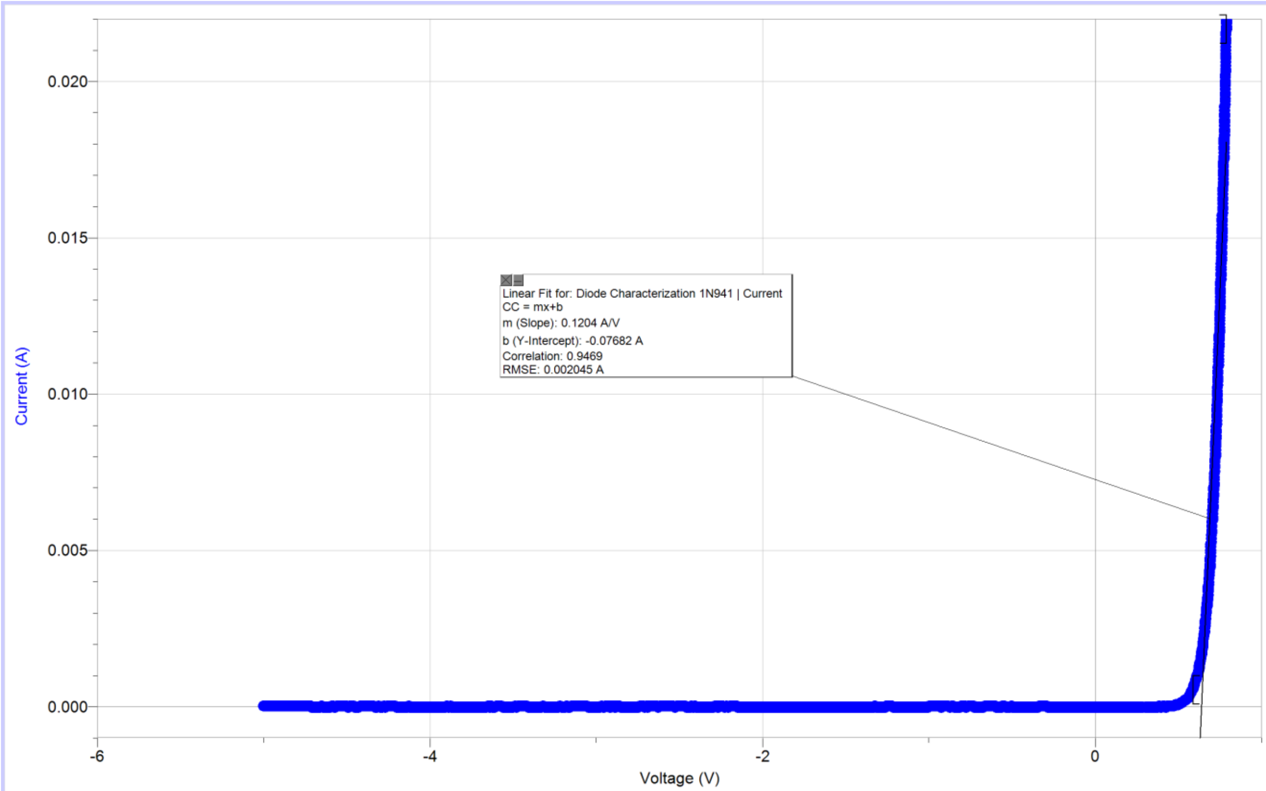

Figure 18 Graph of 1N941 Diode Characterization

From the figures above now analyzing the 1N941 diode. It can be seen that the results are similar to the previous. When analyzing the graph, the turn on voltage was calculated from the linear fit. The turn on voltage came out to be **0.64V** which is even more accurate to the 0.7V used to calculate diode circuits in the class.

3.2 DC Analysis of a Diode

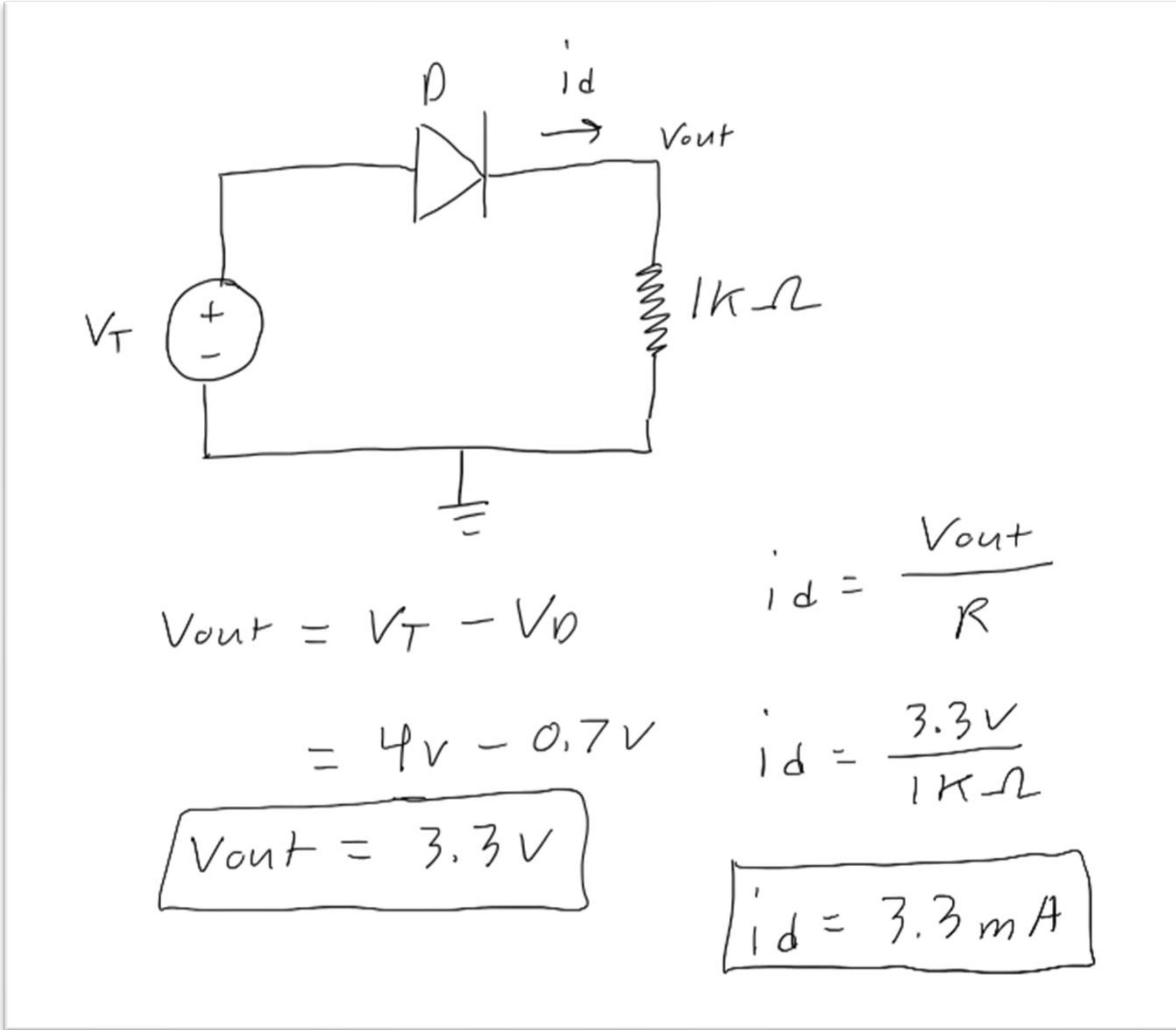

Figure 19 Hand Calculations for Diode DC Analysis

Vout = 3.3v
Id = 3.3mA

Measured resistor value: **986Ω**

With the measured resistor value above the following readings were taken using the handheld multimeter from the physically built circuit.

V_{out} across R = 3.312V

i_d = 3.31mA

V_d = 0.671V

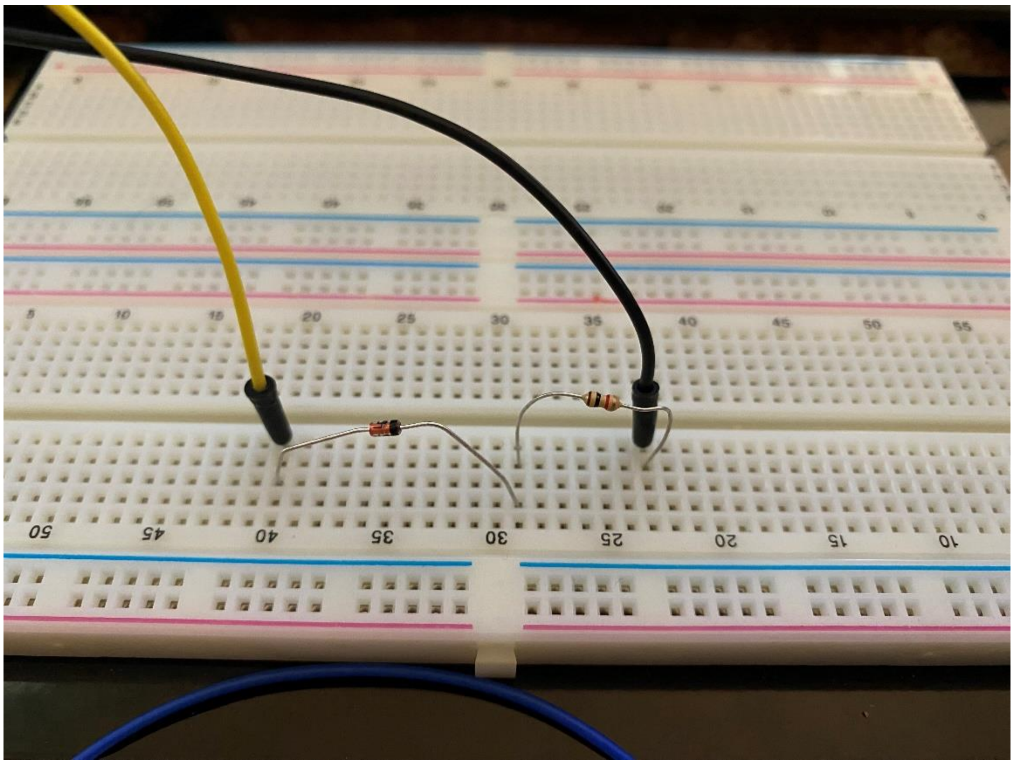

Figure 20 Built Circuit for DC Analysis of a Diode

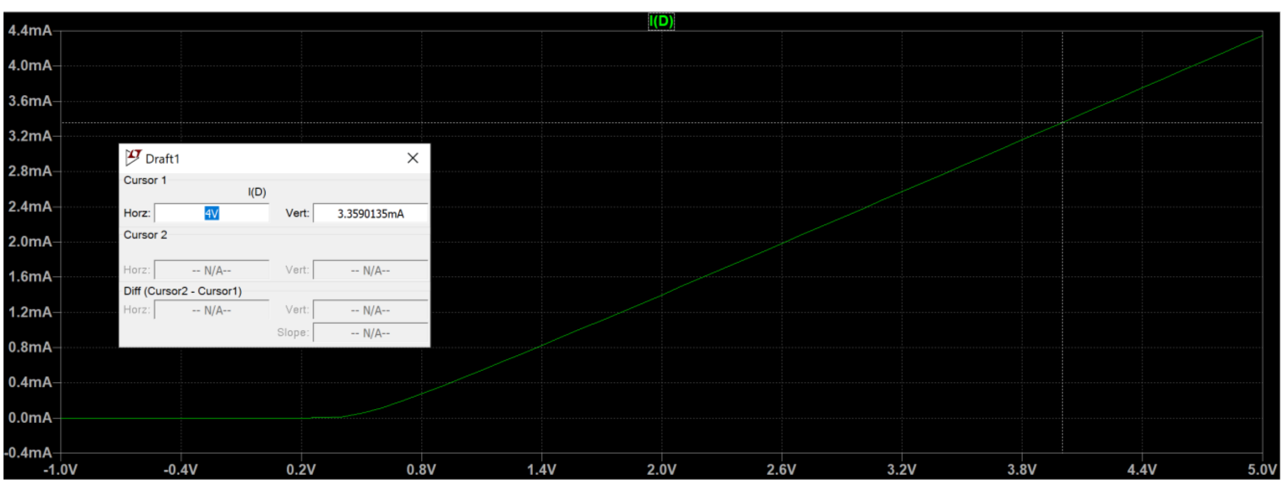

Figure 21 LTSpice DC Sweep of Id at 4V

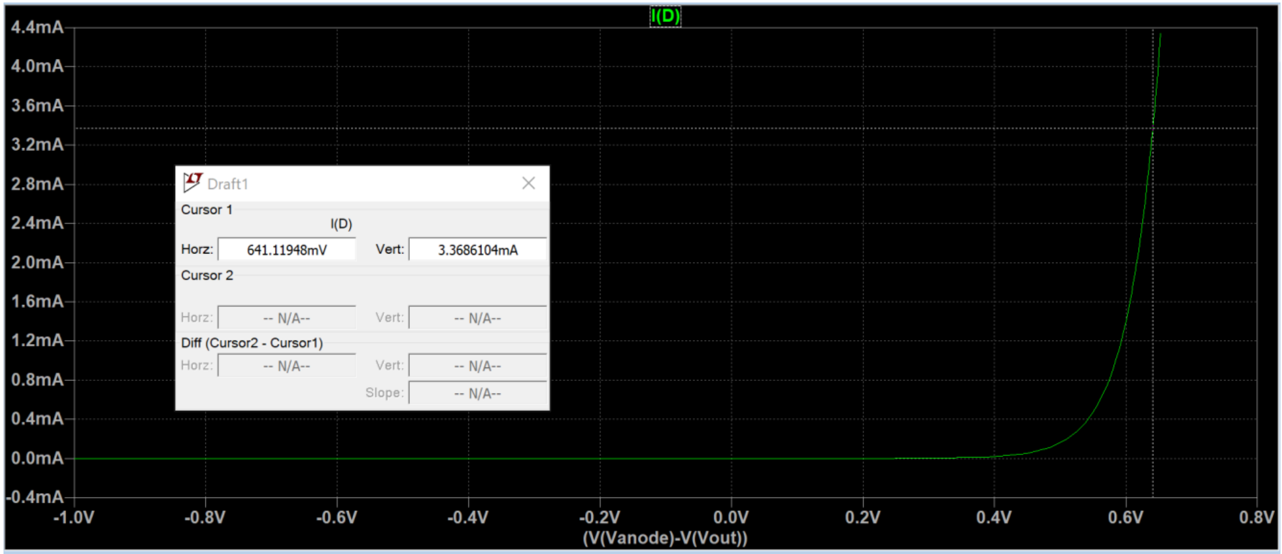

Figure 22 LTSpice DC Sweep Current/Voltage Characteristics

The following readings were taken utilizing the LTSpice Software and the results are as follows:

$(\mathbf{3.35}\boldsymbol{V} * \mathbf{1000}\Omega) = \mathbf{3.35V}$ **(V_{out})**

i_d = 3.35mA

V_d = 0.641V

Table 1 Percent Error Results for DC Analysis of Diode

	Theoretical	LTSpice	ADK Multimeter Values	Percent Error Measured	Percent Error Simulated
V_{out} (V)	3.30V	3.35V	3.31V	0.3%	1.5%
I_d (mA)	3.30mA	3.35mA	3.31mA	0.3%	1.5%
V_d (V)	0.7V	0.641V	0.671V	4.1%	8.4%

3.3 Small Signal (AC) Analysis of a Diode

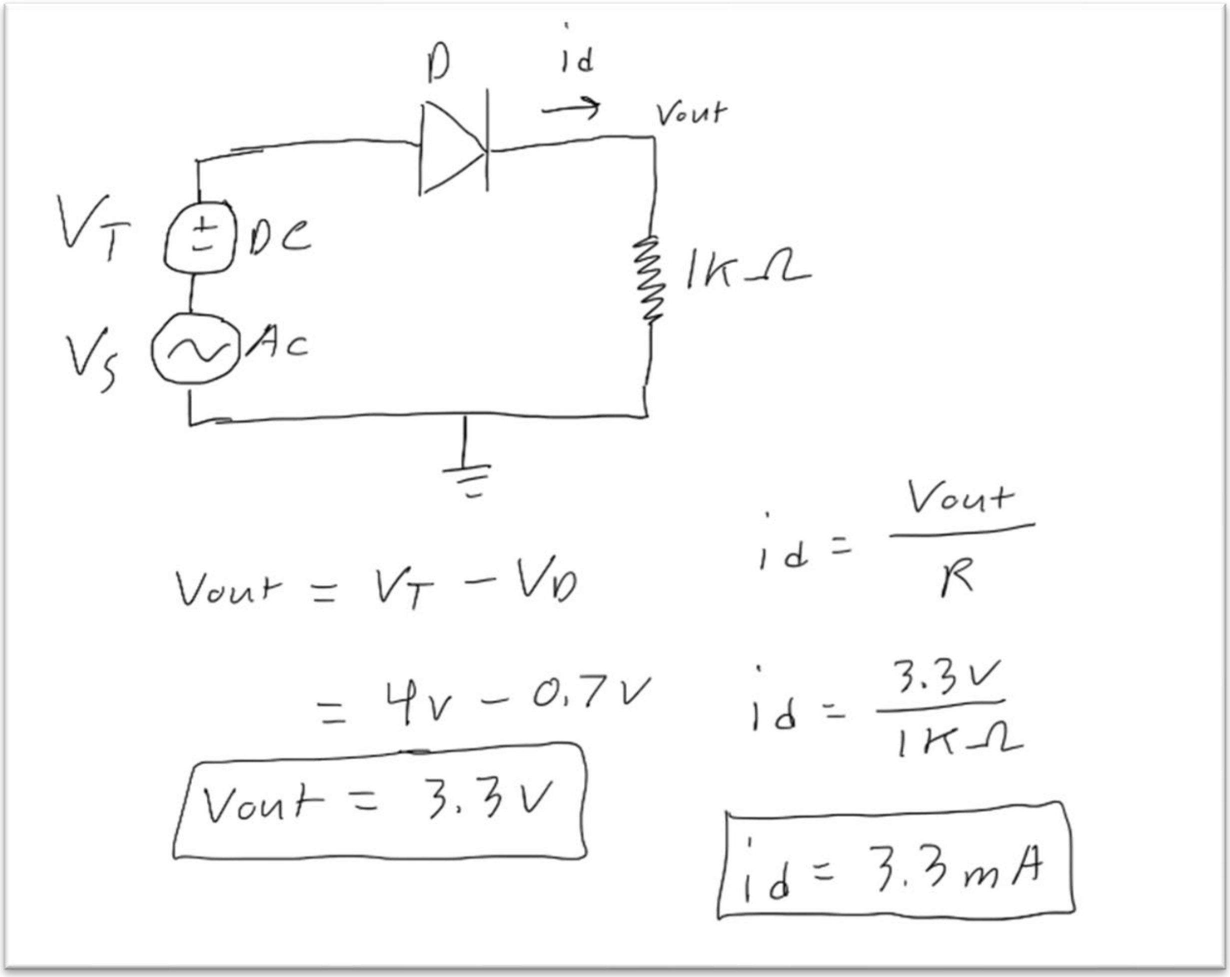

Figure 23 Hand Calculations for Small Signal AC Analysis of a Diode

Vout = 3.3v
Id = 3.3mA

Measured resistor value: **986Ω**

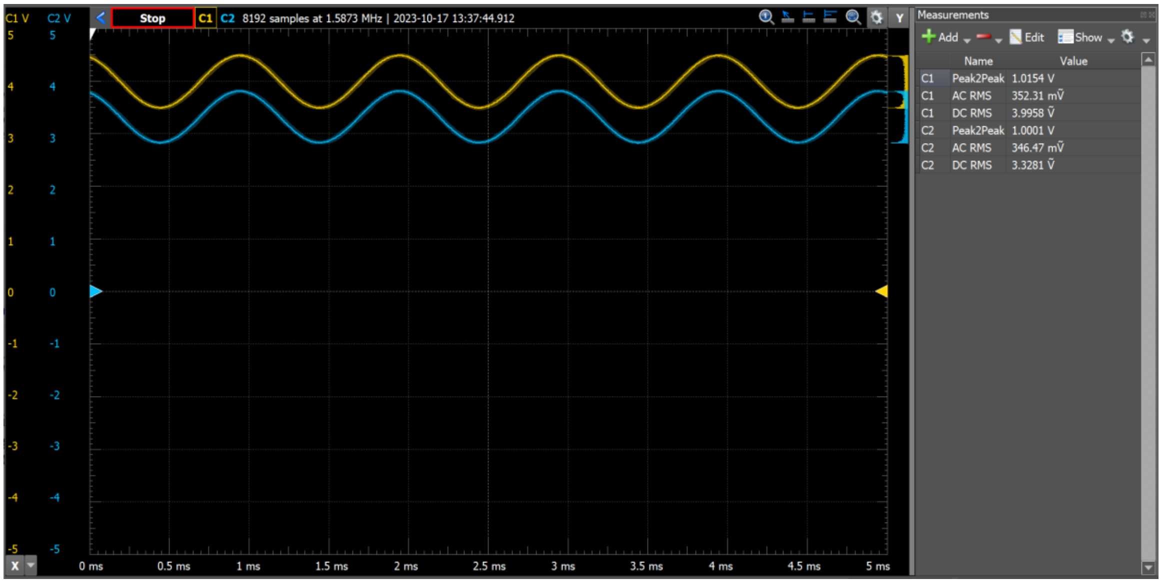

Figure 24 Waveforms for Small Signal Analysis yellow (Vs) and blue (Vout)

Vs Values Measured:
Vpp = 1.02V
Vrms = 352.31mV
Vrms DC = 3.996V

Vout Values Measured:
Vpp = 1.00V
Vrms = 346.47mV
Vrms DC = 3.328V

From the taken values above the DCrms of Vout came out to be 0.672V, very close to the expected value of a voltage drop across a diode of 0.7V. Also, the reason for the offset is due to the minimum voltage that is required for the diode to be "ON" and pass current through it.

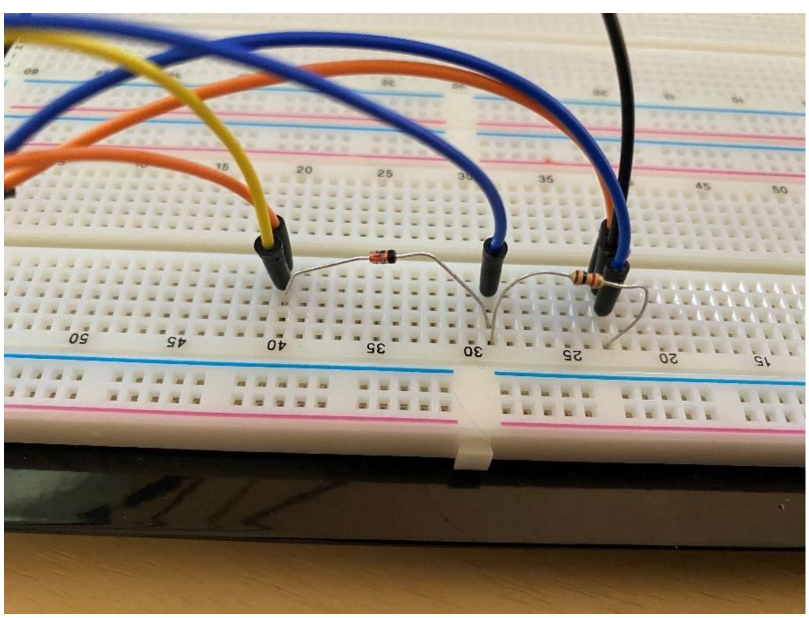

Figure 25 Built Circuit for Small Signal AC Analysis of a Diode

First $V_{S\,RMS}$ Second $V_{out\,RMS}$

$$V_{S\,RMS} = \frac{V_{PP}}{2} = \frac{1.02V}{2} = 0.51 = \frac{0.51}{\sqrt{2}}$$

$$V_{S\,RMS} = 0.3606\,mV$$

$$V_{out\,RMS} = \frac{V_{PP}}{2} = \frac{1.00V}{2} = 0.5 = \frac{0.5}{\sqrt{2}}$$

$$V_{out\,RMS} = 0.3536\,mV$$

Figure 26 Hand Calculations for Vs_rms and Vout_rms

From analysis of the hand calculations finding Vs_rms and Vout_rms, it can be seen the calculated values came out to be very close to the readings from the oscilloscope however there is a slight variation from the readings, so it is not exact.

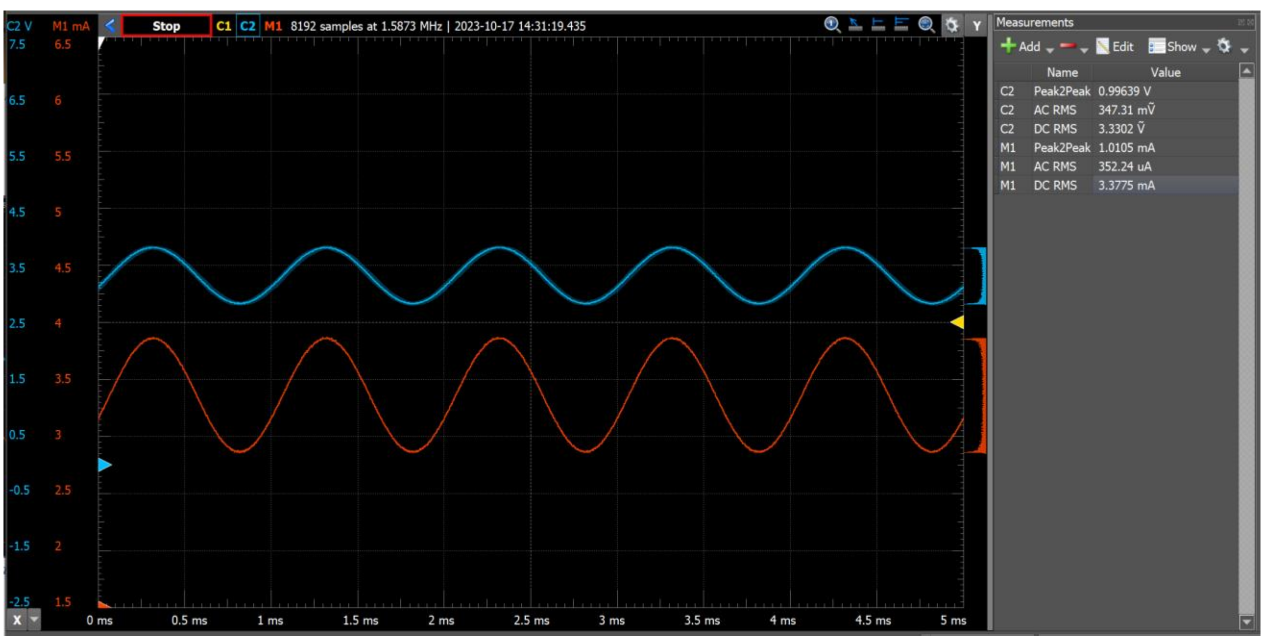

Figure 27 Waveforms for Small Signal Analysis blue (Vout) and red (Id)

From the figure above the math approach was used to find Id in the circuit. The measured values read as follows:

Ipp = 1.01mA
Iac_rms = 352.24µA
Idc_rms = 3.37mA

It should be noted that Idc_rms is the value of the DC current that is running though this circuit.

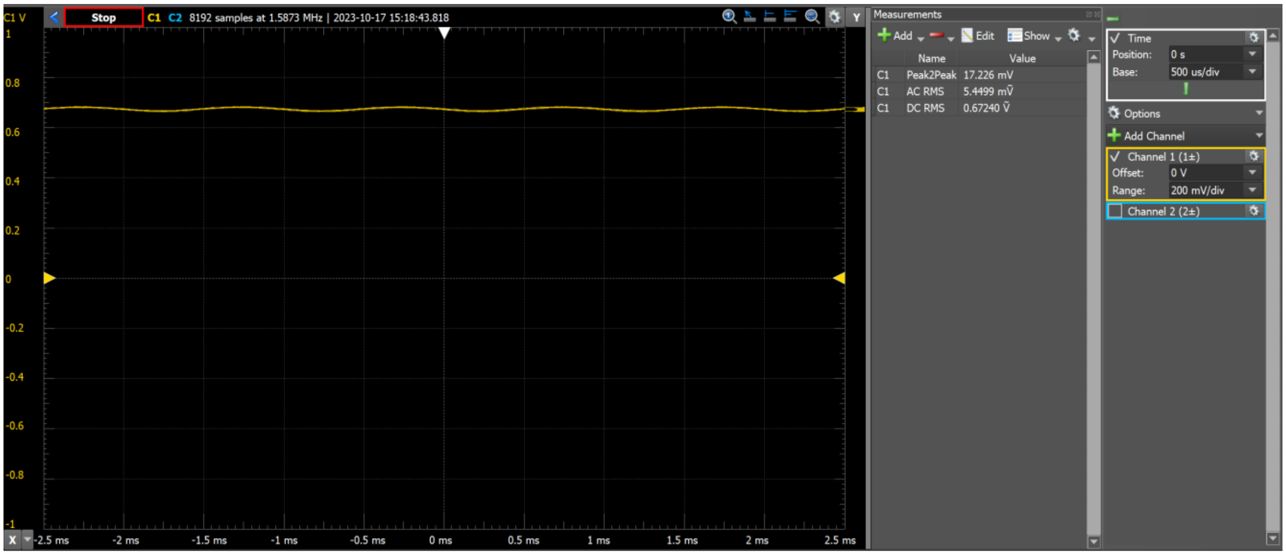

Figure 28 Waveform of Small Signal Analysis Vd Voltage Drop across the Diode

From the figure above the messurments are:
Vpp = 17.226mV
Vac_rms = 5.45mV
Vdc_rms = 0.672V

From the results above the Vdc_rms is the voltage drop across the diode.

