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Objectives

- The analysis of multi-source AC circuits using the Superposition Theorem
- In particular, sources with differing frequencies will be used to illustrate the contributions of each source to the combined result.

Theory Overview

Superposition Theorem

The superposition theorem states that in a linear circuit with several sources, the current and voltage for any element in the circuit is the sum of the currents and voltages produced by each source acting independently. The theorem is valid for any linear circuit. The best way to use superposition with AC circuits is to calculate the complex effective or peak value of the contribution of each source applied one at a time, and then to add the complex values. This is much easier than using superposition with time functions, where one has to add the individual time functions.

To calculate the contribution of each source independently, all the other sources must be removed and replaced without affecting the final result.

- When removing a voltage source, its voltage must be set to zero, which is equivalent to replacing the voltage source with a short circuit.
- When removing a current source, its current must be set to zero, which is equivalent to replacing the current source with an open circuit.

Explanation

The Superposition Theorem can be used to analyze multi-source AC linear bilateral networks. Each source is considered in turn, with the remaining sources replaced by their internal impedance, and appropriate series-parallel analysis techniques employed. The resulting signals are then summed to produce the combined output signal. To see this process more clearly, the exercise will utilize two sources operating at different frequencies. Note that as each source has a different frequency, the inductor and capacitor appear as different reactance to the two sources.

Equipment

1. AC Function Generator
2. Oscilloscope

Components

1. 0.1 μF actual:______0.1 μF_____
2. 10mH actual:_____10mH __
3. 1kΩ actual:______1kΩ_____

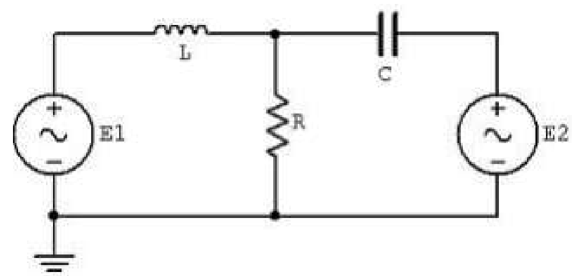


Figure 1:Circuit Schematics

Procedure

To test the Superposition Theorem, sources E1 and E2 will be examined separately and then together.

Source One Only

1. Consider the circuit of Figure 1 with C=0.1 μF, L=10mH, R=1kΩ, using only source E1=2 V p-p at 1 kHz and with source E2 replaced by a 0-V voltage source represented as a short circuit. Using standard series parallel techniques; calculate the voltages across R. Record the results in Table 1.
2. Build the circuit of Figure 1 using C=0.1 μF, L=10mH, and R=1kΩ. Replace E2 with 0-V voltage source represented as a short circuit. Set E1 to 2V p-p at 1 kHz, unloaded. Place probe one across E1 and probe two across R. Measure the voltages across R, and record in Table 1.

Source Two Only

3. Consider the circuit of Figure 1 using only source E2=2 V p-p at 10 kHz and with source E1 replaced by 0-V voltage source represented as a short circuit. Using standard series-parallel techniques; calculate the voltages across R. Record the results in Table 2.
4. Replace the short circuit with source E2 and set it to 2Vp-p at 10 kHz, unloaded. Replace E1 with 0-V voltage source represented as a short circuit. Place probe one across E2 and probe two across R. Measure the voltages across R and record in Table 2.

Source One and Two Only

5. Consider the circuit of Figure 1 using both sources, E1=2Vp-p at 1 kHz and E2=2Vp-p at 10 kHz. Add the calculated voltages across R from Tables 1 and 2. Record the results in Table 3.
6. Replace the short circuit with source E1 and set it to 2Vp-p at 1 kHz, unloaded. Both sources should now be active. Place probe one across R. Measure the voltages across R, and record in Table 3.
7. Repeat the experiment for 1uF capacitor, 1mH inductor and 1kΩ resistor.

