ASEN 3300, Fall 2023: Lab 3 Report Submission

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Section:	012

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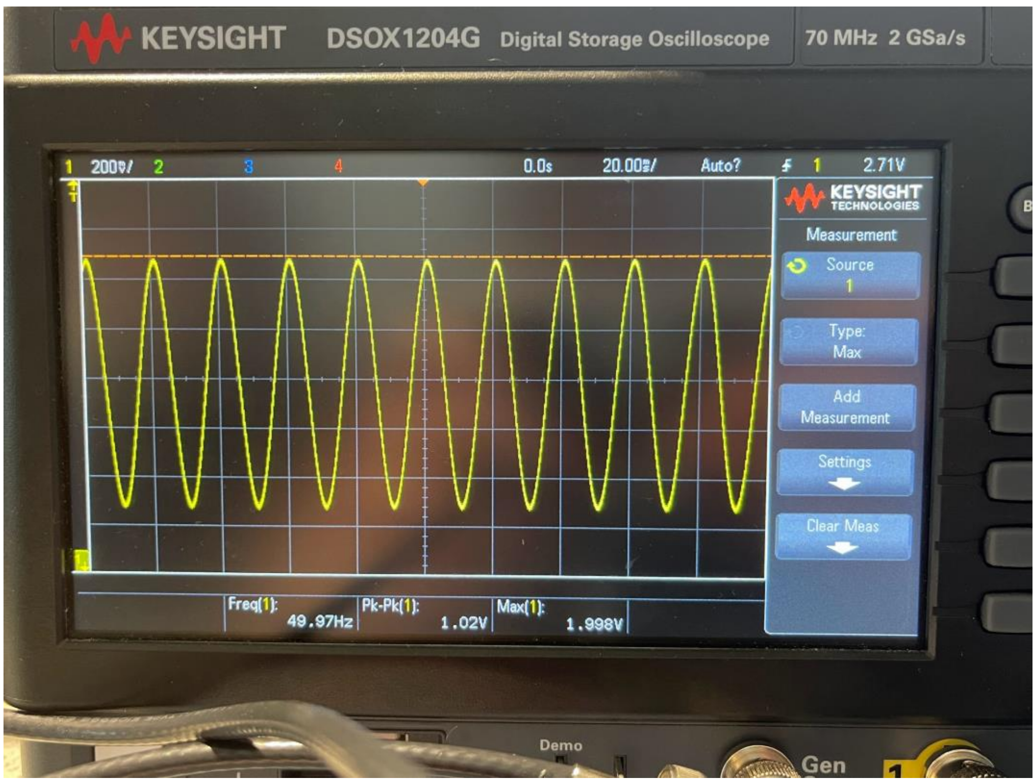
4. Experiment (25 pts)

4.1. Oscilloscope Setup (2 pts)

b. Record your response to 4.1.b below:



4.2. AC/DC Coupling Measurements (5 pts)

a. Record your responses to 4.2.a below:

Resistance of R1:	9.98 kΩ
Resistance of R2:	9.99 kΩ

c. Record your responses to 4.2.c below:

Multimeter Voltage across (R1 + R2):	1.48
Multimeter Voltage across R2:	0.74

d. Record your responses to 4.2.d in the table below:

DC & AC coupling for all measurements in this section

	DC Coupling	AC Coupling
VRMS across (R1 + R2):	1.62V	700mV
VRMS across R2:	794mV	347mV
Frequency	50 Hz	50 Hz

e. Record your response to 4.2.e below:

The DMM measures the average voltage, which can be used to get the RMS voltage. The oscilloscope directly gives the RMS. The AC coupling mode gets rid of the DC offset through internally charging a capacitor. DC coupling includes the DC offset value, which will shift the sine wave up or down.

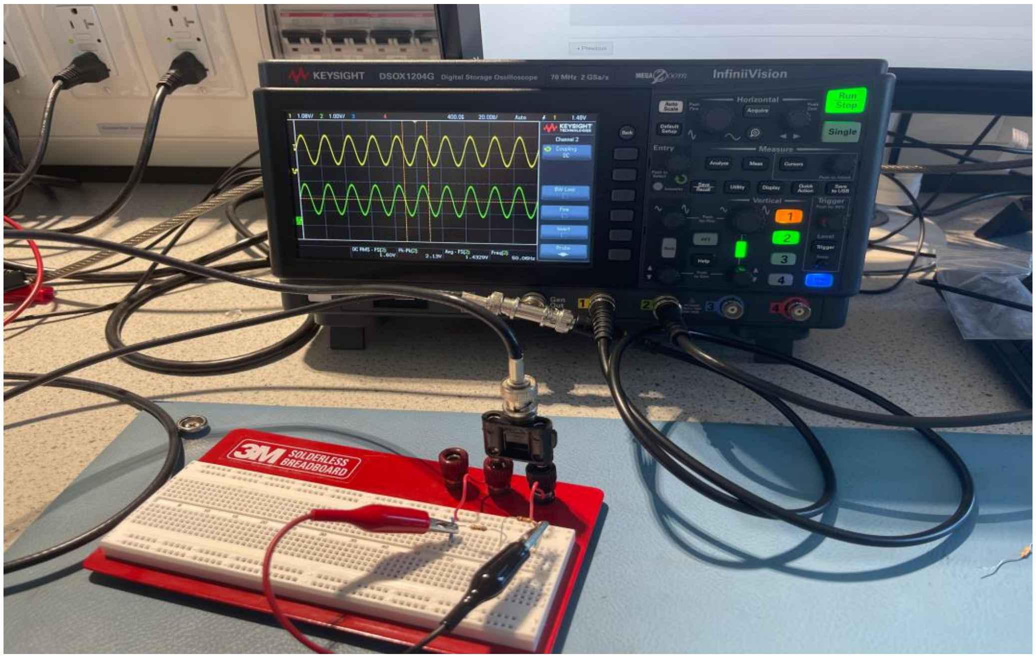
f. Record your responses to 4.2.f in the table below:

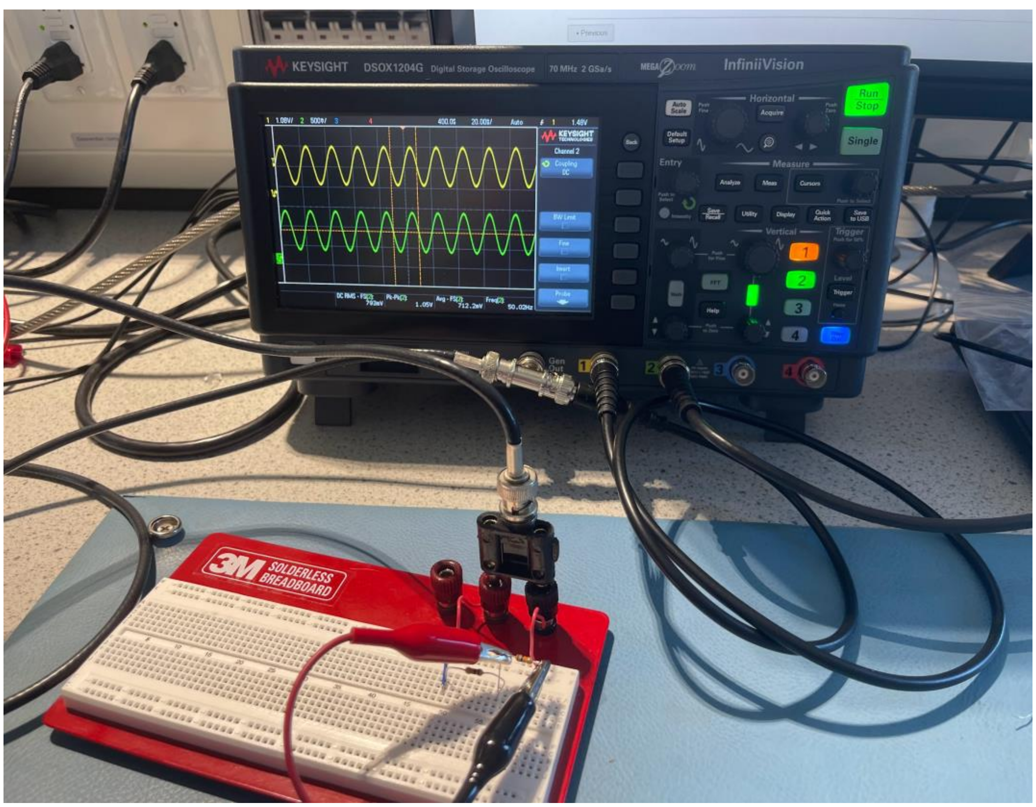
DC & AC coupling for all measurements in this section

	DC Coupling	AC Coupling
V_{pp} across R1 + R2:	2.03 V	2.17 V
V_{pp} across R2:	1.05 V	1.13 V
V_{avg} across R1 + R2:	1.45 V	-23.9 mV
V_{avg} across R2:	707 mV	-22.9 mV
f across R2:	50.02 Hz	50.04 Hz
f across R1 + R2::	49.96 Hz	50.03 Hz

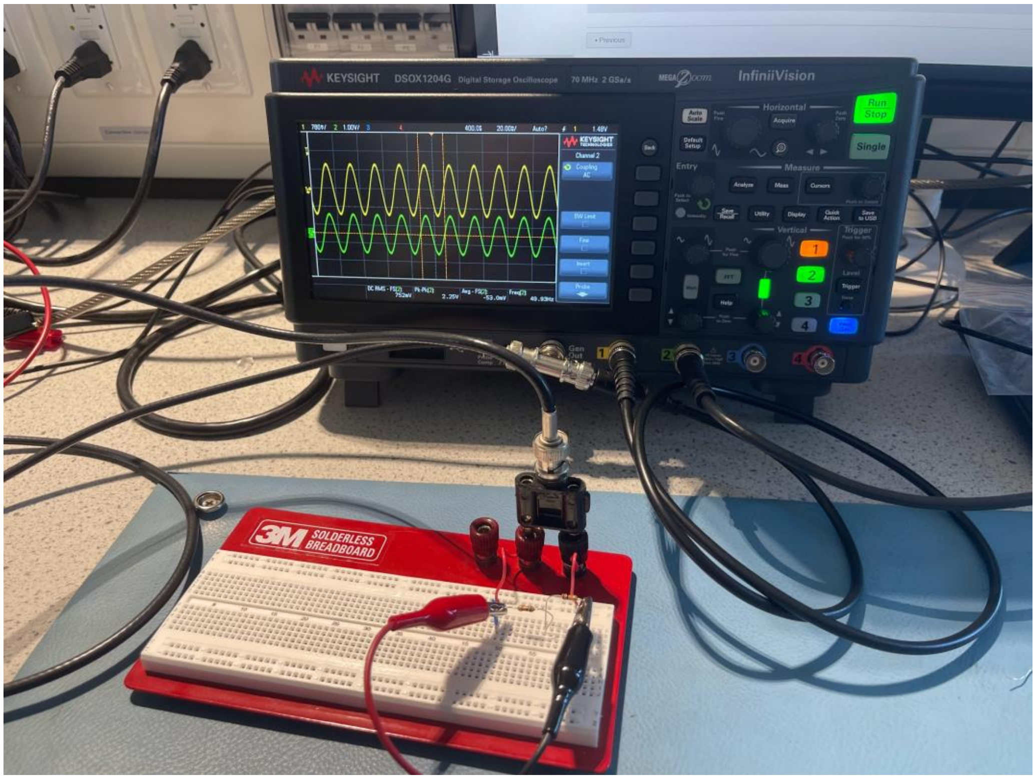
4.3. AC/DC Coupling Sketches (3 pts)