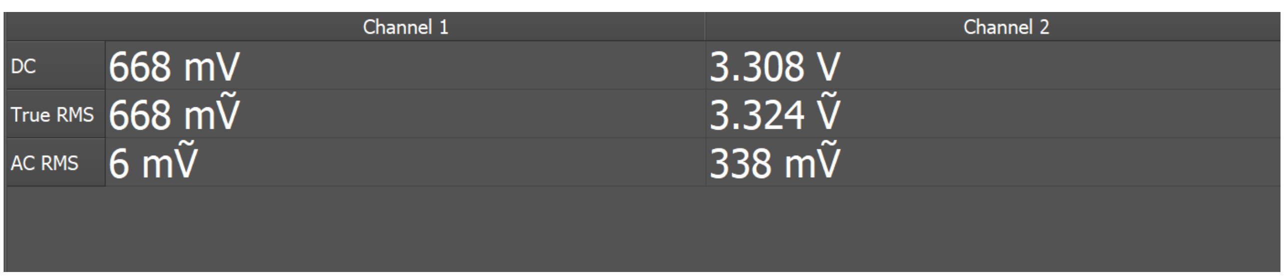

Figure 29 Voltmeter Readings from Waveforms

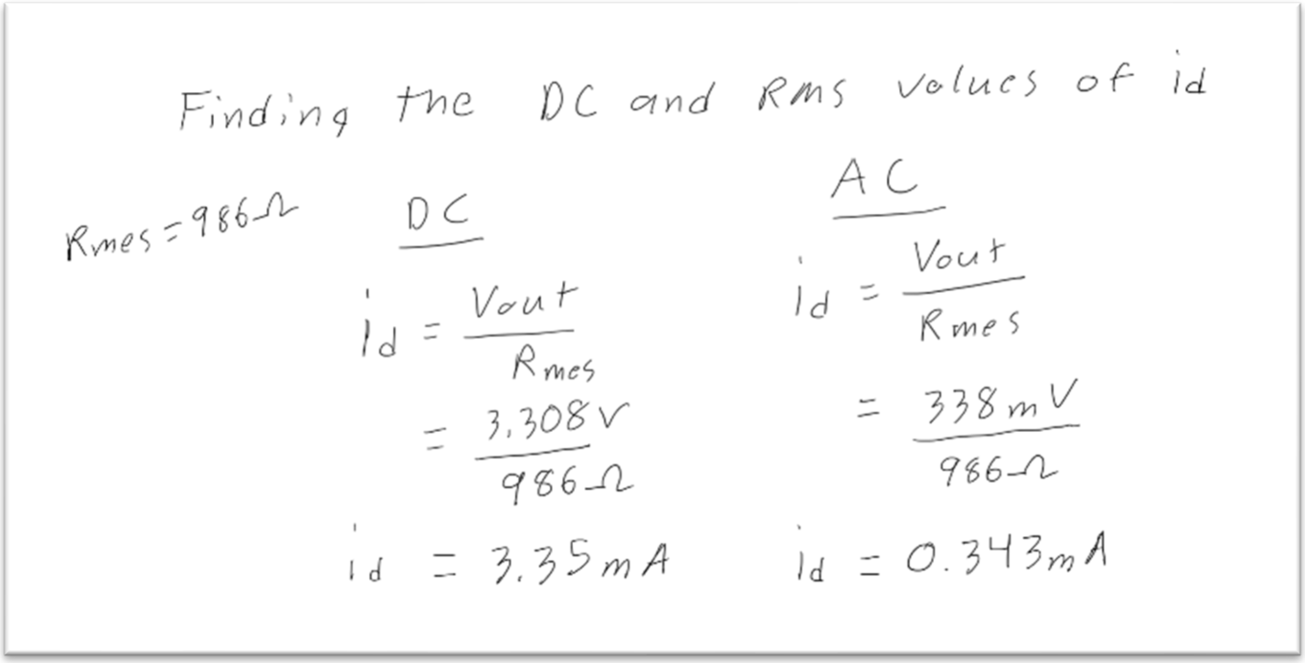

Figure 30 Hand Calculations finding the DC and RMS values of Id

From the waveforms multimeter figure above the Vd values for DC and RMS is:

Vd_ac = 6mV
Vd_dc = 668mV

Here is a table of all found values in one place for easy viewing:

Table 2 Results for Small Signal Analysis of a Diode

	AC	DC
V_d	**5.4mV**	**668mV**
V_{out}	**338mV**	**3.31V**
i_d	**0.352mA**	**3.37mA**

This next part is for the LTSpice simulation of the small signal analysis of a diode.

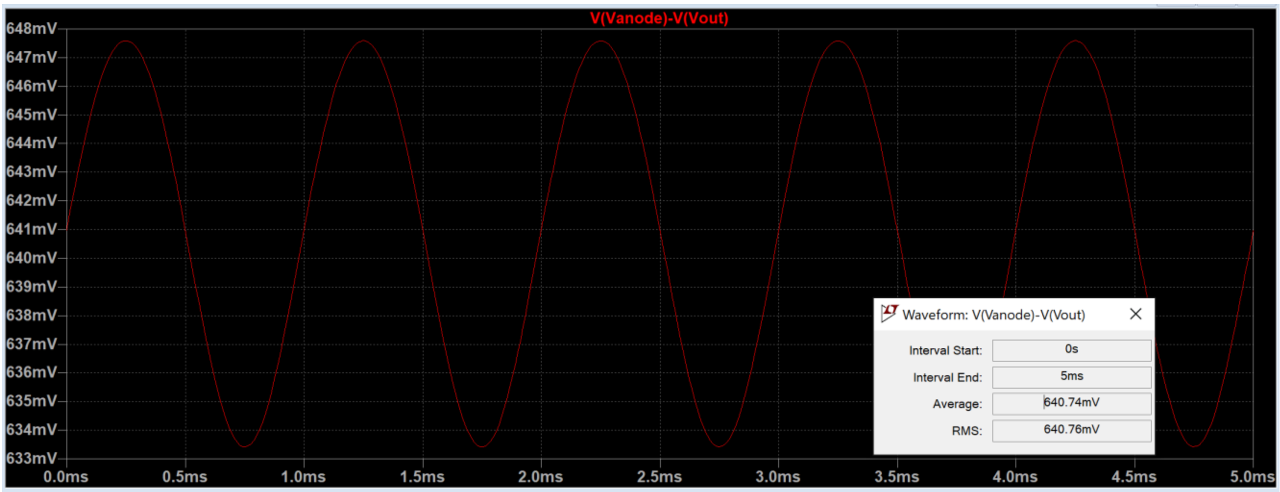

Figure 31 LTSpice Transient Analysis of Vd

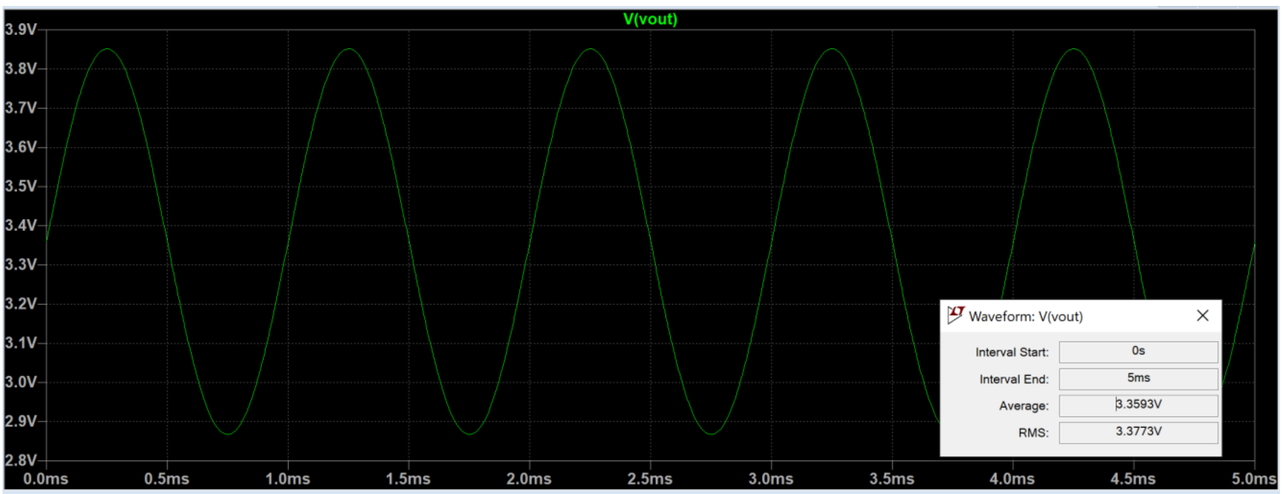

Figure 32 LTSpice Transient Analysis of Vout

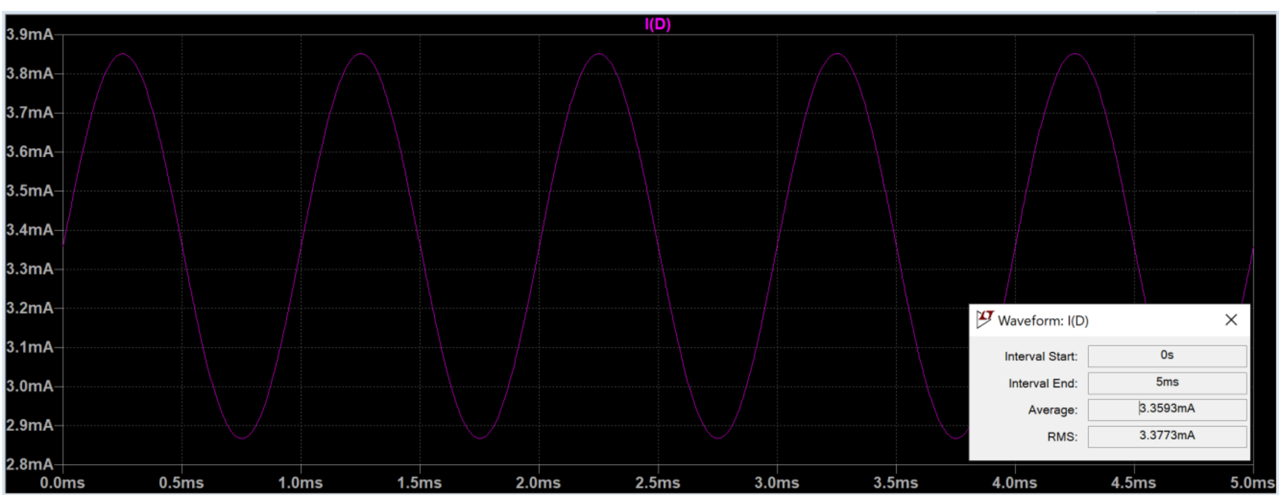

Figure 33 LTSpice Transient Analysis of Id

Table 3 Percent Error Results for Small Signal Analysis of a Diode

	Theoretical	Measured	Simulated	%Error
V_dAC	N/A	5.4mV	5.31mV	1.7%
V_{out}AC	N/A	338mV	348mV	2.87%
I_dAC	N/A	0.352mA	0.348mA	1.15%
V_dDC	0.7V	668mV	N/A	4.5%
V_{out}DC	3.3V	3.31V	N/A	0.3%
I_dDC	3.3mA	3.37mA	N/A	2.1%

3.4 Half-Wave Rectifier

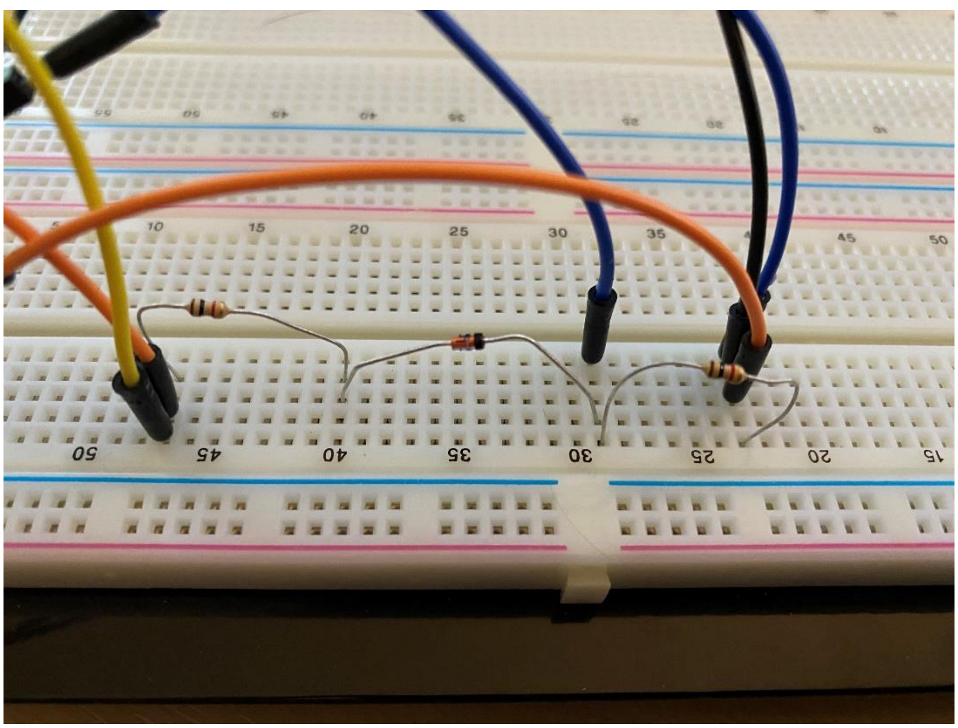

Figure 34 Half-Wave Rectifier

Measured resistor values:
R_S = 982Ω
R_L = 986Ω

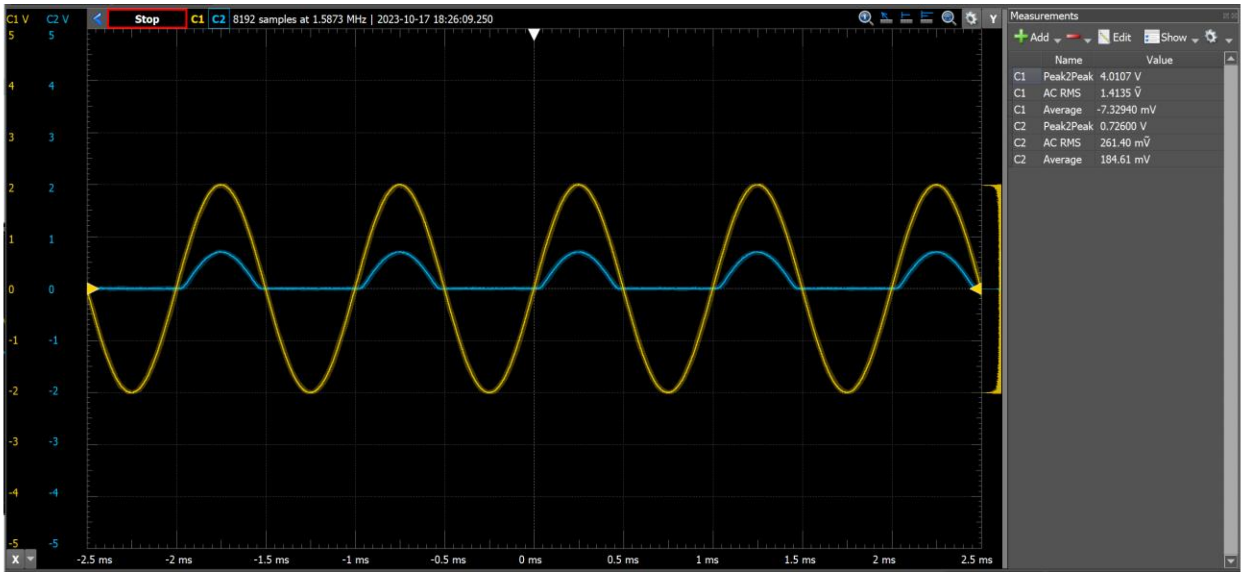

Figure 35 Waveforms Half-Wave Rectifier yellow(Vs) and blue(V_L)

