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Electric Circuit Experiments

Vital information,

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Electric Circuit Experiments

Basic Concept and Laws

1. Verify Kirchhoff's law

2. Measure current in each branch. Testify that for node A and B, the algebraic sum of all branch current is zero.

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1. Verify Kirchhoff's law

Experiment Principal:

There are two laws of Kirchhoff; respectively Kirchhoff's Current Law (KCL) and Kirchhoff's Voltage Law (KVL).

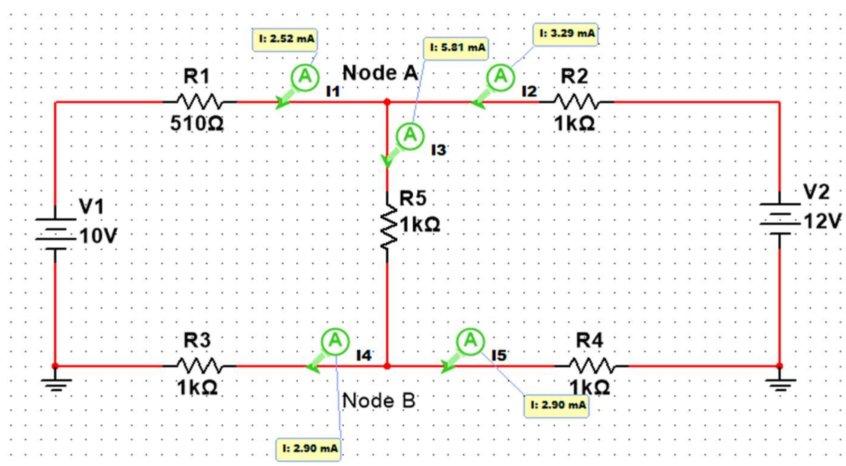
➲ 1. Kirchhoff's current law states that, for any node (junction) in an electrical circuit, the sum of currents flowing into that node is equal to the sum of currents flowing out of that node; or equivalently: The algebraic sum of currents in a network of conductors meeting at a point is zero.

➲ 2. Kirchhoff's voltage law states that the algebraic sum of the potential differences in any loop must be equal to zero.

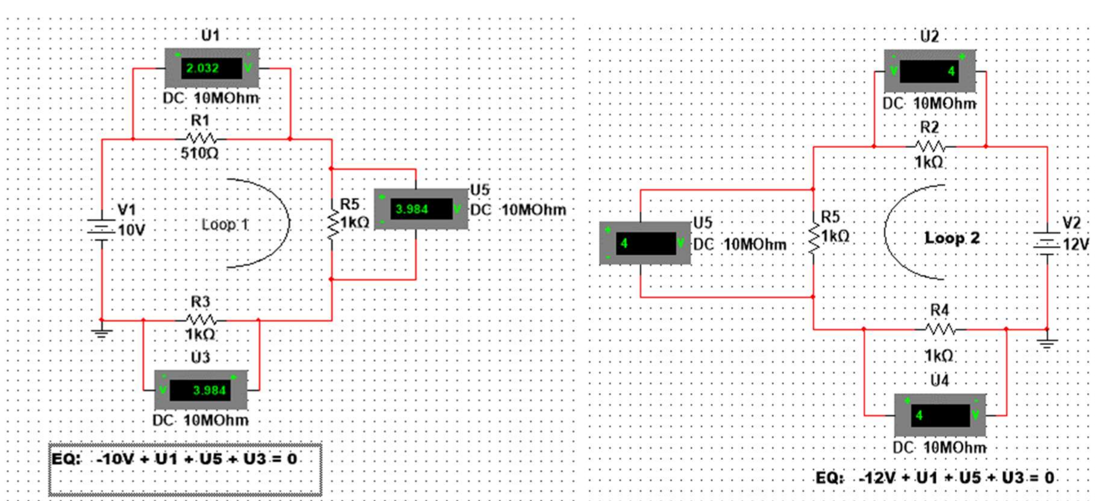
The objective of this experiment is to verify the above rules.

Circuit:

Circuit for Kirchhoff's Current Law



Circuit for Kirchhoff's Voltage Law



Simulation Steps:

1. Open NI Multicim 14.0
2. Draw the circuit for Kirchhoff's Current Law.
3. Start simulation and put the data in the datasheet.
4. Draw the circuits of Kirchhoff's Voltage Law.
5. Start Simulation and put the data in the datasheet.

Simulation Data:

For KCL:

I_1	I_2	I_3	I_4	I_5
2.52mA	3.29mA	5.81mA	2.90mA	2.90mA

For KVL:

Data of Loop 1

V_1	U_1	U_3	U_5
10V	2.032V	3.984V	3.984V

Data of Loop 2

V_2	U_2	U_4	U_5
12V	4V	4V	4V

Analysis and conclusion:

In the circuit of KCL it is evident that

In node A, $+I_1+I_2-I_3=0$ or, $+2.52 +3.29 -5.81=0$

In node B, $+I_3-I_4-I_5=0$ or, $+5.81 - 2.90 -2.90=0$

So, Kirchhoff's Current Law proves.

For the circuits of KVL, in the loop 1,

$$-10V + U1 + U5 + U3 = 0$$

$$\Rightarrow \quad 10V = 2.032V + 3.984V + 3.984V$$

$$\Rightarrow \quad 10V = 10V$$

In the loop 2,

$$-12V + U1 + U5 + U3 = 0$$

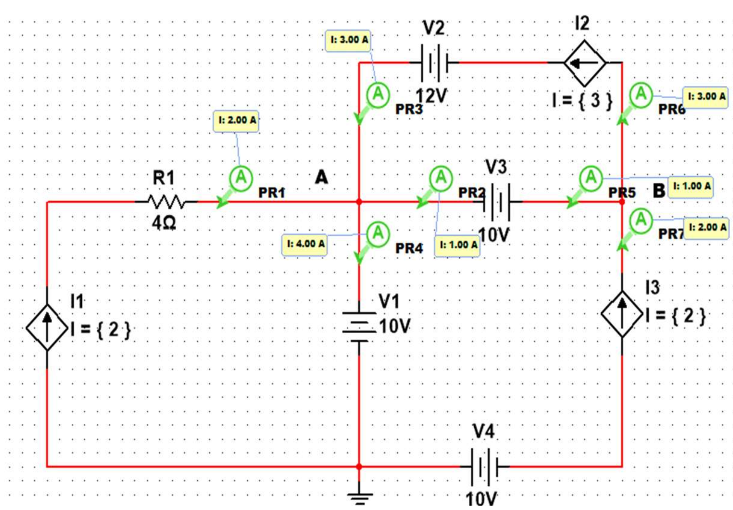
$$\Rightarrow \quad 12V = 4V + 4V + 4V$$

$$\Rightarrow \quad 12V = 12V$$

So, Kirchhoff's Voltage Law proves.

2. Measure current in each branch. Testify that for node A and B, the algebraic sum of all branch current is zero.

Circuit:



Datasheet:

Node A

I_1	I_2	I_3	I_4
2A	1A	3A	4A

Node B

I_5	I_6	I_7
1A	3A	2A

Analysis:

The current law of Kirchhoff states, the algebraic sum of incoming and outgoing current in a node of a circuit will be zero.

According to KCL, in node A, $+I_1 + I_3 - I_2 - I_4 = 0$

and in node B, $+ I_5 + I_7 - I_6 = 0$

Calculating data from the datasheet,

In node A, $+ 2 + 3 – 1 – 4 = 0$;

And in node B, $+ 1 + 2 – 3 = 0$.

From the calculation above it is evident that in node A and node B the algebraic sum of current is 0.

Remarks and Grade (by the instructor)

Instructor Signature:

Grading Date:

Electric Circuit Experiments

Basic Concept and Laws

Source Transformation and Equivalent Source Theorem

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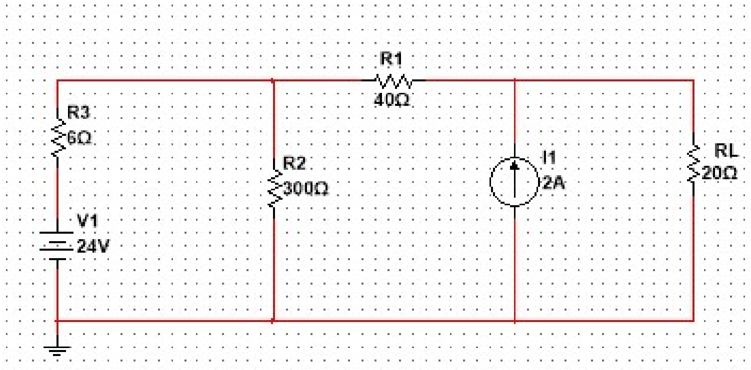
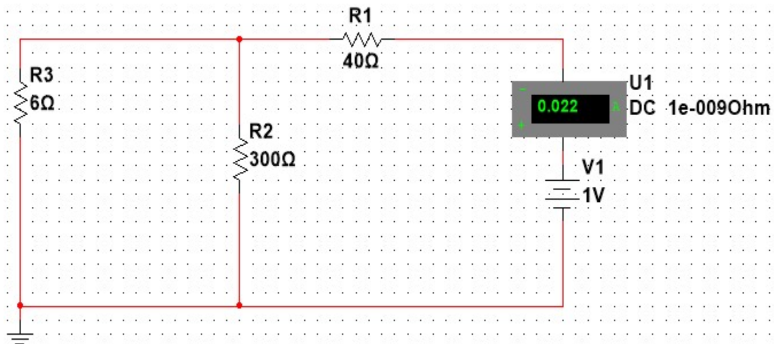
Use Thevenin's theorem to simplify this circuit, calculate the current flowing through R_L, and prove that your simplification is correct.

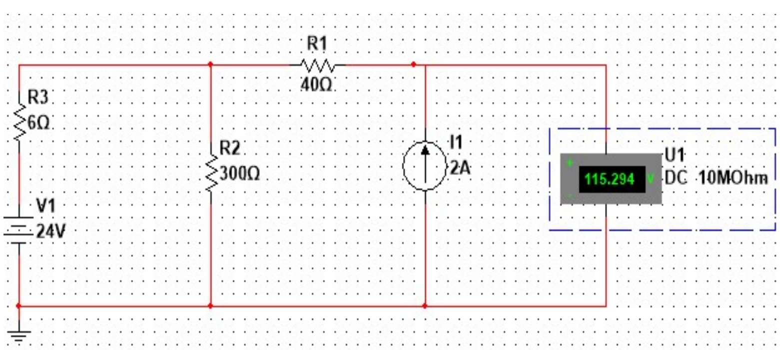


Step 1: *Measuring R_{th} by shorting the voltage source and opening the current source.*



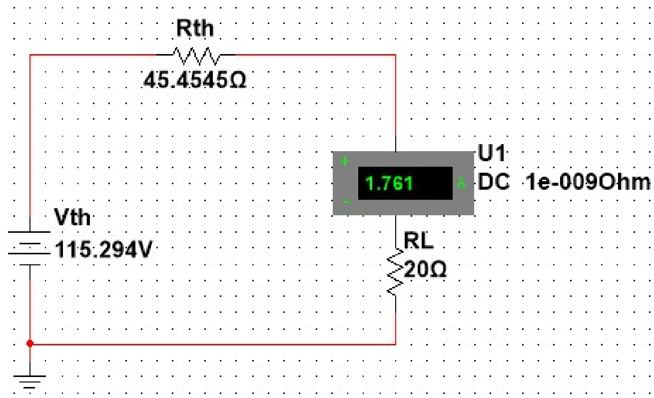
Rth= 1v/0.022A= 45.4545

Step 2: *Measure the V_{th} removing R_L.*



Vth= 115.294V

Step3: *Finding the current I_L through R_L using Thevenin's Equivalent circuit.*

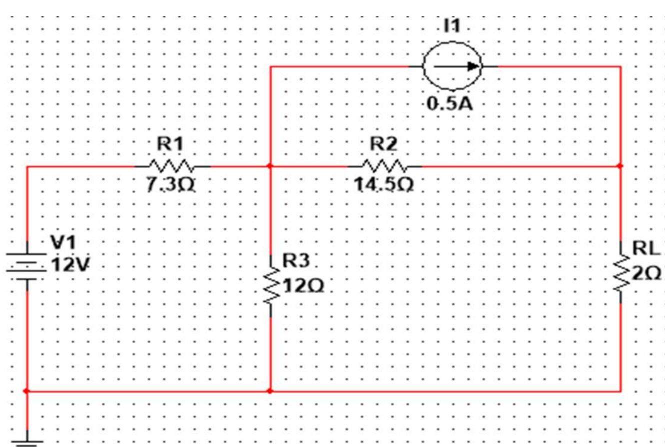


Current through load resistance, I_L= 1.761A

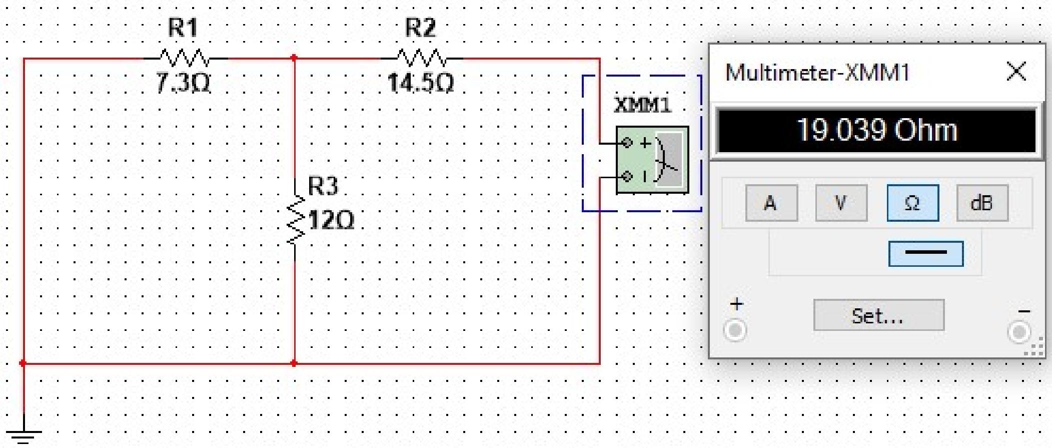
Advantages and disadvantages of open short circuit method, direct measurement method and semi-biased method

	Advantages	Disadvantages
Open short circuit method	No external source is required	doesn't work if the circuit has a dependent source
Direct measurement method	No external source is required	doesn't work if the circuit has a dependent source
Semi-biased method	semi biased method works in any condition	Requires external source

Use Norton's theorem to simplify this circuit, and calculate the current flowing through RL.