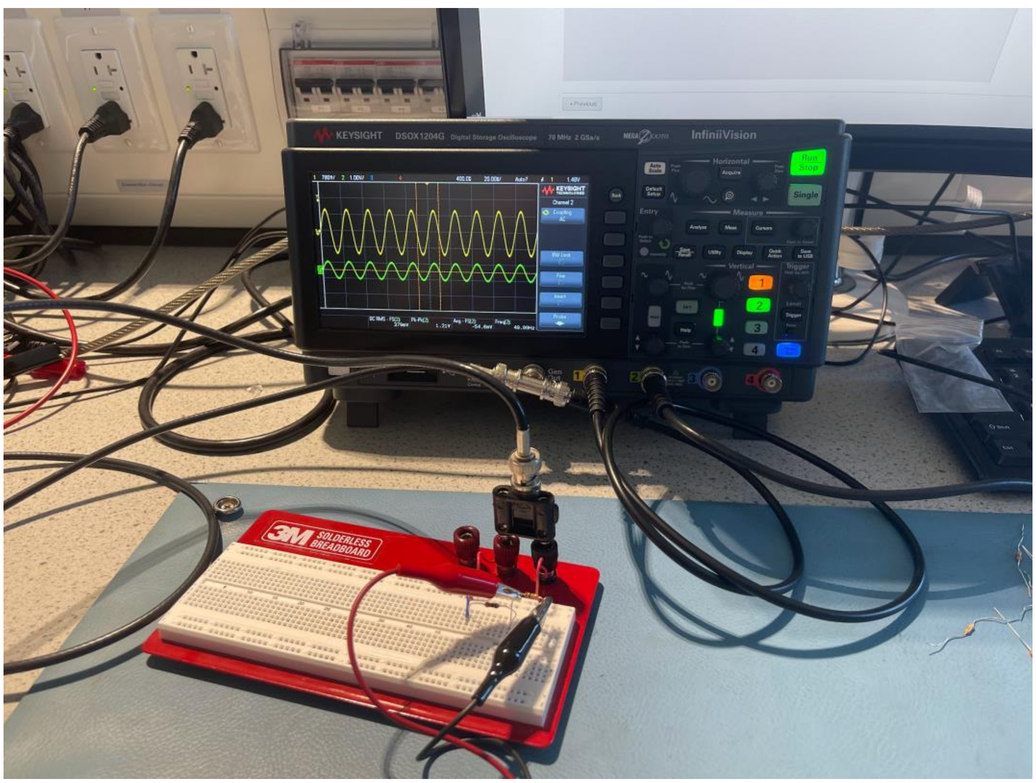
a. Record your responses to 4.3.a below:





b. Record your responses to 4.3.b below:





4.4. RC circuits and time constants (7 pts)

a. Record your responses to 4.4.a below:

R value:	33 kΩ
C value:	0.1 μF

b. Record your responses to 4.4.b below:

Voltage across resistor:	0.008 mV
Voltage across capacitor:	3.29 V

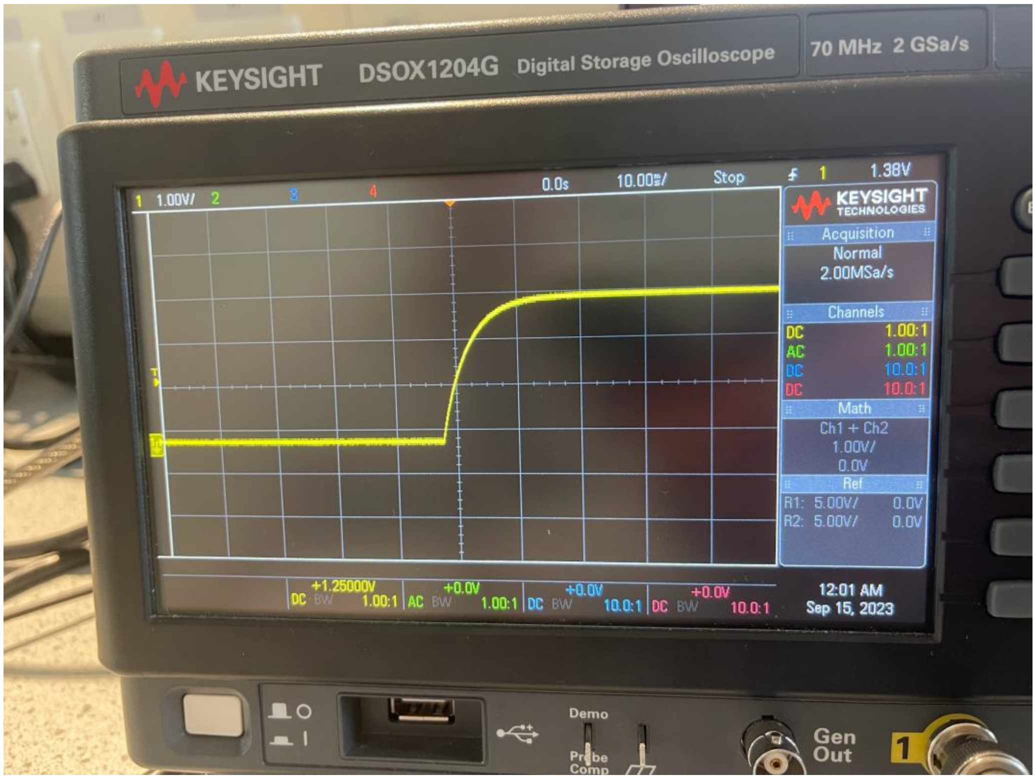
c. Record your response to 4.4.c below:

Voltage across capacitor:	3.005 V

d. Record your responses to 4.4.d below:

Explain the difference:	With the 33 kΩ resistor, the value was 3.29 V, with the 1 MΩ resistor, we got 3.005 V. When the resistor value increases, there is more leakage current going through the DMM. This is due to the impedance of the DMM being closed to the resistor's resistance value. (If the DMM is increased to 10GΩ, we see a value of 3.30V across the capacitor with a 1MΩ resistor)

f. Record your response to 4.4.f below:



g. Record your responses to 4.4.g in the table below:

Time to reach 1.0 V:	14 ms
Time to reach 2.0 V:	37 ms
Time to reach 3.3 V:	178 ms

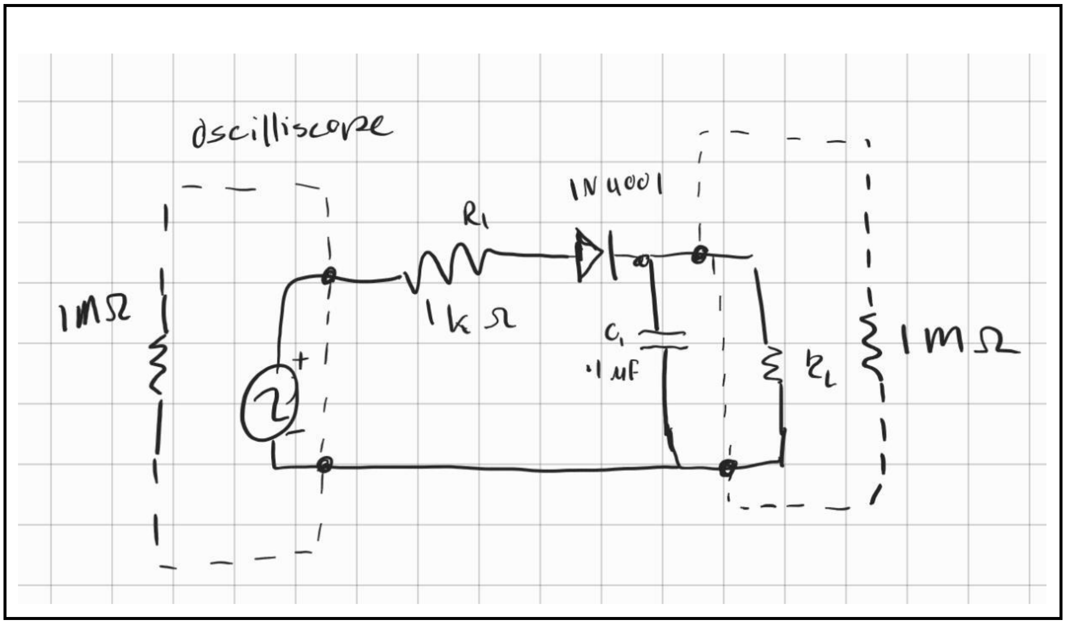
4.5. Measuring / Computing Capacitance (2 pts)

a. Record your responses to 4.5.a below:

Estimate time constant τ	3.5 ms
Estimate Capacitance	0.106 μF

4.6. Power Supply (6 pts)

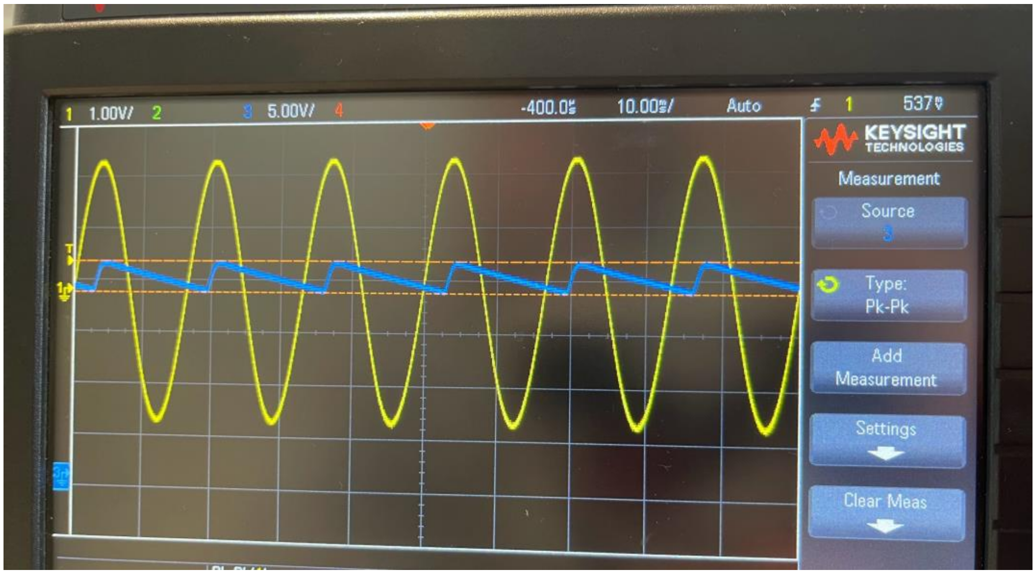
b. Record your response to 4.6.b below:

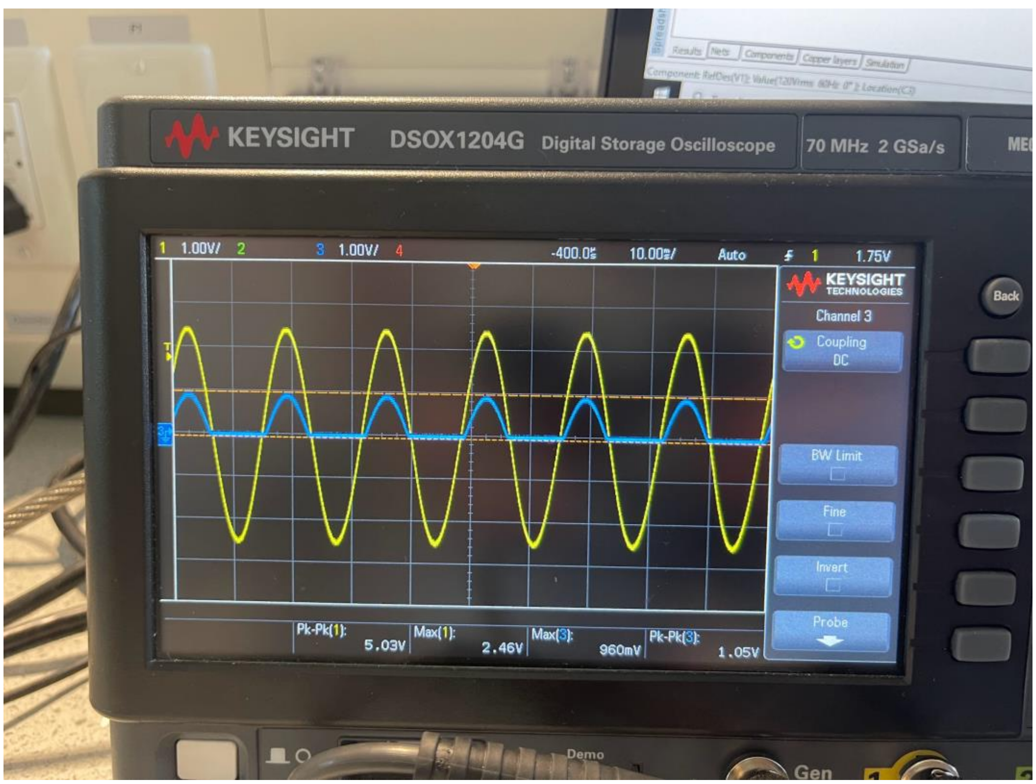


c. Record your responses to 4.6.c below:

	Source Peak Voltage (Maximum V)	Load Peak Voltage (Maximum V)	Load Peak to Peak Ripple Voltage
V_{peak} with $R_L = \infty$:	2.5 V	2.13 V	400 mV
V_{peak} with R_L = 10 kΩ:	2.51 V	1.81 V	1.89 V
V_{peak} with R_L = 100 kΩ:	2.5 V	920 mV	960 mV

d. Record your responses to 4.6.d below:

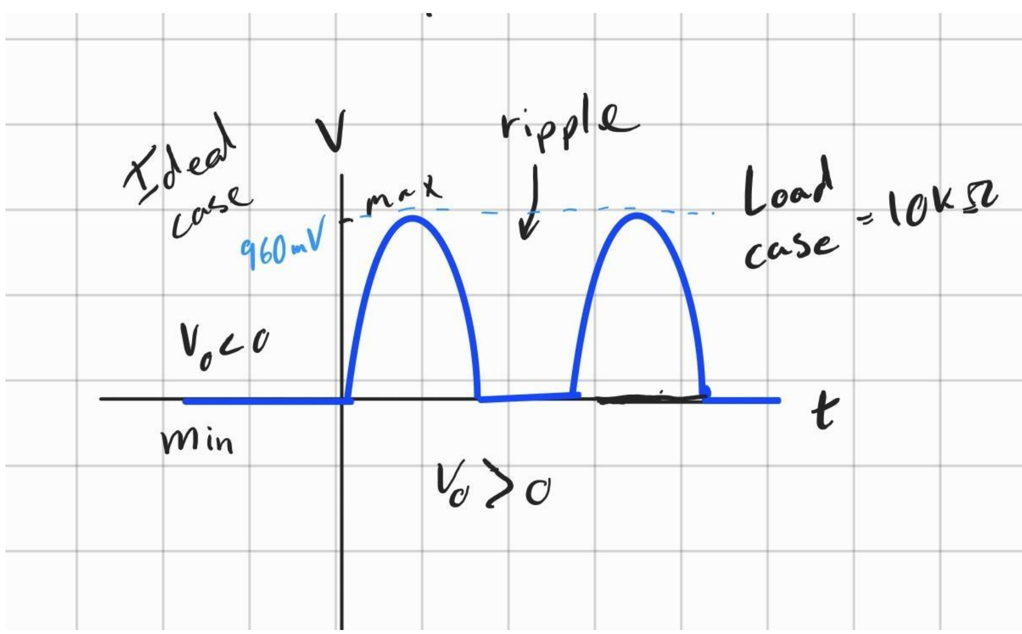

1 1.00V/ 2 3 5.00V/ 4
-400.0s 10.00s/ Auto 1 537
KEYSIGHT TECHNOLOGIES
Measurement
Source
Type: Pk-Pk
Add Measurement
Settings
Clear Meas


KEYSIGHT DSOX1204G Digital Storage Oscilloscope 70 MHz 2 GSa/s
1 1.00V/ 2 3 1.00V/ 4
-400.0s 10.00s/ Auto 1 1.75V
KEYSIGHT TECHNOLOGIES
Channel 3
Coupling DC
BW Limit
Fine
Invert
Probe
Back
Pk-Pk(1): 5.03V
Max(1): 2.46V
Max(3): 960mV
Pk-Pk(3): 1.05V
Demo
Gen