The relevant measured values are:
Vs_rms = 1.41V

$V_{L\text{-}pp}$=0.726V
$V_{L\text{-}RMS}$= 261.4mV
$V_{L\text{-}DC}$=0.184mV

3.5 Full-Wave Rectifier

Measured resistor value:
R = 986Ω

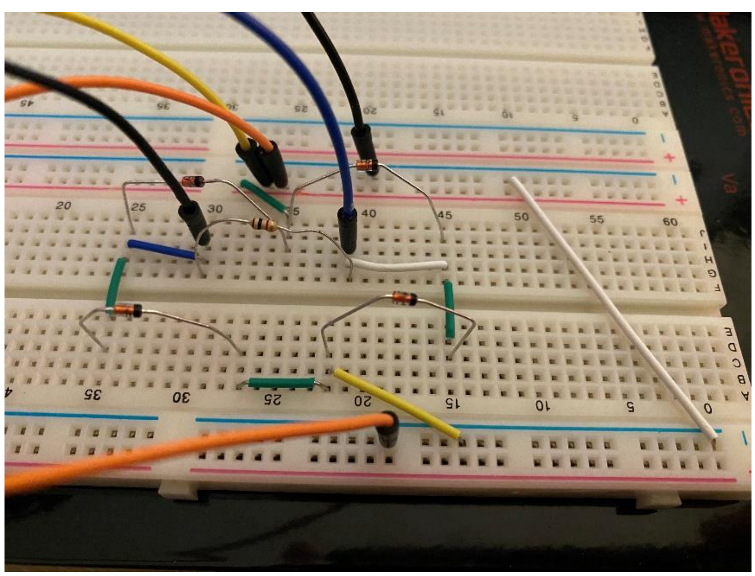
Figure 36 Full-Wave Rectifier

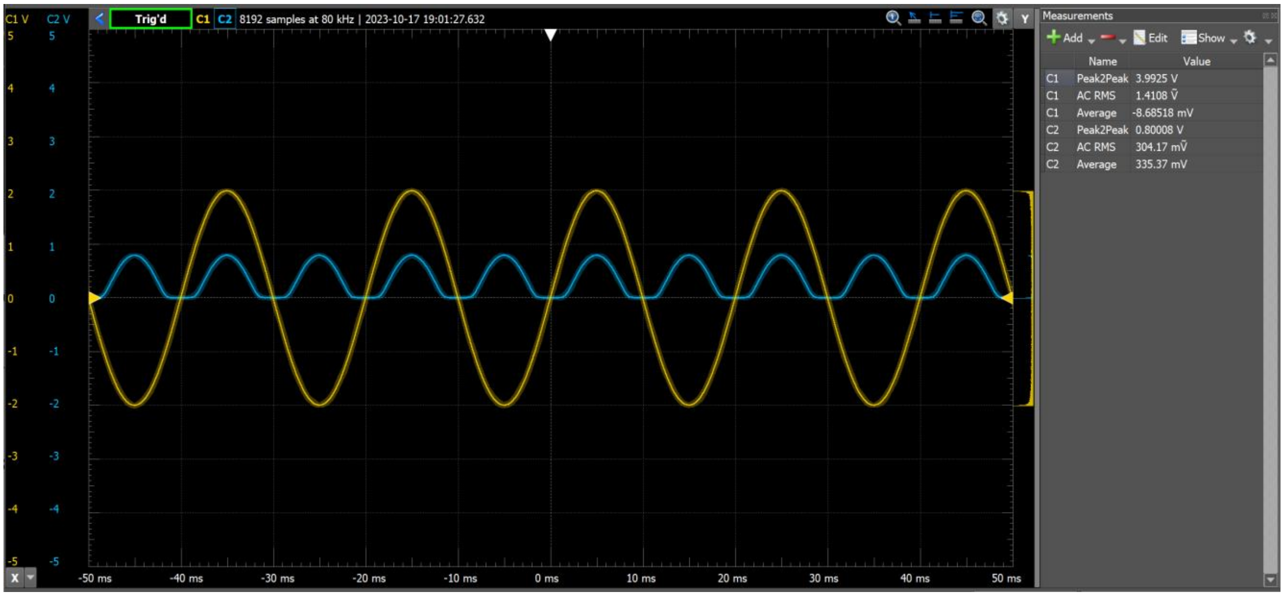

Figure 37 Waveforms Full-Wave Rectifier yellow(Vs) and blue(V_L)

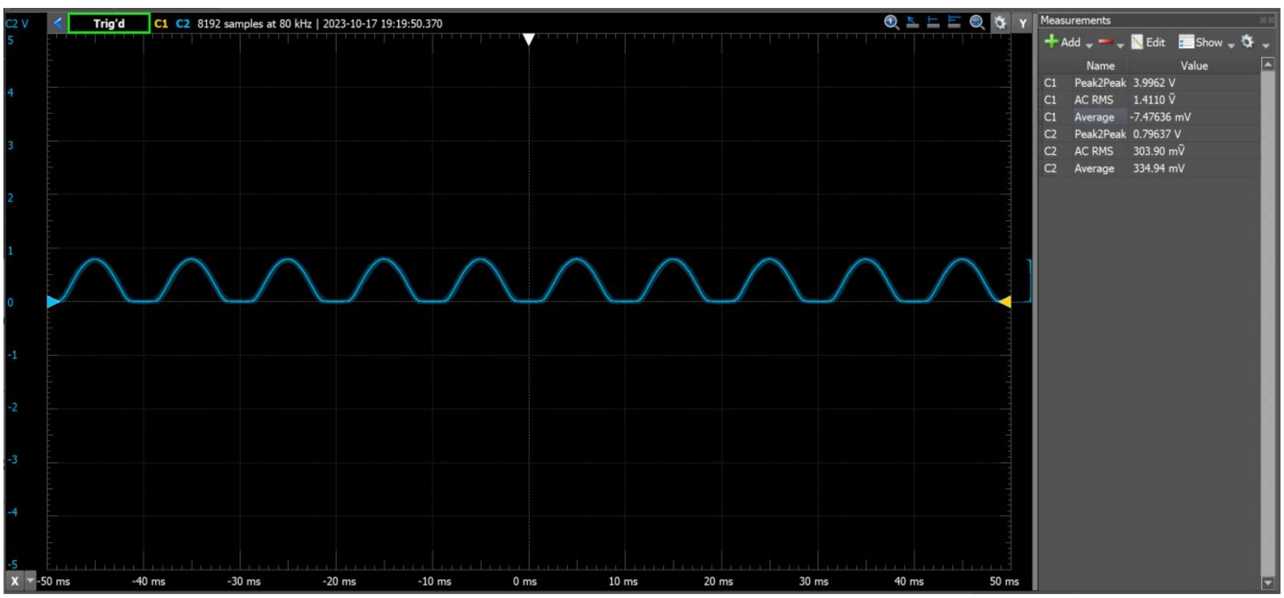

Figure 38 Waveforms Full-Wave Rectifier Output Waveform Only

The relevant measured values are:

V_{Out-pp}=0.796V

$V_{Out-RMS}$= 303.9mV

V_{Out-DC}=334.9mV

3.6 Peak Detector (Rectifier)

Measured Values:

C = 0.0932µF
R = 98700Ω

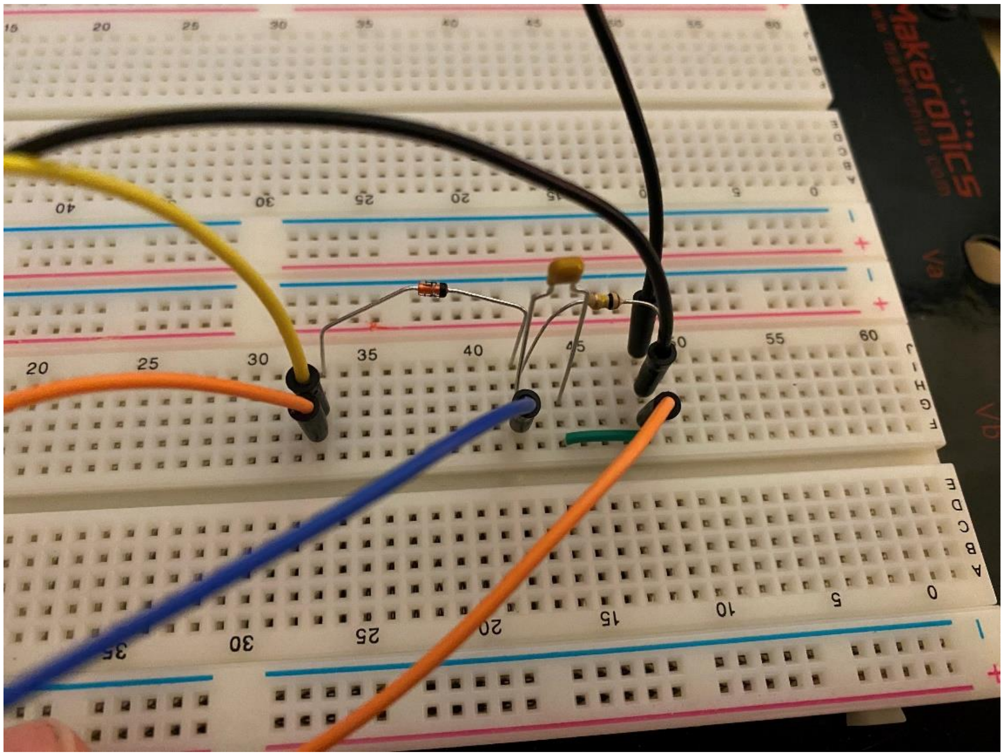

Figure 39 Physical Circuit Peak Detector (Rectifier)

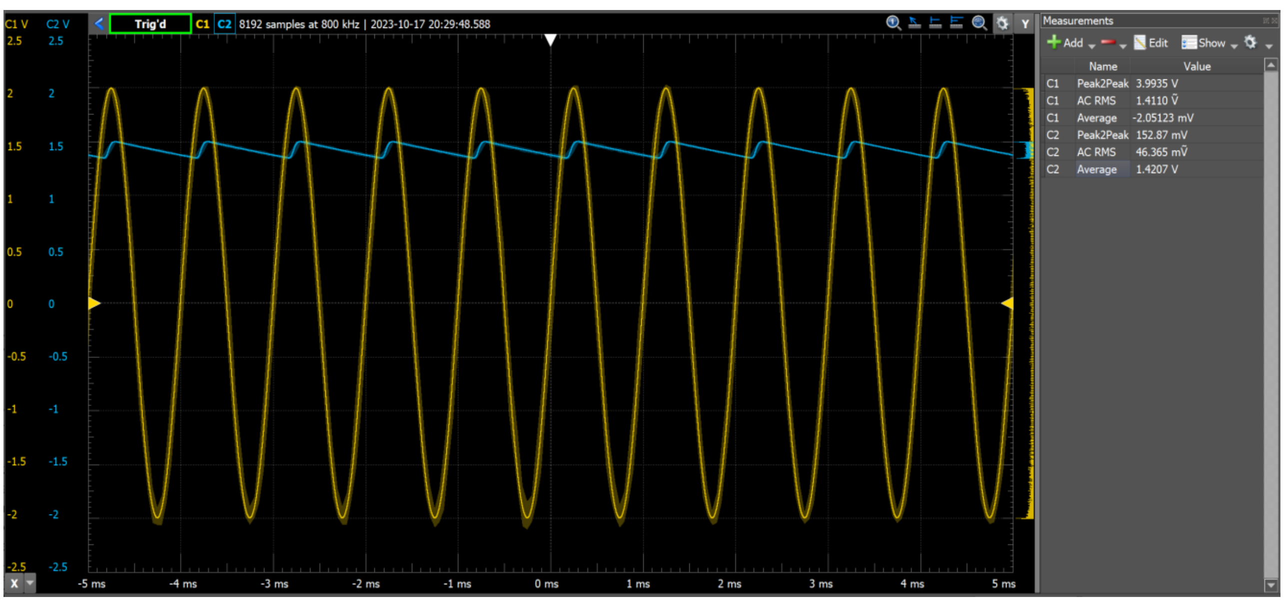

Figure 40 Waveforms Peak Detector (Rectifier) yellow(Vs) and blue(VL)

The relevant measured values are:
Vs_rms = 1.41V

$V_{L\text{-}pp}$=152.8mV
$V_{L\text{-}RMS}$= 46.36mV
$V_{L\text{-}DC}$=1.42V

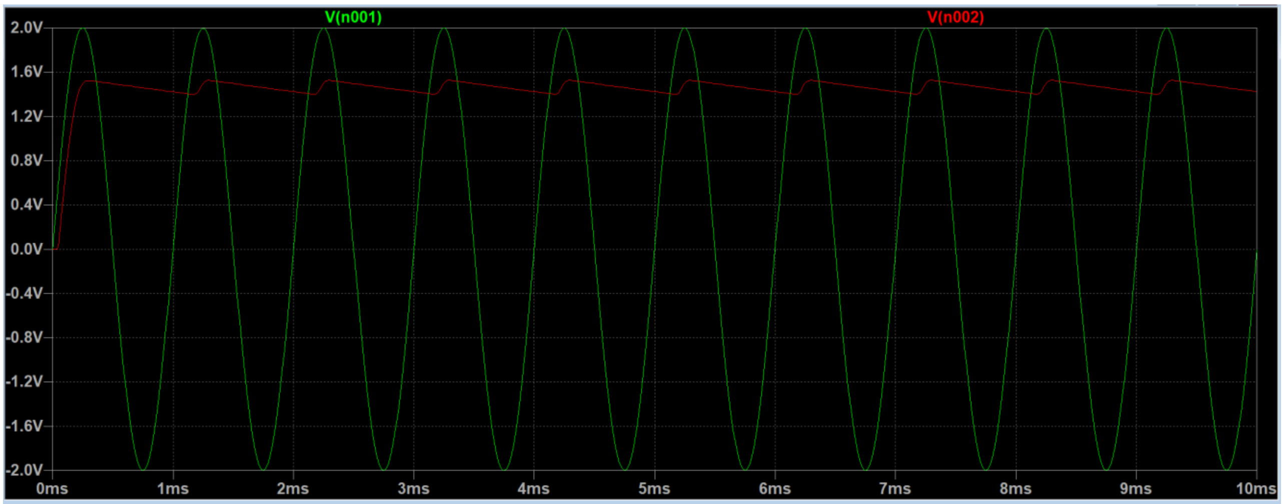

Figure 41 LTSpice Transient Analysis of Peak Detector green(Vs) and red(V_L)

