Proof of Concepts

You will have an entry with the following format for each of the required concepts.

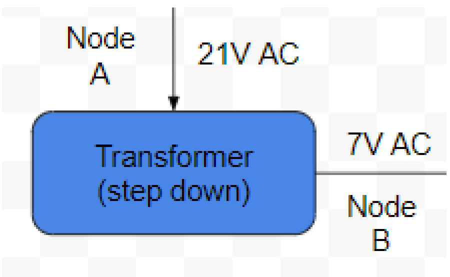
Note: we're a group of two. Our lab partner dropped the class and we never got another assigned...

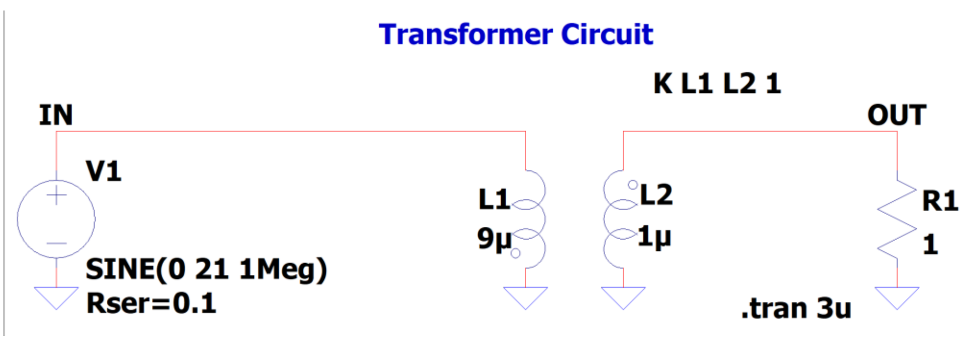
For this rework, we attempted to how our analysis supports our design in each discussion section. Additionally, we attempted to improve some of the issues with the analysis on concepts 3 and 4.

1. Transformer (Ideal, Step Down)

Building Block: Short description and schematic

An ideal transformer being used to step down high voltage input.





Analysis:
Equation and short description.

$$V_{out} = N \cdot V_{in}$$

$$N = \frac{1}{3},\ V_{in} = 21,\ V_{out} = 7V\ peak$$

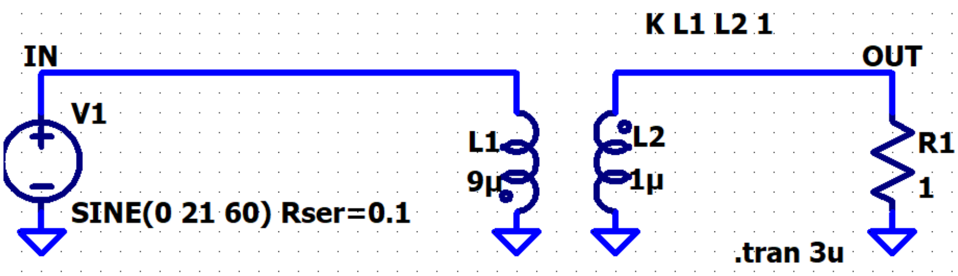
$$V_{in\,RMS} = \frac{21}{\sqrt{2}} = 14.8V_{RMS}$$

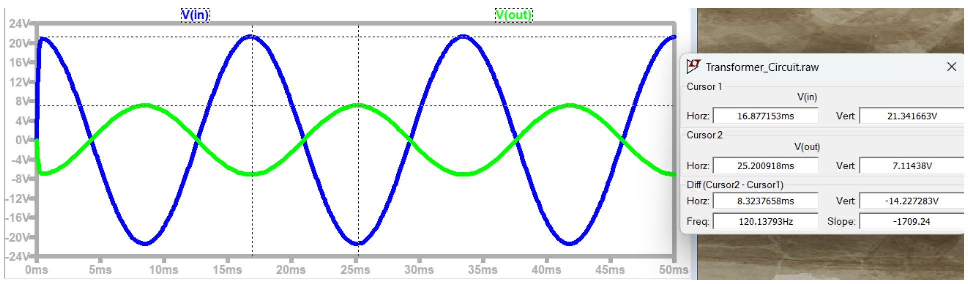
$$V_{out\,RMS} = \frac{7}{\sqrt{2}} = 4.95V_{RMS}$$

An ideal transformer that we are using to step down high voltage input. In a real-world setting this system would be fed a high and unsafe voltage value, however, experimentally, we are stepping 21V down to 7V. The 7V will then feed the rest of the later circuit.