Data Tables

Source One Only

	Theoretical	Experimental	%Deviation
V_{R1}	2.045 V	2.26 V	±2

Table 1

Source Two Only

	Theoretical	Experimental	%Deviation
V_{R2}	2.607 V	2.6 V	0

Table 2

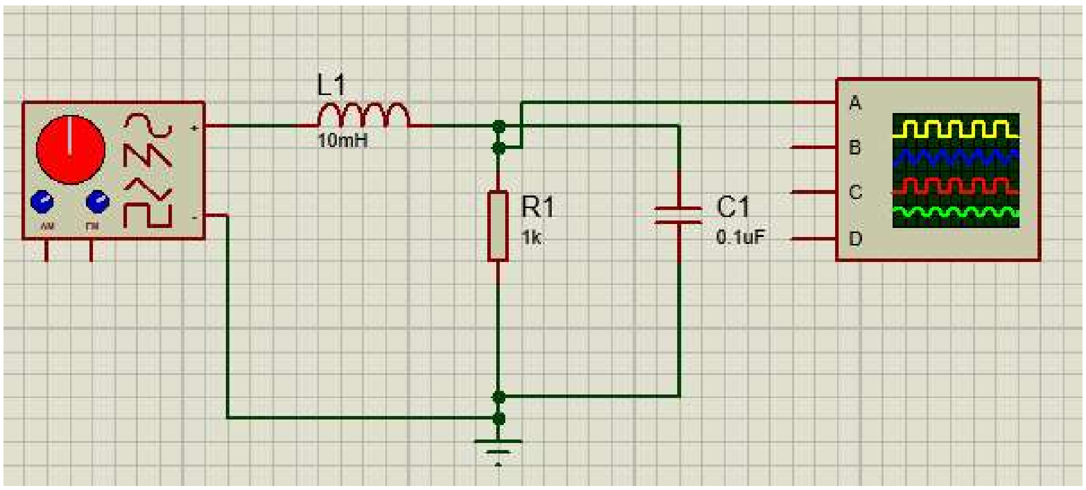
Sources One and Two

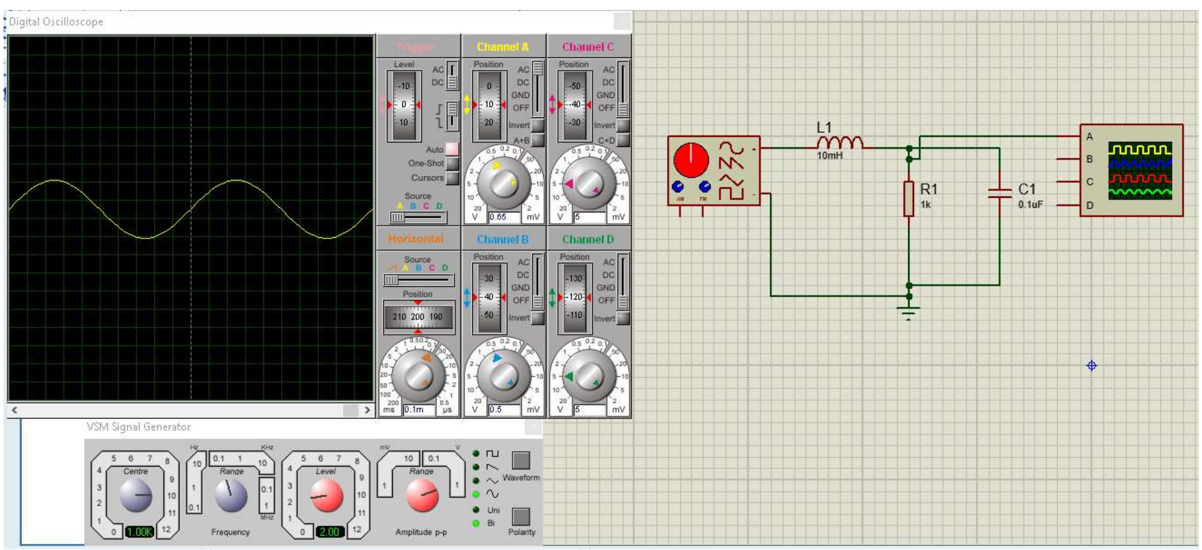
	Theoretical	Experimental	%Deviation
V_R	4.652 V	4.68 V	±1