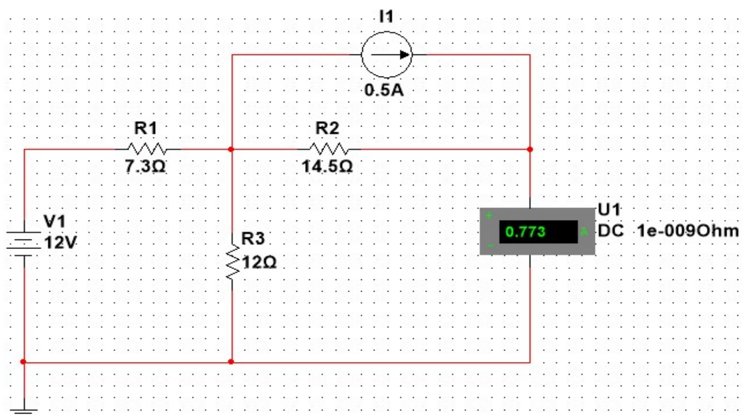


Step 1: *Measuring R_N by shorting the voltage source and opening the current source. Which is same as Thevenin's equivalent resistance.*



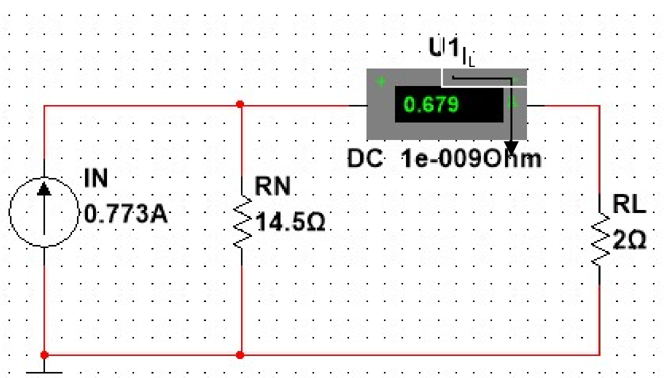
$R_N = R_{Th} = 19.039$ Ohm

Step2: *Measure short circuit current I_{sc} by removing Load resistance and shorting the terminals.*



$I_{sc} = I_N = 0.773A$

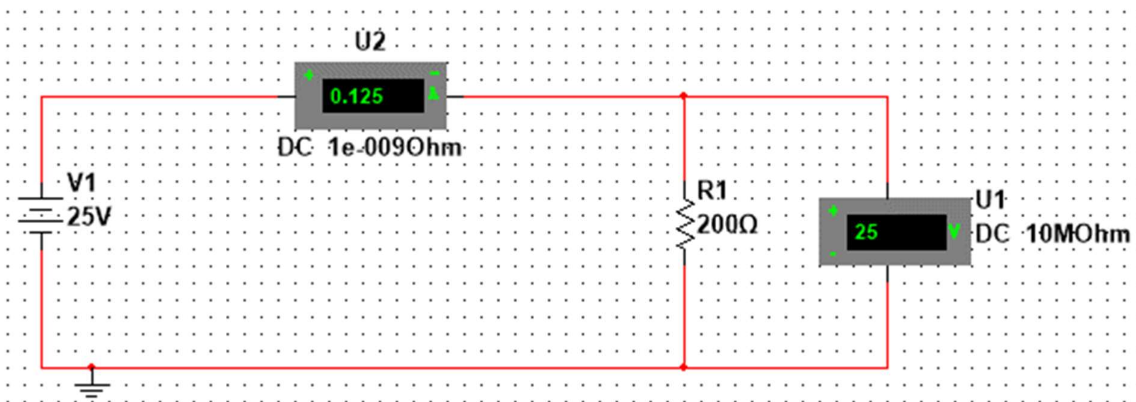
Step3: *Finding the current I_L through R_L using Norton's Equivalent circuit.*



$I_N = 0.679A$

The internal resistor of ideal voltmeter is infinity, and the internal resistor of ideal ammeter is zero. But practical voltmeter and ammeter is different. Use a practical voltmeter and ammeter to measure the voltage-current characteristic of a linear resistor R=200Ω, the internal resistance of voltmeter is 100 kΩ, and the internal resistance of ammeter is 0.2Ω. How do we connect voltmeter and ammeter so that the error is minimal? Design a circuit and give a description or explanation.

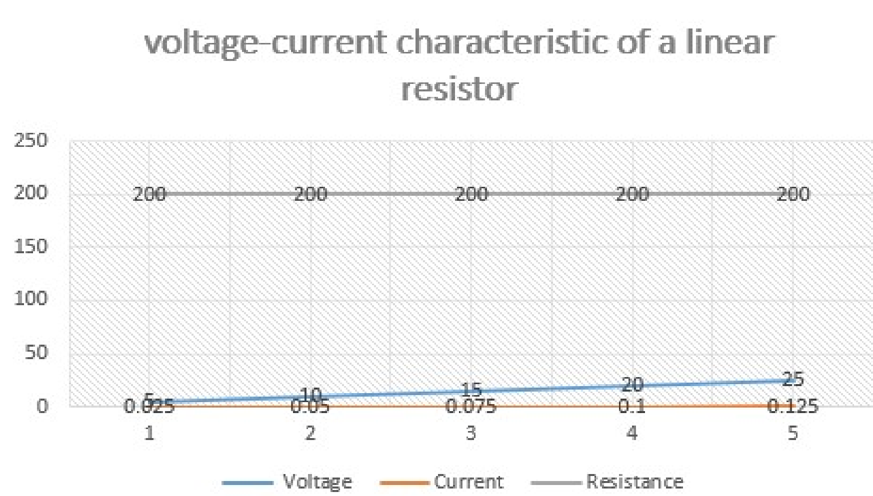
Circuit:



Datasheet:

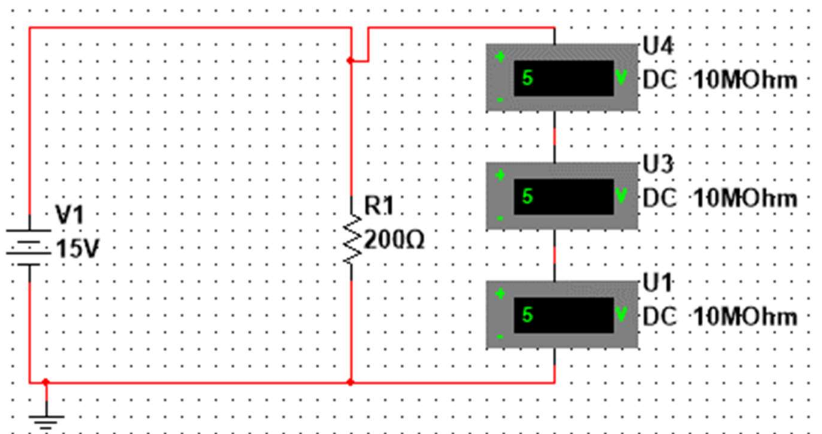
Voltage	5V	10V	15V	20V	25V
Current	0.025A	0.05A	0.075A	0.1A	0.125
Resistance	200Ω	200Ω	200Ω	200Ω	200Ω

Graph:



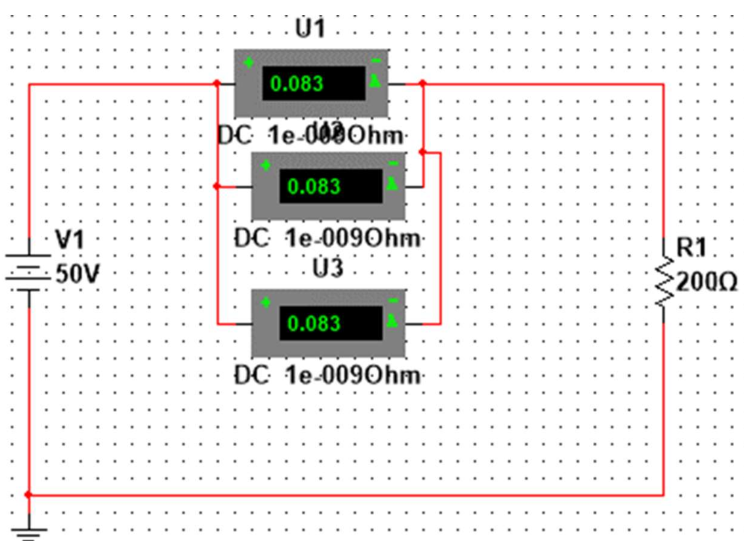
Possible solution to reduce the error of a voltmeter and an ammeter:

The resistance of an ideal voltmeter is near to infinity. If we increase the resistance of a non-ideal voltmeter by putting more non-ideal voltmeter in series, we will be able to reduce the error as less current will leak through the voltmeter. The proposed circuit is shown below.



Here the voltage across the 200-ohm resistor can be measured by summing up the measured data of three voltmeters.

For the ammeter, we know that the internal resistance of an ideal ammeter is 0. So, if we apply the same strategy like before, but instead of putting them in series we need to put the ammeters in parallel to reduce the resistance. In this way, we can keep the errors minimal. The proposed circuit is shown below.



Here, the current flowing through the circuit can be measured be summing up the three ammeters reading.

Remarks and Grade (by the instructor)

Instructor Signature:
Grading Date:

Electric Circuit Experiments

Basic Concept and Laws

Homogeneity Theorem and Superposition Theorem

Vital information,

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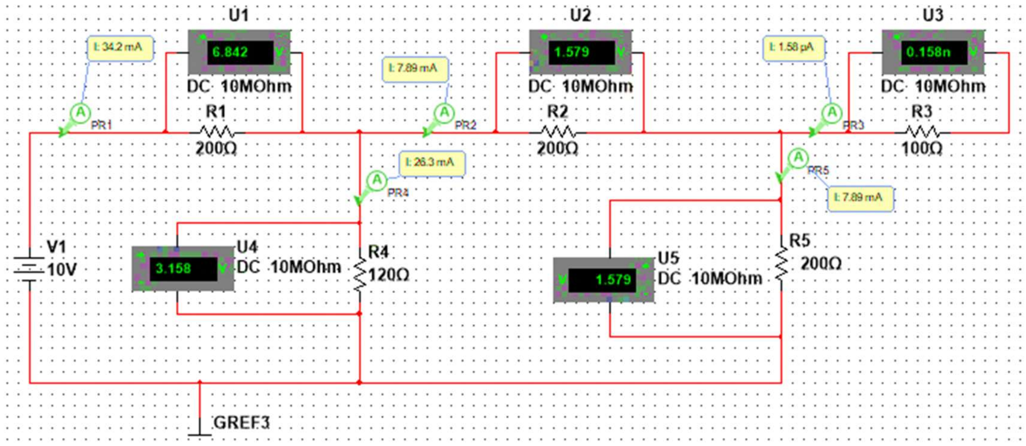
1. **Fill in the blanks of Table 1 in our class (you can find it from replay), and analyze data from the perspective of homogeneity theorem and superposition theorem.**