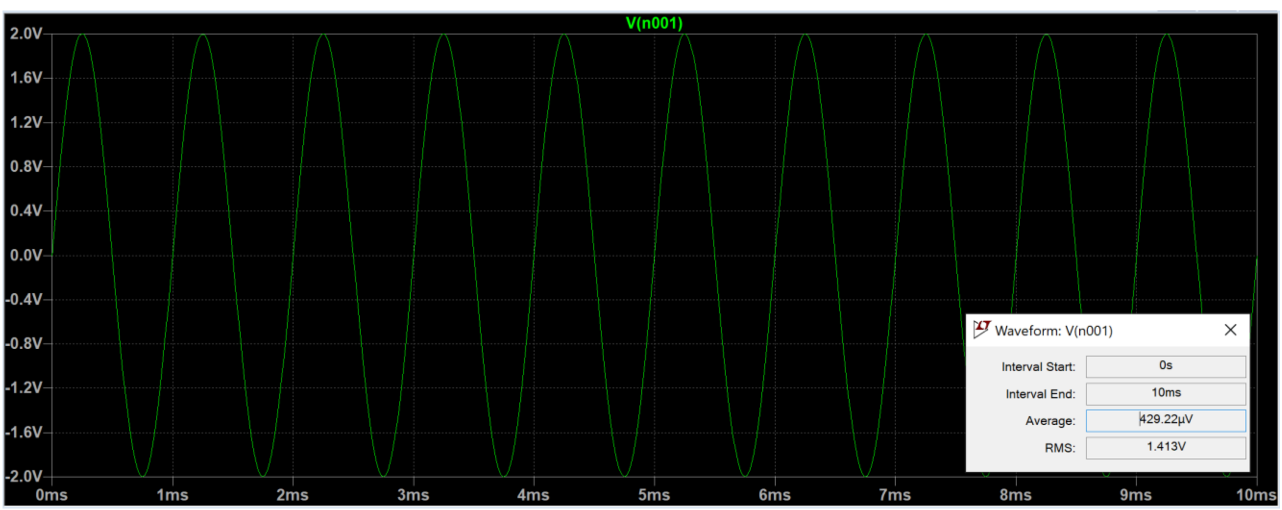

Figure 42 LTSpice Transient Analysis of Peak Detector (Vs)

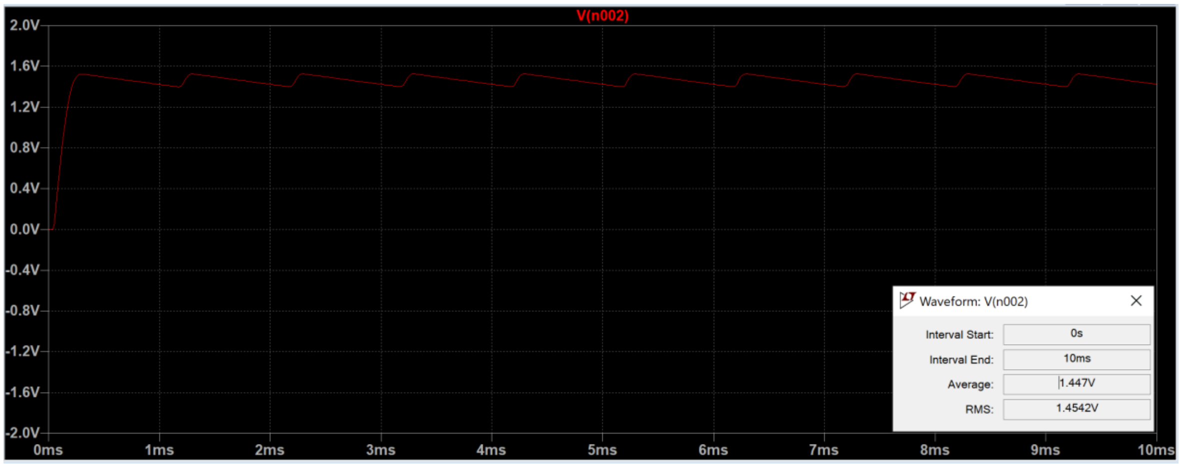

Figure 43 LTSpice Transient Analysis of Peak Detector (V_L)

LTSpice Transient Analysis Measured Values:
Vs_rms = 1.41V
$V_{L\text{-}RMS}$= 1.454V

$V_{L\text{-}DC}$=1.447V

Percent Error Calculation:

$$\frac{|1.44V - 1.42V}{1.44} * 100 = \mathbf{1.39}\%$$

From the calculation above it can be seen that the simulated and measured values are very close.

3.7 Diode Clamper

Measured Values:

C = 0.0932µF

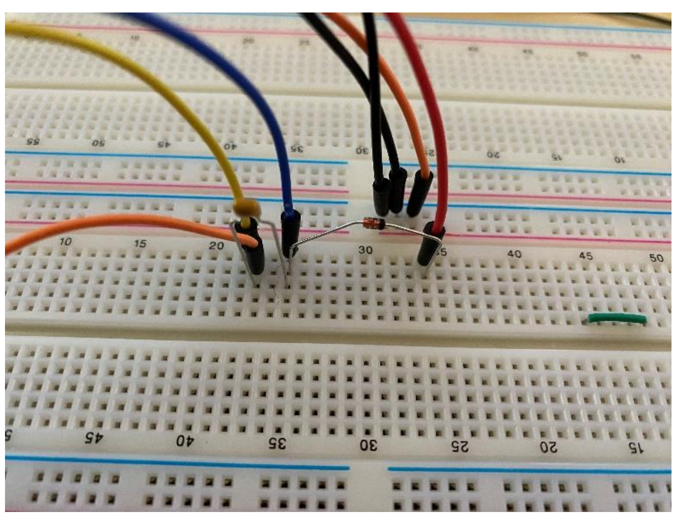

Figure 44 Diode Clamper Physical Build

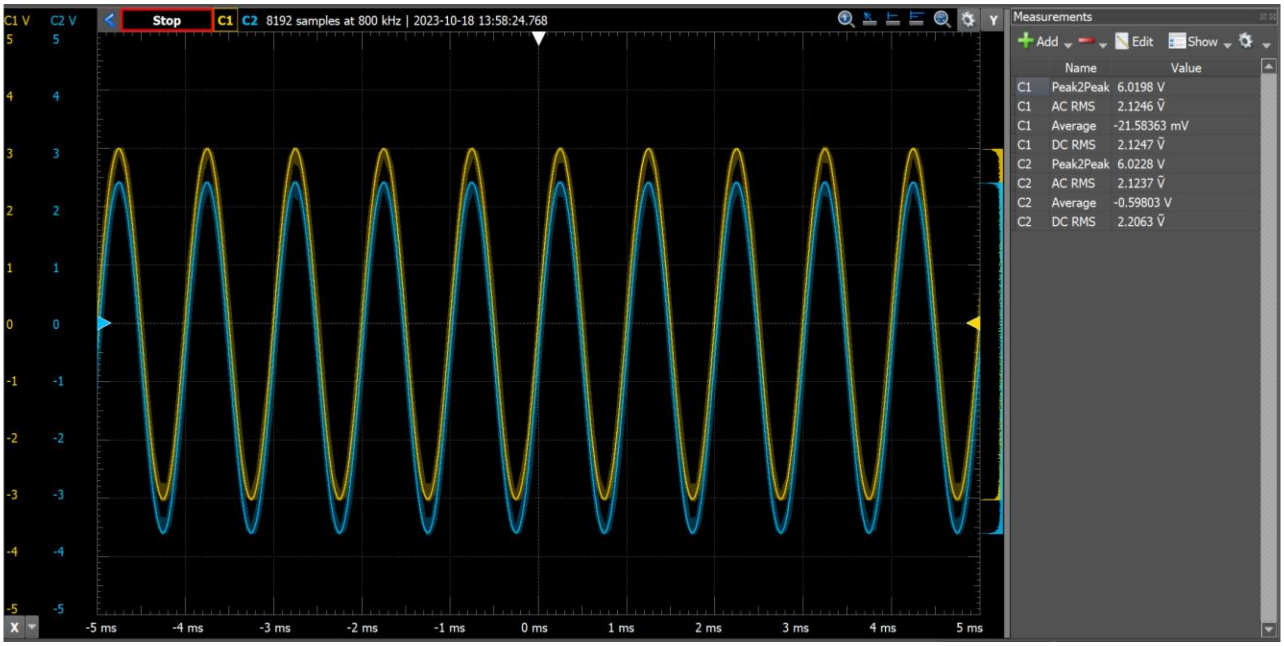

Figure 45 Waveforms Diode Clamper yellow(Vs) and blue(VL)

The relevant measured values are:
Vs_rms = 2.124V

$V_{L\text{-}pp}$=6.002V
$V_{L\text{-}RMS}$= 2.124V
$V_{L\text{-}DC}$=-0.598V

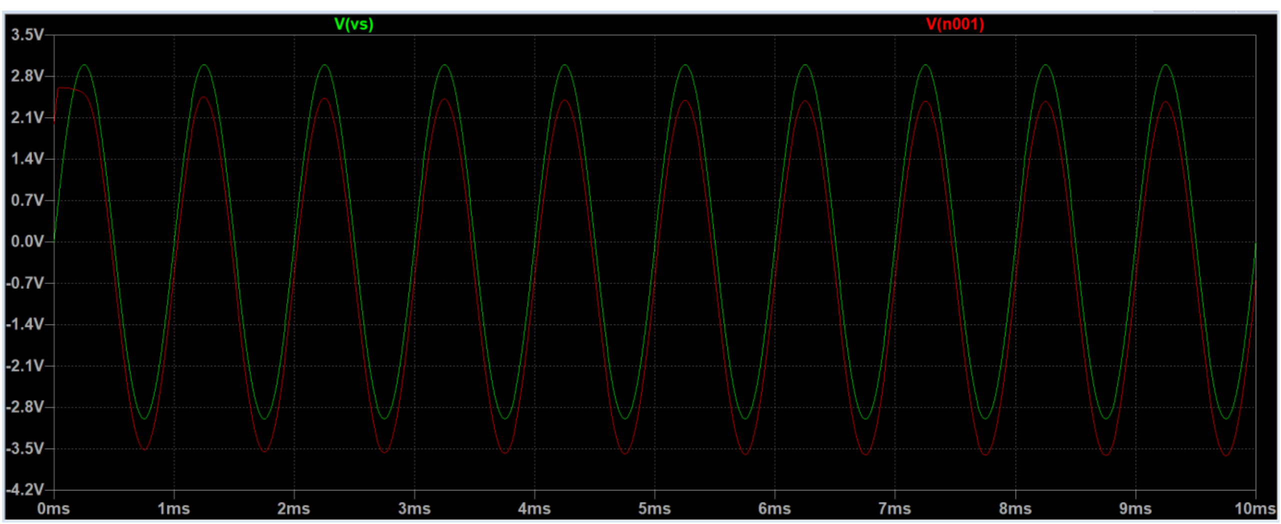

Figure 46 LTSpice Transient Analysis of Diode Clamper green(Vs) and red(VL)

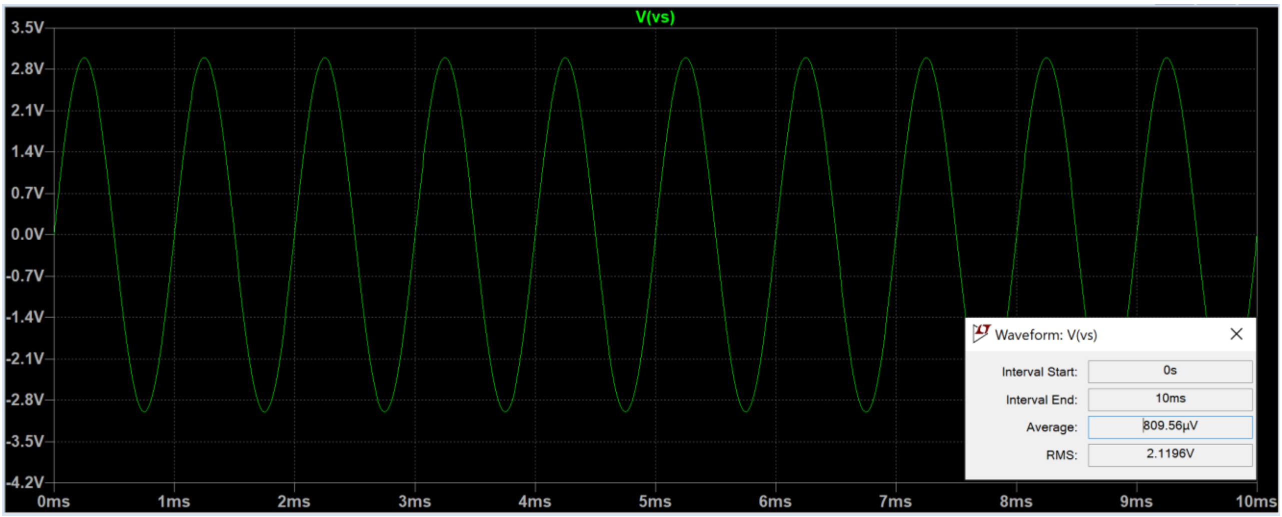

Figure 47 LTSpice Transient Analysis of Diode Clamper (Vs)

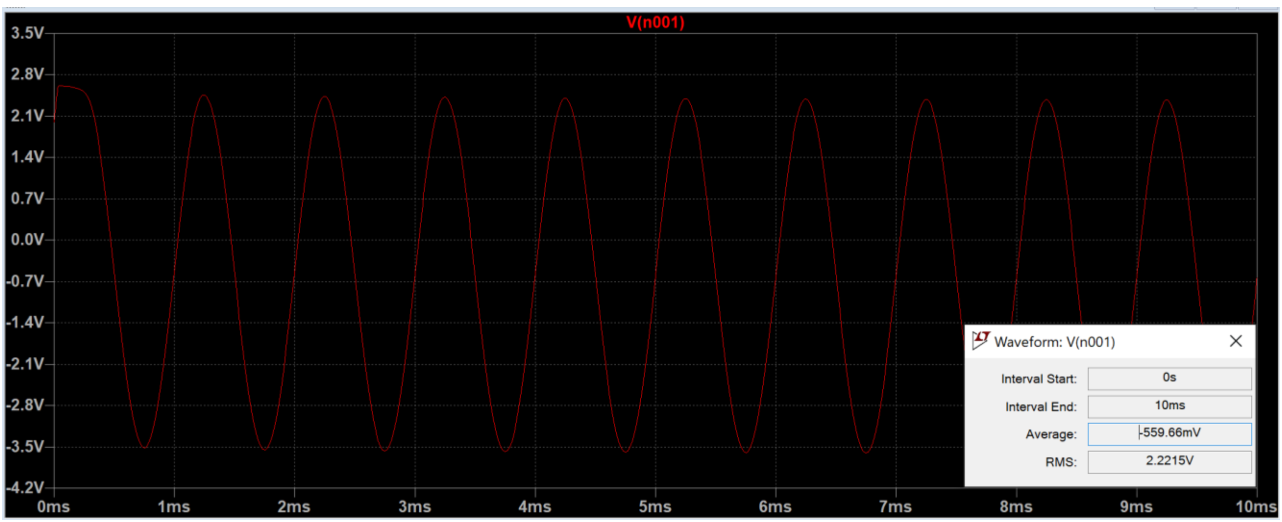

Figure 48 LTSpice Transient Analysis of Diode Clamper (VL)

LTSpice Transient Analysis Measured Values:
Vs_rms = 2.1196V
$V_{L\text{-}RMS}$= 2.2215V

$V_{L\text{-}DC}$=-0.559V

Percent Error Calculation:

$$\frac{|-0.559V-(-0.598)V}{|-0.559V|}*100=\mathbf{6.9}\%$$

This calculation is a little on the higher side but is still okay. Everything was checked over and determined to be correct. This error could be caused by ADK or the capacitor disparity from the measured vs the simulated values.

