Phys219_2017 - Ryan Kaufmann/Exp. 2 (LCR Resonance Circut)/Exp 2 LCR Resonance

SIGNED by Ryan Kaufmann Oct 22, 2017 @09:08 PM PDT

Ryan Kaufmann Oct 21, 2017 @10:10 PM PDT

Experiment 2: LCR Resonance

Partner: Eric Brock

Ryan Kaufmann Oct 20, 2017 @10:18 AM PDT

2.1 Objective

Ryan Kaufmann Oct 20, 2017 @10:53 AM PDT

We've looked at on type of circuit with an interesting transient behavior. In this lab, we will be observing a second one, the LCR circuit. The LCR circuit consists of an inductor, capacitor and resistor. In this lab, we will analyze the several properties of an LCR circuit, including its time constant. We will also look at how the amplitude and phase shift of the voltage across the resistor changes as a function of frequency.

Ryan Kaufmann Oct 20, 2017 @10:18 AM PDT

2.2 Introduction

Ryan Kaufmann Oct 21, 2017 @02:32 PM PDT

An LCR circuit has a similar form to a spring system with a damping force on it. It has a resonant frequency and behavior as well. As you would expect. The LCR circuit has a marginally more complicated behavior than the RC circuit. The equations that describe it contain both exponential and cosine components when viewed with a DC current, and a strange amalgamation of square roots and divisions when viewed with an AC current.

To add to this, our time constant is no longer RC. Instead we can now calculate the time constant as 2*L/R. We can also calculate the resonant frequency and resonant angular frequency as 1/(2*pi*sqrt(L*C)) and 1/sqrt(L*C), respectively.

Now, we will dive into the lab. We will be analyzing the transient state with a DC voltage and the steady state with an AC voltage. Then we will explore the effect of the resistor on the circuit.

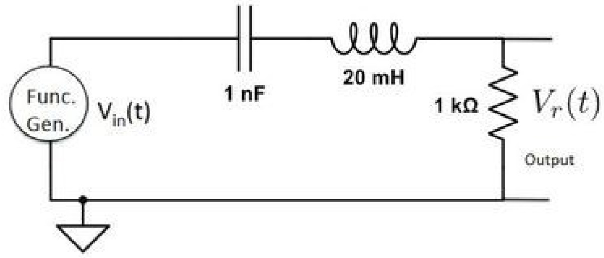
Ryan Kaufmann Oct 20, 2017 @10:19 AM PDT

2.3.1 Transient Response

Ryan Kaufmann Oct 21, 2017 @05:07 PM PDT

We began by setting up our circuit, shown below, and our frequency generator to output a square wave with a frequency of 2.3 kHz, a peak-to-peak voltage of 1V and a voltage offset of 0.5V. We picked this value of frequency based on our results from the prelab in order to get a sizeable number of oscillations, which we decided was approximately 10.

Ryan Kaufmann Oct 21, 2017 @05:07 PM PDT



CircuitDiagram.jpg(20.6 KB)

Ryan Kaufmann Oct 21, 2017 @06:08 PM PDT

We split our function generator's output so that one would go into channel 2 on the oscilloscope. Thus we could view the behavior of the input voltage along with the voltage across the resistor. We then placed the oscilloscope in parallel with the resistor so that we could measure Vr(t), in channel 1. We noticed a decaying sine wave that begins when ever the DC voltage changes. Furthermore, the sine waves seem to oscillate around whatever the voltage is at that point.

We then discussed what the best scales to measure and record the behavior would be. We decided on a time scale that would at least display one set of oscillations, or one half the period we described in the previous part. We didn't want much more or else we wouldn't be able to fit the data as accurately. We had a time scale of 20 microseconds. For the voltage scale, we wanted a similar form. We wanted to capture the tops of the highest peaks but nothing beyond that. Thus our voltage scale was set to 50 milliVolts. Finally we put the oscilloscope into signal averaging mode and took our data.

Ryan Kaufmann Oct 21, 2017 @06:10 PM PDT

RLCTransient.csv(15.7 KB)

Ryan Kaufmann Oct 21, 2017 @09:14 PM PDT

We plotted and fit the data using our Curvefitexpcos.py Python script. While our chi-squared was a small bit higher than what we would like (approximately 1.33), our fit parameters seemed to fit the data very well. In addition, even though our chi-squared was a bit large, our residuals fit very well, showing no pattern and revolving around 0. After adjusting our code, we got a random uncertainty of sigmay=0.0038. The fit thus gave us the following parameters, equation, and graphs:

Ryan Kaufmann Oct 21, 2017 @09:22 PM PDT

$$Amplitude = \frac{2V_0}{\omega_0 \tau} = -0.001006 \pm 0.00003686$$

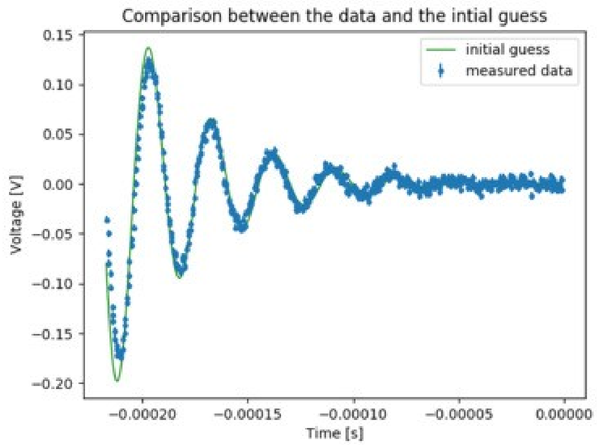
$$RelaxationTime = \tau = 0.00004097 \pm 0.0000003121$$

$$Frequency = f = 34890 \pm 28.75$$

$$PhaseShift = \phi = 2.132 \pm 0.03574$$

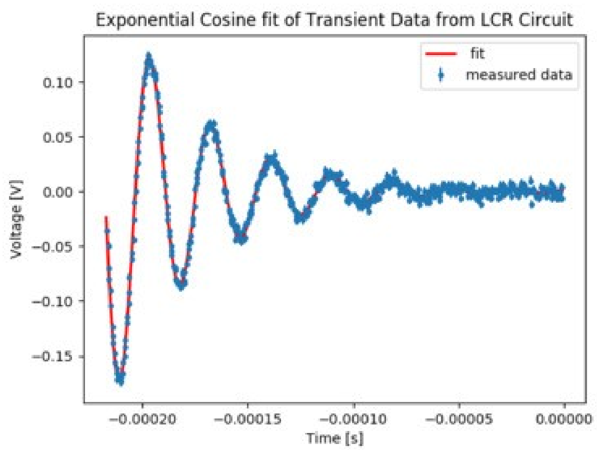
$$V_r(t) = -0.001006 * e^{\frac{-t}{0.00004097}} * \cos(2 * \pi * 34890 * t + 2.132)$$