1



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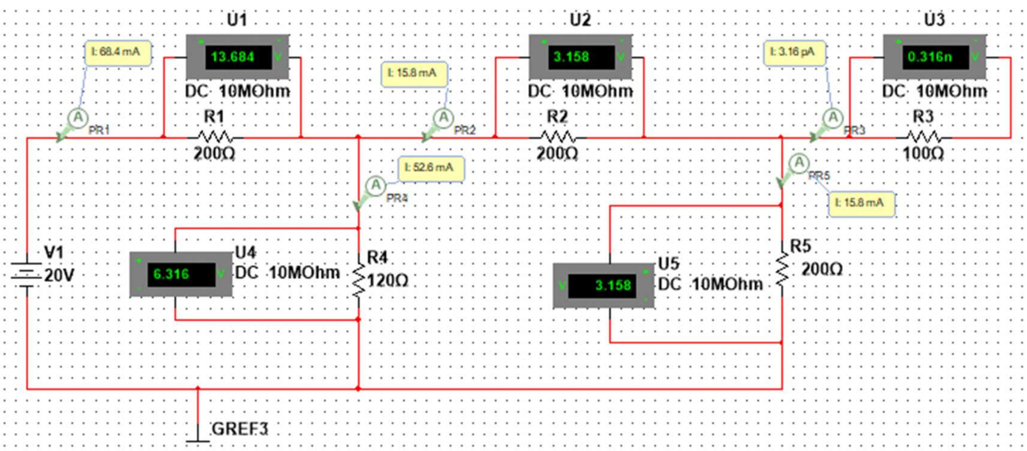
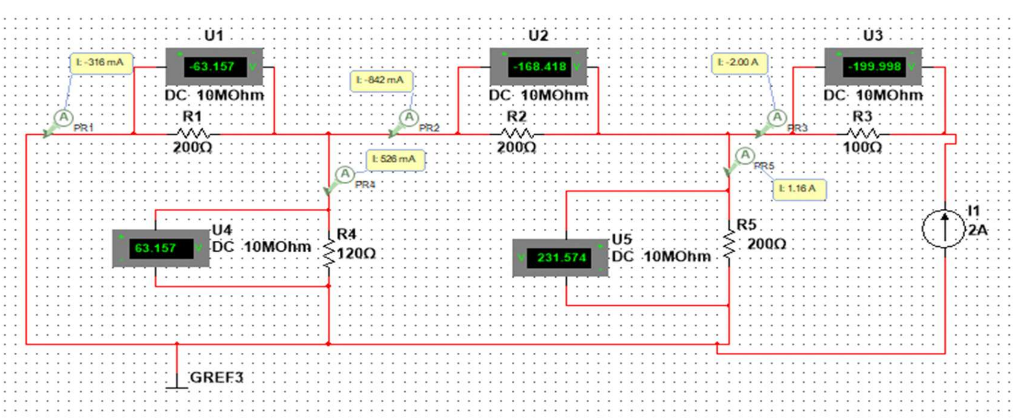
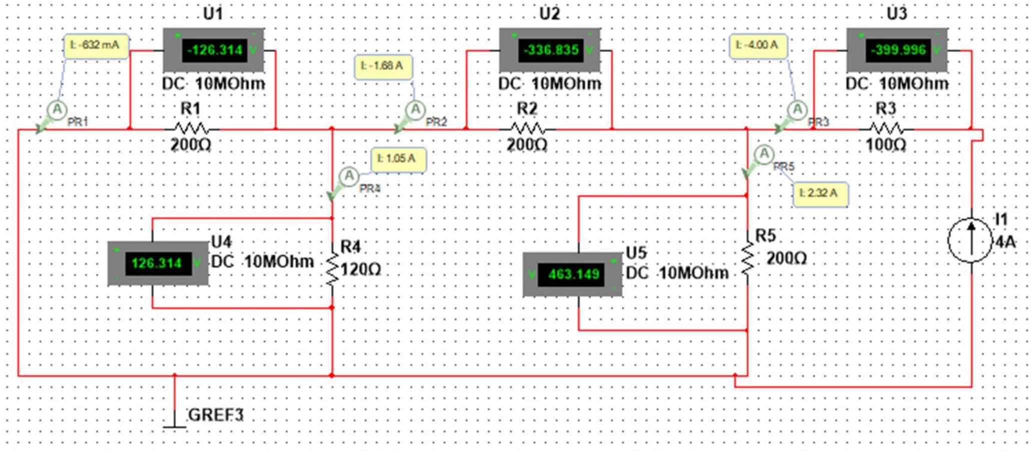


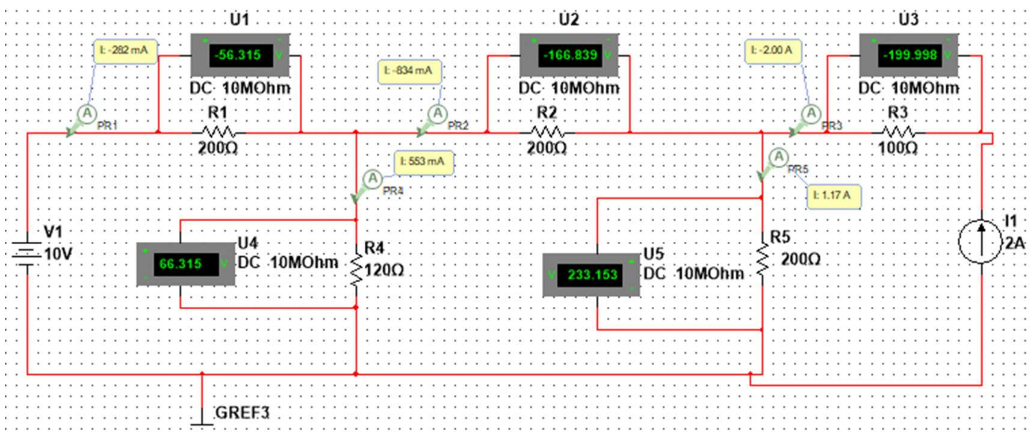
3



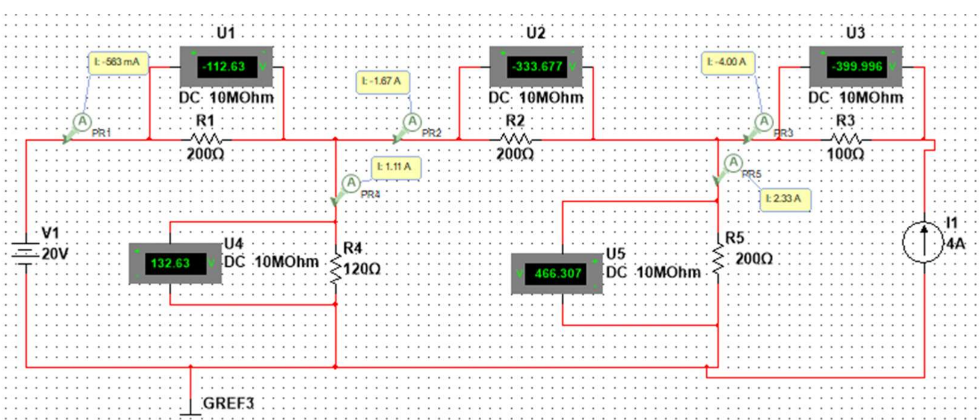
4

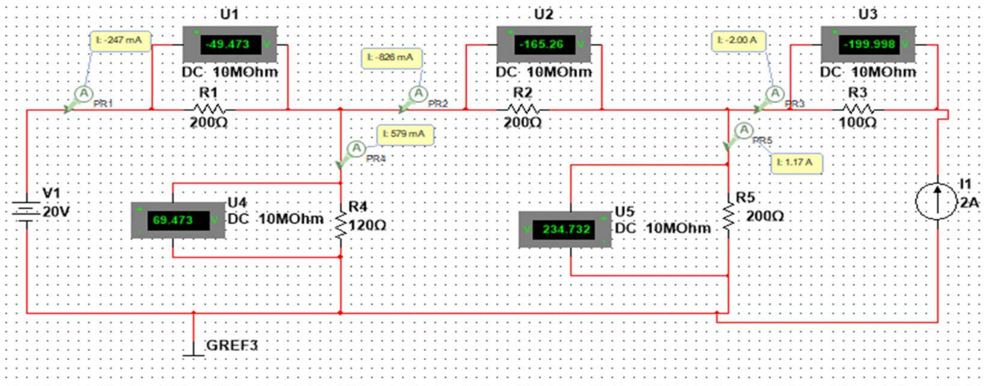

U1
-126.314 V
DC 10MOhm
U2
-336.835 V
DC 10MOhm
U3
-399.996 V
DC 10MOhm
I: -632 mA
PR1
I: -1.68 A
PR2
I: -4.00 A
PR3
I: 1.05 A
PR4
PR5
I: 2.32 A
R1
200Ω
R2
200Ω
R3
100Ω
U4
126.314 V
DC 10MOhm
R4
120Ω
U5
463.149 V
DC 10MOhm
R5
200Ω
I1
4A
GREF3

5


U1
-56.315 V
DC 10MOhm
U2
-166.839 V
DC 10MOhm
U3
-199.998 V
DC 10MOhm
I: -282 mA
PR1
I: -834 mA
PR2
I: -2.00 A
PR3
I: 553 mA
PR4
PR5
I: 1.17 A
R1
200Ω
R2
200Ω
R3
100Ω
V1
10V
U4
66.315 V
DC 10MOhm
R4
120Ω
U5
233.153 V
DC 10MOhm
R5
200Ω
I1
2A
GREF3

6


U1
-112.63 V
DC 10MOhm
U2
-333.677 V
DC 10MOhm
U3
-399.996 V
DC 10MOhm
I: -563 mA
PR1
I: -1.67 A
PR2
I: -4.00 A
PR3
I: 1.11 A
PR4
PR5
I: 2.33 A
R1
200Ω
R2
200Ω
R3
100Ω
V1
20V
U4
132.63 V
DC 10MOhm
R4
120Ω
U5
466.307 V
DC 10MOhm
R5
200Ω
I1
4A
GREF3



Us1	Is1	I1	I2	I3	I4	I5	UR1	UR2	UR3	UR4	UR5
10	0	34.2	7.89	7.89	26.3	7.89	6.842	1.579	0	3.158	1.579
20	0	68.4	15.8	15.8	52.6	15.8	13.684	3.158	0	6.316	3.158
0	2	-316	-842	-2	526	1.16	-63.157	-168.418	-199.998	63.157	231.574
0	4	-632	-1.68	-4	1.05	2.32	-126.314	-336.835	-399.996	126.314	463.149
10	2	-282	-834	-2	553	1.17	-56.315	-166.839	-199.998	66.315	233.153
20	4	-583	-1.67	-4	1.11	2.33	-112.63	-333.677	-399.996	132.63	466.307
20	2	-247	-826	-2	579	1.17	-49.473	-165.26	-199.998	69.473	234.732

From the above data, it is quite evident that when we change the voltage and the current source altogether, the homogeneity theorem holds true. But when we only change the voltage source or the current source the homogeneity theorem doesn't hold true. So, in conclusion, if we want to satisfy the homogeneity theorem, we need to change both sources, not just only one source.

2. Under what condition does superposition theorem not hold true?

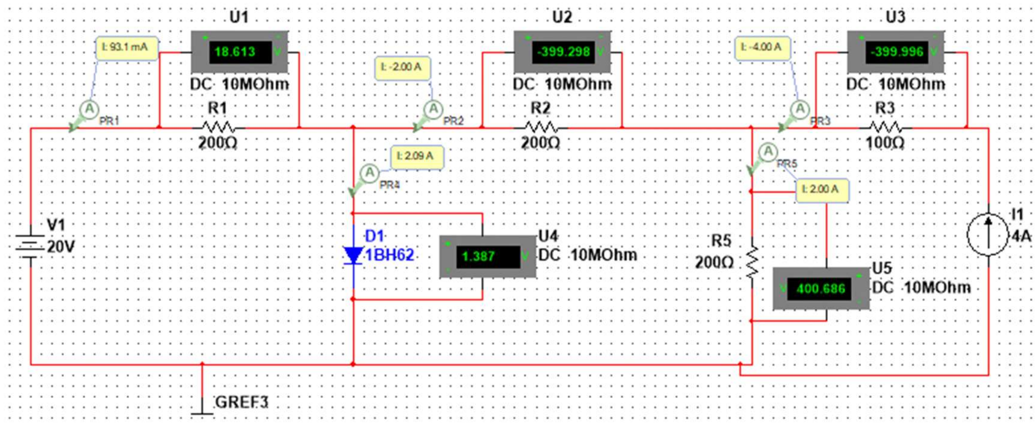
Design an experiment to testify your conclusion.

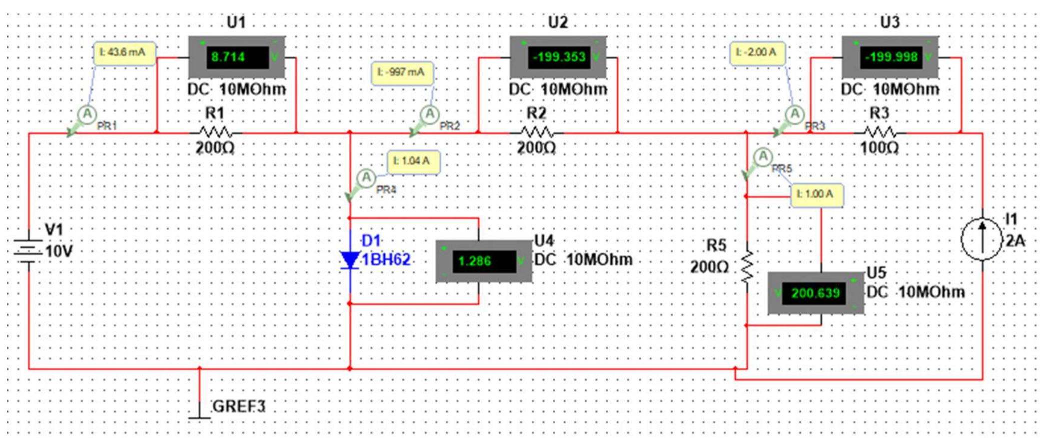
Note: there are two possibilities

1) **we need to change element**
2) **we don't need to change element but there may be some other problems with the circuit.**

Note: There are two possibilities

Superposition theorem only works in linear circuits. Superposition theorem would not work in nonlinear circuits. Here we have used a diode which is a nonlinear element. From the circuits below we can see If we double the value of the voltage and the current source from 10V and 2A respectively to 20V and 4A, the voltage across the R1 and the diode changes. But no relationship can be found which satisfies the linearity of the circuit.





