

Name- Surname:

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Lab 1: Basic RL and RC DC Circuits

Objective

In this exercise, the DC steady state response of simple RL and RC circuits is examined. The transient behavior of RC circuits is also tested.

Theory Overview

The DC steady state response of RL and RC circuits are essential opposite of each other: that is, once steady state is reached, capacitors behave as open circuits while inductors behave as short circuits. In practicality, steady state is reached after five time constants. The time constant for an RC circuit is simply the effective capacitance times the effective resistance, $\tau = RC$. In the inductive case, the time constant is the effective inductance divided by the effective resistance, $\tau = L/R$.

Equipment

- (1) Adjustable DC Power Supply
- (1) Digital Multimeter
- (1) 10 k Ω resistor
- (1) 47 k Ω resistor
- (1) 1 μ F
- (1) 470 μ F
- (1) 10 mH

Schematic

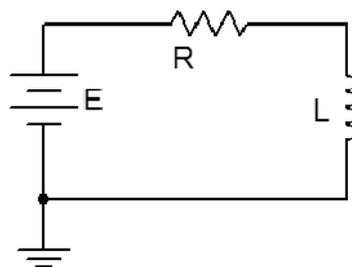


Figure 1.1

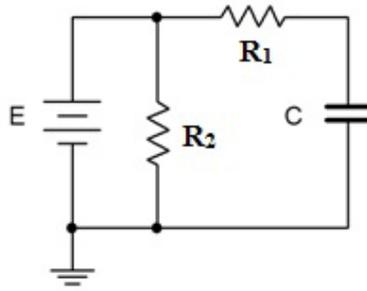


Figure 1.2

Procedure

RL Circuit

1. Using figure 1.1 with $E=10\text{V}$, $R=47\text{k}$, and $L=10\text{ mH}$, calculate the time constant and record it in Table 1.1. Also, calculate and record the expected steady state inductor voltage in Table 1.2.
2. Set the power supply to 10 V but do not hook it up to the remainder of the circuit. After connecting the resistor and inductor, connect the DMM across the inductor set to read DC voltage (20 volt scale).
3. Connect the power supply to the circuit. The circuit should reach steady state very quickly, in much less than one second. Record the experimental inductor voltage in Table 1.2. Also, compute and record the percent deviation between experimental and theory in Table 1.2.

RC Circuit

4. Using figure 1.2 with $E=10\text{V}$, $R_1=47\text{k}$, $R_2=10\text{k}$ and $C=1\text{ }\mu\text{F}$, calculate the time constant and record it in Table 1.3. Also, calculate and record the expected steady state capacitor voltage in Table 1.4.
5. Set the power supply to 10 V but do not hook it up to the remainder of the circuit. After connecting the resistors and capacitor, connect the DMM across the capacitor set to read DC voltage (20 volt scale).
6. Connect the power supply to the circuit. The circuit should reach steady state quickly, in under one second. Record the experimental capacitor voltage in Table 1.4. Also, compute and record the percent deviation between experimental and theory in Table 1.4.

Data Tables

Table 1.1

τ	
--------	--

Table 1.2

V_L (Theory)	V_L (Experimental)	Deviation

Table 1.3

τ	
--------	--

Table 1.4

V_C (Theory)	V_C (Experimental)	Deviation

Questions

1. What is a reasonable approximation for an inductor at DC steady state?
2. What is a reasonable approximation for a capacitor at DC steady state?
3. How can a reasonable approximation for time-to-steady state of an RC circuit be computed?

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Lab 2: Capacitive Reactance

Objective

Capacitive reactance will be examined in this exercise. In particular, its relationship to capacitance and frequency will be investigated, including a plot of capacitive reactance versus frequency.

Theory Overview

The current – voltage characteristic of a capacitor is unlike that of typical resistors. While resistors show a constant resistance value over a wide range of frequencies, the equivalent ohmic value for a capacitor, known as capacitive reactance, is inversely proportional to frequency. The capacitive reactance may be computed via the formula:

$$X_c = -j \frac{1}{2\pi f C}$$

The magnitude of capacitive reactance may be determined experimentally by feeding a capacitor a known current, measuring the resulting voltage, and dividing the two, following Ohm's Law. This process may be repeated across a range of frequencies in order to obtain a plot of capacitive reactance versus frequency. An AC current source may be approximated by placing a large resistance in series with an AC voltage, the resistance being considerably larger than the maximum reactance expected.