Ryan Kaufmann Oct 21, 2017 @07:40 PM PDT



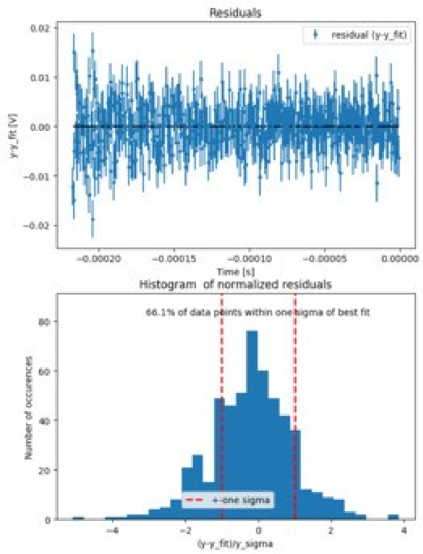
TransientGuess.png(41.5 KB)

Ryan Kaufmann Oct 21, 2017 @07:40 PM PDT



TransientFit.png(41.5 KB)

Ryan Kaufmann Oct 21, 2017 @07:40 PM PDT



TransientResids.png(57.5 KB)

Ryan Kaufmann Oct 21, 2017 @09:38 PM PDT

From our values and their uncertainties, we can get a good approximation of our parameters of interest (tau, wo, and gamma). If we calculate our parameters of interest and their uncertainties, we get the following:

Ryan Kaufmann Oct 21, 2017 @09:41 PM PDT

$$\tau = 0.00004097 \pm 0.0000003121 seconds = 40.97 \pm 0.31 \mu s$$

$$\omega_0 = f * 2 * \pi = 219220 \pm 180.642 \frac{radian}{second}$$

$$\gamma = \frac{2}{\tau} = 48816.2 \pm 371.9 Hz$$

Ryan Kaufmann Oct 21, 2017 @09:42 PM PDT

Which are pretty close to our calculated values of tau, angular resonant frequency, and gamma: 40 microseconds, 223607 radians per second, and 50000 Hz.

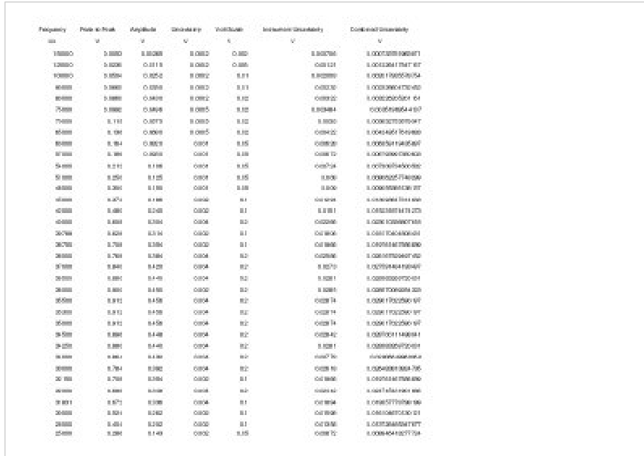
Ryan Kaufmann Oct 20, 2017 @10:19 AM PDT

2.3.2 Steady State AC Response

Ryan Kaufmann Oct 22, 2017 @12:38 AM PDT

Now let's look at the steady state circuit. Using the same circuit as above, we switch the function generator to output a sinusoidal function with a peak-to-peak voltage of 1V and a voltage offset of 0V. We don't quite set our frequency yet, since we will be analyzing several frequencies. We record the voltage drop across the resistor in a csv file. We also record our own random uncertainty as well as the manufacturer uncertainty and combine them. This becomes our uncertainty for each voltage drop. We then test 46 frequencies between 10Hz and 150kHz, giving us the following data:

Ryan Kaufmann Oct 21, 2017 @09:02 PM PDT



RLCCircuitAnalysis.xlsx(13.3 KB)

Ryan Kaufmann Oct 21, 2017 @09:02 PM PDT

RLCSineAmplitudes.csv(1005 Bytes)

Ryan Kaufmann Oct 21, 2017 @09:22 PM PDT

We made sure to get three important points along the frequency interval, the resonance peak (around 35300 Hz) and the two bandwidth points (around 39789 and 31831 Hz). It is important to check both of these points because we want to make sure that the theory holds for not only either side of the resonance peak, but also far away from the peak.

We put the data into the Curvefitlcrres.py Python script. The data is much less favorable than the one we got for the transient analysis. Our chi-squared is 1.975, which is higher than we would like. In addition, our residuals are not favorable, showing a pattern and not looking especially divided around 0. This may be because our uncertainties are so small or a restriction in the python code. Regardless, we got the following parameters, equation, and graphs:

Ryan Kaufmann Oct 21, 2017 @09:29 PM PDT

$$Amplitude = V_{in}^{0} = 0.4882 \pm 0.03173 Volts$$

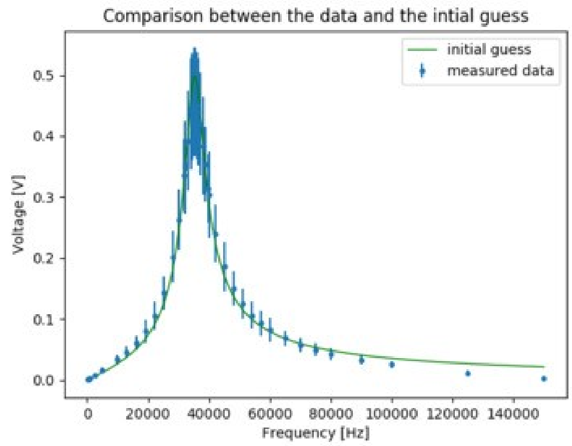
$$ResonantFrequency = f_0 = 34900 \pm 327.2 Hertz$$

$$GammaWidth = \gamma = 36010 \pm 3293 Hertz$$

$$Background = \beta = -0.001804 \pm 0.0009165 Volts$$

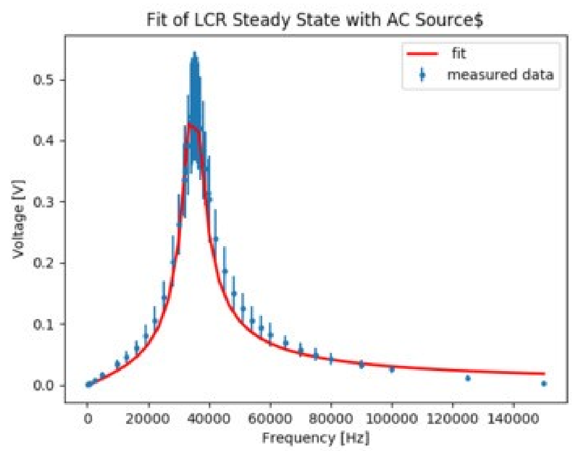
$$V_r^0(f) = \frac{0.4882}{\sqrt{1 + \left(\frac{2\pi}{36010 * 34900}\right)^2 (f^2 - 34900^2)^2}} - 0.001804$$