Remarks and Grade (by the instructor)

Instructor Signature:

Grading Date:

Electric Circuit Experiments

Basic Concept and Laws

Power Factor Improvement

Vital information,

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Improve the power factor of fluorescent lamp

1)Design a circuit to improve power factor of fluorescent lamp, finish the simulation.

2)Fill in the table.

3)Draw the curve I = f(c), analyze it and give a conclusion.

4) Verify and explain the effectiveness of your method.

A circuit to improve power factor of a fluorescent lamp

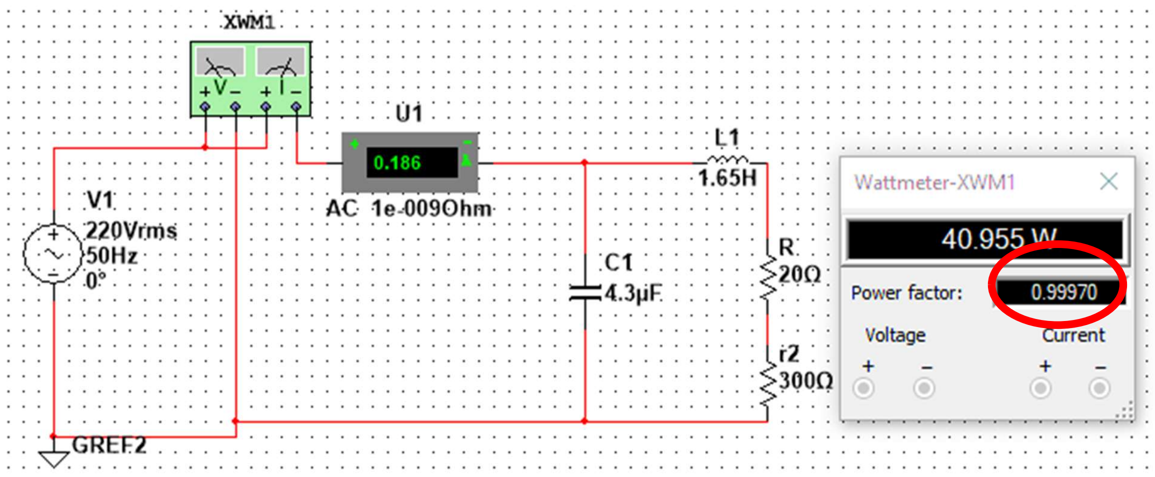
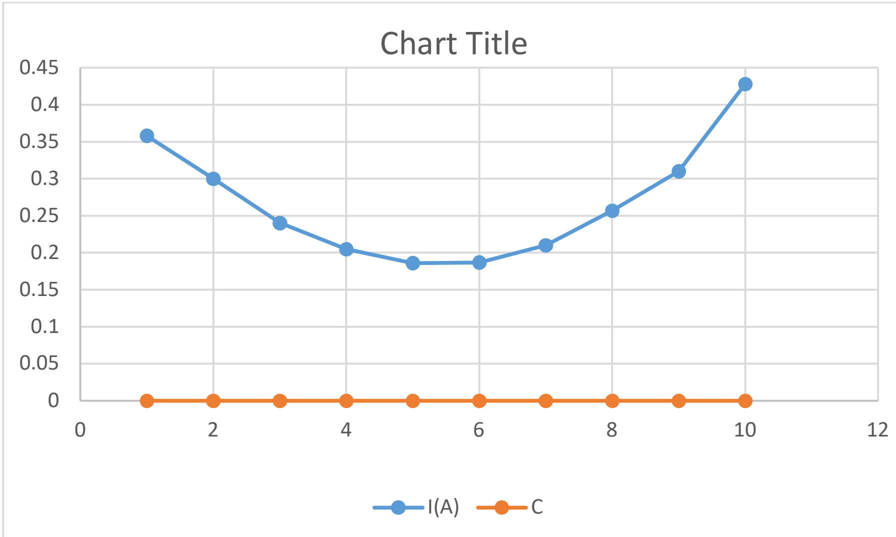


Table:

C	U(V)	I(A)	P (W)	Cos Φ
0	220	0.358	40.951	0.520
1 µF	220	0.3	40.956	0.620
2.2 µF	220	0.24	40.952	0.775
3.2 µF	220	0.205	40.953	0.916
4.3 µF	220	0.186	40.955	0.999
4.6 µF	220	0.187	40.956	0.996
5.7 µF	220	0.21	41.036	0.893
6.9 µF	220	0.257	40.948	0.723
7.9 µF	220	0.31	40.961	0.600
9.87µF	220	0.428	40.958	0.434

The curve I = f(c):



Analysis:

From the chart above it is quite evident that the current flow of the circuit reduces as the capacitance increases. After a certain point the current rises again.
It is because at the beginning, the power factor was lagging as there was no capacitor; only the inductor and resistors were connected. The circuit started to take less current as we increase the capacitance which decreased the power factor to nearly unity. After a certain point the current flow started to rise again as the capacitor connected to the circuit was more than enough to made the power factor unity which made the power factor leading; thus, increased the current flow of the circuit again.

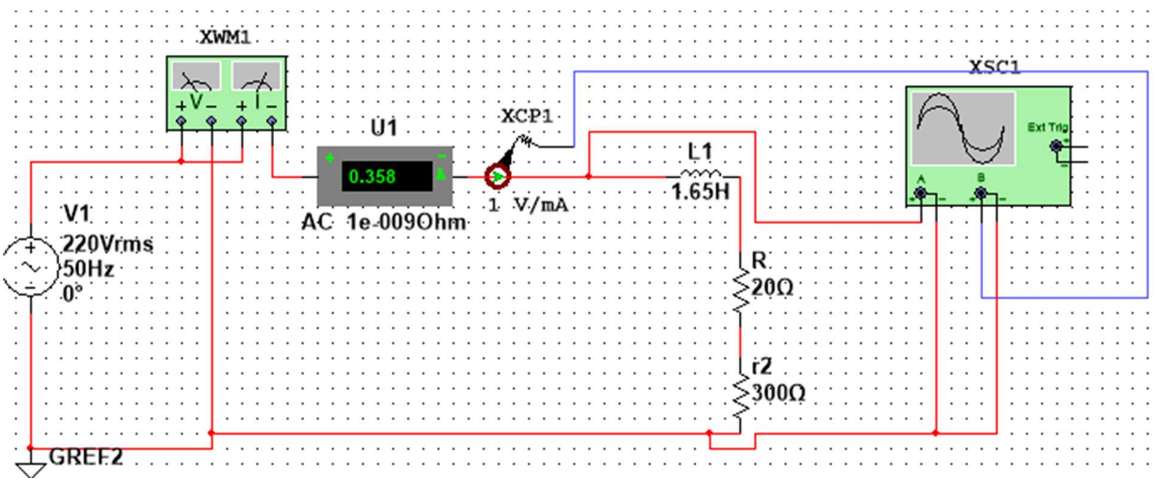
The effectiveness of my method:

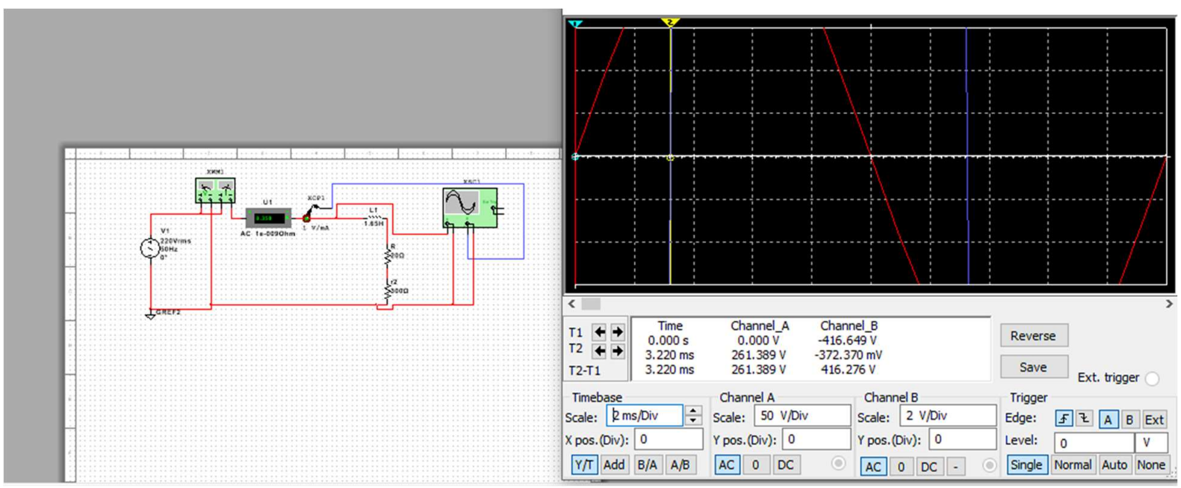
The goal is to make the power factor of the circuit unity or close to unity. When we used an inductor of the fluorescent lamp, it made the power factor lagging (0.520). From the reading of the oscilloscope, it is seen that the angle between voltage and current is 58.66°.

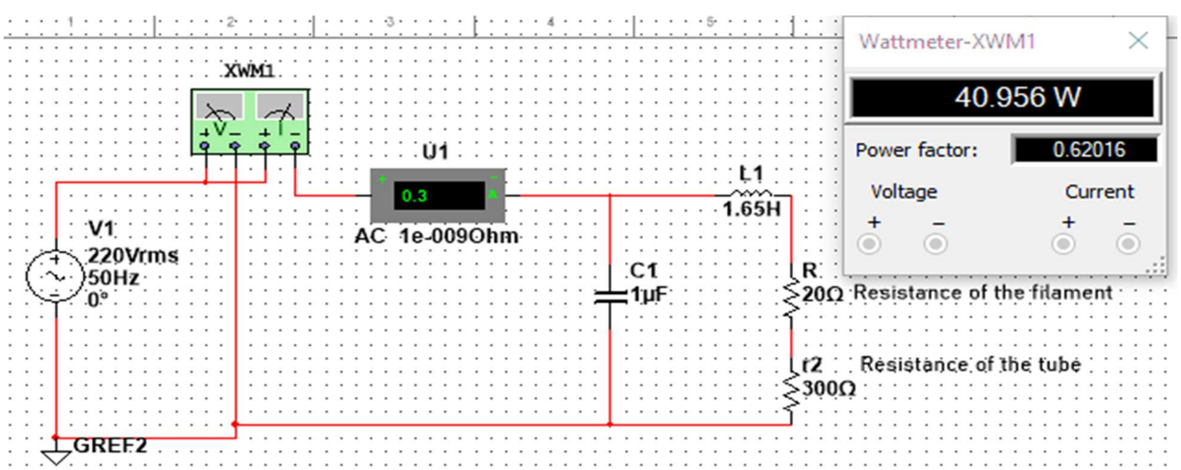
To improve the power factor of the circuit, a capacitor is used in parallel to the inductor and filament lamp (which in this case a resistor). The best value of the capacitor (4.3 µF) to make the circuit nearly unity is taken from the chart above. From the wattmeter reading, it is clear that the power factor is nearly 1. From the reading of the oscilloscope, it also clarifies that the angle between the voltage and current is indeed nearly zero (2.56°). So, attaching a 4.3µF capacitor improved the power factor of the fluorescent lamp to nearly 1.