Equipment

- (1) AC Function Generator
- (1) Oscilloscope
- (1) 10 kΩ resistor
- (1) 1 uF
- (1) 2.2 uF

Schematic

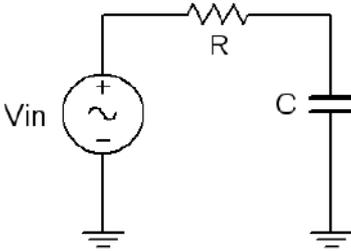


Figure 2.1

Procedure

Current Source

1. Using figure 4.1 with $V_{in}=10Vp-p$ and $R=10k$, and assuming that the reactance of the capacitor is much smaller than $10k$ and can be ignored, determine the circulating current using measured component values and record in Table 2.1.

Measuring Reactance

2. Build the circuit of figure 4.1 using $R=10k$, and $C=1 \mu F$. Place one probe across the generator and another across the capacitor. Set the generator to a 200 Hz sine wave and 10 Vp-p. Make sure that the Bandwidth Limit of the oscilloscope is engaged for both channels. This will reduce the signal noise and make for more accurate readings.
3. Calculate the theoretical value of X_c using the measured capacitor value and record in Table 2.2.
4. Record the peak-to-peak capacitor voltage and record in Table 2.2.
5. Using the source current from Table 2.1 and the measured capacitor voltage, determine the experimental reactance and record it in Table 2.2. Also compute and record the deviation.
6. Repeat steps three through five for the remaining frequencies of Table 2.2.
7. Replace the $1 \mu F$ capacitor with the $2.2 \mu F$ unit and repeat steps two through six, recording results in Table 2.3.
8. Using the data of Tables 2.2 and 2.3, create plots of capacitive reactance versus frequency.

Data Tables

Table 2.1

I_{source}	
--------------	--

Table 2.2

Frequency	X_C (Theory)	V_C (Experimental)	Deviation
200			
400			
600			
800			
1.0 k			
1.2 k			
1.6 k			
2.0 k			

Table 2.3

Frequency	X_C (Theory)	V_C (Experimental)	X_C (Experimental)	% Dev
200				
400				
600				
800				
1.0 k				
1.2 k				
1.6 k				
2.0 k				

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Lab 3: Inductive Reactance

Objective

Inductive reactance will be examined in this exercise. In particular, its relationship to inductance and frequency will be investigated, including a plot of inductive reactance versus frequency.

Theory Overview

The current – voltage characteristic of an inductor is unlike that of typical resistors. While resistors show a constant resistance value over a wide range of frequencies, the equivalent ohmic value for an inductor, known as inductive reactance, is directly proportional to frequency. The inductive reactance may be computed via the formula:

$$X_L = j2\pi fL$$

The magnitude of inductive reactance may be determined experimentally by feeding an inductor a known current, measuring the resulting voltage, and dividing the two, following Ohm's Law. This process may be repeated across a range of frequencies in order to obtain a plot of inductive reactance versus frequency. An AC current source may be approximated by placing a large resistance in series with an AC voltage, the resistance being considerably larger than the maximum reactance expected.

Equipment

- (1) AC Function Generator
- (1) Oscilloscope
- (1) DMM
- (1) 10 kΩ resistor
- (1) 1 mH
- (1) 10 mH

Schematic

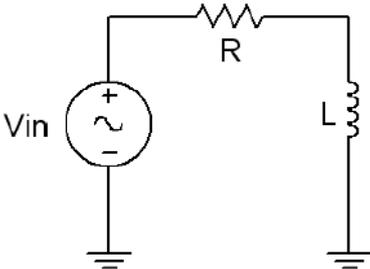


Figure3.1

Procedure

Current Source

1. Using figure 3.1 with $V_{in}=10V_{p-p}$ and $R=10k$, and assuming that the reactance of the inductor is much smaller than $10k$ and can be ignored, determine the circulating current using measured component values and record in Table 3.1. Also, measure the DC coil resistances of the inductors using an ohmmeter or DMM and record in Table 3.1.

Measuring Reactance

2. Build the circuit of figure 3.1 using $R=10k$, and $L=10\text{ mH}$. Place one probe across the generator and another across the inductor. Set the generator to a 1000 Hz sine wave and 10 V_{p-p} . Make sure that the *Bandwidth Limit* of the oscilloscope is engaged for both channels. This will reduce the signal noise and make for more accurate readings.
3. Calculate the theoretical value of X_L using the measured inductor value and record in Table 3.2.
4. Record the peak-to-peak inductor voltage and record in Table 3.2.
5. Using the source current from Table 3.1 and the measured inductor voltage, determine the experimental reactance and record it in Table 3.2. Also compute and record the deviation.
6. Repeat steps three through five for the remaining frequencies of Table 3.2.
7. Replace the 10 mH inductor with the 1 mH unit and repeat steps two through six, recording results in Table 3.3.
8. Using the data of Tables 3.2 and 3.3, create plots of inductive reactance versus frequency.