Simulation:

Screenshot of simulation





Measurement:

Screenshot of Waveforms output from circuit above. Remember to clearly show all axes in a measurement plot. Also identify any important portions of the output.

We were told by TA Saad that if we are unable to get a transformer before the necessary due date for this lab, we were told that we only had to simulate the transformer.

Discussion (and answer related questions in Alpha Lab):

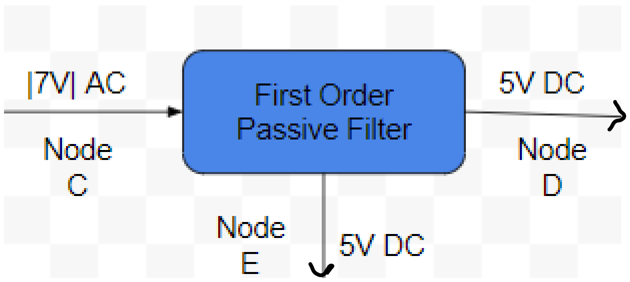
Comparison of Analysis, Simulation and Measurement results. Both a simple summary of results (like a numerical chart of values) and a simple description that details if the results are as you expect. Also include any speculation as to why they may be different from one another if they are different. What variation is too much for example…explore this.

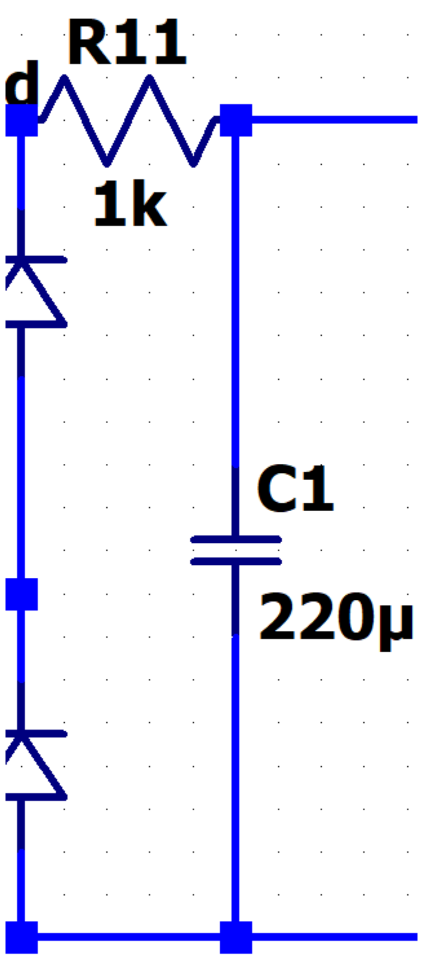
The analysis and simulation results agree that by using an ideal transformer, we are able to take 21V and step it down to 7V. Notably, LTSpice does not have a transformer component or a turns counter for inductors, but we are able to simulate one a transformer by including the square of the turns ratio in the inductive values. So, since we want a 3:1 turns ratio, our first inductor has a value of 9µH, and our second inductor has a value of 1µH.

This analysis supports our design by proving to us that the transformer steps down the exact voltage we supply it, to the expected voltage we need to use for the rest of the circuit. This confirmation is important because it allows us to safely test and operate the rest of the circuit. Additionally, it will help us pinpoint any inconsistencies later in the circuit.

2. First Order Passive Filter

Building Block: Short description and schematic





A first order passive filter that converts AC input into DC output.

Analysis:

Equation and short description.

A first order passive filter that takes our rectified 60Hz AC signal (now 120Hz) and filters it into a flat DC signal.

