Final Exam
Study Guide

Circuits to build

lab_03.pdf

from the function generator, and four identical blue LEDs for the diodes. Connect the input sine wave from the function generator to your circuit. Start by setting the frequency of the generator to 1 Hz. **Make sure the output is oscillating around 0V.** To do this, pull out on the DC offset knob on the signal generator (second knob from the left), and make sure the indicator is at a middling value (pointed up). Make sure the amplitude is large enough to be beyond the threshold of two diodes in series.

2. What parts of the circuit are at ground? Are any diodes connected to ground?
3. Try changing the frequency from 0.1 Hz to 1 MHz. Also try square waves and triangle waves. Describe what you see and explain why the circuit is behaving this way.

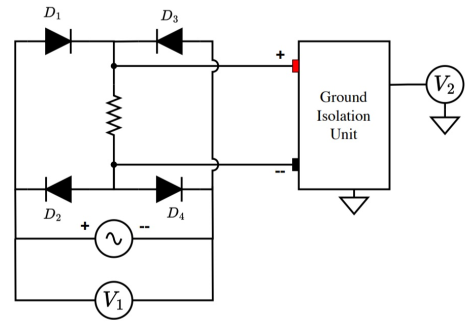


Fig. 4: The same full wave rectifier as in Fig. 3 but now with additional measurement channels.

4. Modify your circuit to become Fig. 4. To do this, you must add two oscilloscope channels, one of which is connected through the ground isolation unit. Why do you need to use the ground isolation amplifier here? You can use the BNC "T" connector to split the output of the signal generator output.
5. Set the signal generator frequency to 1 kHz and a peak-to-peak amplitude of about 20 V. Display Channel 1 and Channel 2 on the scope together, check that both channels are DC

lab_04.pdf

ExpertTA prelab? Explain.

2 Power Supply

The goal of this part of the lab is to build a basic power supply, shown in Fig. 2. We will do this by combining the full wave rectifier (which you built in lab 3) with an RC low-pass filter (which you just built in section Sec. 1). You will see how a low-pass filter can be used to "clean-up" the ripple in the output from a full-wave rectifier. The "ripple" refers to the fact that the output of your rectifier had big bumps and big dips. This kind of rectifier and filter circuit is commonly used in power supplies that produce a DC voltage from a 60 Hz AC power input.

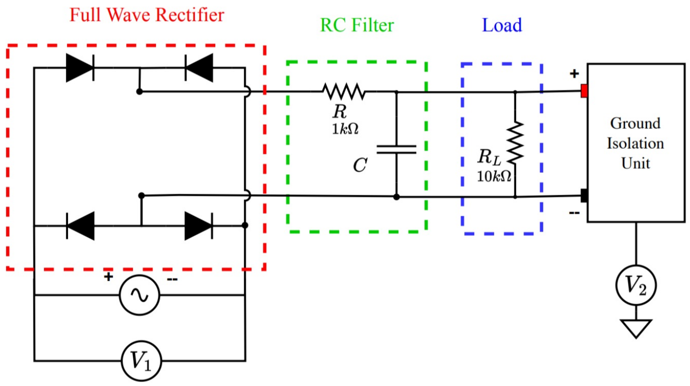


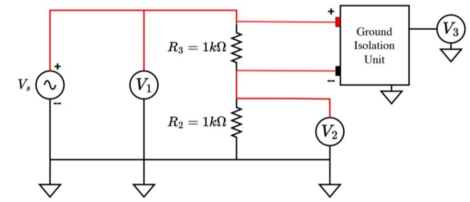
Fig. 2: Power supply circuit built from full-wave rectifier circuit and a low-pass RC filter. It takes AC power, converts it to DC, and uses it to drive current through a load resistor R_L.

⚠ ⚠ ⚠

What just happened is the most common mistake on the final!
Before attaching channel 3, neither end of R_3 is at ground potential. But one part of the scope lead—the jacket—is always at ground. By attaching the jacket to the end of R_3, you forced the junction P to ground.
Never introduce ground into more than one place on a circuit!

⚠ ⚠ ⚠

To correctly probe elements like R_3, which we will do often in this class, we must use the **ground isolation unit** (sometimes called a ground isolation amplifier). The isolation amplifier has two inputs $+$ and $-$, that are not grounded.