Data Tables

Table 3.1

I_{source}	
R_{coil} of 10 mH	
R_{coil} of 1 mH	

Table 3.2

Frequency	X_L (Theory)	V_L (Experimental)	X_L (Experimental)	% Dev
1 k				
2 k				
3 k				
4 k				
5 k				
6 k				
8 k				
10 k				

Table 3.2

Frequency	X_L (Theory)	V_L (Experimental)	X_L (Experimental)	% Dev
10 k				
20 k				
30 k				
40 k				
50 k				
60 k				
80 k				
100 k				

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Lab 4: Series R, L, C Circuits

Objective

This exercise examines the voltage and current relationships in series R, L, C networks. Of particular importance is the phase of the various components and how Kirchhoff's Voltage Law is extended for AC circuits. Both time domain and phasor plots of the voltages are generated.

Theory Overview

Each element has a unique phase response: for resistors, the voltage is always in phase with the current, for capacitors the voltage always lags the current by 90 degrees, and for inductors the voltage always leads the current by 90 degrees. Consequently, a series combination of R, L, and C components will yield a complex impedance with a phase angle between +90 and -90 degrees. Due to the phase response, Kirchhoff's Voltage Law must be computed using vector (phasor) sums rather than simply relying on the magnitudes. Indeed, all computations of this nature, such as a voltage divider, must be computed using vectors.

$$X_L = j2\pi fL$$

The magnitude of inductive reactance may be determined experimentally by feeding an inductor a known current, measuring the resulting voltage, and dividing the two, following Ohm's Law. This process may be repeated across a range of frequencies in order to obtain a plot of inductive reactance versus frequency. An AC current source may be approximated by placing a large resistance in series with an AC voltage, the resistance being considerably larger than the maximum reactance expected.

Equipment

- (1) AC Function Generator
- (1) Oscilloscope
- (1) DMM
- (1) 1 k Ω resistor
- (1) 10 nF
- (1) 10 mH

Schematic

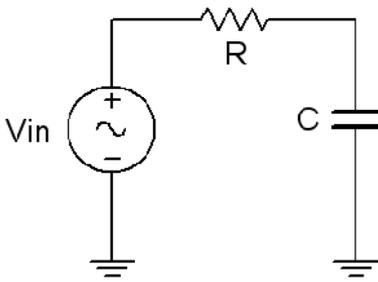


Figure 4.1

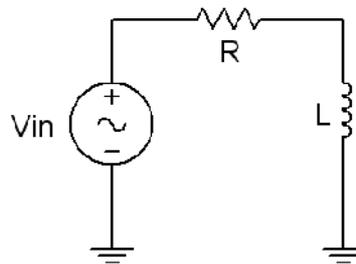


Figure 4.2

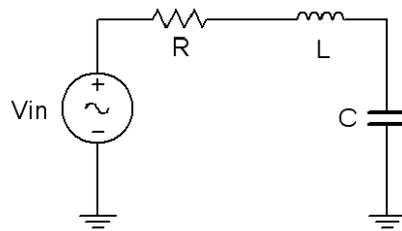


Figure 4.3

Procedure

Current Source

1. Using Figure 4.1 with $V_{in}=1$ Vp-p sine at 10 kHz, $R=1$ k Ω , and $C=10$ nF, determine the theoretical capacitive reactance and circuit impedance, and record the results in Table 4.1. Using the voltage divider rule, compute the resistor and capacitor voltages and record them in Table 4.2.
2. Build the circuit of Figure 4.1 using $R=1$ k Ω , and $C=10$ nF. Place one probe across the generator and another across the capacitor. Set the generator to a 10k Hz sine wave and 1 Vp-p. Make sure that the *Bandwidth Limit* of the oscilloscope is engaged for both channels. This will reduce the signal noise and make for more accurate readings.
3. Measure the voltage across the capacitor and record in Table 4.2. Along with the magnitude, be sure to record the time deviation between V_C and the input signal (from which the phase may be determined). Using the *Math* function, measure and record the voltage and time delay for the resistor ($V_{in} - V_C$). Compute the phase angle and record these values in Table 4.2.
4. Take a snapshot of the oscilloscope displaying V_{in} , V_C , and V_R .
5. Compute the deviations between the theoretical and experimental values of Table 4.2 and record the results in the final columns of Table 4.2. Based on the experimental values, determine the experimental Z and X_C values via Ohm's Law ($i=V_R/R$, $X_C=V_C/i$, $Z=V_{in}/i$) and record back in Table 4.1 along with the deviations.
6. Create a phasor plot showing V_{in} , V_C , and V_R . Include both the time domain display from step 4 and the phasor plot with the technical report.