$\omega_c = \frac{1}{RC}$

C=220µF, R=1000Ω

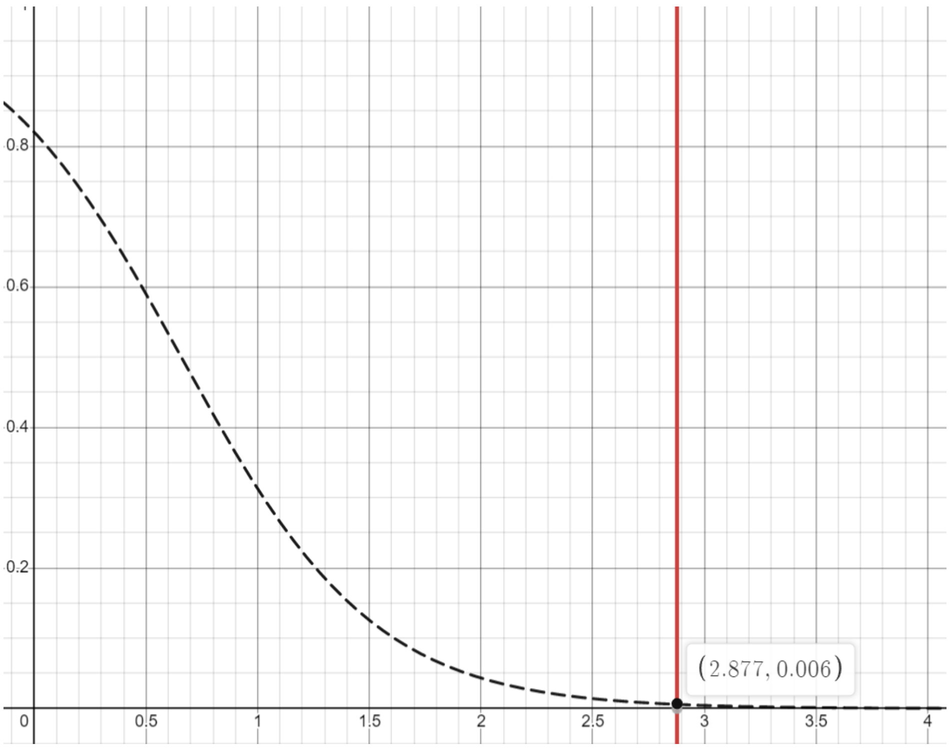
$\omega_c = \frac{1}{1k \cdot 220\mu} = 4.545$ rad/s

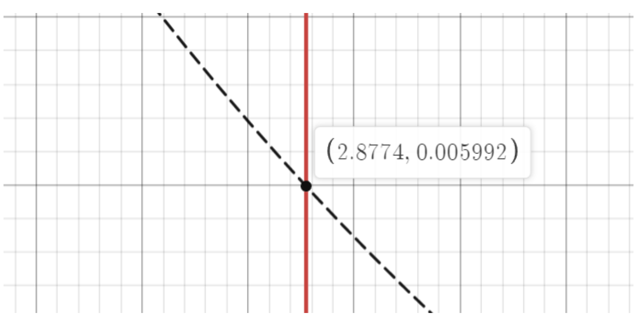
$$H(s) = \frac{\omega_c}{s + \omega_c}$$