Table 3

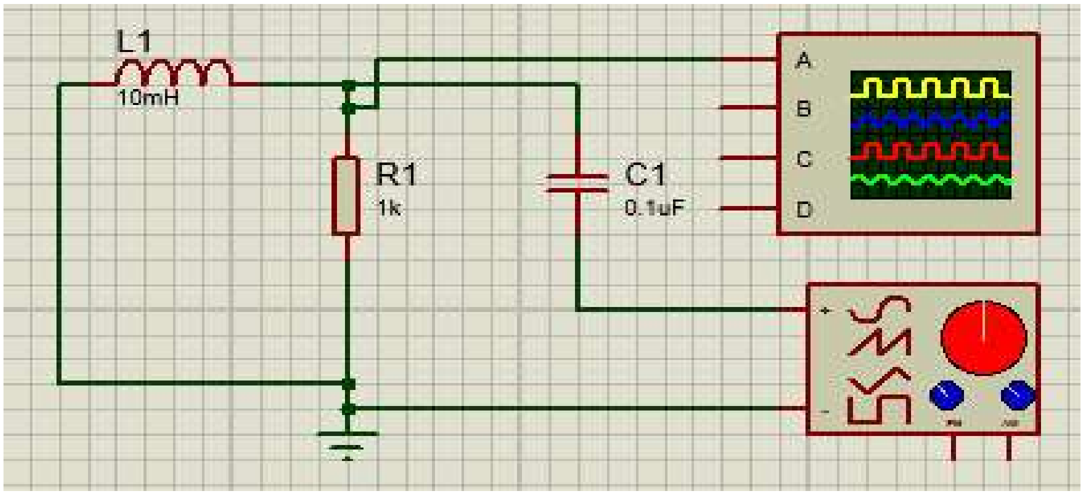
Experimental Pictures

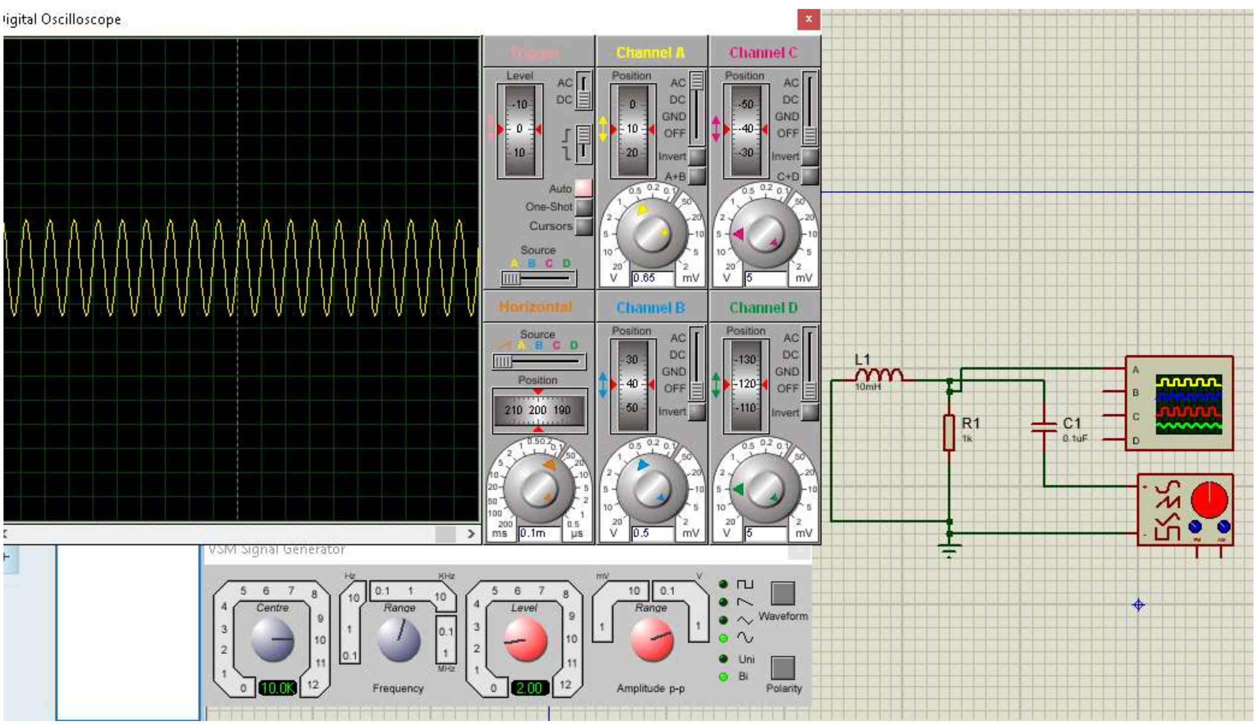
- **Source One Only**



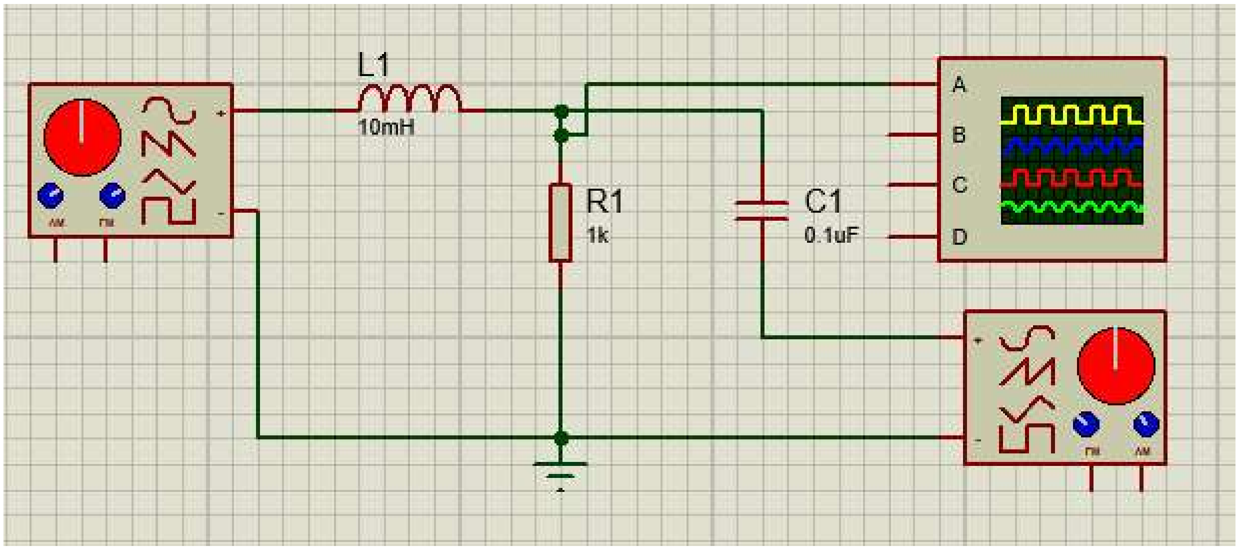


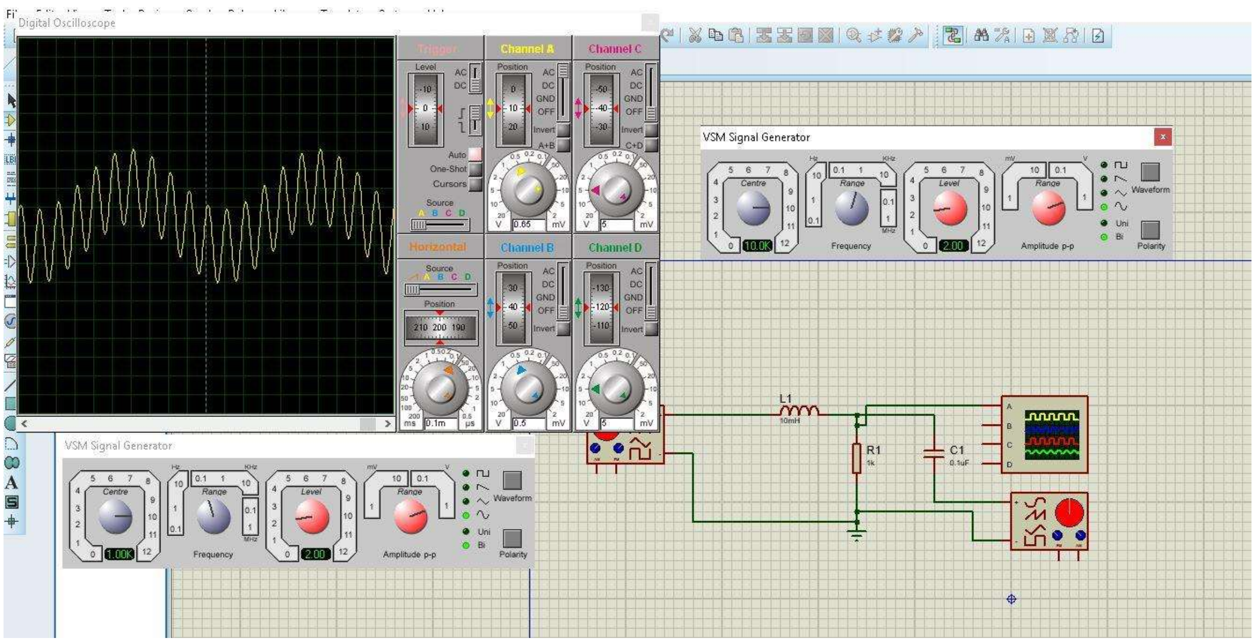
- **Source Two Only**





- **Sources One and Two**





MATLAB Calculation

Editor - I:\3rd Sem\CS-II\CS-II Lab\Lab6.m

Lab6.m

```
clc
clear all
a1 = -1591550j/(1000 - 1591.55j);
b1 = 62.83j + a1;
Vr1 = a1/b1 * (2+0j);

M1 = abs(Vr1);
thetha1 =  angle(Vr1);
deg1 = thetha1 * (180/pi);

a2 = 62830j/(1000 + 628.32j);
b2 = -159.15j +a2;
Vr2 = a2/b2 * (2+0j);

M2 = abs(Vr2);
thetha2 = angle(Vr2);
deg2 = thetha2 * (180/pi);

t=0:0.000001:0.003;
f1=1000;
f2=10000;
w1=2*pi*f1;
w2=2*pi*f2;
Vr1 = M1*sin(w1*t + deg1);
Vr2 = M2*sin(w2*t - deg2);
Vr = Vr1 + Vr2;

subplot(311)
plot(t,Vr1)
grid on
title('Source On Only')
subplot(312)
plot(t,Vr2)
grid on
title('Soutce Two Only')
subplot(313)
plot(t,Vr)
grid on
title('Both Sources')
```