Ryan Kaufmann Oct 21, 2017 @09:30 PM PDT



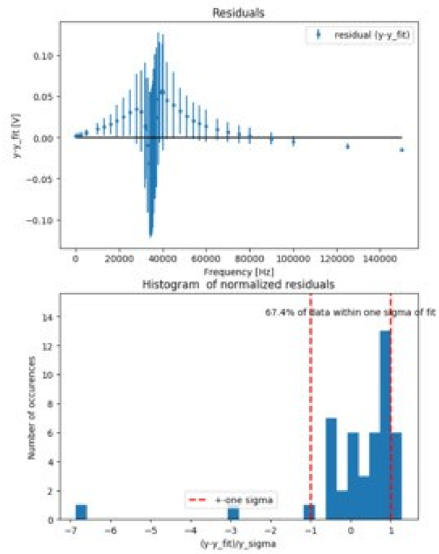
SteadyStateGuess.png(32.6 KB)

Ryan Kaufmann Oct 21, 2017 @09:30 PM PDT



SteadyStateFit.png(30.5 KB)

Ryan Kaufmann Oct 21, 2017 @09:30 PM PDT



SteadyStateResids.png(45 KB)

Ryan Kaufmann Oct 21, 2017 @09:35 PM PDT

We noticed that the graph does it best directly before and after the resonance peak, while not exactly the best at the peak, and worse at the peak and much farther away from it. However, after going through several ideas of changing the code, including taking out the background voltage parameter, we couldn't quite find a way to improve our residuals or chi-squared.

Now that we have our values, we can find our parameters of interest using this set of data. We get the following:

Ryan Kaufmann Oct 21, 2017 @09:46 PM PDT

$$\tau = \frac{2}{\gamma} = 0.00005554 \pm 0.00000508$$

$$\omega_0 = f_0 * 2\pi = 219283 \pm 2056$$

$$\gamma = 36010 \pm 3293 Hz$$

Ryan Kaufmann Oct 21, 2017 @09:51 PM PDT

These values mostly seem similar to the ones we received before, with exception of the gamma. However, except for the resonant frequency, they seem a bit far from the values we expected: 40 microseconds, 223607 radians per second, and 50000 Hz, respectively. Let us look closer at these comparisons.

Ryan Kaufmann Oct 20, 2017 @10:22 AM PDT

2.3.3 Comparison of Transient and Steady State

Ryan Kaufmann Oct 21, 2017 @10:23 PM PDT

Let us start by looking at the resonance frequency. We had a resonance frequency determined by each method. We can compare them using the T-score, which will show us if there is a difference between the values themselves:

Ryan Kaufmann Oct 21, 2017 @10:40 PM PDT

$$T_{DC-AC} = \frac{f_{DC} - f_{AC}}{\sqrt{\sigma_{fDC}^2 + \sigma_{fAC}^2}} = \frac{34890 - 34900}{\sqrt{28.75^2 + 327.2^2}} = \frac{10}{328.461} = 0.030445$$

Ryan Kaufmann Oct 21, 2017 @10:42 PM PDT

Our T-score is very far below 1, showing us that there is not a difference between the two numbers. Furthermore, the expected value is in between them, almost directly. Thus all three values seem to agree consistently.

The other parameter we want to look at is the value of gamma (R/L). We calculated gamma from tau and vice versa when we were analyzing the transient and steady state response. We can now use the T-score to compare these values, although already we can predict that they will be different:

Ryan Kaufmann Oct 21, 2017 @10:38 PM PDT

$$T_{DC-AC} = \frac{\gamma_{DC} - \gamma_{AC}}{\sqrt{\sigma_{\gamma DC}^2 + \sigma_{\gamma AC}^2}} = \frac{48816.2 - 36010}{\sqrt{371.9^2 + 3293^2}} = \frac{12806.2}{3313.93} = 3.864$$

Ryan Kaufmann Oct 21, 2017 @10:46 PM PDT

The values of gamma, however, do not show the same agreement. The t-score is well above 1. The DC value is much closer to the actual value as well, so there seems to be some problem in the AC circuit. This difference in the two values may be caused by several factors. Our uncertainties may be too small, or our frequency generator may have had a bit of error in the frequencies, or our inductor, capacitor, or resistor may have been somehow affected, as we took these measurements in two different lab sessions. The best thing would be to retake this data again or more data if we had time or another session.

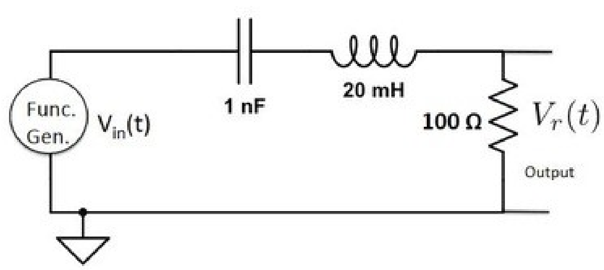
Ryan Kaufmann Oct 20, 2017 @10:21 AM PDT

2.3.4 Influence of Resistance in LCR Resonance

Ryan Kaufmann Oct 22, 2017 @01:16 PM PDT

We also want to observe the effect of the resistance on the circuit. We then switched the 1 kOhm resistor in our circuit with a 100 Ohm resistor, giving us the following circuit:

Ryan Kaufmann Oct 22, 2017 @01:16 PM PDT



CircuitDiagram100Ohm.jpg(26.6 KB)

Ryan Kaufmann Oct 22, 2017 @03:04 PM PDT

We then changed our function generator and oscilloscope accordingly. Our function generator now outputs a square wave with a peak-to-peak voltage of 1V, a voltage offset of 0.5V, and a frequency of 1 kHz. We decreased our frequency because the circuit doesn't decay as fast and we can get more data before it becomes unresolvable. We also set our oscilloscope, still on signal averaging, to 50mV and 50 microseconds.