f=120Hz ω=240π

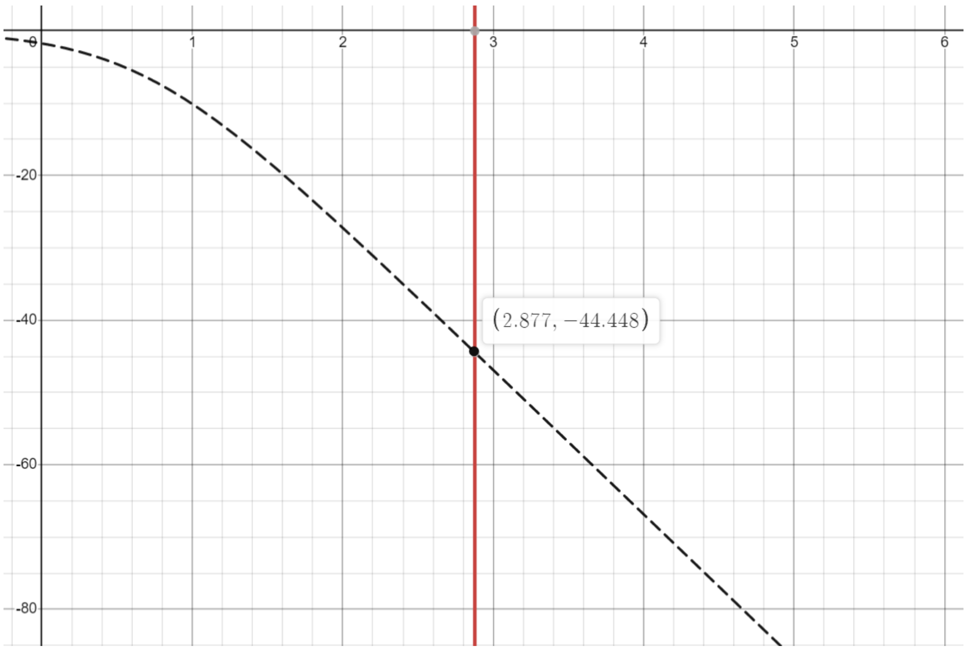
$H(s) = \frac{\omega_c}{s+\omega_c} = \frac{4.545}{240\pi+4.545} = 0.00599$, basically flat, almost everything is filtered out and we're left with nice flat DC.

H(s): (x is log scale)



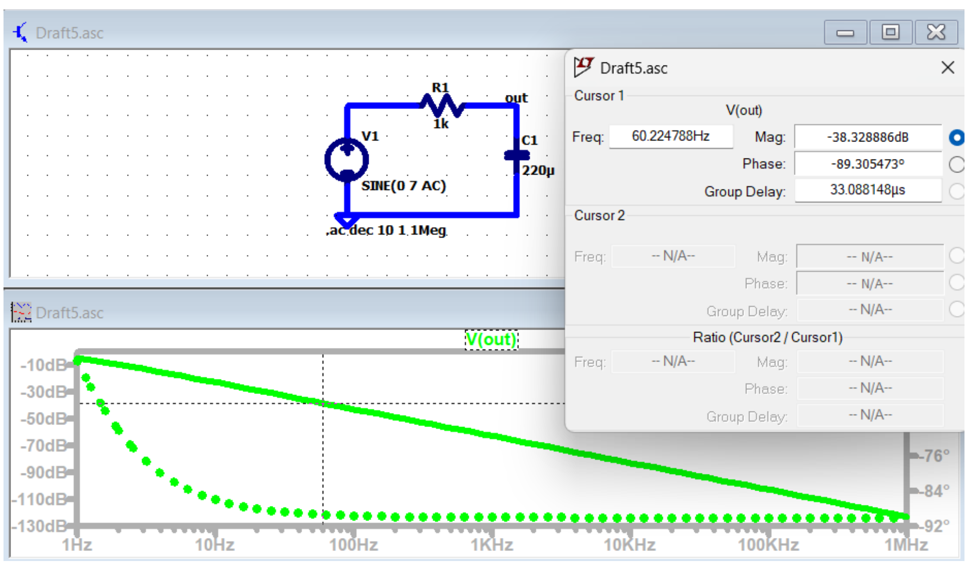


Bode plot = 20log(H(60))=-44.448dB



Simulation:

Screenshot of simulation



Much less curvature

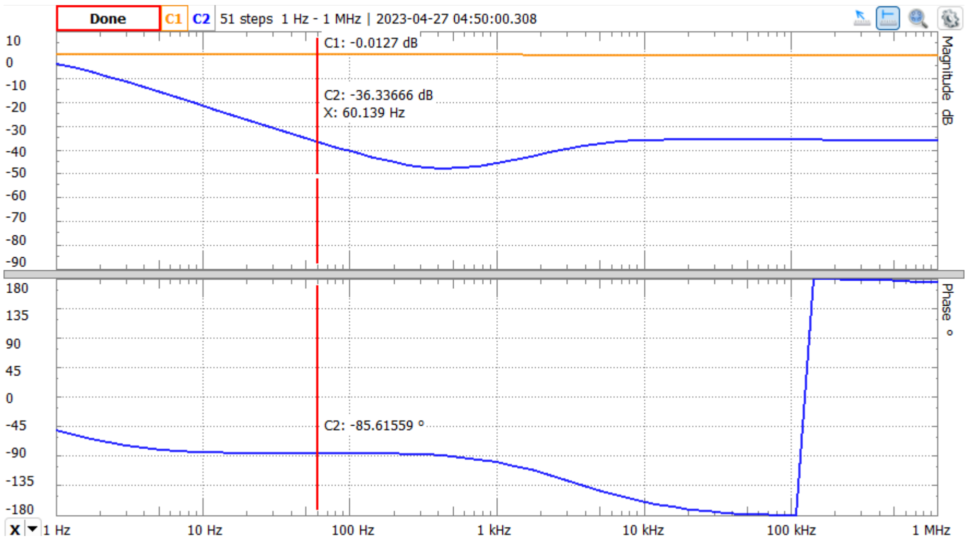
At 60Hz, -38.3dB

Picking some random points on the bottom half, slope is $\frac{-70.727773+86.226059}{\log(2.4924324)-\log(14.970295)} = -19.9051467435$

Measurement:

Screenshot of Waveforms output from circuit above.

Remember to clearly show all axes in a measurement plot. Also identify any important portions of the output.



It acts as expected around the 60Hz frequency we use, actual –36.33dB

Discussion:

Comparison of Analysis, Simulation and Measurement results. Both a simple summary of results (like a numerical chart of values) and a simple description that details if the results are as you expect. Also include any speculation as to why they may be different from one another if they are different. How different is too much for example…explore this.

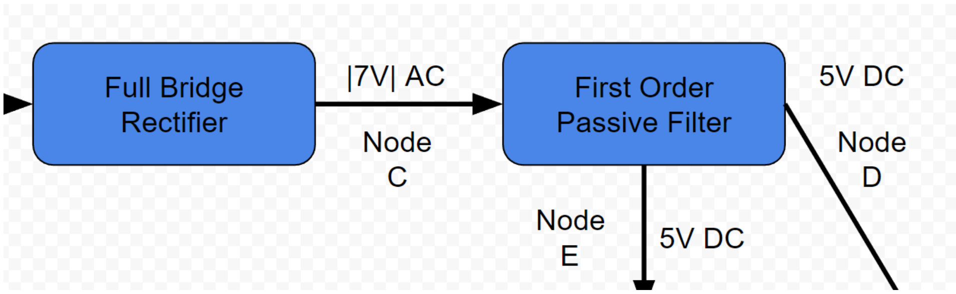
Our analytical, simulation, and experimental measurement results all approximately agreed. Simulated gave only 2dB more reduction than expected, but the calculation gave a full 8dB more reduction. This is insignificant for our purposes but could be significant in certain applications.

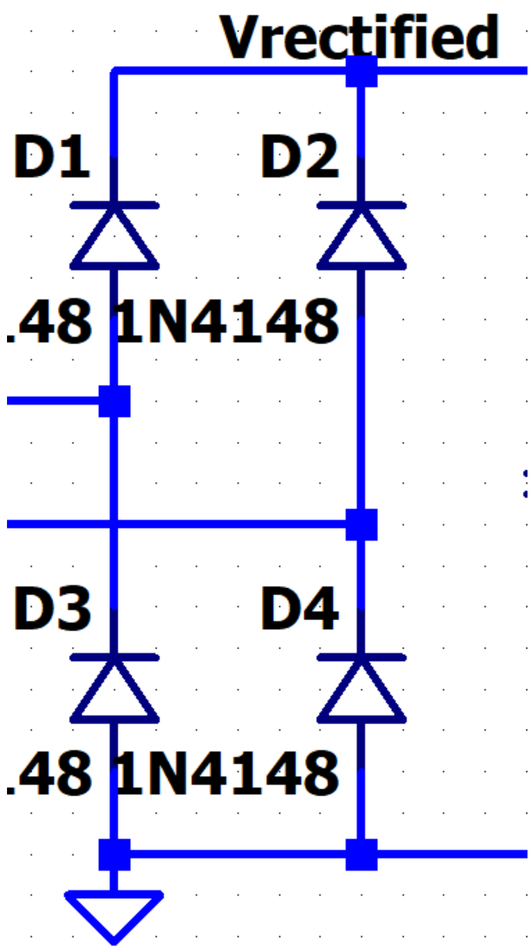
This analysis supports our design by helping us understand that this part of the circuit is functioning primarily in accordance with our expectations. If any further inconsistencies occur in later components, we will know it may require more testing with and without the filter attached, allowing us to troubleshoot that component and this filter.