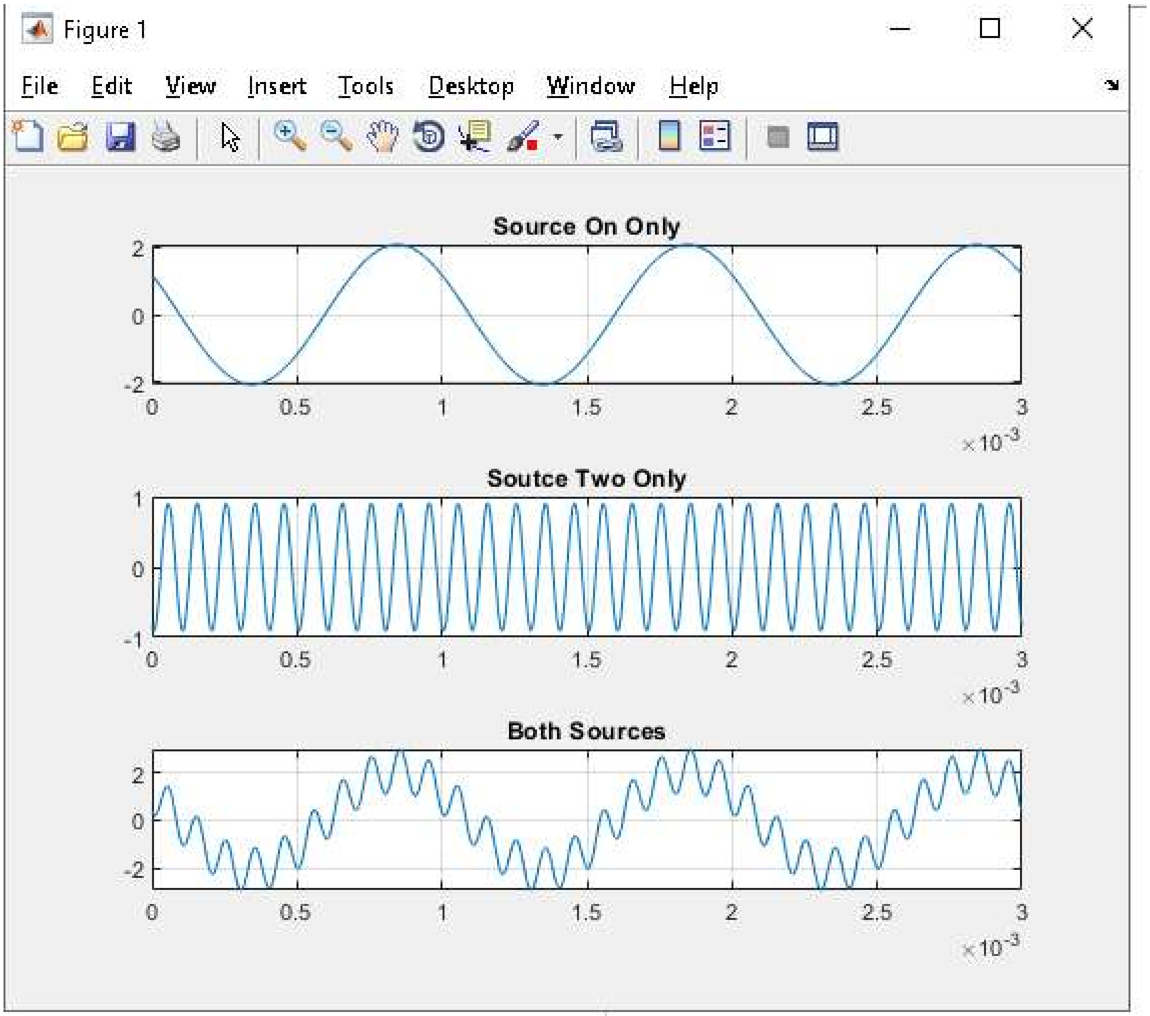


Figure : MATLAB Plotting of Voltages

Data Tables: FOR 1mH and 1uF Capacitor

Source One Only

	Theoretical	Experimental	%Deviation
V_{R1}	2.045 V	2.08 V	±2

Table 1