Lab 6: AC Circuits, Impedance, and Filters

Abstract

The main goals of this lab is to build and study the properties of a low-pass filter constructed out of an RC circuit.

1 The Low Pass Filter

The goal of this part of the lab is to build a low-pass filter out of an RC circuit, and to measure the amplitude response of that filter as a function of frequency.

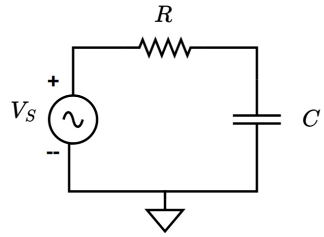


Fig. 1: A low pass RC filter: the source voltage, V_S is applied across R and C. Typically, the output signal is measured across the capacitor. In this lab you will record the source voltage V_S, as well as voltages across R and across C. Connections to the oscilloscope are not shown in this diagram. Use $R = 10k\Omega$ and $C = 0.1\mu F$.

1. Find the $10\,k\Omega$ resistor and $0.1\,\mu F$ capacitor in your component parts box. Use the appropriate meters to measure the resistance of the resistor and the capacitance of the capacitor. Record

lab_05.pdf

Lab 5: Magnetic Fields and Inductance

Abstract

In this lab you will examine effects due to Faraday's Law, observe the electrical behavior of inductors, and build a simple audio speaker based on a moving inductive coil.

1 The RL Circuit

The goal of this part is to build an RL circuit (shown in Fig. 1) and measure its response to a square wave input.

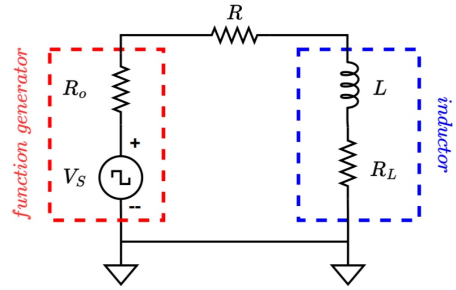


Fig. 1: A function generator (red dashed box) that is generating a square wave is connected to a resistor R and inductor L (blue dashed box). Note that this schematic shows that the function generator has an output impedance of R_o =50 Ω and the inductor has stray resistance R_L.

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Lab 7: RLC Circuits and Resonance

Abstract

The main goal of this lab is to observe resonant phenomena in a LRC circuit.

1 Wiring up the RLC Circuit

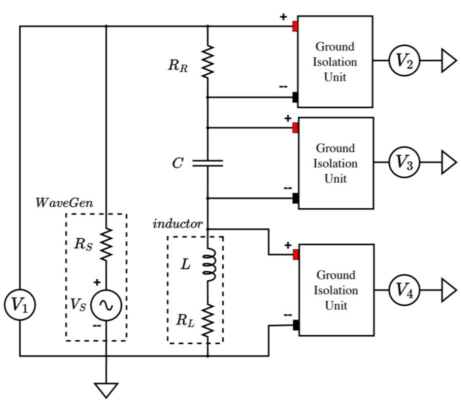


Fig. 1: Series RLC circuit connected to the Wave Generator voltage source. The source has output impedance R_S = 50 Ω and the inductor L has internal resistance R_L. The circuit is shown

4. Set up the circuit shown in Fig. 2 Before you put the transistor into the breadboard, spread the leads a bit so they will not go into the same hole and short out. Next add the resistors. Add the multimeters last, using one to measure the DC collector current and the other to measure V_{BE}. To help keep things straight, we also strongly recommend:

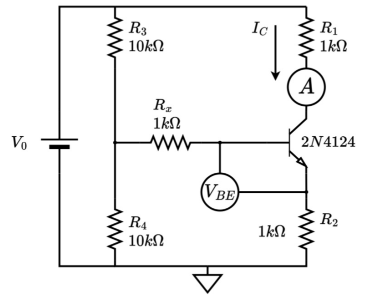


Fig. 2: An NPN transistor (type 2N4124) is connected to a resistor biasing network and variable supply voltage V_0. Note the location of the two meters. The ammeter is measuring the collector current I_C, the voltmeter labeled V_{BE} is measuring the base-to-emitter voltage drop V_{BE}.