3+4. Phasors + Complex Power

Building Block: Short description and schematic

Clearly label all nodes you will reference





Analysis:

Equation and short description.

Phasors:

$V_{out} = |V_{in}|$ (this is absolute value of the real component, not magnitude)

$V_{out} = |14|\angle 0$ (I'm struggling to find a good way to represent this, the internet yields no results on phasor form of a rectified sin wave. I could use a peacewise, but that's not very clear or readable.)

We are using phasors to find the voltage output from the full bridge rectifier, which flips any negative input voltage to positive, giving us rectified AC voltage.. There is an input voltage of about 14V coming from the transformer, so the output will be the absolute value of the same wave.

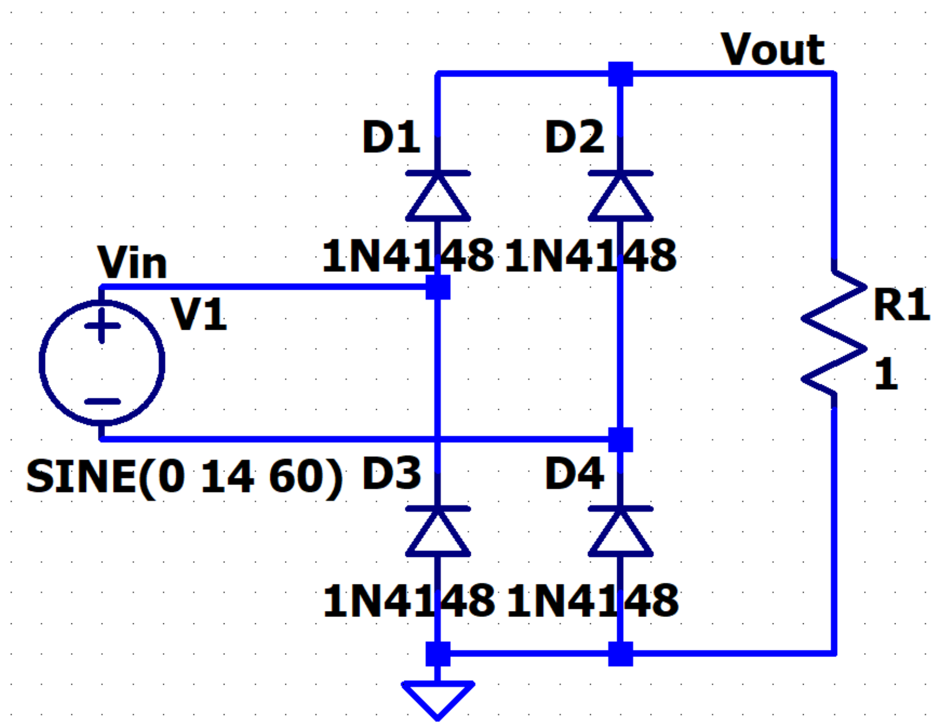
This is a phasor still, but instead of a phasor that spins the full 360deg, the real component stays positive, and it simply bounces back and fourth on the right side between 90deg and −90deg.