Source Two Only

	Theoretical	Experimental	%Deviation
V_{R2}	2.607 V	2.6 V	0

Table 2

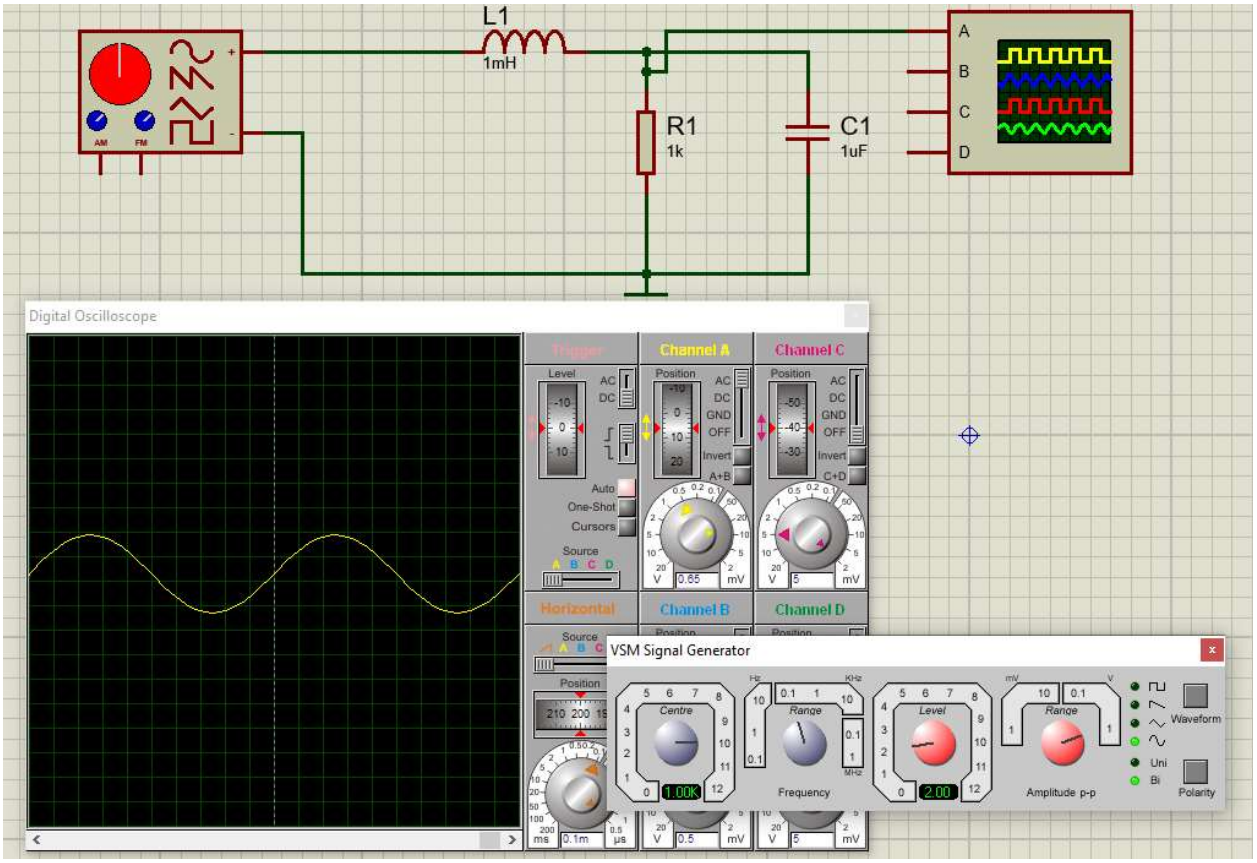
Sources One and Two

	Theoretical	Experimental	%Deviation
V_R	4.652 V	4.68 V	±1

Table 3