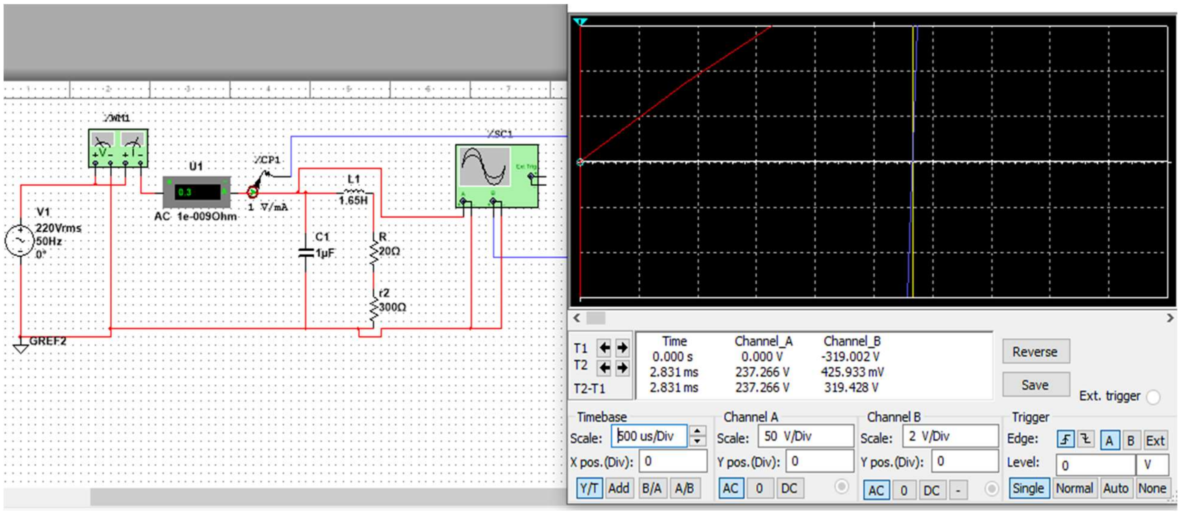
Appendix:

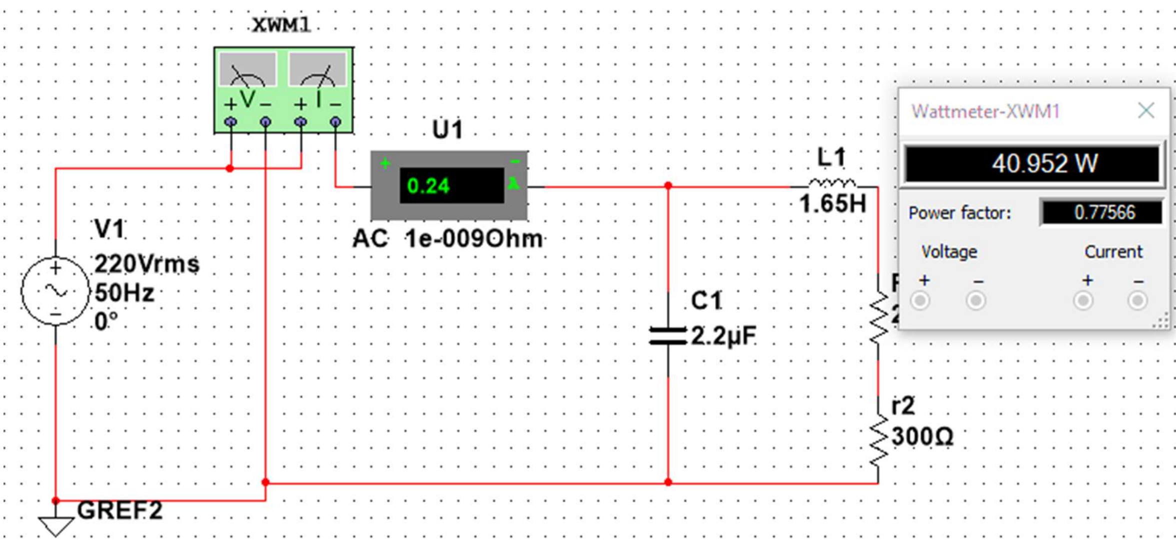
Simulation Pictures:

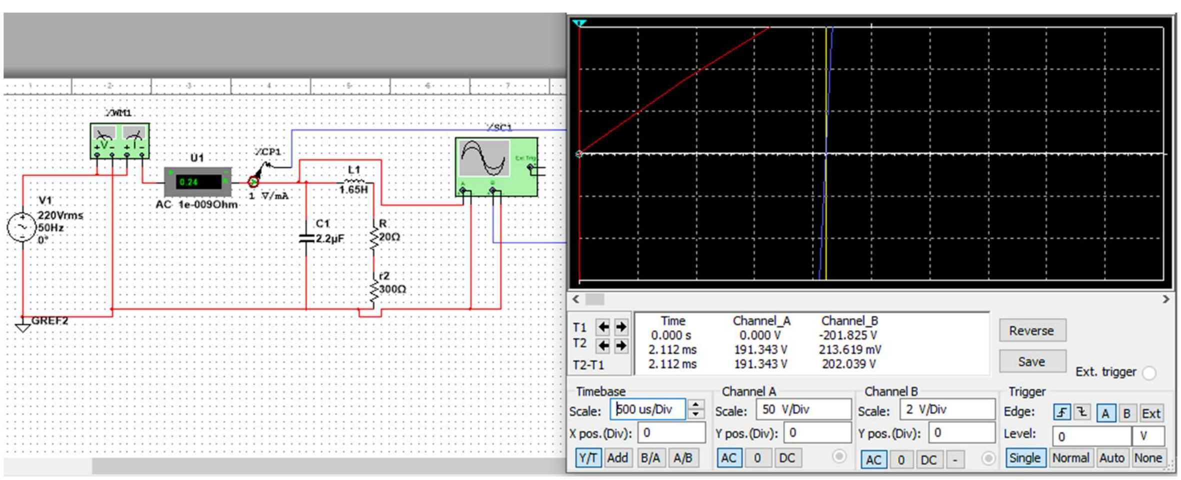


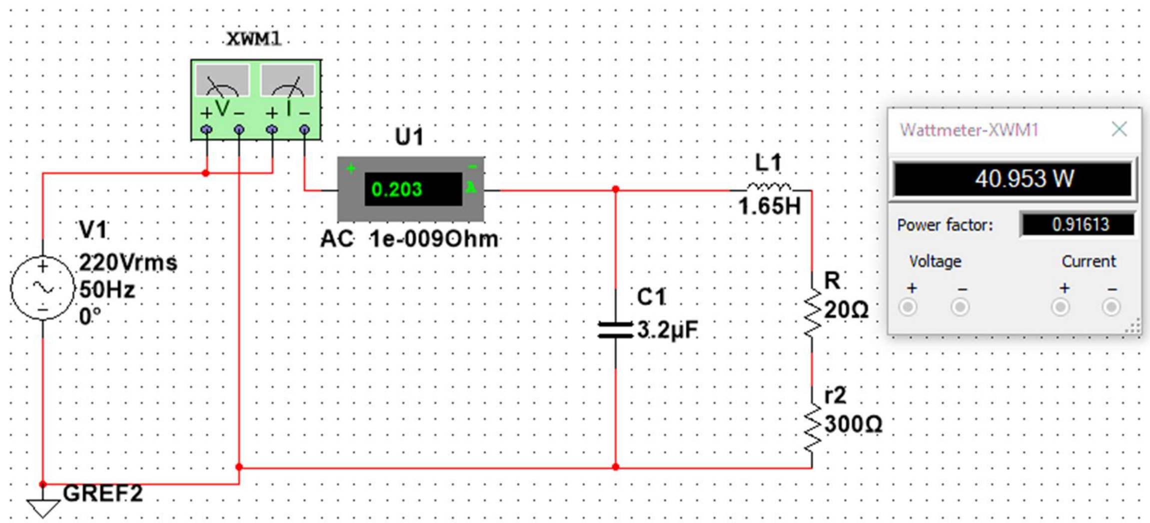


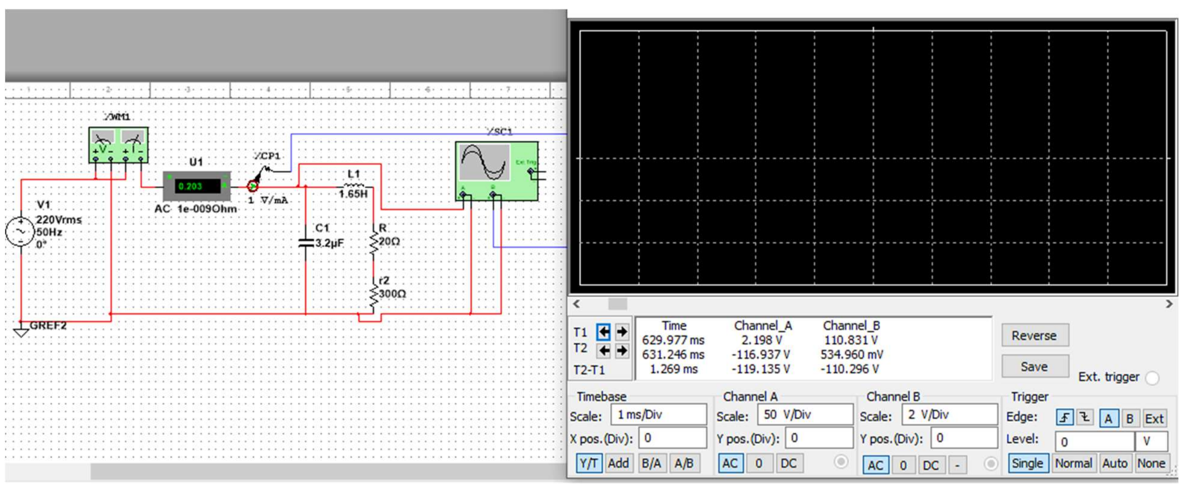


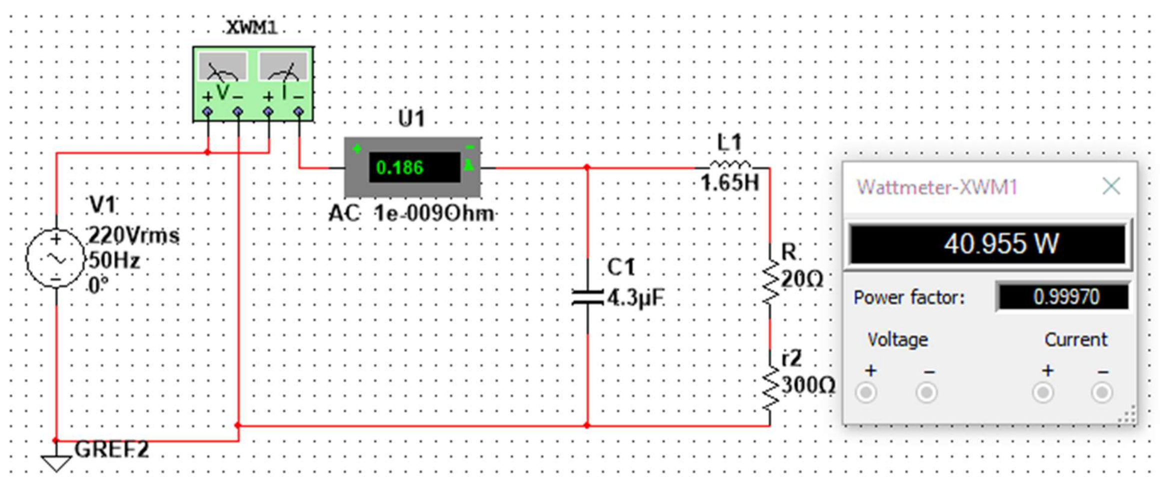

XWM1
U1
0.3
AC 1e-009Ohm
XCP1
1 V/mA
L1
1.65H
XSC1
V1
220Vrms
50Hz
0°
C1
1µF
R
20Ω
r2
300Ω
GREF2
Time
Channel_A
Channel_B
T1
0.000 s
0.000 V
-319.002 V
T2
2.831 ms
237.266 V
425.933 mV
T2-T1
2.831 ms
237.266 V
319.428 V
Reverse
Save
Ext. trigger
Timebase
Scale: 500 us/Div
X pos.(Div): 0
Channel A
Scale: 50 V/Div
Y pos.(Div): 0
Channel B
Scale: 2 V/Div
Y pos.(Div): 0
Trigger
Edge:
Level: 0 V
Y/T Add B/A A/B
AC 0 DC
AC 0 DC -
Single Normal Auto None

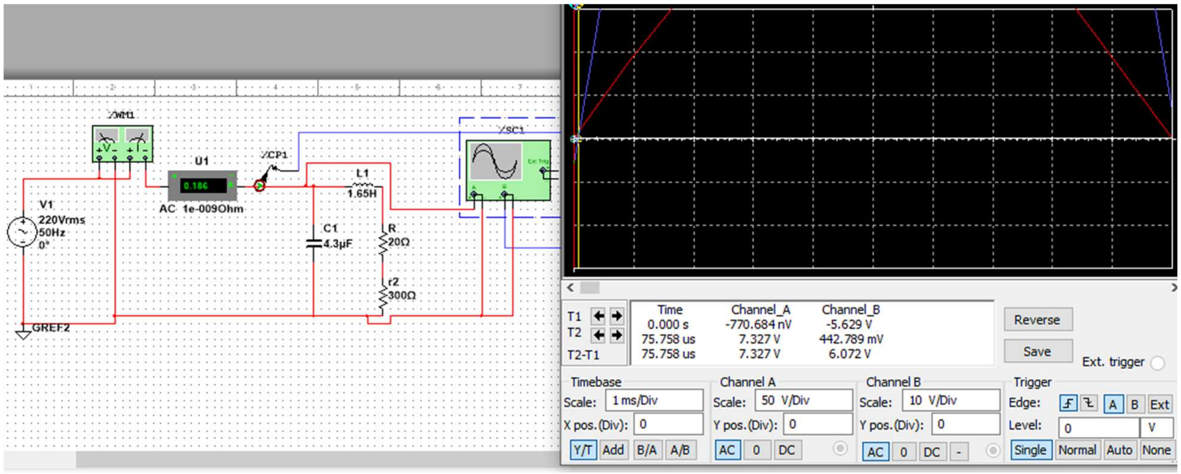

XWM1
+V−
+I−
U1
0.24
AC 1e-009Ohm
L1
1.65H
V1
220Vrms
50Hz
0°
C1
2.2µF
r2
300Ω
GREF2
Wattmeter-XWM1
40.952 W
Power factor:
0.77566
Voltage
Current
+
−
+
−