Just like before, we took the data from our oscilloscope and used the Curvefitexpcos.py script to fit the data. We get the following data:

Ryan Kaufmann Oct 22, 2017 @03:05 PM PDT

RLCCircuit100Ohm.csv(14.7 KB)

Ryan Kaufmann Oct 22, 2017 @03:15 PM PDT

When we fit the data, we get an okay fit. Our chi-squared is below one, about 0.86, indicating a good relationship between the data and the fit. However, we notice that our residuals, while not showing a pattern, revolve more around -1 than 0, which means there might be an offset problem. However, this first fit gives us the following parameters, equation, and graphs:

Ryan Kaufmann Oct 22, 2017 @03:22 PM PDT

$$Amplitude = \frac{2V_0}{\omega_0 \tau} = 0.002211 \pm 0.00003237$$

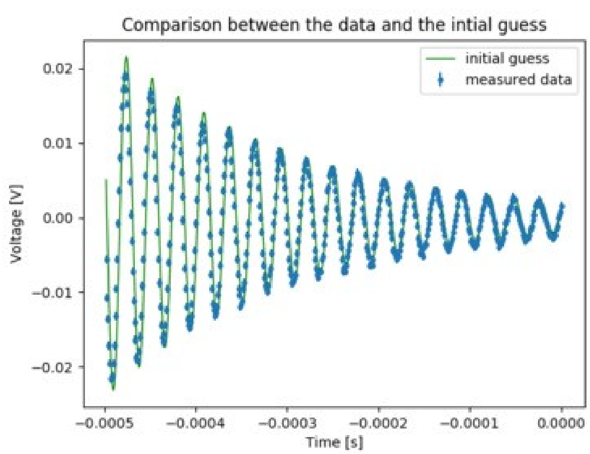
$$RelaxationTime = \tau = 0.0002178 \pm 0.000001708$$

$$Frequency = f = 35270 \pm 5.738$$

$$PhaseShift = \phi = 5.358 \pm 0.01463$$

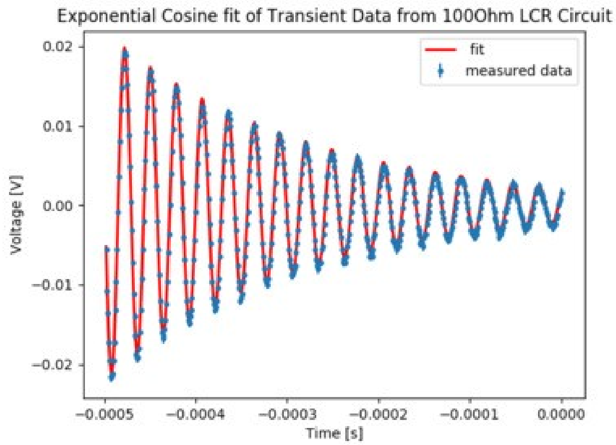
$$V_r(t) = -0.002211 * e^{\frac{-t}{0.0002178}} * \cos(2 * \pi * 35270 * t + 5.358)$$

Ryan Kaufmann Oct 22, 2017 @03:16 PM PDT



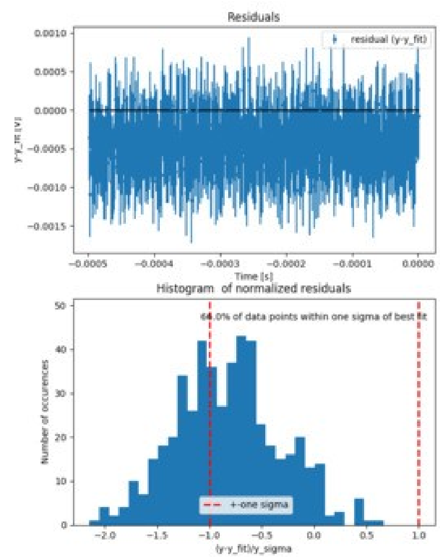
TransientGuess100Ohm1.png(58.6 KB)

Ryan Kaufmann Oct 22, 2017 @03:16 PM PDT



TransientFit100Ohm1.png(64.4 KB)

Ryan Kaufmann Oct 22, 2017 @03:16 PM PDT



TransientResids100Ohm1.png(50.6 KB)

Ryan Kaufmann Oct 22, 2017 @03:41 PM PDT

We thought that we could get a better fit if we changed our fit to include an offset, to try and fix our residuals, so we did just that. Our new fit is much better, although the chi-squared isn't as good. The chi-squared sits right on the border at 1.0008, which is ambiguous but judging by our residuals and equation, we will say that this is a good fit. Furthermore, now our residuals are centered around 0. We get the following from our new code:

Ryan Kaufmann Oct 22, 2017 @03:36 PM PDT

$$Amplitude = \frac{2V_0}{\omega_0 \tau} = -0.002220 \pm 0.00001624$$

$$RelaxationTime = \tau = 0.0002185 \pm 0.0000008592$$

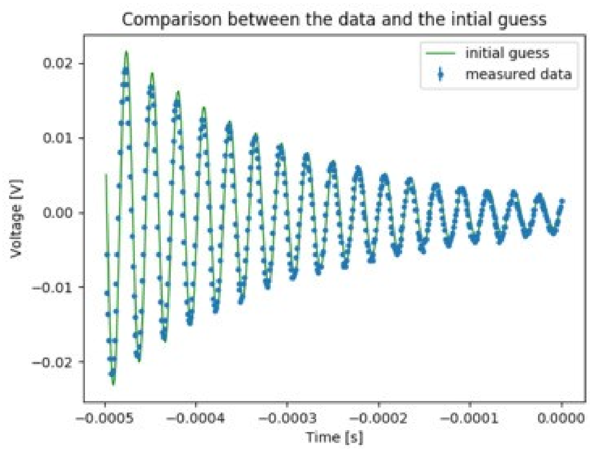
$$Frequency = f = 35270 \pm 2.868$$

$$PhaseShift = \phi = 5.360 \pm 0.007308$$

$$Offset = V_{off} = -0.0004325 \pm 0.00001242$$

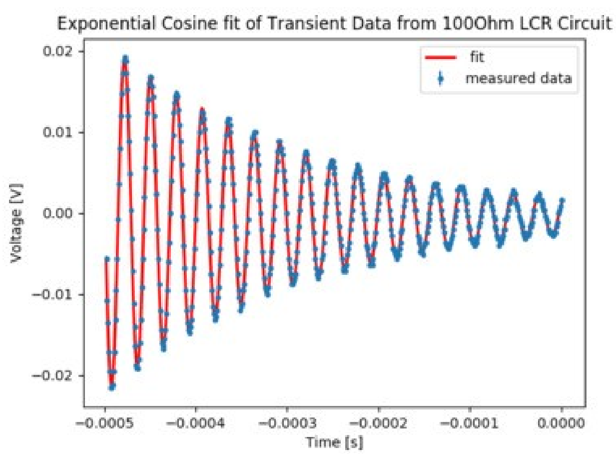
$$V_r(t) = -0.002220 * e^{\frac{-t}{0.0002185}} * \cos(2 * \pi * 35270 * t + 5.360) - 0.0004325$$

Ryan Kaufmann Oct 22, 2017 @03:42 PM PDT



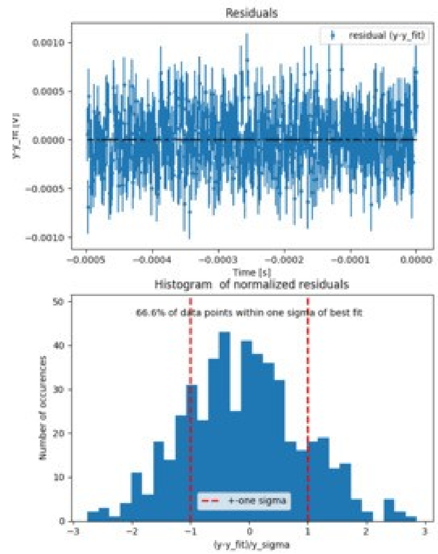
TransientGuess100Ohm2.png(59.3 KB)