Notes

- p value
- chi squared
- quantitive comparison

2 Diodes

1. Build a circuit using a silicon diode and a resistor in series. Drive the circuit with a sinusoidal source voltage with a peak-to-peak voltage of 3 V, and measure the voltage drop across the resistor using an oscilloscope. Choose a trigger setting. → Wave gen
2. Draw the circuit diagram. Did you use a ground isolation unit? Why or why not?
3. Inspect the trace on the scope carefully and explain what you see. Does the general shape of the signal make sense? What about the the maximum and minimum values?
4. Consider the following rectifier circuit driven by a sinusoidal source voltage.

use Cursors

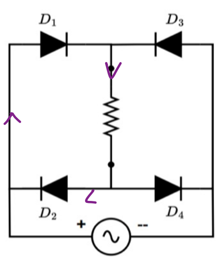
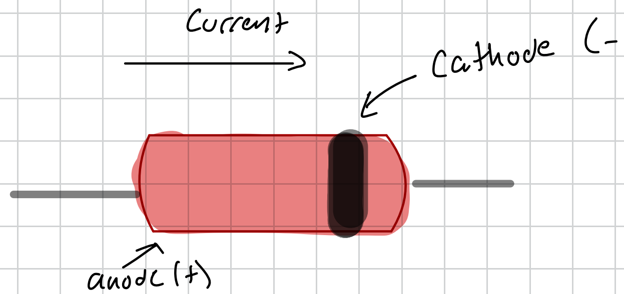
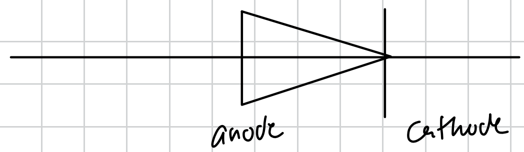


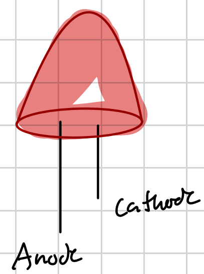
Fig. 1: Rectifier circuit

(a) What kind of rectifier circuit is this? full wave
(b) Copy the circuit in your paper-notebook, then draw the path of the current for the positive half cycle.
(c) State where and how you would connect the oscilloscope to observe the rectified signal.
(d) Using proper units and scales on both axes, draw the trace you would see on the scope.



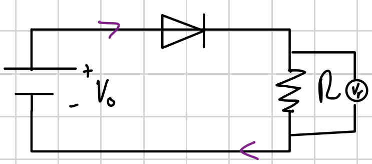
Current flows from left to right





1.

2.



3. the trace shows a sinusodial wave which cuts off at the bottom it only shows half the wave only the positive values

If we measure voltage across diode we need a grand isolation unit here we dont need it because we measure voltage across the resistor

GIU prevents us from introducing ground when we don't want it In this circuit half of this resistor is already at grand and we attach the ground part of the oscilloscope so grand is attached to grand

3. min = -12.5 mV
max = 485 mV

3 LR circuit:

In your parts box find two resistors with resistance of approximately $10\,k\Omega$ and an inductor with inductance $L = 100\,\text{mH}$.

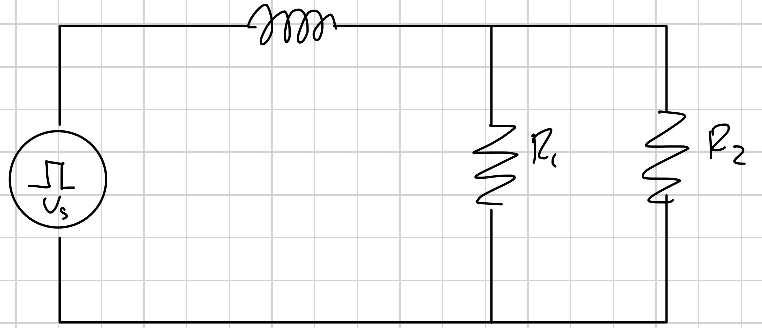
1. How would you connect these elements so that your circuit has a characteristic time constant of $20\,\mu\text{s}$?
2. Measure the values of the resistance and the inductance, calculate the expected time constant τ with the parts you have, and propagate uncertainties to determine the uncertainty in the expected value of τ.
3. Draw your circuit that shows the resistor combination and the inductor in series with a square wave source. Build the circuit and drive it with a positive square wave between 0 V and 5 V. Set up your scope to measure the voltages across the resistors and across the inductor. Think about whether you need to use a ground isolation unit. Display these traces together with the source voltage on your scope.
4. Transfer the traces to the computer and analyze the data to extract the time constant, τ, of your circuit using a linear fit.
5. You must also determine the uncertainty in τ and evaluate the goodness of your fit. To simplify data acquisition, you may consider that the uncertainty for all voltage values is 3%. State your reduced χ^2 value and the P-value for your comparison between data and fit.
6. Quantitatively compare your calculated and measured values of tau. Do your calculation on paper, and use the notebook only to compute numerical values.