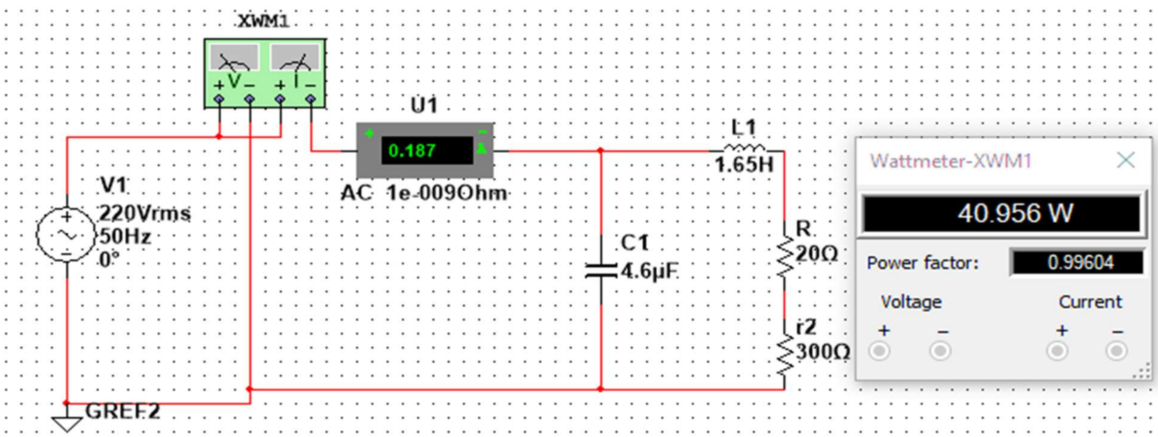

XWM1
U1
0.24
AC 1e-009Ohm
XCP1
1 V/mA
L1
1.65H
XSC1
V1
220Vrms
50Hz
0°
C1
2.2µF
R
20Ω
r2
300Ω
GREF2
Time
Channel_A
Channel_B
T1
0.000 s
0.000 V
-201.825 V
T2
2.112 ms
191.343 V
213.619 mV
T2-T1
2.112 ms
191.343 V
202.039 V
Reverse
Save
Ext. trigger
Timebase
Scale: 500 us/Div
X pos.(Div): 0
Channel A
Scale: 50 V/Div
Y pos.(Div): 0
Channel B
Scale: 2 V/Div
Y pos.(Div): 0
Trigger
Edge:
Level: 0 V
Y/T Add B/A A/B
AC 0 DC
AC 0 DC -
Single Normal Auto None

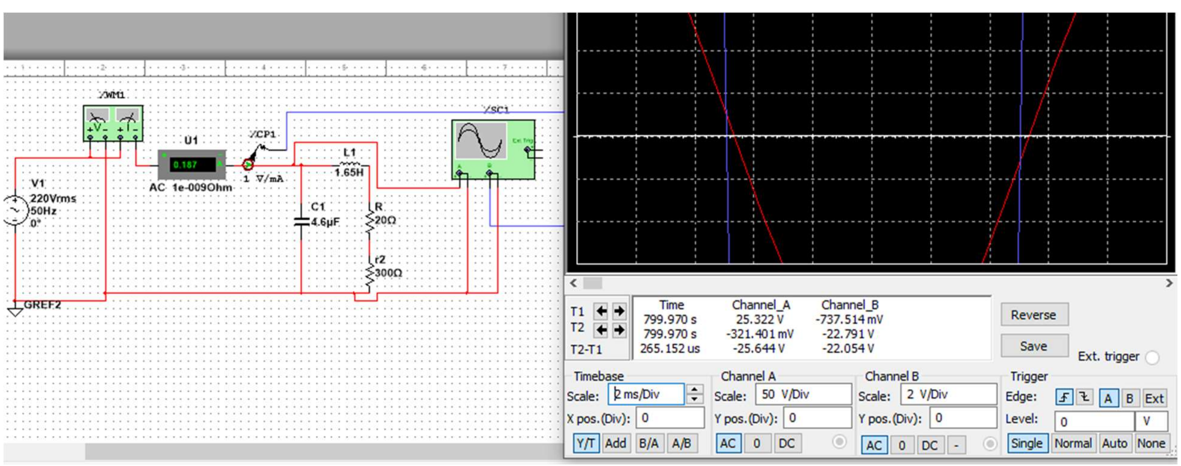

XWM1
U1
0.203
AC 1e-009Ohm
L1
1.65H
V1
220Vrms
50Hz
0°
C1
3.2µF
R
20Ω
r2
300Ω
GREF2
Wattmeter-XWM1
40.953 W
Power factor:
0.91613
Voltage
Current

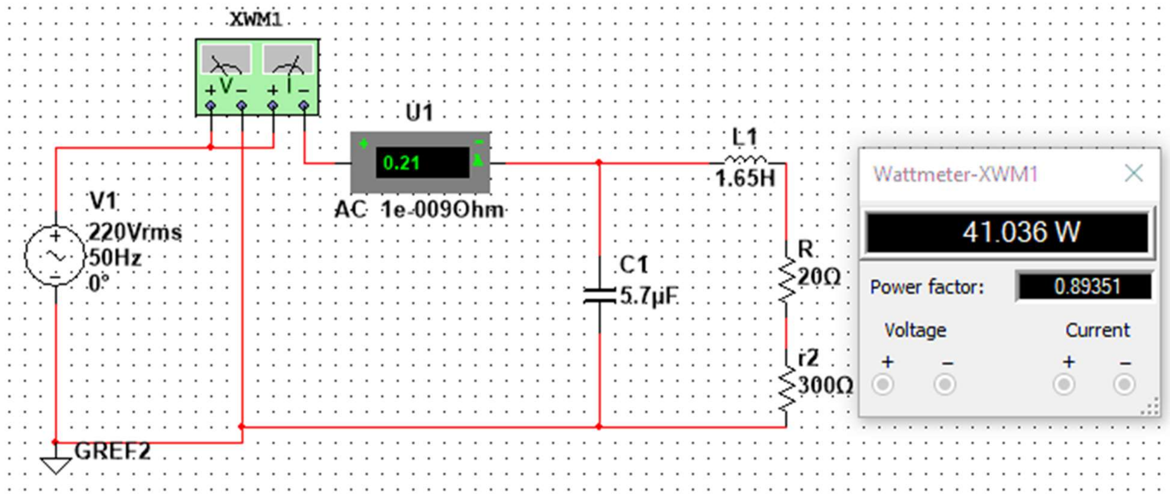

Time
Channel_A
Channel_B
T1
629.977 ms
2.198 V
110.831 V
T2
631.246 ms
-116.937 V
534.960 mV
T2-T1
1.269 ms
-119.135 V
-110.296 V
Reverse
Save
Ext. trigger
Timebase
Scale: 1 ms/Div
X pos.(Div): 0
Y/T Add B/A A/B
Channel A
Scale: 50 V/Div
Y pos.(Div): 0
AC 0 DC
Channel B
Scale: 2 V/Div
Y pos.(Div): 0
AC 0 DC -
Trigger
Edge:
A B Ext
Level: 0 V
Single Normal Auto None

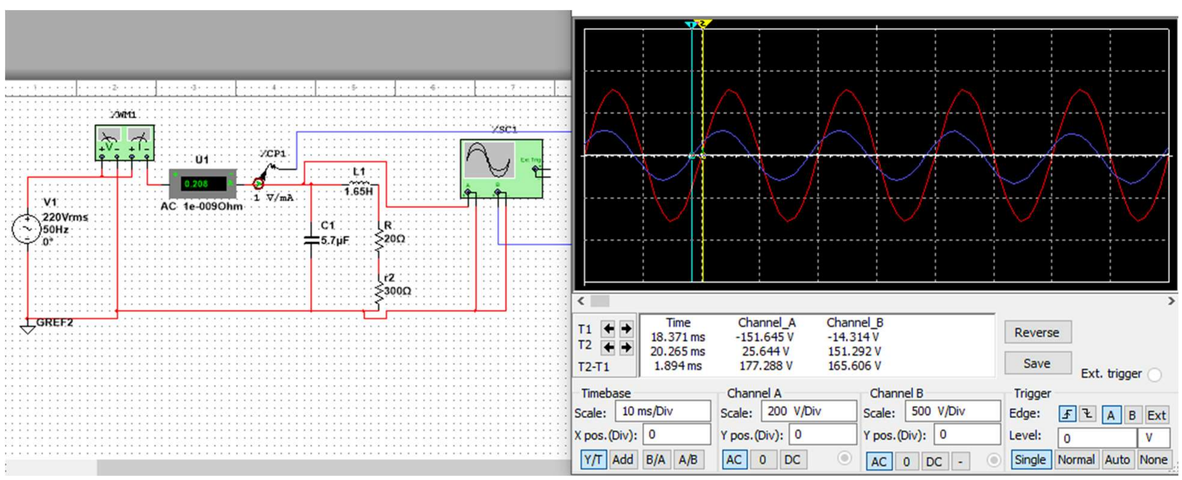

XWM1
U1
0.186
AC 1e-009Ohm
L1
1.65H
V1
220Vrms
50Hz
0°
C1
4.3µF
R
20Ω
r2
300Ω
GREF2
Wattmeter-XWM1
40.955 W
Power factor:
0.99970
Voltage
Current

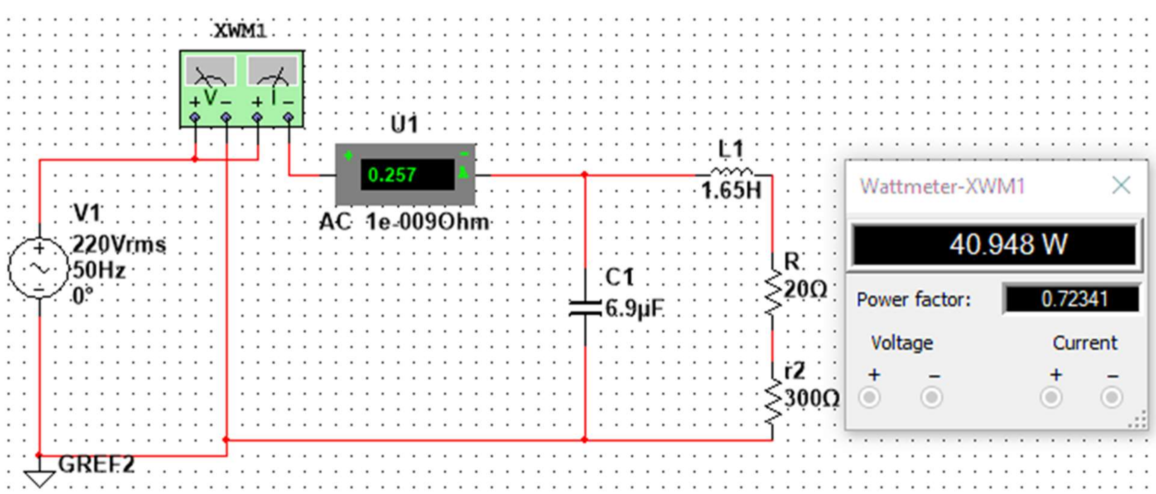

XWM1
U1
0.186
AC 1e-009Ohm
XCP1
L1
1.65H
V1
220Vrms
50Hz
0°
C1
4.3µF
R
20Ω
r2
300Ω
GREF2
XSC1
Time
Channel_A
Channel_B
T1
0.000 s
-770.684 nV
-5.629 V
T2
75.758 us
7.327 V
442.789 mV
T2-T1
75.758 us
7.327 V
6.072 V
Reverse
Save
Ext. trigger
Timebase
Scale: 1 ms/Div
X pos.(Div): 0
Y/T Add B/A A/B
Channel A
Scale: 50 V/Div
Y pos.(Div): 0
AC 0 DC
Channel B
Scale: 10 V/Div
Y pos.(Div): 0
AC 0 DC -
Trigger
Edge:
A B Ext
Level: 0 V
Single Normal Auto None

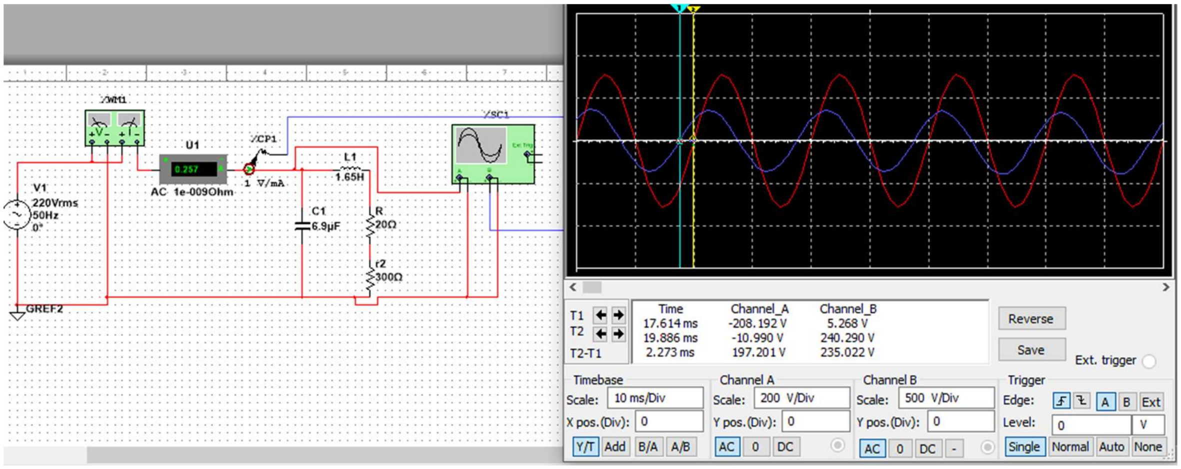

XWM1
U1
0.187
AC 1e-009Ohm
L1
1.65H
V1
220Vrms
50Hz
0°
C1
4.6µF
R
20Ω
r2
300Ω
GREF2
Wattmeter-XWM1
40.956 W
Power factor:
0.99604
Voltage
Current