3.8 Diode Limiter (Clipper)

Measured value of the resistor was determined to be: **979Ω**

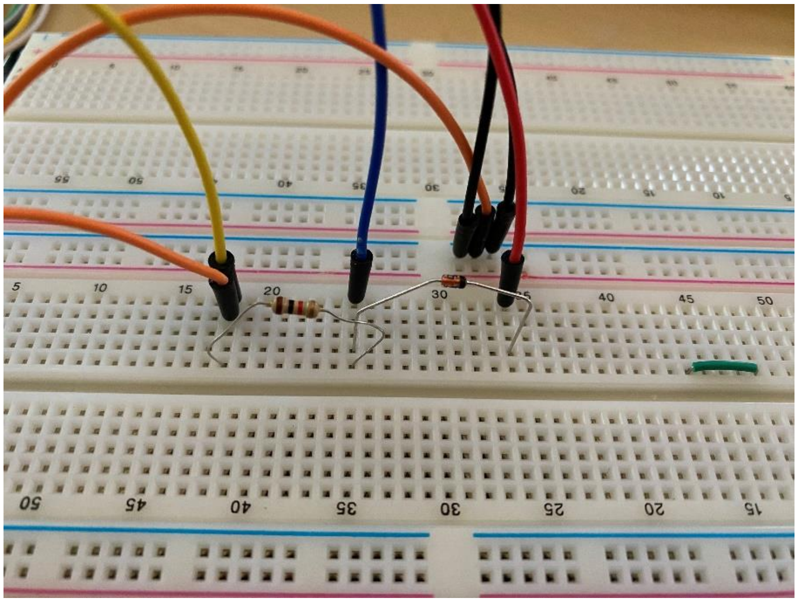

Figure 49 Diode Limiter (Clipper) Physical Build

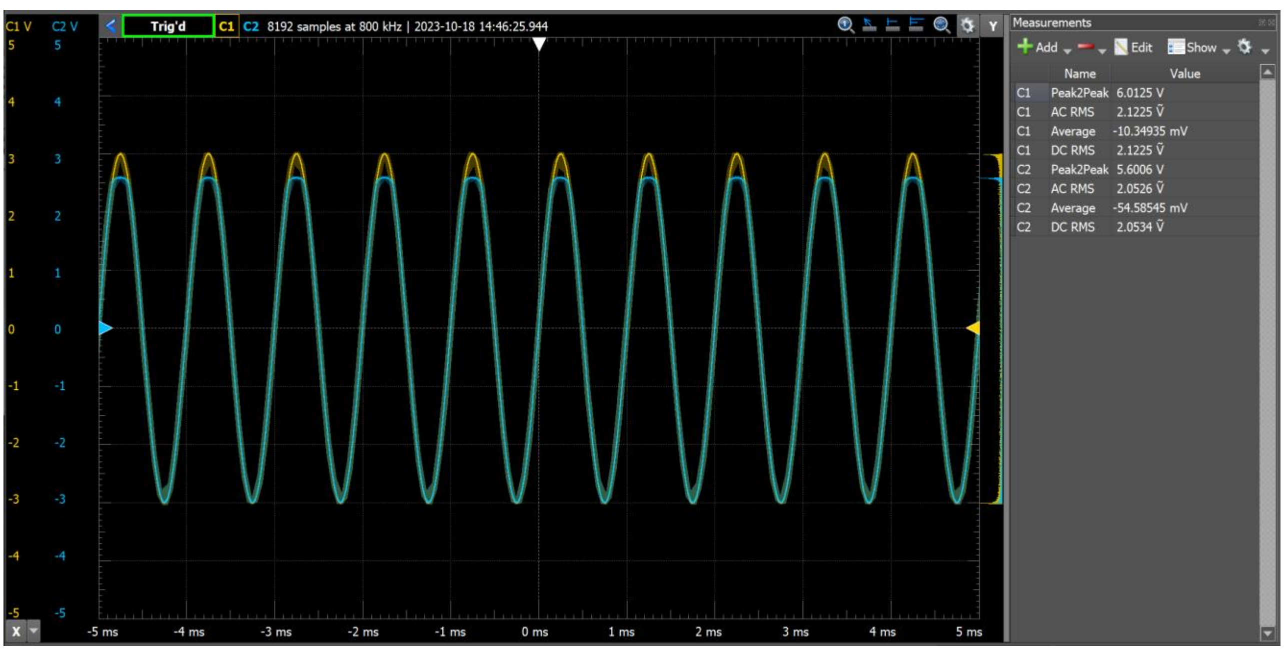

Figure 50 Waveforms Diode Limiter (Clipper) yellow(Vs) and blue(VL)

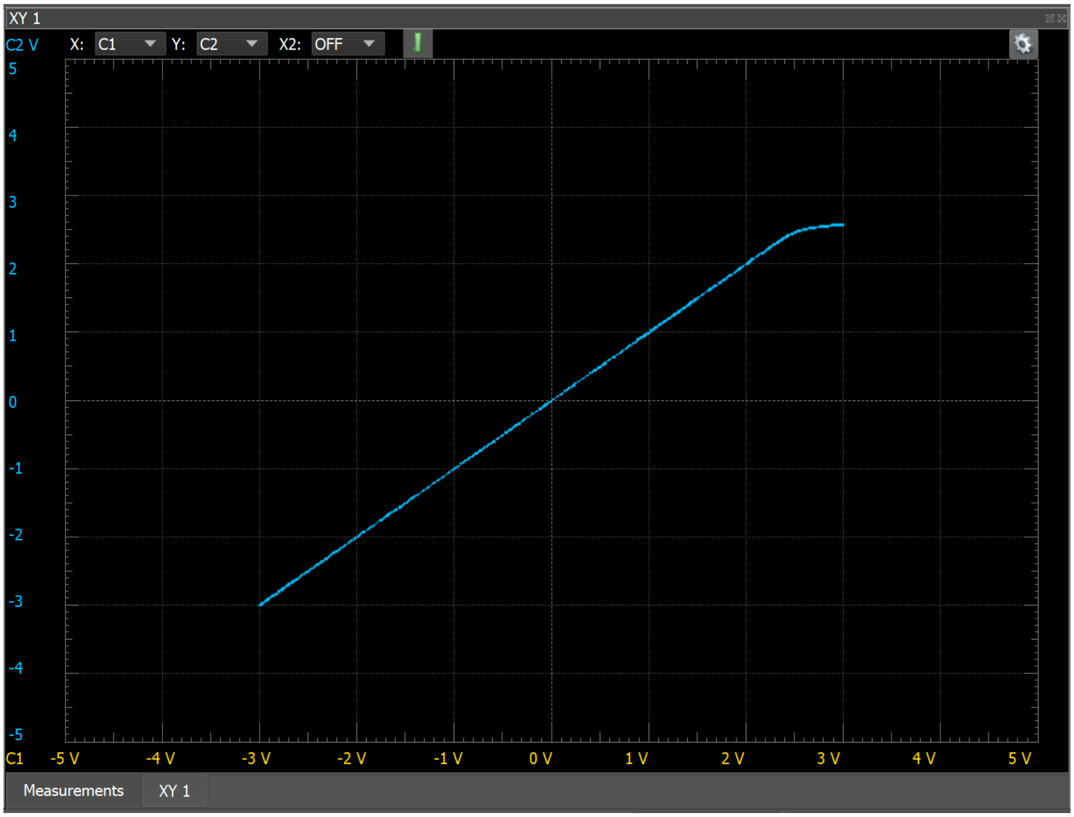

Figure 51 Waveforms Diode Limiter (Clipper) Transfer Function V_L vs Vs

The relevant measured values are:
Vs_rms = 2.122V

$V_{L\text{-}pp}$=5.600V
$V_{L\text{-}RMS}$= 2.052V
$V_{L\text{-}DC}$=-54.585mV

V_L vs V_s = 2.55V

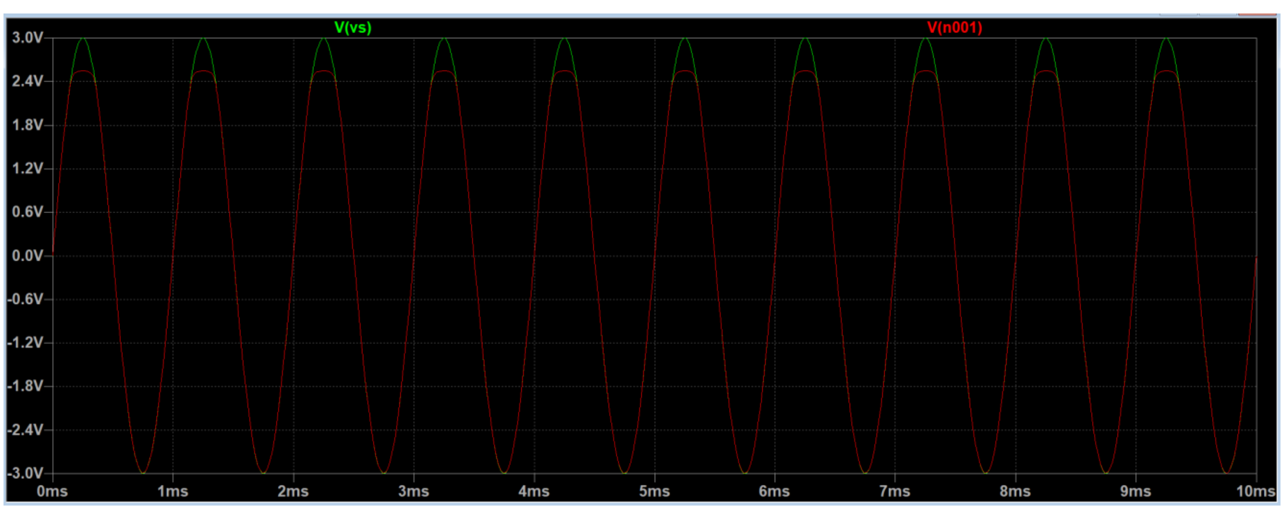

Figure 52 LTSpice Transient Analysis of Diode Limiter green(Vs) and red(VL)

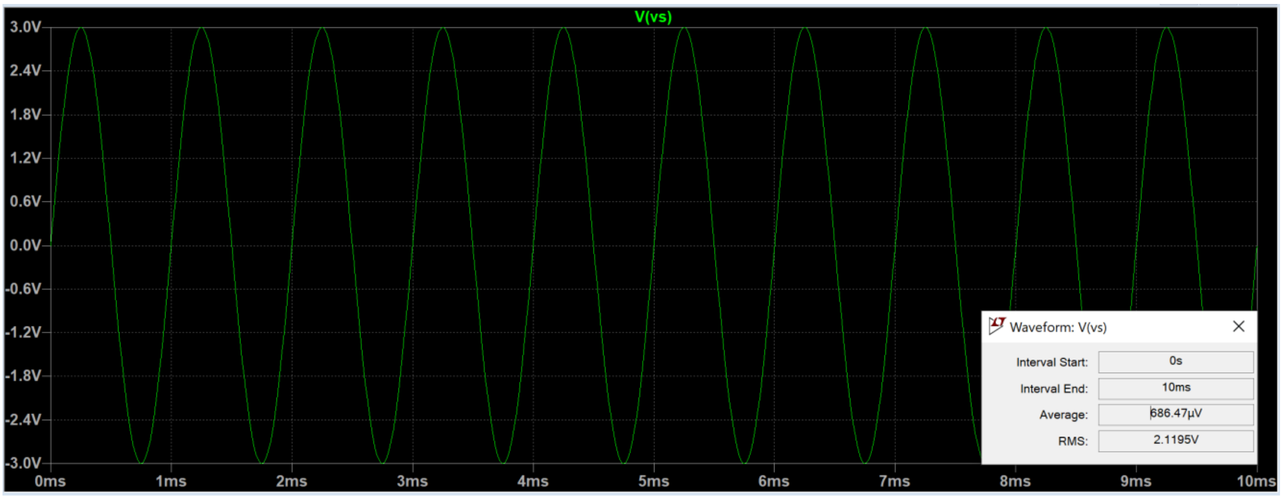

Figure 53 LTSpice Transient Analysis of Diode Limiter (Vs)