RL Circuit

7. Replace the capacitor with the 10 mH inductor (i.e. Figure 6.2), and repeat steps 1 through 6 in like manner, using Tables 4.3 and 4.4.

RLC Circuit

8. Using Figure 4.3 with both the 10 nF capacitor and 10 mH inductor, repeat steps 1 through 6 in like manner, using Tables 4.5 and 4.6. Unfortunately, it will be impossible to see the voltage of all three components simultaneously with the source voltage using a two channel oscilloscope. To obtain proper readings, place the first probe at the input and the second probe across the capacitor in order to see the phase and magnitude of V_C . Then, swap C and L (placing the second probe across the inductor) to see V_L , and finally, swap L and R (with the second probe across R) in order see V_R .

Data Tables

RC Circuit

Table 4.1

	Theory	Experimental	% Deviation
X_C			
Z Magnitude			
Z θ			

Table 4.2

	Theory Mag	Theory θ	Exp Mag	Exp Delay	Exp θ	%Dev Mag	%Dev θ
V_C							
V_R							

RL CIRCUIT

Table 4.3

	Theory	Experimental	% Deviation
X_L			
Z Magnitude			
Z θ			

Table 4.4

	Theory Mag	Theory θ	Exp Mag	Exp Delay	Exp θ	%Dev Mag	%Dev θ
V_L							
V_R							

RLC Circuit**Table 4.5**

	Theory	Experimental	% Deviation
X_L			
X_C			
Z Magnitude			
Z θ			

Table 4.6

	Theory Mag	Theory θ	Exp Mag	Exp Delay	Exp θ	%Dev Mag	%Dev θ
V_C							
V_R							
V_L							

Questions

1. What is the phase relationship between R, L, and C components in a series AC circuit?
2. Based on measurements, does Kirchhoff's Voltage Law apply to the three tested circuits (show work)?

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Lab 5: Parallel R, L, C Circuits

Objective

This exercise examines the voltage and current relationships in parallel R, L, C networks. Of particular importance is the phase of the various components and how Kirchhoff's Current Law is extended for AC circuits. Both time domain and phasor plots of the currents are generated. A technique to measure current using a current sense resistor will also be explored.

Theory Overview

Recall that for resistors, the voltage is always in phase with the current, for capacitors the voltage always lags the current by 90 degrees, and for inductors the voltage always leads the current by 90 degrees. Because each element has a unique phase response between +90 and -90 degrees, a parallel combination of R, L, and C components will yield a complex impedance with a phase angle between +90 and -90 degrees. Due to the phase response, Kirchhoff's Current Law must be computed using vector (phasor) sums rather than simply relying on the magnitudes. Indeed, all computations of this nature, such as a current divider, must be computed using vectors.

Equipment

- (1) AC Function Generator
- (1) Oscilloscope
- (1) DMM
- (1) 1 k Ω resistor
- (1) 10 nF
- (1) 10 mH
- (1) 10 Ω resistor