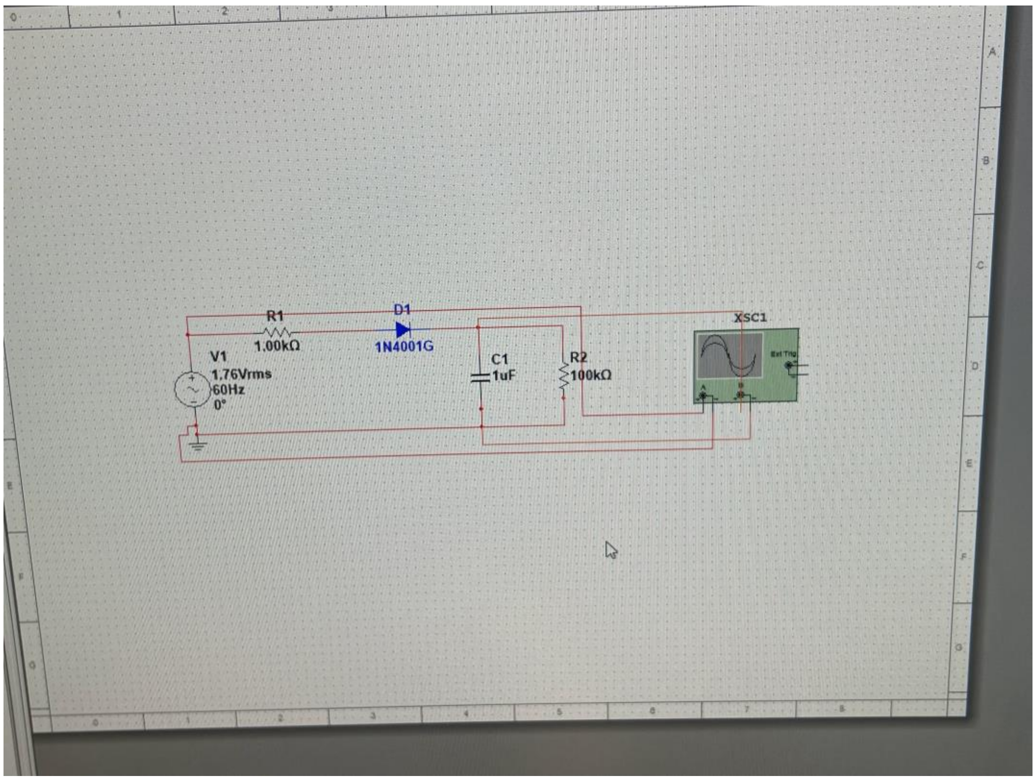
R_L= 10 kΩ

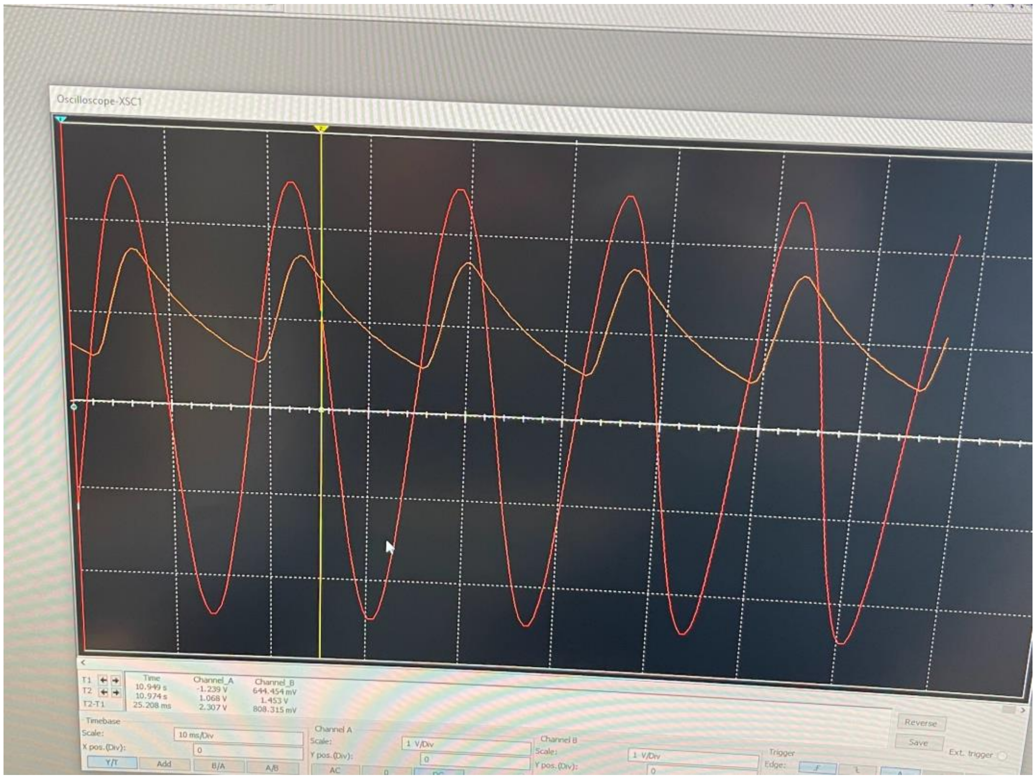
R_L= 100 kΩ

e. Record your responses to 4.6.e below:

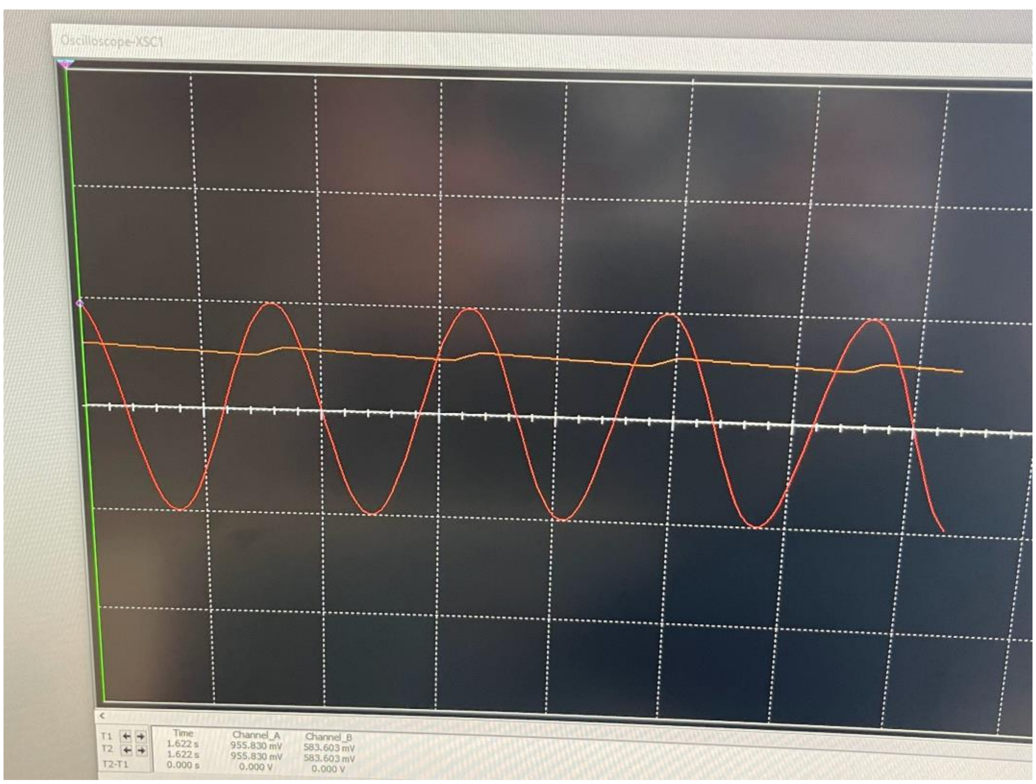


g. Record your responses to 4.6.g below:





h. Record your response to 4.6.h below:



i. As the capacitance of C1 gets smaller, the voltage across the capacitor becomes more parabolic and closely resembles our AC signal. No visible changes can be seen when R1 changes.

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5. Analysis (25 pts)

5.1. Oscilloscope Setup (1 pt)

a. Record your response to 5.1.a below:

Our oscilloscope measures 50 samples per second.

5.2. AC measurements (2 pts)

a. Record your response to 5.2.a below:

The multimeter does have an AC mode, it outputs RMS voltage. This is the case because the RMS voltage is as close as you can get to the DC equivalent.

b. Record your response to 5.2.b below:

In DC mode, there is no peak-to-peak or peak voltage. It outputs the average voltage. This is because ideal DC voltage doesn’t vary so it should be a flat value. Realistically there is some noise, so the value fluctuates minimally around the actual DC voltage.