Experimental Pictures

- **Source One Only**



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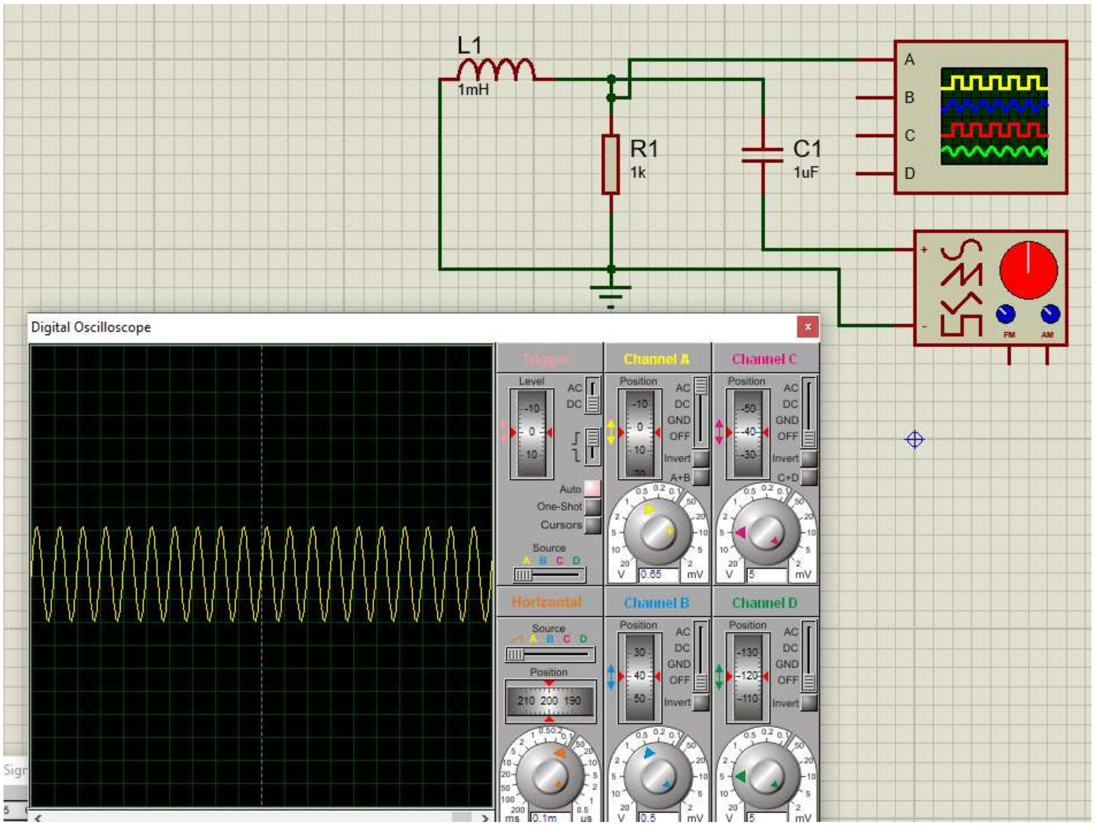
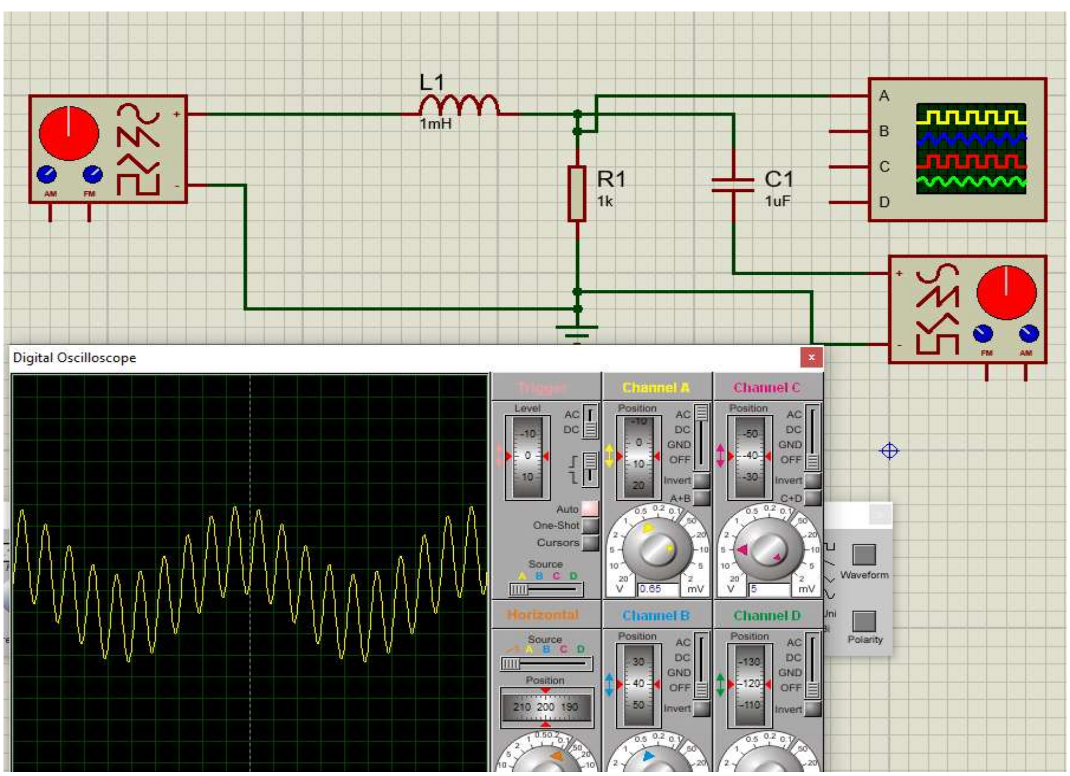


- **Source One and Two**



MATLAB Graph