Schematic

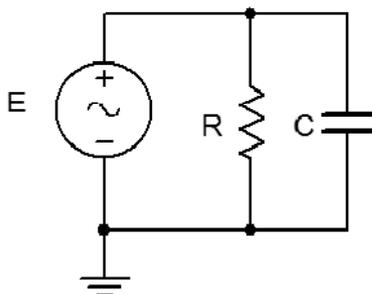


Figure 5.1

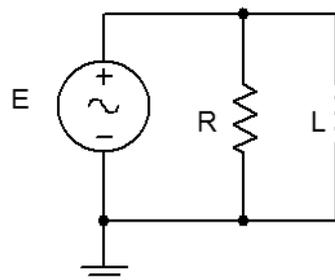


Figure 5.2

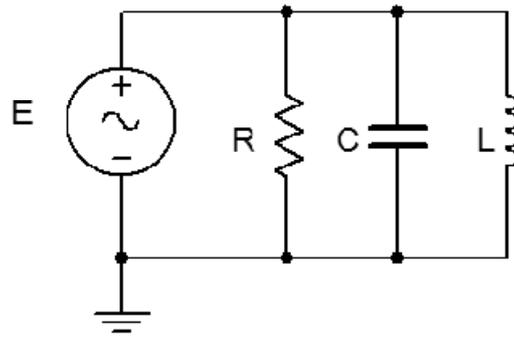


Figure 5.3

Procedure

RC Circuit

- Using Figure 5.1 with a 10 V p-p 10 kHz source, $R=1$ k ohm, and $C=10$ nF, determine the theoretical capacitive reactance and circuit impedance, and record the results in Table 5.1. Using the current divider rule, compute the resistor and capacitor currents and record them in Table 5.2.
- Build the circuit of Figure 5.1 using $R=1$ kohm, and $C=10$ nF. A common method to measure current using the oscilloscope is to place a small *current sense resistor* in line with the current of interest. If the resistor is much smaller than the surrounding reactances it will have a minimal effect on the current. Because the voltage and current of the resistor are always in phase with each other, the relative phase of the current in question must be the same as that of the sensing resistor's voltage. Each of the three circuit currents will be measured separately and with respect to the source in order to determine relative phase. To measure the total current, place a 10 ohm resistor between ground and the bottom connection of the parallel components. Set the generator to a 10k Hz sine wave and 10 Vp-p. Make sure that the *Bandwidth Limit* of the oscilloscope is engaged for both channels. This will reduce the signal noise and make for more accurate readings.
- Place probe one across the generator and probe two across the sense resistor. Measure the voltage across the sense resistor, calculate the corresponding total current via Ohm's Law and record in Table 5.2. Along with the magnitude, be sure to record the time deviation between the sense waveform and the input signal (from which the phase may be determined eventually).
- Remove the sense resistor and place one 10 ohm resistor between the capacitor and ground to serve as the capacitor current sense. Place a second 10 ohm resistor between the resistor and ground to sense the resistor current. Leave probe one at the generator and move probe two across the sense resistor in the resistor branch. Repeat the process to obtain its current, recording the magnitude and phase angle in Table 5.2. Finally, move probe two so that it is across the capacitor's sense resistor. Measure and record the appropriate values in Table 5.2.
- Move probe one to the resistor's sense resistor and leave probe two at the capacitor's sense resistor. Save a picture of the oscilloscope displaying the voltage waveforms representing i_R , i_C and i_{in} (i.e., the *Math* waveform computed from $i_R + i_C$).

6. Compute the deviations between the theoretical and experimental values of Table 5.2 and record the results in the final columns of Table 5.2. Based on the experimental values, determine the experimental Z and X_C values via Ohm's Law ($X_C = V_C / i_C$, $Z = V_{in} / i_{in}$) and record back in Table 5.1 along with the deviations.
7. Create a phasor plot showing i_{in} , i_C , and i_R . Include both the time domain display from step 4 and the phasor plot with the technical report.

RL Circuit

8. Replace the capacitor with the 10 mH inductor (i.e. Figure 5.2), and repeat steps 1 through 7 in like manner, using Tables 5.3 and 5.4.

RLC Circuit

9. Using Figure 5.3 with both the 10 nF capacitor and 10 mH inductor (and a third sense resistor), repeat steps 1 through 7 in like manner, using Tables 5.5 and 5.6. Note that it will not be possible to see all four waveforms simultaneously in step 5.

Data Tables

RC Circuit

Table 5.1

	Theory	Experimental	% Deviation
X_L			
Z Magnitude			
Z θ			

Table 5.2

	Theory Mag	Theory θ	Exp Mag	Exp Delay	Exp θ	%Dev Mag	%Dev θ
I_C							
I_R							
I_{in}							

RL Circuit

Table 5.3

	Theory	Experimental	% Deviation
X_L			
Z Magnitude			
Z θ			

Table 5.4

	Theory Mag	Theory θ	Exp Mag	Exp Delay	Exp θ	%Dev Mag	%Dev θ
I_L							
I_R							
I_{in}							

RLC Circuit

Table 5.5

	Theory	Experimental	% Deviation
X_L			
X_C			
Z Magnitude			
Z θ			

Table 5.6

	Theory Mag	Theory θ	Exp Mag	Exp Delay	Exp θ	%Dev Mag	%Dev θ
I_L							
I_R							
I_{in}							
I_C							

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Lab 6: Series Resonance

Objective

This exercise investigates the voltage relationships in a series resonant circuit. Of primary importance are the establishment of the resonant frequency and the quality factor, or Q , of the circuit with relation to the values of the R , L , and C components.