XWM1
U1
0.187
AC 1e-009Ohm
XCP1
1 V/mA
L1
1.65H
V1
220Vrms
50Hz
0°
C1
4.6µF
R
20Ω
r2
300Ω
GREF2
XSC1
Time
Channel_A
Channel_B
T1
799.970 s
25.322 V
-737.514 mV
T2
799.970 s
-321.401 mV
-22.791 V
T2-T1
265.152 us
-25.644 V
-22.054 V
Reverse
Save
Ext. trigger
Timebase
Scale: 2 ms/Div
X pos.(Div): 0
Y/T Add B/A A/B
Channel A
Scale: 50 V/Div
Y pos.(Div): 0
AC 0 DC
Channel B
Scale: 2 V/Div
Y pos.(Div): 0
AC 0 DC -
Trigger
Edge:
A B Ext
Level: 0 V
Single Normal Auto None

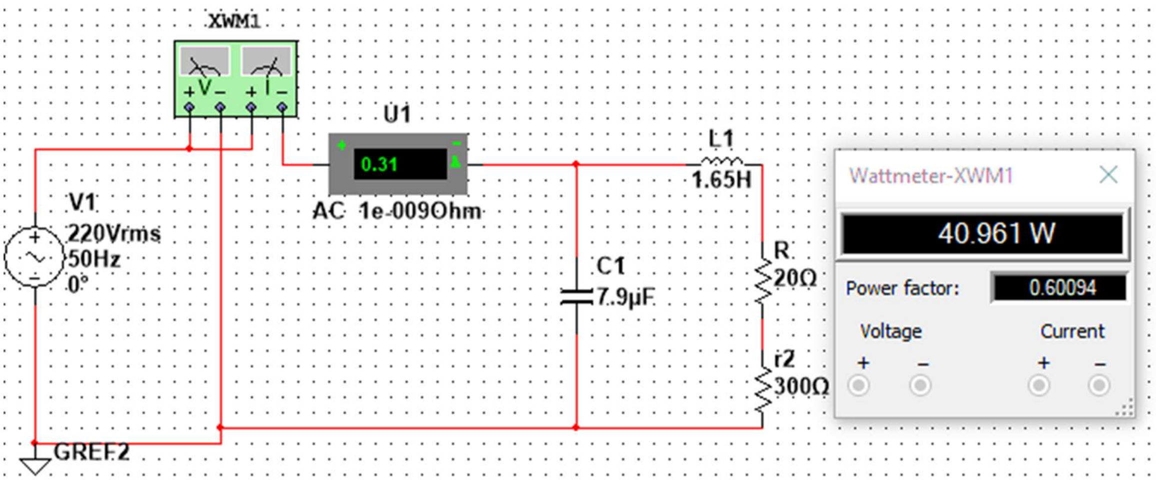

XWM1
U1
0.21
AC 1e-009Ohm
L1
1.65H
V1
220Vrms
50Hz
0°
C1
5.7µF
R
20Ω
r2
300Ω
GREF2
Wattmeter-XWM1
41.036 W
Power factor:
0.89351
Voltage
Current
+
–
+
–


XWM1
U1
0.208
AC 1e-009Ohm
XCP1
1 V/mA
L1
1.65H
XSC1
V1
220Vrms
50Hz
0°
C1
5.7µF
R
20Ω
r2
300Ω
GREF2
Time
Channel_A
Channel_B
T1
18.371 ms
-151.645 V
-14.314 V
T2
20.265 ms
25.644 V
151.292 V
T2-T1
1.894 ms
177.288 V
165.606 V
Reverse
Save
Ext. trigger
Timebase
Scale:
10 ms/Div
X pos.(Div):
0
Y/T
Add
B/A
A/B
Channel A
Scale:
200 V/Div
Y pos.(Div):
0
AC
0
DC
Channel B
Scale:
500 V/Div
Y pos.(Div):
0
AC
0
DC
-
Trigger
Edge:
A
B
Ext
Level:
0
V
Single
Normal
Auto
None

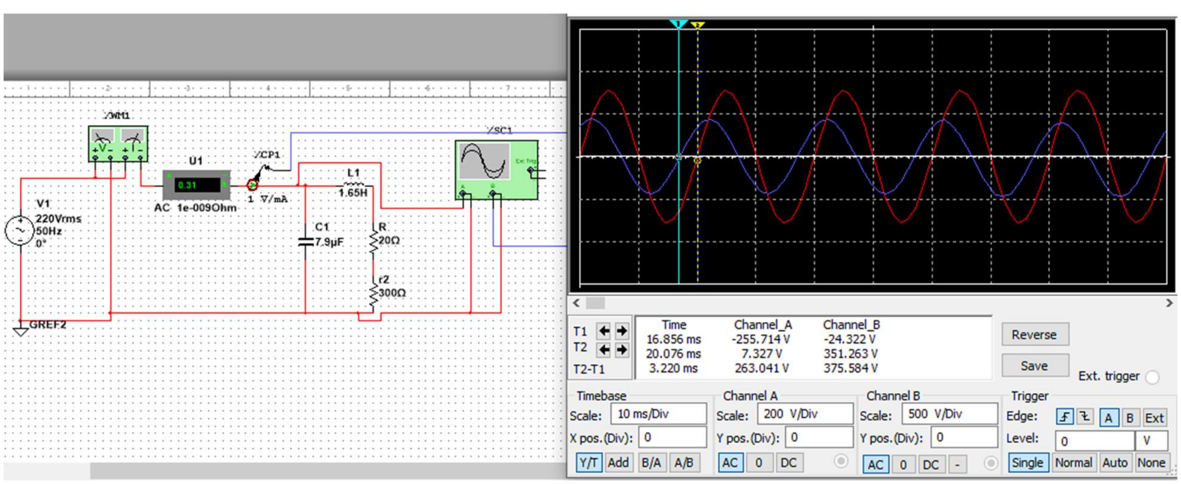

XWM1
U1
0.257
AC 1e-009Ohm
L1
1.65H
V1
220Vrms
50Hz
0°
C1
6.9µF
R
20Ω
r2
300Ω
GREF2
Wattmeter-XWM1
40.948 W
Power factor:
0.72341
Voltage
Current
+
–
+
–



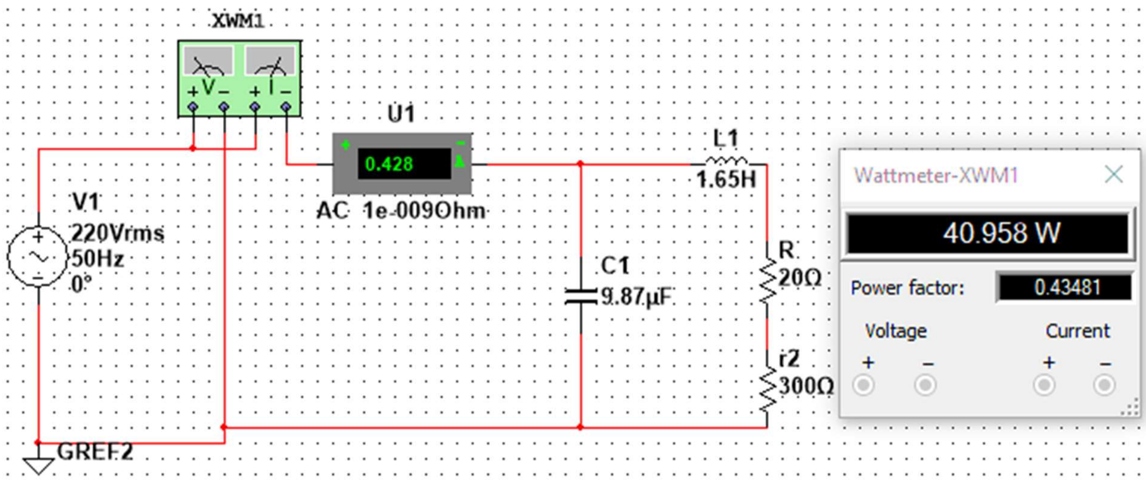
XWM1
U1
0.257
AC 1e-009Ohm
XCP1
1 V/mA
L1
1.65H
XSC1
V1
220Vrms
50Hz
0°
C1
6.9µF
R
20Ω
r2
300Ω
GREF2
T1
T2
T2-T1
Time
Channel_A
Channel_B
17.614 ms
-208.192 V
5.268 V
19.886 ms
-10.990 V
240.290 V
2.273 ms
197.201 V
235.022 V
Reverse
Save
Ext. trigger
Timebase
Scale: 10 ms/Div
X pos.(Div): 0
Y/T Add B/A A/B
Channel A
Scale: 200 V/Div
Y pos.(Div): 0
AC 0 DC
Channel B
Scale: 500 V/Div
Y pos.(Div): 0
AC 0 DC -
Trigger
Edge:
A B Ext
Level: 0 V
Single Normal Auto None

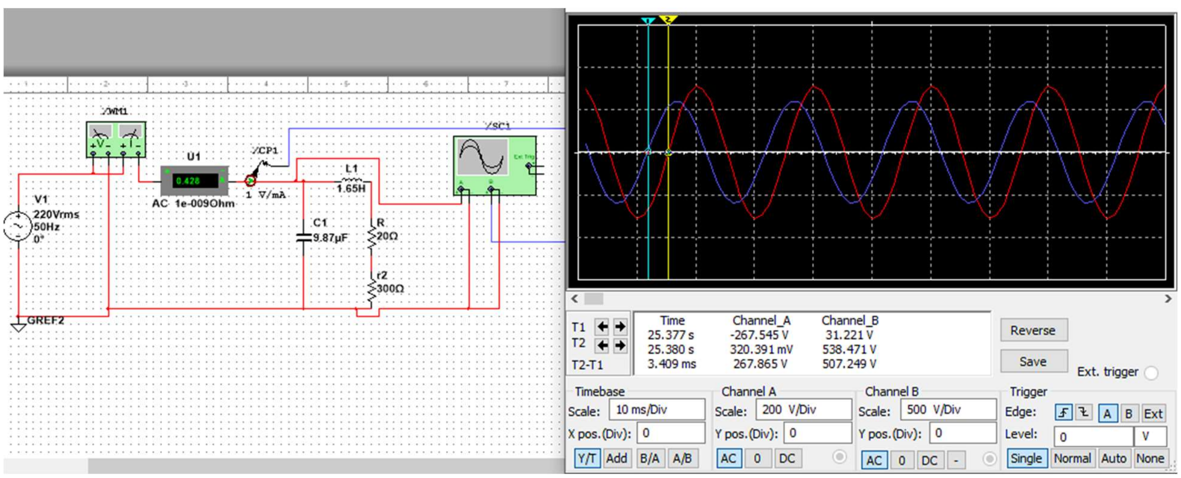


XWM1
U1
0.31
AC 1e-009Ohm
L1
1.65H
V1
220Vrms
50Hz
0°
C1
7.9µF
R
20Ω
r2
300Ω
GREF2
Wattmeter-XWM1
40.961 W
Power factor:
0.60094
Voltage
Current



XWM1
U1
0.31
AC 1e-009Ohm
XCP1
1 V/mA
L1
1.65H
XSC1
V1
220Vrms
50Hz
0°
C1
7.9µF
R
20Ω
r2
300Ω
GREF2
T1
T2
T2-T1
Time
Channel_A
Channel_B
16.856 ms
-255.714 V
-24.322 V
20.076 ms
7.327 V
351.263 V
3.220 ms
263.041 V
375.584 V
Reverse
Save
Ext. trigger
Timebase
Scale: 10 ms/Div
X pos.(Div): 0
Y/T Add B/A A/B
Channel A
Scale: 200 V/Div
Y pos.(Div): 0
AC 0 DC
Channel B
Scale: 500 V/Div
Y pos.(Div): 0
AC 0 DC -
Trigger
Edge:
A B Ext
Level: 0 V
Single Normal Auto None





Remarks and Grade (by the instructor)

Instructor Signature:
Grading Date:

Electric Circuit Experiments

Basic Concept and Laws

05 Resonance

Vital information,

RAIHAN MD RAKIBUL ISLAM

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Build a series RLC circuit, keep the output voltage value of AC source unchanged, and adjust frequency of the source signal.