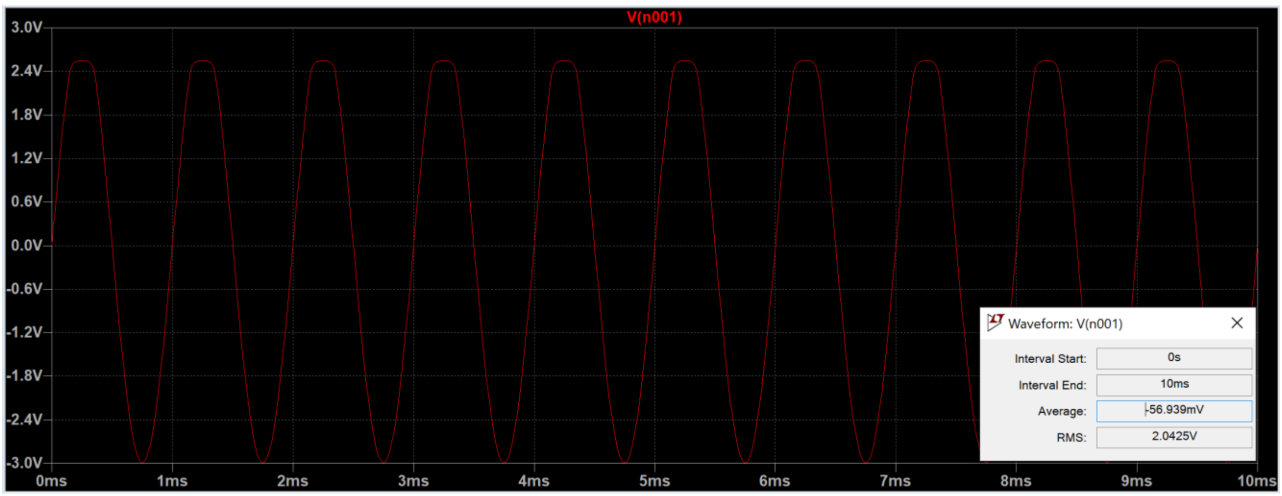

Figure 54 LTSpice Transient Analysis of Diode Limiter (VL)

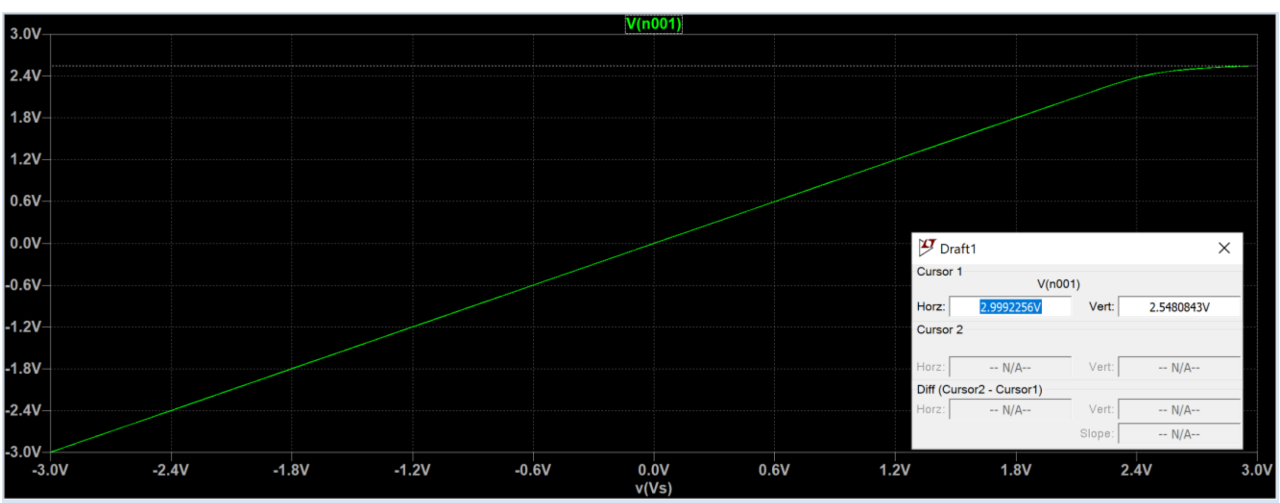

Figure 55 LTSpice Trsnsfer Function of Diode Limiter (VL) vs (Vs)

LTSpice Transient Analysis Measured Values:
V_{s_rms} = 2.119V
$V_{L\text{-}RMS}$= 2.042V

$V_{L\text{-}DC}$=-56.939V

V_L vs V_s = 2.54V

Percent Error Calculation of V_L vs V_S:

$$\frac{|2.54V - 2.55V}{|2.54V|} * 100 = \mathbf{0.39}\%$$

3.9 Voltage Multiplier Circuit

Measured Values:

C1 = 44.6µF
C2 = 46.9µF
R = 2182Ω

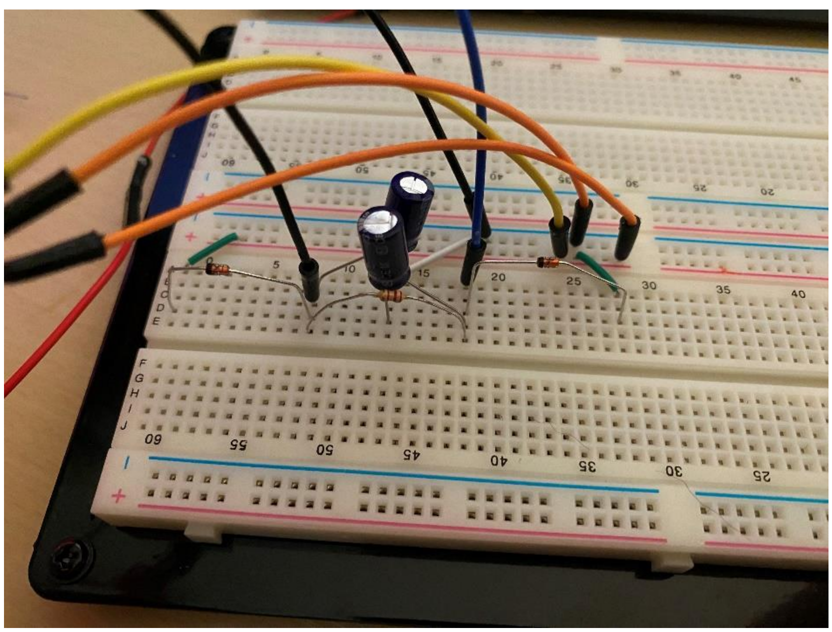

Figure 56 Voltage Multiplier Circuit Physical Build

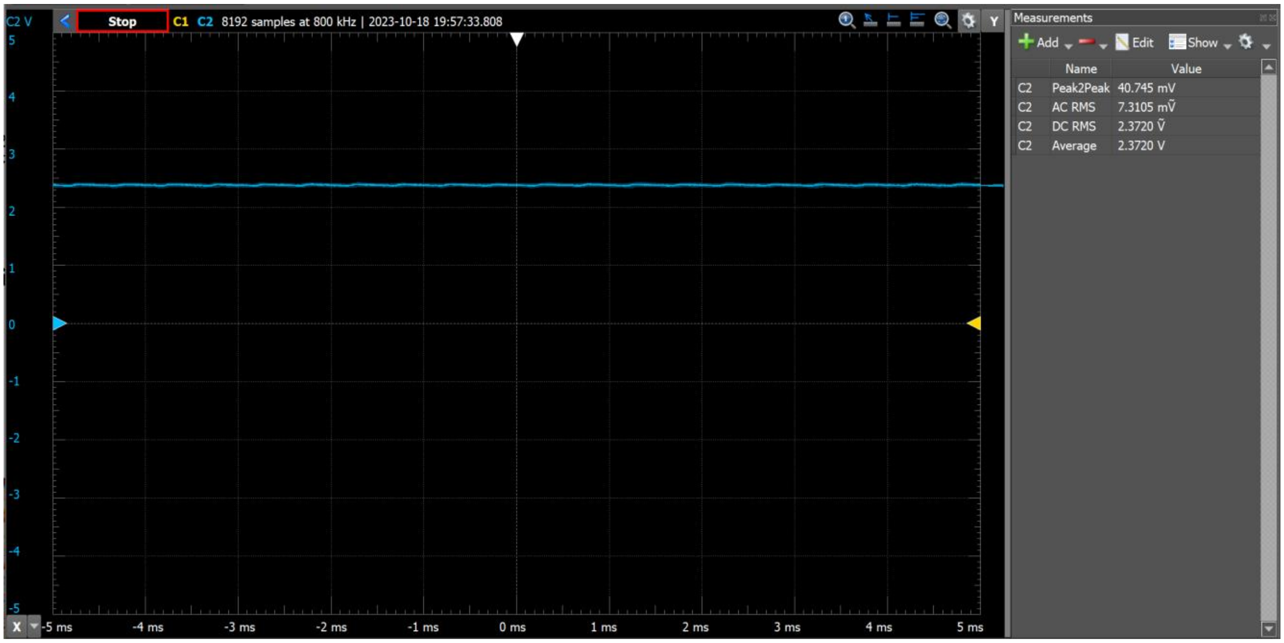

Figure 57 Waveforms Voltage Multiplier Circuit (Vo)

The relevant measured values are:

$V_{0\text{-pp}}$=40.745mV

$V_{0\text{-RMS}}$= 7.3105mV

$V_{0\text{-DC}}$=2.372V

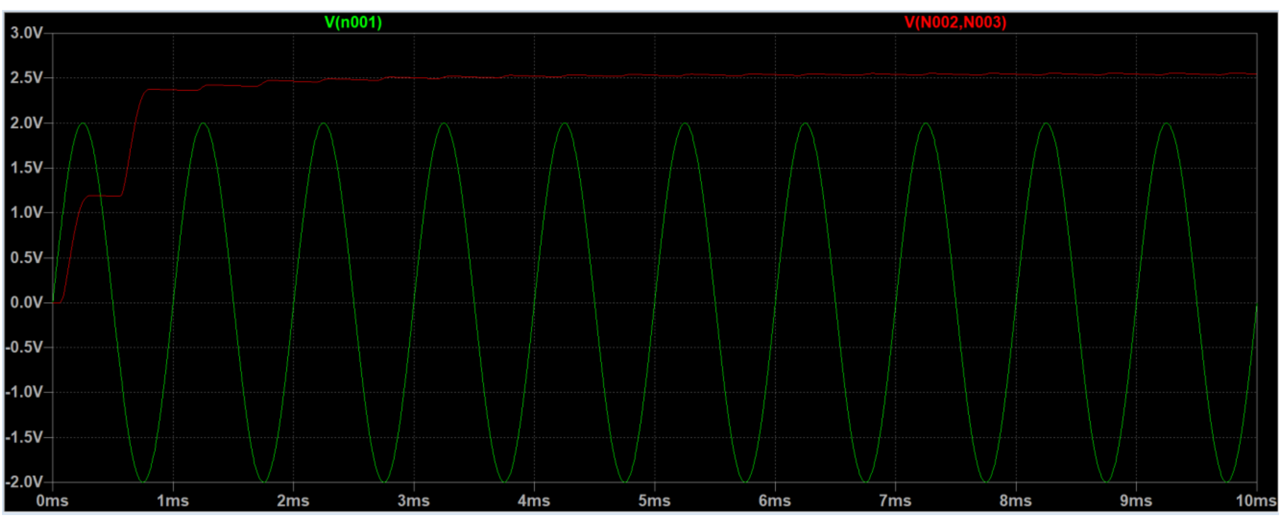

Figure 58 LTSpice Transient Analysis of Voltage Multiplier green(Vs) and red(Vo)

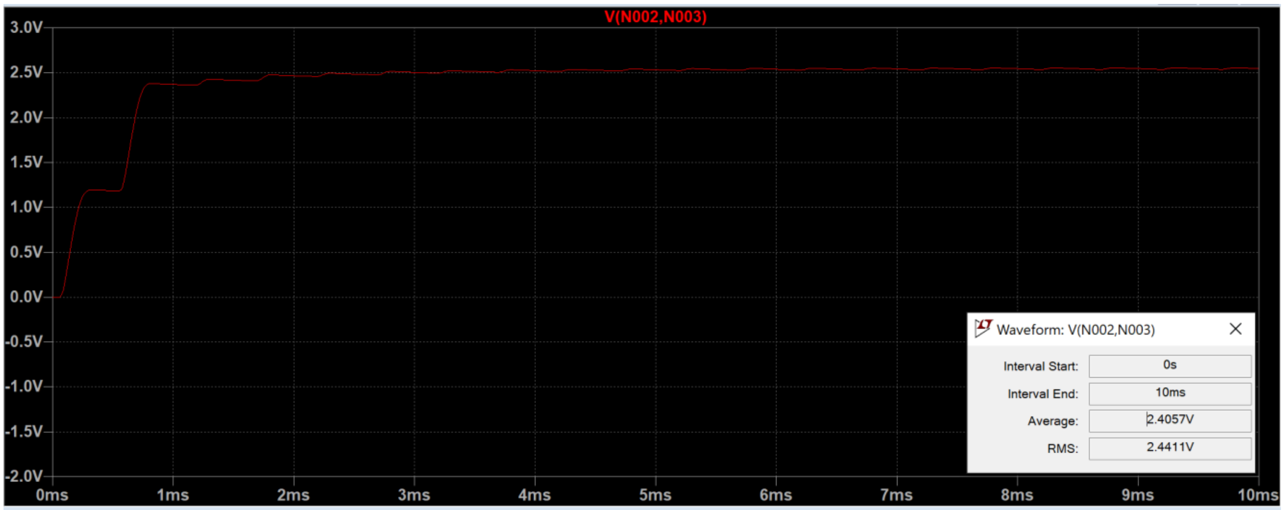

Figure 59 LTSpice Transient Analysis of Voltage Multiplier (Vo)

LTSpice Transient Analysis Measured Values:
$V_{o\text{-}RMS}$= 2.441V

$V_{o\text{-}DC}$=2.405V

Percent Error Calculation of V_L vs V_S:

$$\frac{|2.405V - 2.372V}{|2.405V|} * 100 = \mathbf{1.37}\%$$

As can be seen from the percent error calculation above the results are very close to each other.

CONCLUSION

This lab's main purpose was to allow the student to get a deeper understanding of how diodes fundamentally work. This was done by analyzing, simulating, and building 9 different diode circuits.

For the first section 3.1, the main focus was analyzing the characteristics of PN junction diodes. The circuit was built, simulated, and checked for accuracy. This section was very interesting because its main purpose was to focus on when a diode is "ON" or "OFF". From the results section it can be seen through the figures of I-V curves and the analyzed graphs of diode characteristics the expected results were very close to the measured results. Since the basic diode analysis uses 0.7V this section concluded a value of around 0.6V for the first diode tested and 0.64V for the second diode. Both are very close to 0.7V.

As for the second section 3.2, this was focused on the dc analysis of a diode. This was similar to the first section when verifying hand calculations against the physical build of the circuit. Here are the overall results:

	Theoretical	LTSpice	ADK Multimeter Values	Percent Error Measured	Percent Error Simulated
V_{out} (V)	3.30V	3.35V	3.31V	0.3%	1.5%
I_d (mA)	3.30mA	3.35mA	3.31mA	0.3%	1.5%
V_d (V)	0.7V	0.641V	0.671V	4.1%	8.4%

As can be seen both Vout and Id came out to be fairly accurate. While Vd was a little on the higher end of error. This is best attributed to errors built into the physical diodes themselves. When using 0.7V for diode analysis this is a rough estimate of when a diode turns on however in real practice diodes seem to range from 0.6V-0.7V. This estimate is built off knowledge gained from this lab.