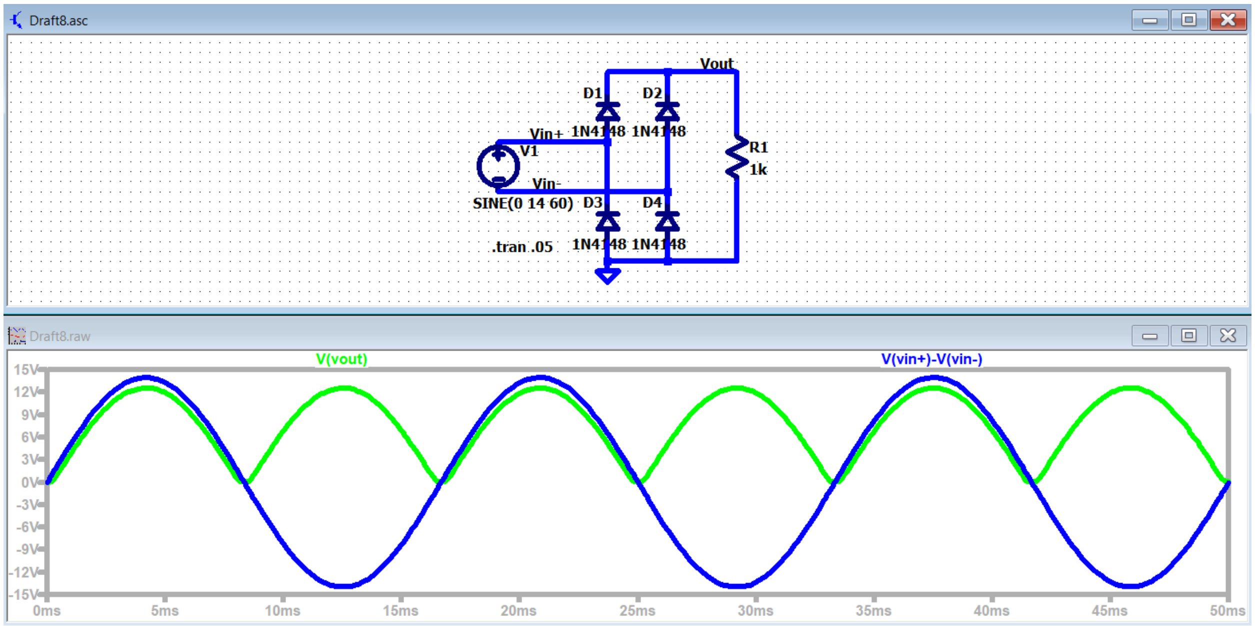
Complex power:

$$V_{out} = |V_{Real}| + jV_{imaginary}$$
$$V_{out} = |14| + 0j$$

Simulation:

Screenshot of simulation





Phasor:

This simulation is a bit strange due to grounding in LT spice, so we measure both sides of the source and subtract, but this demonstrates phasors as we take the absolute value of the real component, giving us only the "right side". We can clearly see that all negative real parts of the phasor (left/bottom) are now positive real (flipped to the right/top).

Complex power:

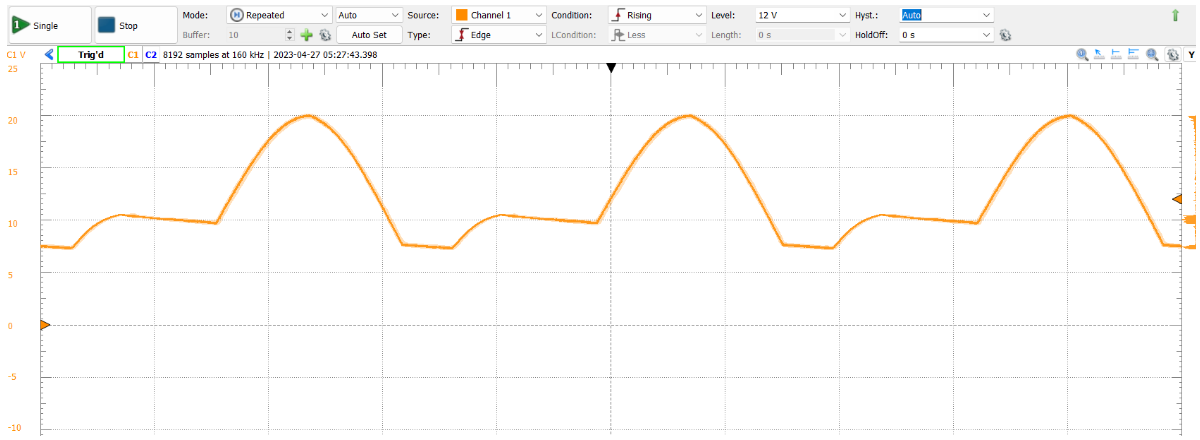
This demonstrates complex power as again, we can see that we've taken the absolute value of the real component of the complex number.