Theory Overview

A series resonant circuit consists of a resistor, a capacitor, and an inductor in a simple loop. At some frequency the capacitive and inductive reactances will be of the same magnitude, and as they are 180 degrees in opposition, they effectively nullify each other. This leaves the circuit purely resistive, the source “seeing” only the resistive element. Consequently, the current will be at a maximum at the resonant frequency. At any higher or lower frequency, a net reactance (the difference between X_L and X_C) must be added to the resistor value, producing a higher impedance and thus, a lower current. As this is a simple series loop, the resistor’s voltage will be proportional to the current. Consequently, the resistor voltage should be a maximum at the resonant frequency and decrease as the frequency is either increased or decreased. At resonance, the resistor value sets the maximal current and consequently has a major effect on the voltages developed across the capacitor and inductor as well as the “tightness” of the voltage versus frequency curve: The smaller the resistance, the tighter the curve and the higher the voltage seen across the capacitor and inductor. The Q of the circuit can be defined as the ratio of the resonant reactance to the circuit resistance, $Q=X/R$, which also corresponds to the ratio of the resonant frequency to the circuit bandwidth, $Q=F_0/BW$.

Equipment

- (1) AC Function Generator
- (1) Oscilloscope
- (1) DMM
- (1) 470 Ω resistor
- (1) 10 nF
- (1) 10 mH
- (1) 47 Ω resistor

Schematic

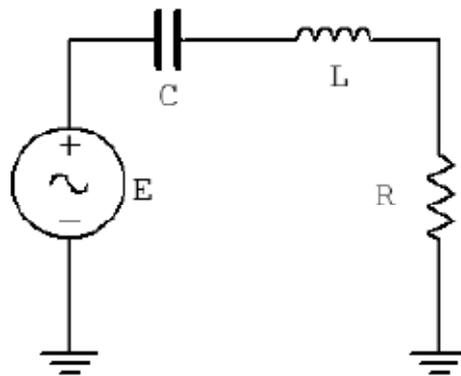


Figure 6.1

Procedure

Low Q Circuit

1. Using Figure 6.1 with $R=470\text{ohm}$, $L= 10 \text{ mH}$, and $C=10 \text{ nF}$, determine the theoretical resonance frequency and Q , and record the results in Table 6.1. Based on these values determine the upper and lower frequencies defining the bandwidth, f_1 and f_2 , and record them in Table 6.1.
2. Build the circuit of Figure 6.1 using $R=470\text{ohm}$, $L=10 \text{ mH}$ and $C=10 \text{ nF}$. Place a probe across the resistor. Set the output of the generator to a 1 V p-p sine wave. Set the frequency to the theoretical resonance frequency of Table 6.1. Make sure that the *Bandwidth Limit* of the oscilloscope is engaged for both channels. This will reduce the signal noise and make for more accurate readings.
3. Adjust the frequency in small amounts, up and down, until the maximum voltage is found. This is the experimental resonance frequency. Record it in Table 6.1. Note the amplitude (it should be approximately equal to the source voltage of 1 V p-p). Sweep the frequency above and below the resonance frequency until the experimental f_1 and f_2 are found. These will occur at a voltage amplitude of approximately 0.707 times the resonant voltage (i.e., the half-power points). Record these frequencies in Table 6.1. Also, determine and record the experimental Q based on the experimental f_0 , f_1 , and f_2 .
4. Transcribe the experimental frequencies of Table 6.1 to the top three entries of Table 6.2. For all of the frequencies in Table 6.2, measure and record the voltage across the resistor. Also measure and record the inductor and capacitor voltages. Note that the inductor and capacitor will have to be swapped with the resistor position in order to maintain proper ground reference with the oscilloscope.
5. Based on the data from Table 6.2, plot V_R , V_C , and V_L as a function of frequency.
6. Change R to 47ohm and repeat steps 1 through 5 but using Tables 6.3 and 6.4 for high Q .