In section 3.3, this was the small signal analysis of a diode. This was by far the worst part of this lab due to the vagueness of the lab manual. However, this was very similar to section 3.2 but with AC signals now induced into the circuit. After all hand calculations, physical build, and simulations were ran these were the results:

	Theoretical	Measured	Simulated	%Error
V_dAC	N/A	5.4mV	5.31mV	1.7%
V_{out}AC	N/A	338mV	348mV	2.87%
I_dAC	N/A	0.352mA	0.348mA	1.15%
V_dDC	0.7V	668mV	N/A	4.5%
V_{out}DC	3.3V	3.31V	N/A	0.3%
I_dDC	3.3mA	3.37mA	N/A	2.1%

As seen again very accurate results achieved when comparing all the different steps in the analysis. All of these percentage errors are well within parameters but the reason they are not dead-on is due to physical build issues in diode or the resistor values not being the expected value due to manufacturing errors.

Section 3.4 was focused on the half wave rectifier circuit. This circuit's overall purpose is to filter out the bottom half of the sine wave induced to the circuit. From the measurements using the oscilloscope the expected results came out true, so safe to assume this circuit was done correctly.

Section 3.5 was focused on the full wave rectifier circuit. This circuit's overall purpose is to cut the amplitude by almost half while also inverting the bottom half of the sine wave. From the measurements using the oscilloscope the expected results came out true, so safe to assume this circuit was done correctly.

Section 3.6 was focused on the Peak Detector (Rectifier) circuit. This circuit started to introduce capacitors into the build and shows how capacitors could be used in diode circuits. This circuit overall seems to take a sine wave and smooths out the signal towards the Vp voltage. However, there are spikes when the sine wave hits its peak. From the measured and simulation results it was concluded that the circuit was indeed built correctly due to the circuit only having a percent error calculation coming out to be 1.39%.

Section 3.7 was focused on the Diode Clamper circuit. This circuit overall seems to take a sine wave and shifts the output down slightly. From the measured and simulation results it was concluded that the circuit was indeed built correctly but having a percent error calculation coming out to be 6.9%. This calculation is a little on the higher side but is still okay. Everything was checked over and determined to be correct. This error could be caused by ADK or the capacitor disparity from the measured vs the simulated values.

Section 3.8 was focused on the Diode Limiter (Clipper) circuit. This circuit overall seems to take a sine wave and clips the top half of the wave off. From the measured and simulation results it was concluded that the circuit was indeed built correctly but having a percent error calculation coming out to be 0.39%. This was by far the most accurate thing completed in the lab!

Lastly, section 3.9 was focused on the Voltage Multiplier Circuit. The physical build of this circuit was also the most difficult to build but was not too horrible. Once determined to be built correctly this circuit seems to obviously act as an amplifier and multiply the output while also smoothing out the sine wave to almost mimic a DC output signal. From the measured results and simulated results, the percentage error came out to be 1.37%. This is also very accurate and safe to say the circuit was built correctly.

POST LAB QUESTIONS

1. Explain the function of the ADK Curve Tracer in this experiment.

   The main reason for the ADK curve tracker is to create an easy way to visualize when a diode would be “ON” or “OFF. This is done by showing the relationship of Vin and the current that is running thought the diode.

2. In Fig. 3.4 (DC analysis of a diode), what would be Id if:

   a. The resistor, R, was shunted (parallel) with a resistor, Rshunt, of equal value (1kΩ).

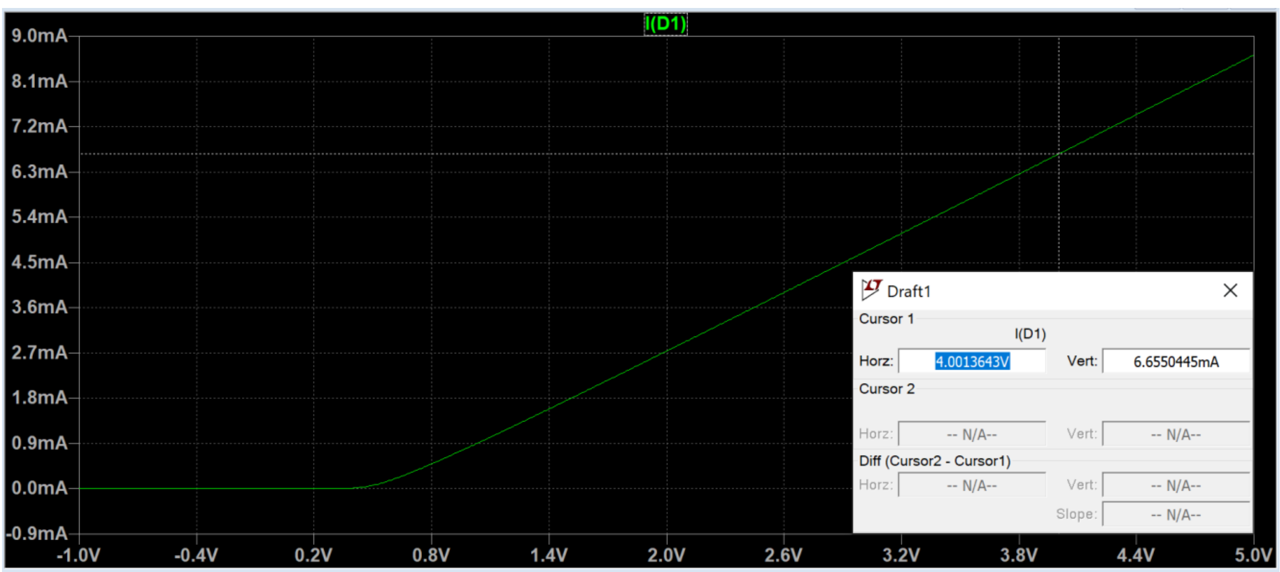

Figure 60 LTSpice Analysis for shunted R question 2a

From analyzing the results of the figure above it seems that when shunting the resistor with the same value resistor in parallel the current doubles.

   b. The resistor R was connected with another 1kΩ resistor in series.

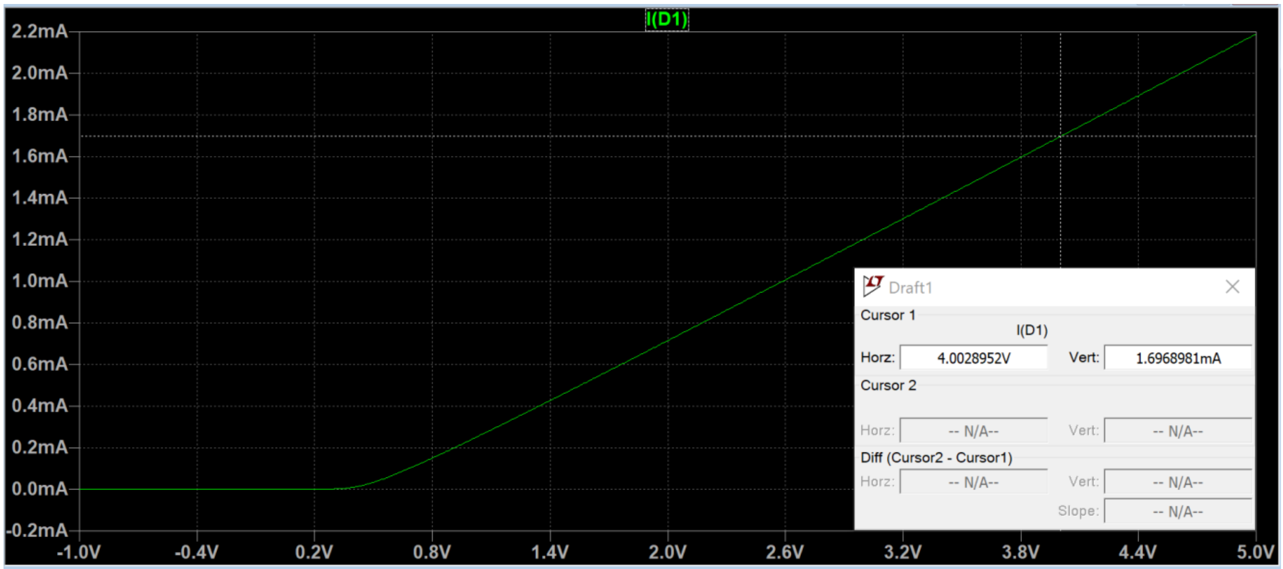

Figure 61 LTSpice Analysis for extra R in series question 2b

From analyzing the results of the figure above it seems that when adding another resistor in series the current is cut in half.

c. The diode, D, were shunted (parallel) with a diode, Dshunt (assumed to be matched).

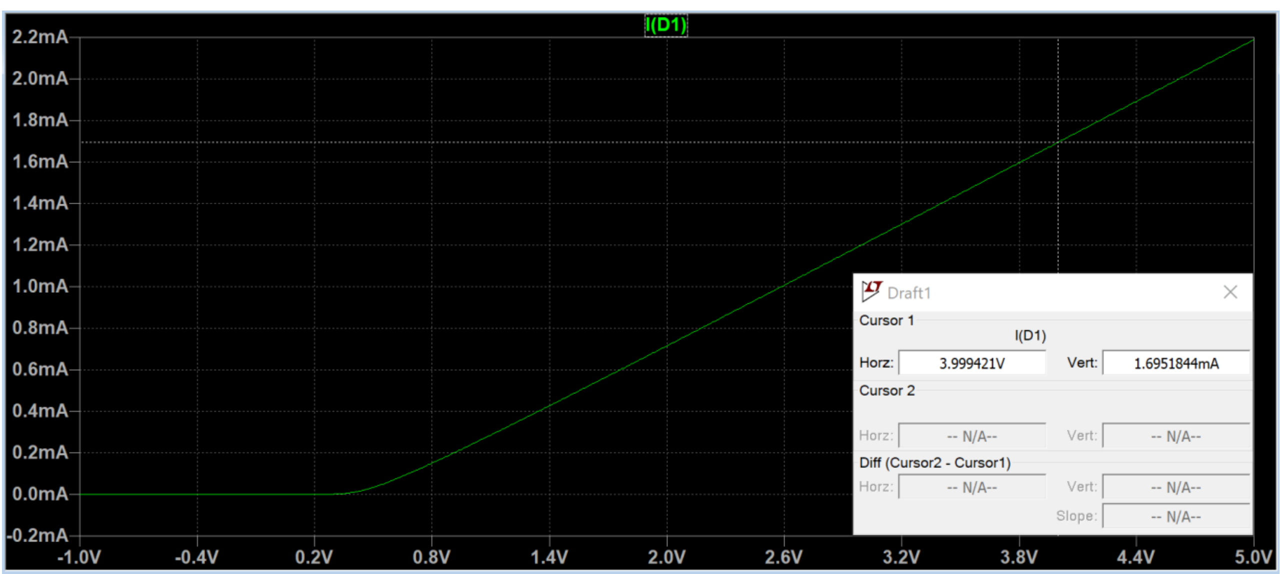

Figure 62 LTSpice Analysis for parallel diode question 2c

From analyzing the results of the figure above it seems that when adding another diode in parrel the current is cut in half similar to 2b.

3. In Fig. 3.5 (Small signal (AC) analysis of a diode), what would happen if the polarity of the DC voltage source were reversed?

With this question, the diode would be reversed biased. This means that no current would flow through it. Except the very small amount of leakage current physical diodes have.

4. What would happen if a capacitor C=47μF were added (in parallel with R) to the diode circuit shown in Fig. 3.5?

If a 47 μF capacitor was added the circuit it would essentially no longer have an output of AC. The result would just be bumpy dc signal.

5. Use LTSpice to implement and verify what would happen if the capacitor were increased ten times in the Peak Detector Rectifier? Explain.

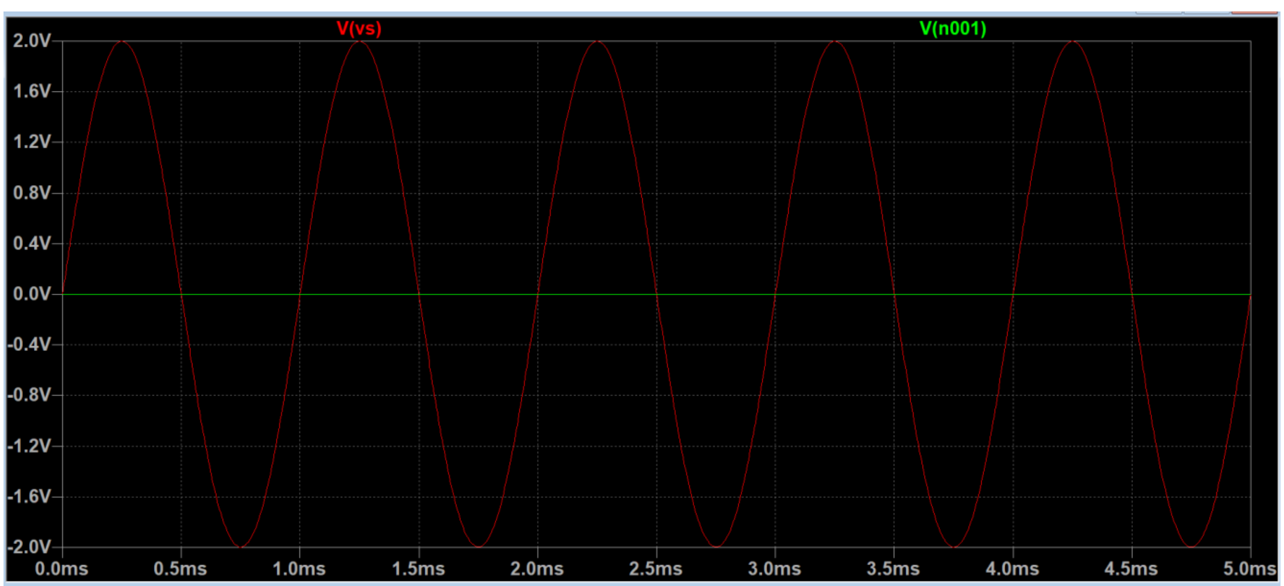

Figure 63 Post lab question #5 Modified Peak Detector LTSpice Analysis #1

Figure 64 Post lab question #5 Modified Peak Detector LTSpice Analysis #2

From the analysis of question 5 it seems by modifying the capacitor the current becomes extremely small. This is due to the capacitor being much larger and holding more charge. So, when the voltage drops the capacitor keeps it constant because the discharge time is significantly longer. This means the bumps in the signal will smooth out which can be seen in figure 63.

6. Discuss briefly the operation of the voltage multiplier circuit. What would happen if the capacitors (C1 and C2) were 1µF in the voltage multiplier circuit? Explain.

The main operation of the voltage multiplier is to essentially act as an amplifier that smooths out the ripples in a sine wave to mimic more of a dc voltage output. As for what would happen if you decreased the capacitors, this would no longer allow the capacitors to smooth out the signal. This would result in increased ripples in the signal. This result would be a negative for a voltage multiplier circuit because the whole point of the circuit is to multiply the voltage while also smoothing out the ripples in a sine wave input signal.