5.3. AC/DC measurements (4 pts)

a. Record your response to 5.3.a below:

For peak-to-peak voltage for both DC and AC coupling we don't see too much variation. This makes sense due to the fact that peak-to-peak voltage shouldn't change regardless of the DC offset. For average voltage, we see that in AC coupling the value is close to zero while in DC coupling, it is around 1.5 V for R1 + R2 and half that for just R2. These values are around the expected values as well. It should be around 0 for AC coupling because it doesn't consider DC offset and the average for a sine wave would be zero without any offset. For DC coupling, the DC offset is considered (which was 1.5 V), so across R1 + R2, we expect to see around 1.5 V and about half that for just R2. For RMS voltage, we should expect a similar result. In AC coupling, the DC offset is not considered so we should see lower values for RMS voltage across R1 + R2 and half of those values for just R2. In DC coupling, the RMS voltage is considering both the AC signal and the DC offset, so the voltage values would be higher. For both AC and DC coupling it would be 0.707 multiplied by the peak voltage (1 V for AC and 2.5 V for DC).

b. Record your response to 5.3.b below:

For average voltage, we see in DC coupling, it is around 1.5 V for R1 + R2 and half that for just R2. These values are around the expected values because for DC coupling, the DC offset is considered (which was 1.5 V), so across R1 + R2, we expect to see around 1.5 V and about half that for just R2. In DC coupling, the RMS voltage is considering both the AC signal and the DC offset, so the voltage values would be 0.707 multiplied by the peak voltage (2.5 V for DC). For peak-to-peak voltage, we should expect to see double the voltage value across R1 + R2 than across just R2.

5.4. RC circuits and time constants (6 pts)

a. Record your response to 5.4.a below:

The results changed when putting in the 10 MΩ resistor because now the resistor in our circuit was 1/10 of the value of the impedance of the DMM. When switching the DMM to 10 GΩ of impedance, the voltage value was much closer to the 3.3 V we would expect to see.

b. Record your response to 5.4.b below:

The predicted time constant value based on the 33 kΩ and 0.1 μF capacitor was 3.3 ms while the observed was 3.5 ms. The discrepancy is very small, so we can effectively say the time constant value matched.

5.5. Measuring capacitance (4 pts)

a. Record your response to 5.5.a below:

5.5 a. $R = 33\ k\Omega$ 3 - 50 samples

For 1 MHz $T_{max} = \frac{1}{3 \cdot (1 \times 10^6\ Hz)}$ $T_{min} = \frac{1}{50 \cdot (1 \times 10^6\ Hz)}$

$= 333.333\ ns$ $= 20\ ns$

$\tau = RC$ $\frac{\tau}{R} = C$

$C_{min} = \frac{T_{min}}{R}$ $C_{max} = \frac{T_{max}}{R}$

$C_{min} = 0.606\ pF$ $C_{max} = 10.1\ pF$

For 70 MHz

$T_{max} = \frac{1}{3 \cdot (70 \times 10^6\ Hz)}$ $T_{min} = \frac{1}{50 \cdot (70 \times 10^6\ Hz)}$

$= 4.76\ ns$ $= 0.286\ ns$

$C_{min} = \frac{T_{min}}{R}$ $C_{max} = \frac{T_{max}}{R}$

$8.67\ aF$ $= 0.144\ ns$

As seen in our calculations, for sampling at 1 MHz, the lowest measurable capacitance value we could measure would be 0.606 pF. For sampling at 70 MHz, the lowing capacitance value we could measure would be 8.67 aF. A higher frequency would result in being able to measure a smaller time constant and therefore, a smaller capacitance.

5.6. Power Supply (8 pts)

a. Record your response to 5.6.a below:

The peak voltage for the rectified signal should be less than the peak voltage of the input signal. This is because the rectified signal has to overcome the forward voltage drop of the diode. When the current from the input voltage flows through the diode, there is a forward current that acts against the input current due to the forward voltage of the diode.

b. Record your response to 5.6.b below:

In 4.6g we see the 5Vpp while in 4.6h we see the 2 Vpp and after running the test we could see a noticeable change. With the 5Vpp we see a much larger waver that is much closer to input V when measuring across the capacitor. And with the 2Vpp we see a much smaller output that gets closer to a flat line. From this we could expect something like a 1Vpp to look even closer to a flat line. Also when changing the R1 to a larger number we observed the output get a higher peak. As R1 was increased, we saw the output get closer to the peak of the AC wave. And of course as R1 was decreased, we saw the peak get much lower And finally, when changing C1 we observed the ripples changing. As C1 was lowered, the ripples became much more noticeable in comparison to increasing C1. When it was increased the output wave began to look much closer to a straight line. And this makes sense as the capacitor's job is to eliminate the ripple and get it to look like a DC voltage.

c. Record your response to 5.6.c below:

When changing the load resistance we expect the output to change the rectification of the signal. If the load were to increase we would observe a greater rectifier as there would be more accurate signal for the high resistance. The additional impedance would cause less leak in current to produce that output.

d. Record your response to 5.6.d below:

$$V_{ripple} = \frac{I_L}{fC}$$

$$\boxed{C = \frac{I_L}{V_{ripple} f} = \frac{0.001}{(0.1)(60)} = 0.167\,mF}$$

You would need a capacitor greater than 0.167 mF to get your Vripple to be below .1 V. The equation above was derived from a similar equation in the book with ohm's law. And because it was mentioned to be a half wave we don't include the extra 2 in the equation. This makes sense as the capacitor has a great impact on the ripple and 0.167 mF is a reasonable number to have.

e. Record your response to 5.6.e below:

The required open circuit peak amplitude of the AC source voltage would be 10.6 V.

f. Record your response to 5.6 f below:

The maximum possible charging current would be computed by 10.6 V (Input voltage) - 0.6 V (Forward voltage drop) / 1000 Ω. This results in a current of 10 mA.