Data Tables

Low Q Circuit

Table 6.1

	Theory	Experimental	% Deviation
F_0			
Q			
F_1			
F_2			

Table 6.2

Frequency	X_L (Theory)	V_L (Experimental)	X_L (Experimental)	% Dev
$F_0 =$				
$F_1 =$				
$F_2 =$				
1 kHz				
5 kHz				
20 kHz				
50 kHz				
100 kHz				

High Q Circuit

Table 6.3

	Theory	Experimental	% Deviation
F_0			
Q			
F_1			
F_2			

Name- Surname:

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Lab 7: Parallel Resonance

Objective

This exercise investigates the voltage relationships in a parallel resonant circuit. Of primary importance are the establishment of the resonant frequency and the quality factor, or Q , of the circuit with relation to the values of the R , L , and C components.

Theory Overview

A parallel resonant circuit consists of a resistor, a capacitor, and an inductor in parallel, typically driven by a current source. At some frequency the capacitive and inductive reactances will be of the same magnitude, and as they are 180 degrees in opposition, they effectively nullify each other. This leaves the circuit purely resistive, the source “seeing” only the resistive element. At any lower or higher frequency the inductive or capacitive reactance will shunt the resistance. The result is a maximum impedance magnitude at resonance, and thus, a maximum voltage. Any resistance value in series (such as the inductor’s coil resistance) should be transformed into a parallel resistance in order to gauge its effect on the system voltage. The combined parallel resistance sets the Q of the circuit and can be defined as the ratio of the combined resistance to the resonant reactance, $Q=R/X$, which also corresponds to the ratio of the resonant frequency to the circuit bandwidth, $Q=f_0/BW$.

Equipment

- (1) AC Function Generator
- (1) Oscilloscope
- (1) DMM
- (1) 2.2 k Ω resistor
- (1) 10 nF
- (1) 10 mH
- (1) 10 k Ω resistor
- (1) 100 k Ω resistor

Schematic

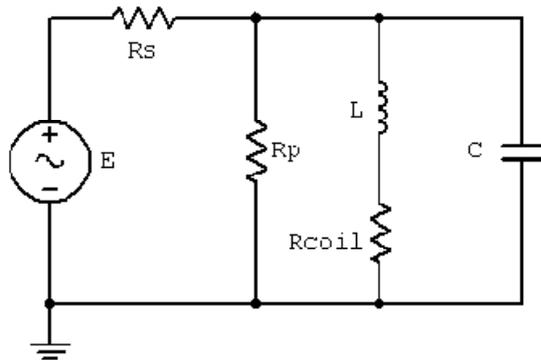


Figure 7.1

Procedure

1. Using Figure 7.1 with $R_s=100$ kohm, $R_p=2.2$ k ohm, $L=10$ mH, $R_{coil}=7$ ohm and $C=10$ nF, determine the theoretical resonance frequency and Q, and record the results in Table 7.1. Based on these values determine the upper and lower frequencies defining the bandwidth, f_1 and f_2 , and record them in Table 7.1 also.
2. Build the circuit of Figure 7.1 using $R_s=100$ kohm, $R_p=2.2$ kohm, $L=10$ mH and $C=10$ nF. Set the output of the generator to a 10 V p-p sine wave at the theoretical resonant frequency. The large value of R_s associated with the voltage source will make it appear as a current source of approximately .1 mA p-p, assuming the parallel branch impedance is much less than R_s . Place a probe across the parallel branch. Set the frequency to the theoretical resonance frequency of Table 7.1. Make sure that the *Bandwidth Limit* of the oscilloscope is engaged for both channels. This will reduce the signal noise and make for more accurate readings.
3. Adjust the frequency in small amounts, up and down, until the maximum voltage is found. This is the experimental resonant frequency. Record it in Table 7.1. Note the amplitude. Sweep the frequency above and below the resonance frequency until the experimental f_1 and f_2 are found. These will occur at a voltage amplitude of approximately 0.707 times the resonant voltage (i.e., the half-power points). Record these frequencies in Table 7.1. Also, determine and record the experimental Q based on the experimental f_0 , f_1 , and f_2 .
4. Transcribe the experimental frequencies of Table 7.1 to the top three entries of Table 7.2. For all of the frequencies in Table 7.2, measure and record the voltage across the parallel branch.
5. Based on the data from Table 7.2, plot the parallel branch voltage as a function of frequency.
6. Change R to 10 kohm and repeat steps 1 through 5 but using Tables 7.3 and 7.4.