Measurement:

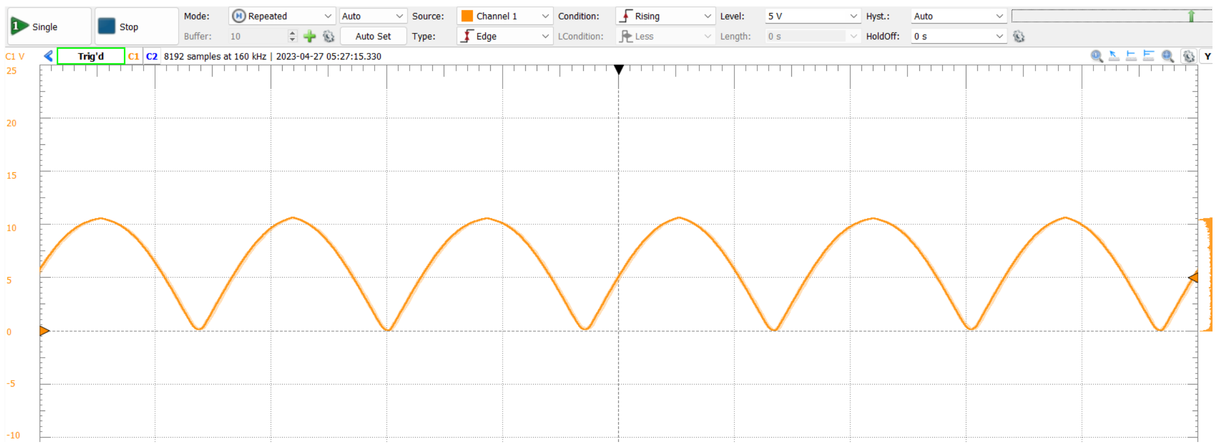
Screenshot of Waveforms output from circuit above.

This is where there are lots of issues with shared ground for measurement. It works fine- until you measure it and accidentally ground something via little to no resistance (measured to be 0.3Ω between our function generator and oscilloscope)

Here's waveforms with my laptop plugged in to charge: can't really make any sort of phasor out of this



Here's waveforms with my laptop unplugged. $|5|VAC$



I couldn't show the input, as that would require either grounding the input, which would lead to shared ground issues mentioned earlier and in the above "laptop plugged in" image, or using a differential pair, which isn't possible since one of the two channels of the Analog Discovery 2 is already taken to measure output. We also couldn't reach the full 14V input due to a limited 10V function generator.

Phasor:

Otherwise, this shows phasors in the same way as shown in simulation is a bit strange due to grounding in LT spice, so we measure both sides of the source and subtract, but this demonstrates phasors as we take the absolute value of the real component, giving us only the "right side". We can clearly see that all negative real parts of the phasor (left/bottom) are now positive real (flipped to the right/top).

Complex power:

Again, this shows complex power as we've taken the absolute value of the real component of the complex number.

Discussion:

Comparison of Analysis, Simulation and Measurement results. Both a simple summary of results (like a numerical chart of values) and a simple description that details if the results are as you expect. Also include any speculation as to why they may be different from one another if they are different. How different is too much for example…explore this.

Firstly, this has been an issue all day, I didn’t have my laptop with me to test this until now, so I could only speculate (as was shown in our video presentation). Now to look into any good ways of isolating grounds? Anyway, once solved, our calculations, simulation, and experiment all agree and we get the absolute value of the real component of the voltage, all the regular absolute value math applies to complex power and phasors too.