Ryan Kaufmann Oct 22, 2017 @03:42 PM PDT



TransientFit100Ohm2.png(59.6 KB)

Ryan Kaufmann Oct 22, 2017 @03:42 PM PDT



TransientResids100Ohm2.png(55.1 KB)

Ryan Kaufmann Oct 22, 2017 @03:46 PM PDT

Before we compare our values with our previous transient experiment, let us compare the between themselves. We can use t-score to see how different, if at all, these values are:

Ryan Kaufmann Oct 22, 2017 @04:04 PM PDT

$$T_A = \frac{A_{off} - A_{none}}{\sqrt{\sigma_{off}^2 + \sigma_{none}^2}} = \frac{0.002220 - 0.002211}{\sqrt{0.00001624^2 + 0.00003237^2}} = \frac{0.000009}{0.00003622} = 0.249$$

$$T_{RT} = \frac{\left|RToff - RT_{none}\right|}{\sqrt{\sigma_{off}^2 + \sigma_{none}^2}} = \frac{0.0002185 - 0.0002178}{\sqrt{0.0000008592^2 + 0.000001708^2}} = \frac{0.0000007}{0.0000019119} = 0.366$$

$$T_F = \frac{F_{off} - F_{none}}{\sqrt{\sigma_{off}^2 + \sigma_{none}^2}} = \frac{35270 - 35270}{\sqrt{2.868^2 + 5.738^2}} = \frac{0}{6.41483} = 0$$

$$T_{PS} = \frac{PS_{off} - PS_{none}}{\sqrt{\sigma_{off}^2 + \sigma_{none}^2}} = \frac{5.360 - 5.358}{\sqrt{0.007308^2 + 0.01463^2}} = \frac{0.002}{0.01635} = 0.122$$

Ryan Kaufmann Oct 22, 2017 @04:29 PM PDT

From these t-scores, we can assume that there is little to no difference between these values. Since we had a better fit from the second code, we will use those values of the fit. We can't directly compare these values to the one from our first transient, since they have different resistors in them. Instead, we can calculate the values for the inductor and compare those. Thus, we get the following calculations:

Ryan Kaufmann Oct 22, 2017 @05:28 PM PDT

$$L_{1000} = \frac{\tau R}{2} = \frac{0.00004097 * 995.69}{2} = 20.397mH$$

$$\sigma_{1000} = L_{1000}\sqrt{\frac{\sigma_\tau^2}{\tau^2} + \frac{\sigma_R^2}{R^2}} = 20.397\sqrt{0.000058 + 0.0000000101}mH = 0.155mH$$

$$L_{100} = \frac{\tau R}{2} = \frac{0.0002185 * 104.978}{2} = 11.469mH$$

$$\sigma_{100} = L_{100}\sqrt{\frac{\sigma_\tau^2}{\tau^2} + \frac{\sigma_R^2}{R^2}} = 11.469\sqrt{0.0000155 + 0.0000000000227}mH = 0.045mH$$

$$T_L = \frac{L_{1000} - L_{100}}{\sqrt{\sigma_{1000}^2 + \sigma_{100}^2}} = \frac{20.397 - 11.469}{\sqrt{0.155^2 + 0.045^2}} = \frac{8.928}{0.1614} = 55.316$$

Ryan Kaufmann Oct 22, 2017 @05:33 PM PDT

We can tell from this t-score and the individual values that these are not the same inductance. This may come from before when we switched between inductors (It is hard to keep track of the one inductor). Otherwise it may be because the inductor was plugged in improperly. Errors in resistance, function generator, or oscilloscope do not explain this big of a difference.

Ryan Kaufmann Oct 20, 2017 @10:22 AM PDT

2.3.5 Phase Shift of the Output Signal

Ryan Kaufmann Oct 22, 2017 @06:36 PM PDT

For the last part of this experiment, let us look at the phase shift of the system. When we were analyzing the steady state behavior, we noticed that there was a slight phase shift every time we increased or decreased the frequency past the resonance frequency. In order to observe what this behavior is, we took three sets of data, both the input voltage and the voltage drop across the resistor at frequencies at, far above, and far below the resonance frequency. More specifically, we took data when our function generator outputted a peak-to-peak frequency of 1V, and offset of 0V, and frequencies of 34990Hz (resonance), 2000Hz (below), and 100000Hz (above). Our data is as follows:

Ryan Kaufmann Oct 22, 2017 @05:52 PM PDT

RLCPhaseShift100OhmBelowCH2.csv(11.7 KB)

Ryan Kaufmann Oct 22, 2017 @05:52 PM PDT

RLCPhaseShift100OhmResonanceCH1.csv(11.8 KB)

Ryan Kaufmann Oct 22, 2017 @05:52 PM PDT

RLCPhaseShift100OhmResonanceCH2.csv(11.7 KB)

Ryan Kaufmann Oct 22, 2017 @05:52 PM PDT

RLCPhaseShift100OhmAboveCH1.csv(11.7 KB)

Ryan Kaufmann Oct 22, 2017 @05:52 PM PDT

RLCPhaseShift100OhmAboveCH2.csv(11.7 KB)

Ryan Kaufmann Oct 22, 2017 @05:52 PM PDT

RLCPhaseShift100OhmBelowCH1.csv(11.7 KB)

Ryan Kaufmann Oct 22, 2017 @06:39 PM PDT

We fit all three of these data sets in our python script. While some were able to be fit, others seemed to have too much noise or randomness to be fitted well. Let us first look at the resonance frequency. We received chi-squareds of 0.879 and 1.089 for the resistor voltage and input voltage, respectively, showing that our fits are mostly good. However, our residuals for the resistor voltage don't look as good as the input voltage. There is a slight pattern, but it doesn't seem to be able to be fixed. We get the following phase shifts and graphs:

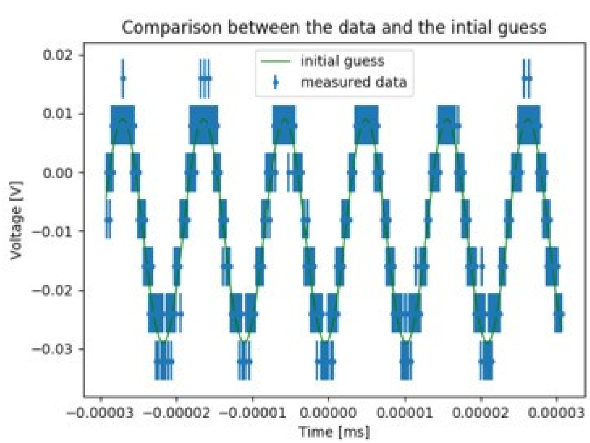
Ryan Kaufmann Oct 22, 2017 @06:44 PM PDT

$$\phi_{\Omega} = -1.31331 \pm 0.01021$$

$$\phi_{in} = 0.163452 \pm 0.0003275$$

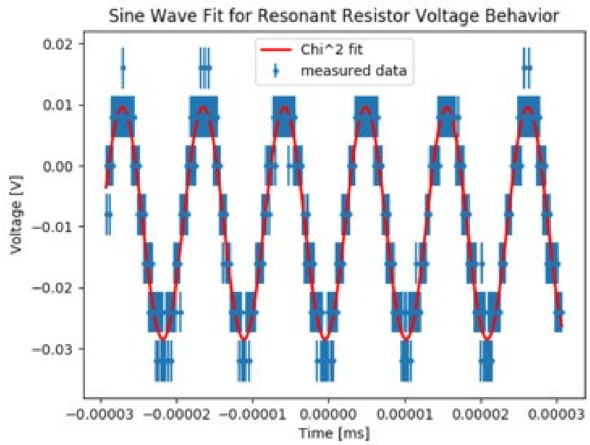
$$\phi_{diff} = 1.476762 \pm 0.0102153$$

Ryan Kaufmann Oct 22, 2017 @06:45 PM PDT



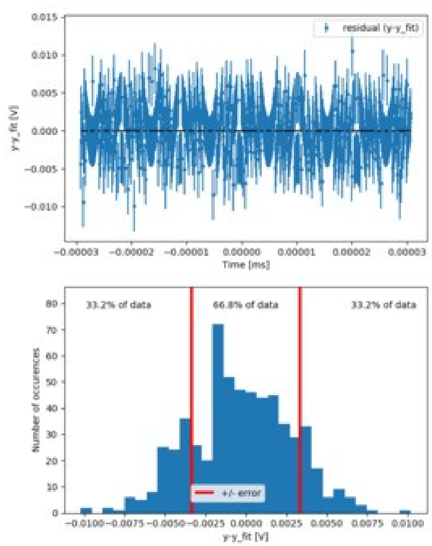
PhaseResonanceCh1Guess.png(45.6 KB)

Ryan Kaufmann Oct 22, 2017 @06:45 PM PDT



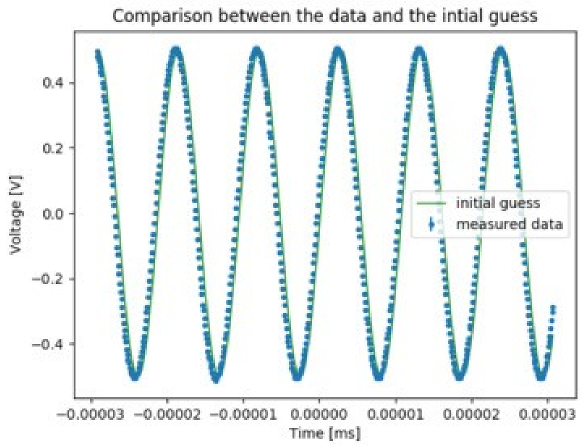
PhaseResonanceCh1Fit.png(50 KB)

Ryan Kaufmann Oct 22, 2017 @06:45 PM PDT



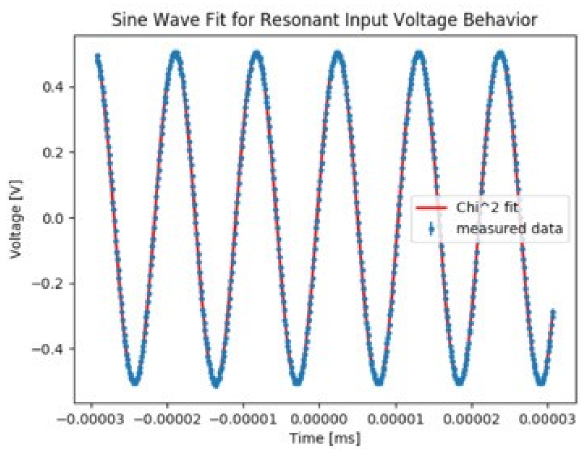
PhaseResonanceCh1Resids.png(49.7 KB)

Ryan Kaufmann Oct 22, 2017 @06:45 PM PDT



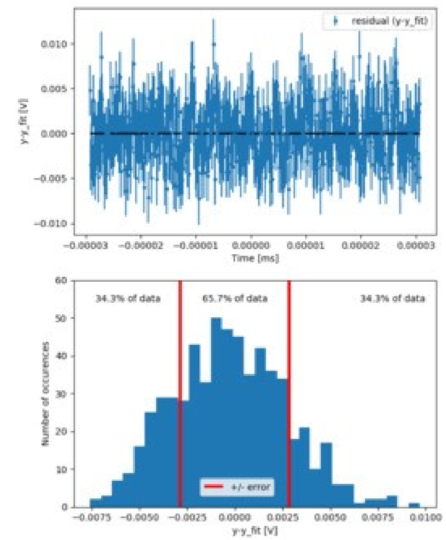
PhaseResonanceCh2Guess.png(60.8 KB)

Ryan Kaufmann Oct 22, 2017 @06:45 PM PDT



PhaseResonanceCh2Fit.png(56.5 KB)

Ryan Kaufmann Oct 22, 2017 @06:45 PM PDT



PhaseResonanceCh2Resids.png(46.5 KB)

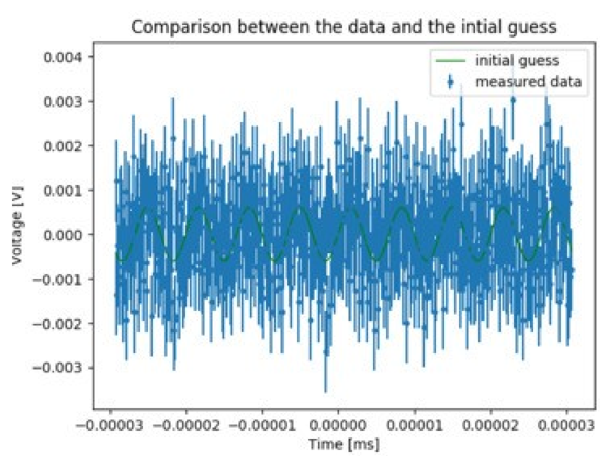
Ryan Kaufmann Oct 22, 2017 @07:25 PM PDT

Next, let us compare this to our data far above resonance. Our fits are slightly better, although it is hard to tell in some cases. We have chi-squareds of 0.9898 for resistor voltage and 0.9184 for input voltage. In addition, the residuals don't seem to have a pattern and revolve around zero. The fits gave us the following phase shifts and graphs:

Ryan Kaufmann Oct 22, 2017 @07:29 PM PDT

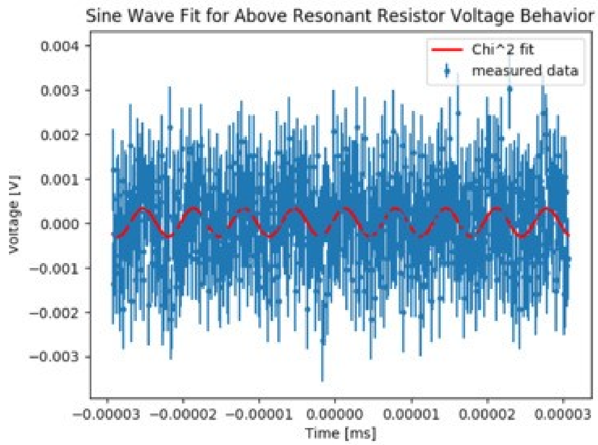
$$\phi_{\Omega} = 0.316445 \pm 0.1676$$
$$\phi_{in} = 0.274665 \pm 0.0003268$$
$$\phi_{diff} = 0.04178 \pm 0.1676$$

Ryan Kaufmann Oct 22, 2017 @07:29 PM PDT



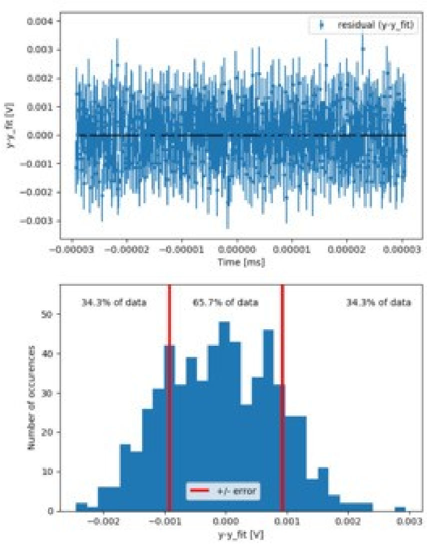
PhaseAboveCh1Guess.png(48.5 KB)

Ryan Kaufmann Oct 22, 2017 @07:29 PM PDT



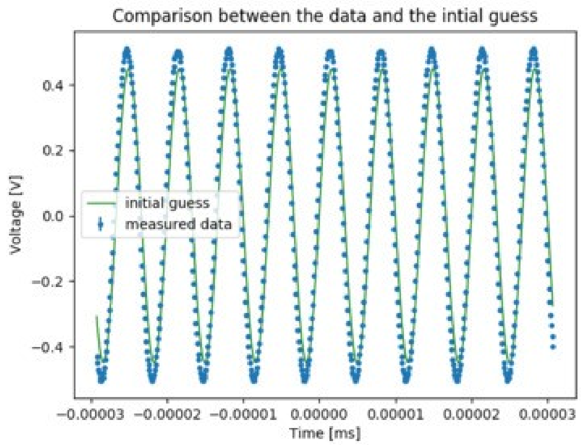
PhaseAboveCh1Fit.png(50.3 KB)

Ryan Kaufmann Oct 22, 2017 @07:29 PM PDT



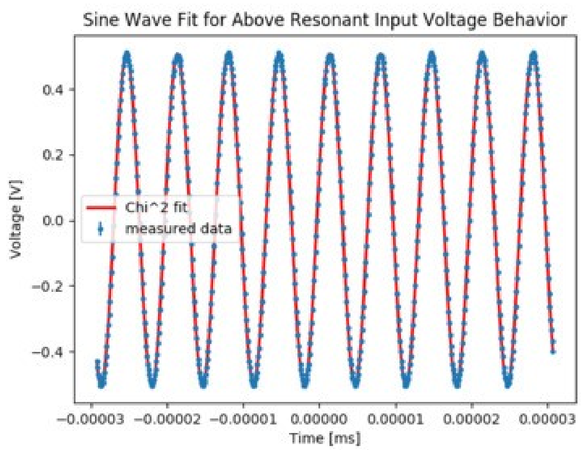
PhaseAboveCh1Resids.png(51 KB)

Ryan Kaufmann Oct 22, 2017 @07:29 PM PDT



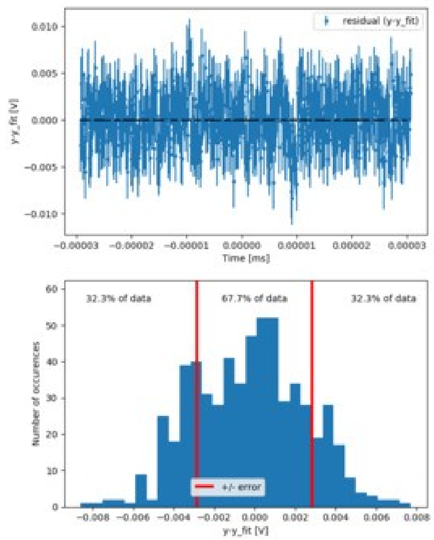
PhaseAboveCh2Guess.png(66.5 KB)

Ryan Kaufmann Oct 22, 2017 @07:29 PM PDT



PhaseAboveCh2Fit.png(65.3 KB)

Ryan Kaufmann Oct 22, 2017 @07:29 PM PDT



PhaseAboveCh2Resids.png(46.3 KB)

Ryan Kaufmann Oct 22, 2017 @07:38 PM PDT

Finally let us look at the last set of data, the below portion. Once again we have good fits that are easier to resolve from the last two set, for the most part. We get slightly worse chi-squareds, around 1.198 for the resistor and 1.089 for the input. However our residuals are still fairly good. We get the following phase shifts and graphs:

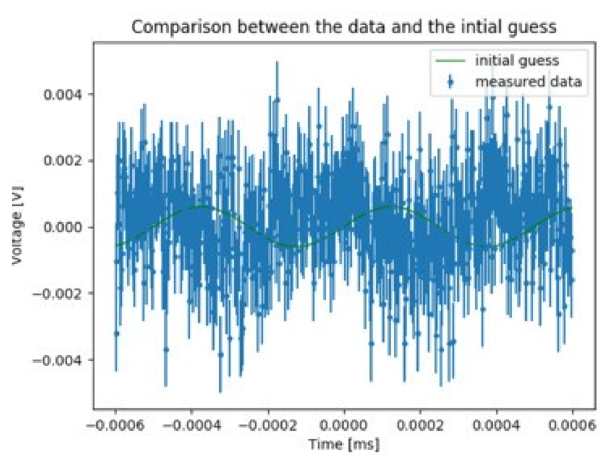
Ryan Kaufmann Oct 22, 2017 @07:41 PM PDT