Data Tables

Low Q Circuit

Table 7.1

	Theory	Experimental	% Deviation
F_0			
Q			
F_1			
F_2			

Table 7.2

Frequency	V_R	V_R	V_L
$F_0 =$			
$F_1 =$			
$F_2 =$			
1 kHz			
5 kHz			
20 kHz			
50 kHz			
100 kHz			

High Q Circuit

Table 7.3

	Theory	Experimental	% Deviation
F_0			
Q			
F_1			
F_2			

Table 7.4

Frequency	V_R	V_R	V_L
$F_0 =$			
$F_1 =$			
$F_2 =$			
1 kHz			
5 kHz			
20 kHz			
50 kHz			
100 kHz			

Questions

1. What is the effect of changing resistance on Q?
2. Are f_1 and f_2 spaced symmetrically around f_0 ?
3. In practical terms, what sets the limit on how high Q may be?

Name- Surname:

ID:

Department:

Lab 8: AC Maximum Power Transfer

Objective

In this exercise, maximum power transfer to the load will be examined for the AC case. Both the load's resistive and reactive components will be independently varied to discover their effect of load power and determine the values required for maximum load power.

Theory Overview

In the DC case, maximum power transfer is achieved by setting the load resistance equal to the source's internal resistance. This is not true for the AC case. Instead, the load should be set to complex conjugate of the source impedance, the complex conjugate having the same magnitude as the original but with the opposite sign for the angle. By using the complex conjugate, the load and source reactive components will cancel out leaving a purely resistive circuit similar to the DC case. When calculating the true load power, care must be taken to remember that the load voltage appears across a complex load impedance. Only the real portion of this voltage appears across the resistive component, and only the resistive component dissipates power.

Equipment

- (1) AC Function Generator
- (1) Oscilloscope
- (1) DMM
- (1) Decade Box or Potentiometer
- (1) Impedance Meter
- (1) 2.2 k Ω resistor
- (1) 10 nF
- (1) 22 nF
- (1) 33nF
- (1) 47 nF
- (1) 0.1 uF
- (1) 10 mH
- (1) 50 Ω resistor
- (1) 1 k Ω resistor
- (1) 100 k Ω resistor

Schematic

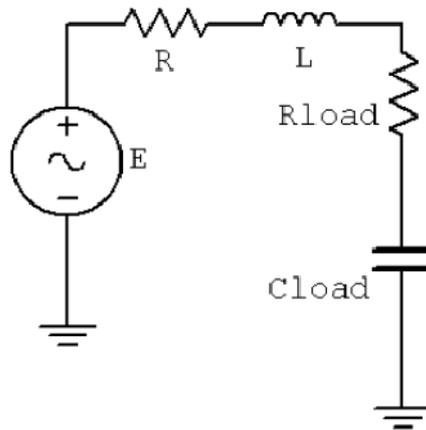


Figure 8.1

Procedure

1. Build the circuit of figure 8.1 using $R=1\text{ k}\Omega$ and $L=10\text{ mH}$, but leaving off the load components. Replace the generator with a 50Ω resistor and determine the effective source impedance at 10 kHz using the impedance meter. Record this value in Table 8.1, including both magnitude and phase. Determine the load impedance which should achieve maximum power transfer according to the theorem and record in Table 8.1. Finally, determine values for R_{load} and C_{load} to achieve this load impedance and record in Table 8.1, also copying the resistance value to the first R_{load} entry of Table 8.2.

Testing R_{load}

2. Replace the 50Ω resistor with the generator. Insert the decade resistance box in the position of R_{load} and set it to the value calculated in Table 8.1. For C_{load} , use the value calculated in Table 8.1. Use multiple capacitors if necessary to achieve a close value. Set the generator to 10 volt peak at 10 kHz , making sure that the amplitude is measured on the oscilloscope with the generator loaded by the circuit. Make sure that the Bandwidth Limit of the oscilloscope is engaged for the channel. This will reduce the signal noise and make for more accurate readings.
3. Measure the magnitude of the load voltage and record in Table 8.2. Also compute the expected load voltage from theory and the load power based on the measured load voltage and record in Table 8.2. Repeat these measurements and calculations for the remaining load resistance values in the table.
4. Return the decade box to the value calculated in Table 8.1. For C_{load} , insert the first capacitor listed in Table 8.3. Repeat step four for each load capacitance in Table 8.3, calculating and recording the required results using Table 8.3.

5. Generate a plot of P_{load} with respect to R_{load} and another of P_{load} with respect to C_{load} .

Data Tables

Table 8.1

Z_{Source}	
Z_{Load}	
R_{Load}	
C_{Load}	

Table 8.2

Variable R_{load}

R_{load}	V_{load}	R_{load} (Exp)	P_{load} (Exp)
100			
400			
600			
800			
1.2 k			
1.8 k			
3 k			
10 k			