1. resistors in parallel

2. tau expected = $L / \text{sum } R$
propagate errors later

3.

Since we measure voltage across the inductor we introduce ground, so we use the GIU



$$\frac{1}{R_{ef}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$R_{ef} = \left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1}$$

4 RC filters

Draw two circuits: a high pass and a low pass RC filter, each driven by a square wave source.

(a) Explain why one is called a high pass and the other a low pass filter.

(b) Suppose $R = 3\,k\Omega$ and $C = 40$ nF. Calculate the characteristic time constant, τ, and the cut-off frequency f_0 of each circuit.

(c) Draw the frequency response of each circuit and mark any relevant values on the voltage axis and on the frequency axis.

(d) You want to measure the voltages across the resistor and the capacitor. How would you connect the oscilloscope to each circuit? Draw the corresponding connections on each circuit diagram and explain why you chose to connect the way you did.

(e) Choose one of the filters. Suppose you are driving it at the cutoff frequency f_0 with a sinusoidal source that has a peak to peak voltage of 1 V. Draw the voltage across the resistor that you expect to see on the oscilloscope. Mark any relevant values on the axes.

(f) Build the circuit you chose, and display the trace of the voltage across R on the scope. Take the time to compare this display with your prediction. Tune the function generator first above and then below the cut-off frequency. Each time compare the amplitude of the signal to the one you measured at f_0. Compare your observation with the frequency response you drew in (c) above. Does it make sense?

(g) Imagine you changed out the square wave generator for a simple switch and a battery. Redraw your circuit diagram. What would the voltage across the resistor look like just after the switch was closed? What would it look like a long time after the switch was closed? What about for the capacitor? Mark any relevant values on the axes.

(h) Imagine further you changed out the capacitor for an inductor, and repeat the analysis above: what would the voltage across the resistor look like just after the switch was closed? What would it look like a long time after the switch was closed? What about for the inductor? Mark any relevant values on the axes.

$\tau = RC$

$f_{cutoff} = \dfrac{1}{2\pi\tau}$

5 LRC circuit

1. Choose a resistor, an inductor and a capacitor from your parts box and measure their resistance, inductance and capacitance, respectively.
2. Use these values to predict the resonance frequency and the quality factor of your circuit. Be sure to propagate uncertainties as needed. Don't forget about the 50Ω in the source, as well as the internal resistance of the inductor.
3. Draw the circuit diagram for an RLC circuit using these parts and a sine wave generator.
4. Imagine you drove the system at resonance. Sketch a plot of what you expect the voltage across the resistor, inductor, and capacitor to look like. Pay attention to the relative magnitudes and phases.
5. Now, build your RLC circuit with these elements using the function generator as your source. Choose a sine-wave as source, and set the peak-to-peak voltage of your source to 1 V. Measure the voltages across all three circuit elements and display them together with your source voltage on the screen of the oscilloscope.
6. Tune the frequency of the source signal to resonance. In your notebook, comment on the relative phase shifts between the four signals displayed. Do they agree with your prediction above?
7. Determine the quality factor of the circuit from the traces displayed.
8. Compare the measured quality factor with the predicted one. Do they agree? You must give a quantitative answer.
9. Review the resonance curve that you measured in Lab 7 (voltages vs frequency) and explain why the curves for V_C and V_L are asymmetric. Be sure to understand how the capacitor and the inductor behave below and above resonance.