$$\phi_{\Omega} = -1.01827 \pm 0.1059$$

$$\phi_{in} = 0.382580 \pm 0.0001535$$

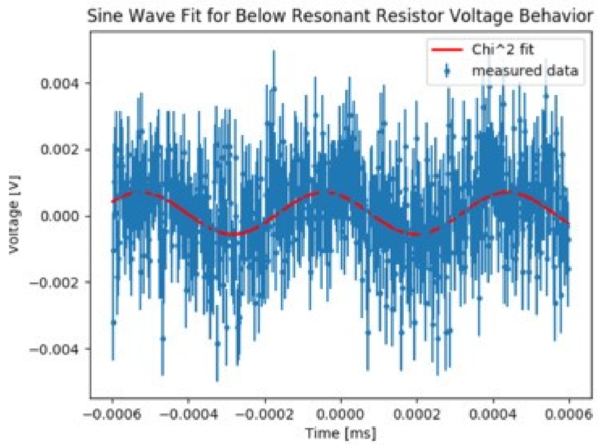
$$\phi_{diff} = 1.40085 \pm 0.105900$$

Ryan Kaufmann Oct 22, 2017 @07:41 PM PDT



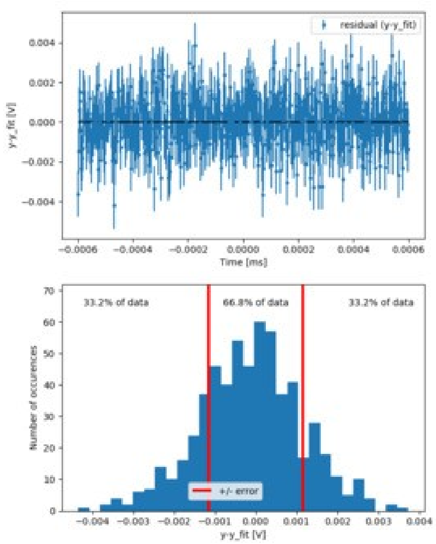
PhaseBelowCh1Guess.png(41.7 KB)

Ryan Kaufmann Oct 22, 2017 @07:41 PM PDT



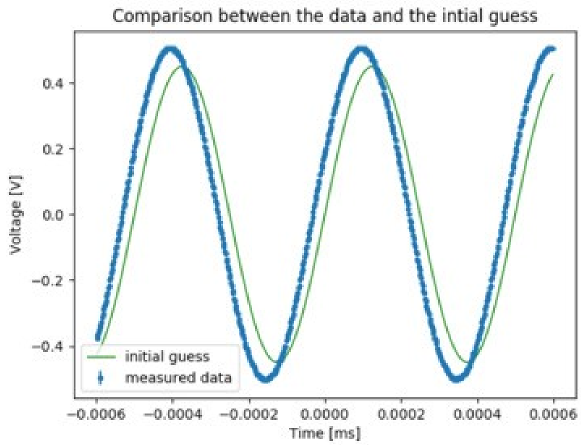
PhaseBelowCh1Fit.png(45.6 KB)

Ryan Kaufmann Oct 22, 2017 @07:41 PM PDT



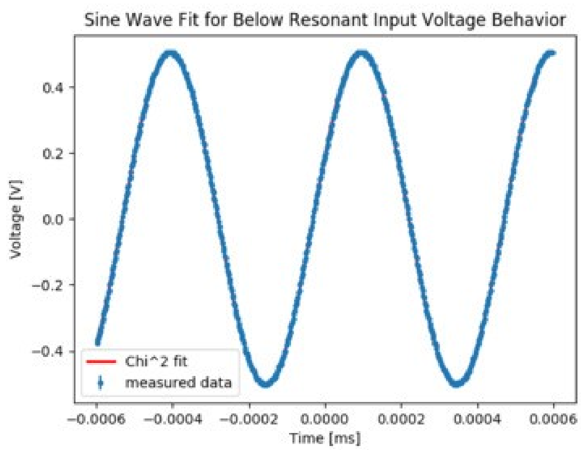
PhaseBelowCh1Resids.png(49.4 KB)

Ryan Kaufmann Oct 22, 2017 @07:41 PM PDT



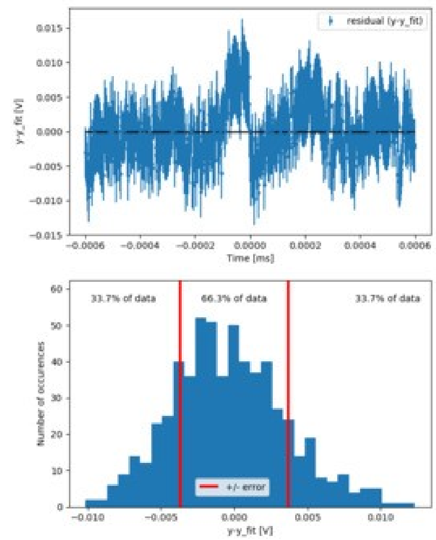
PhaseBelowCh2Guess.png(48.1 KB)

Ryan Kaufmann Oct 22, 2017 @07:41 PM PDT



PhaseBelowCh2Fit.png(39.8 KB)

Ryan Kaufmann Oct 22, 2017 @07:41 PM PDT



PhaseBelowCh2Resids.png(43.7 KB)

Ryan Kaufmann Oct 22, 2017 @07:57 PM PDT

The behavior with the resonant frequency is not what we expect. We thought that the resonant frequency would have the lowest phase shift compared to the rest of the data sets, at that the other data sets would have phase shifts much larger. But it seems something different has happened. The resonant frequency had a similar phase shift to the data far below resonant frequency, while the far above resonant frequency data had the smallest phase shift.

This may have been because of the amount of oscillations we had when we took our data. However, the oscilloscope could not give us any smaller time scale so we had to use that one. Further optimizing the code could also help with resolving this issue. Otherwise, we are led to believe that the phase shift is not so dependent on resonant frequency as we believed.

Ryan Kaufmann Oct 20, 2017 @10:26 AM PDT

2.4 Conclusion

Ryan Kaufmann Oct 22, 2017 @08:44 PM PDT

This lab revolved around the LCR circuit and how it changes based on certain parameters. Furthermore, it was a lab focused on intensely accurate data measurements. Many of our data sets did not end up matching as we had hoped, which we believe to have been because of the change in inductors or the precision of the oscilloscope. We found our steady state to match our first transient in resonant frequency but not gamma. Thus we think there might have either been some error in the fit or the resistor, although the same resistor was used across both measurements.

When we compared our second transient to the first one later on and noticed that the inductance we had hoped for fell by half, giving us another mismatch. We couldn't find any reasonable explanation for why the inductance was halved for the second transient other than some change that occurred in the inductor that we used or some change in the plotting. There may have been another explanation, but we were unable to come across anything that would put in that much of a difference.

Finally we looked at the phase shift portion. We found that the data we took did not match the theory at all. Instead, it did something completely unpredictable. We attributed this cause to some amount of inaccuracy within the oscilloscope and the fact that we could not get higher resolution data points.

All of these errors may be fixed by going through the lab over again or comparing notes with other groups. If we were to take other measurements, we may pick better frequencies to check the phase shifts, go through the entire lab with the same inductor, or take more and better data points for the steady state. However, this lab taught us to be more careful about the measurements we take, being more precise with the data. We will make sure to include this in the next lab.