1. When current of resistor reaches maximum I_{max} , the resonance frequency is found. When current of resistor reaches $0.707I_{max}$ the half power frequency is found.

Table 1

R=5-ohm, L=30mH, C= 1uF

f/Hz			f1	905.73	f0	919	f2	932.26	
Ir/A			i1	0.401	i0	0.325	i2	0.205	

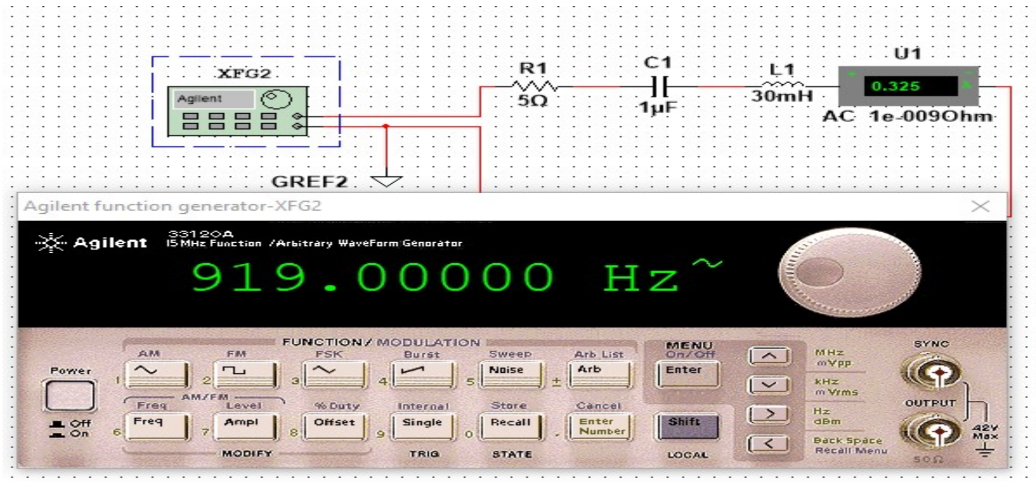
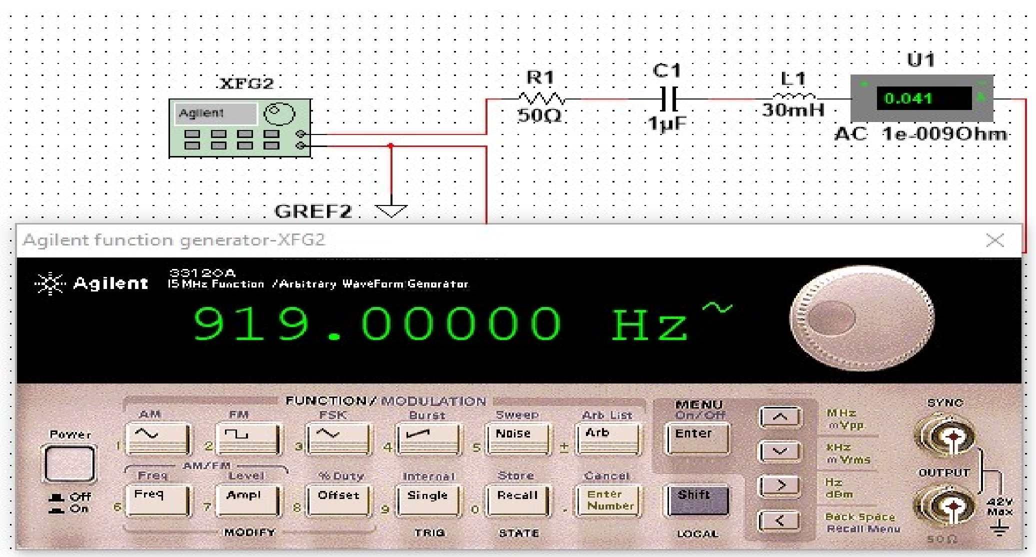


Table 2

R=50-ohm, L=30mH, C= 1uF

f/Hz			f1	786.37	f0	919	f2	1051.63	
Ir/A			i1	0.029	i0	0.041	i2	0.029	



2. When voltage of resistor reaches maximum U_{max} , the resonance frequency is found. When current of resistor reaches $0.707I_{max}$ the half power frequency is found.

Table 3

R=5-ohm, L=30mH, C= 1uF

f/Hz			f1	905.73	f0	919	f2	932.26	
Ur/A			U1	2.006	U0	1.645	U2	1.027	

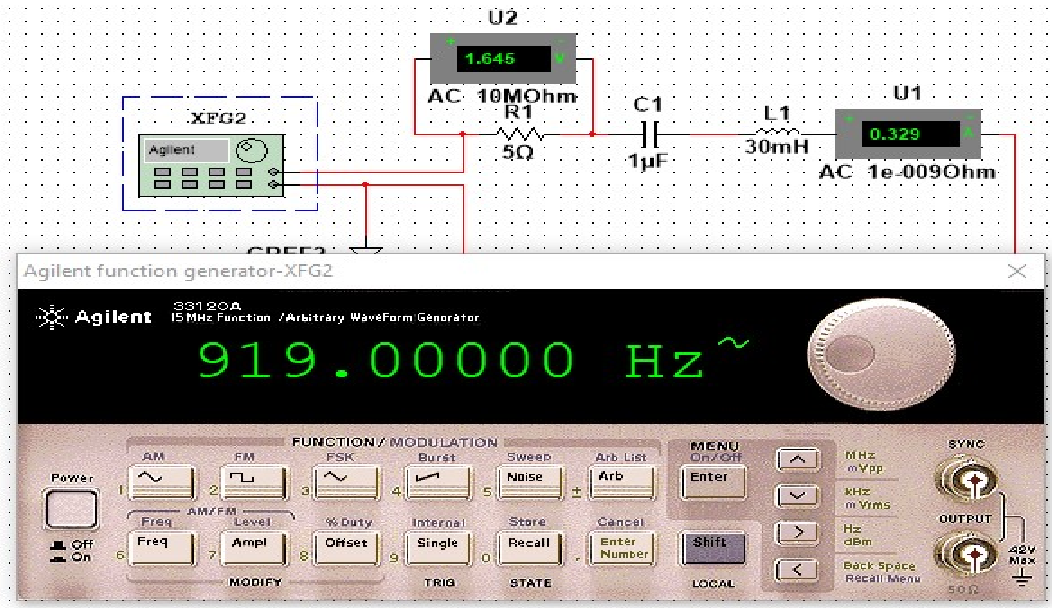
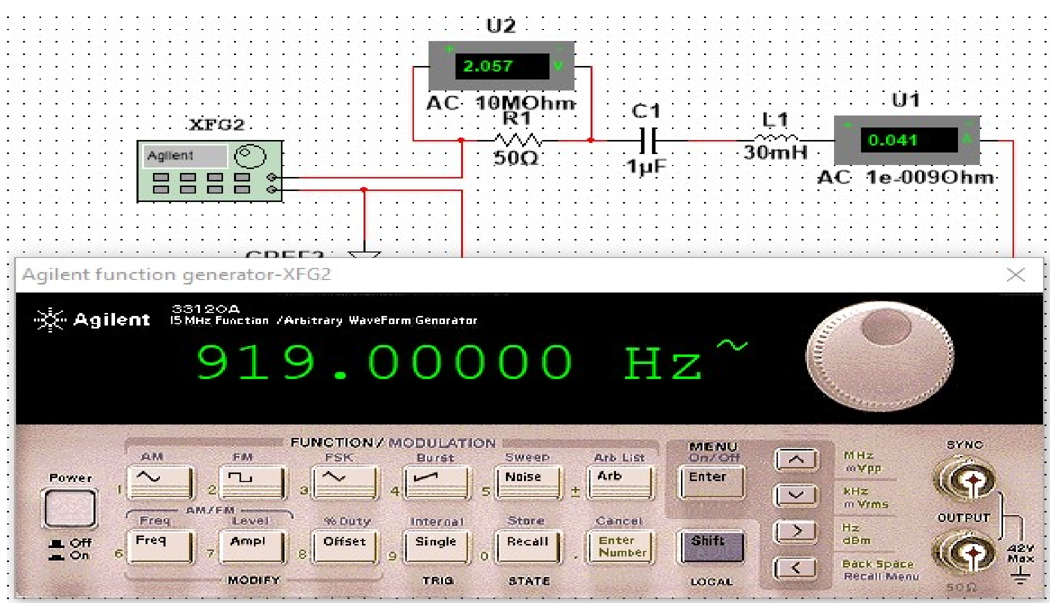


Table 4

R=50-ohm, L=30mH, C= 1uF

f/Hz			f1	786.37	f0	919	f2	1051.63	
Ur/A			U1	1.464	U0	2.057	U2	1.453	

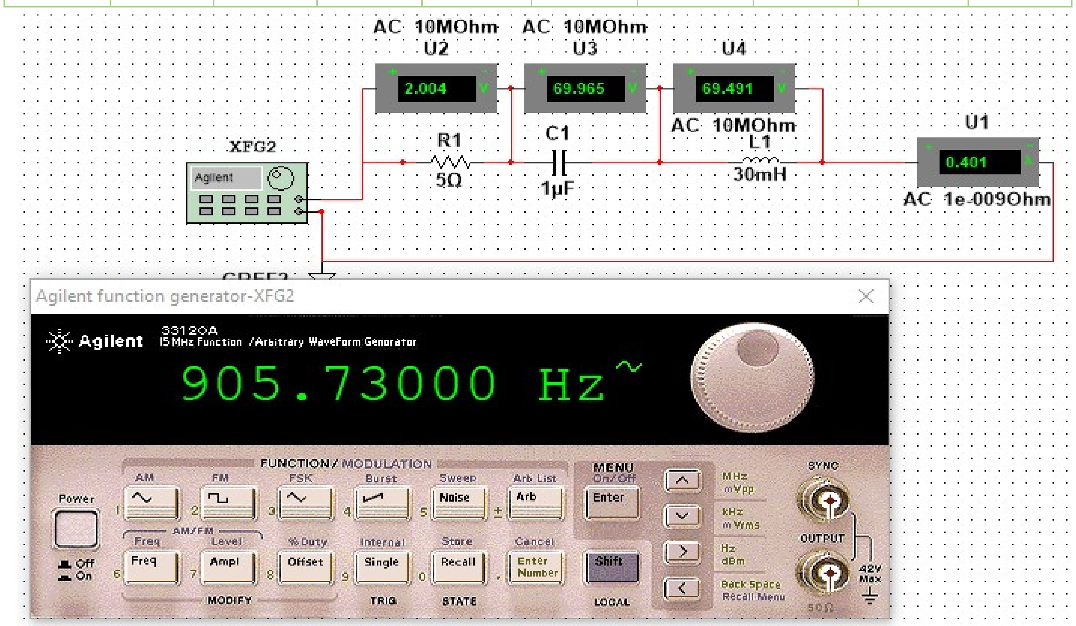


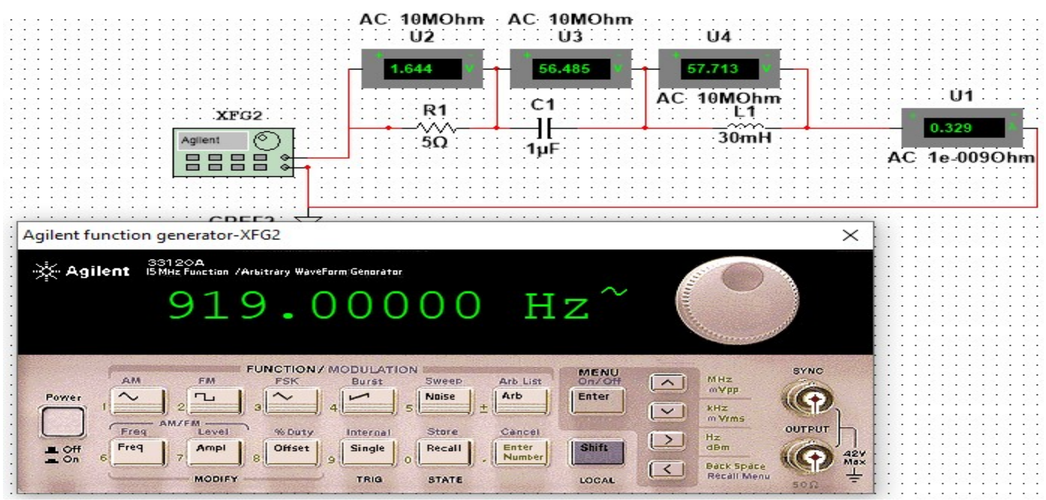
3. When voltage values on inductor and capacitor are the same, the resonance frequency is found. Record maximum voltage Umax on resistor, then found half power frequency.

Table 5

R=5-ohm, L=30mH, C= 1uF

f/Hz			f_1	905.73	f_0	919	f_2	932.26	
I_R/A			I_{R1}	0.401	I_{R0}	0.329	I_{R2}	0.205	
U_R/V			U_{R1}	2.004	U_{R0}	1.644	U_{R2}	1.027	
U_L/V			U_{L1}	69.491	U_{L0}	57.713	U_{L2}	36.387	
U_C/V			U_{C1}	69.965	U_{C0}	56.485	U_{C2}	34.624	





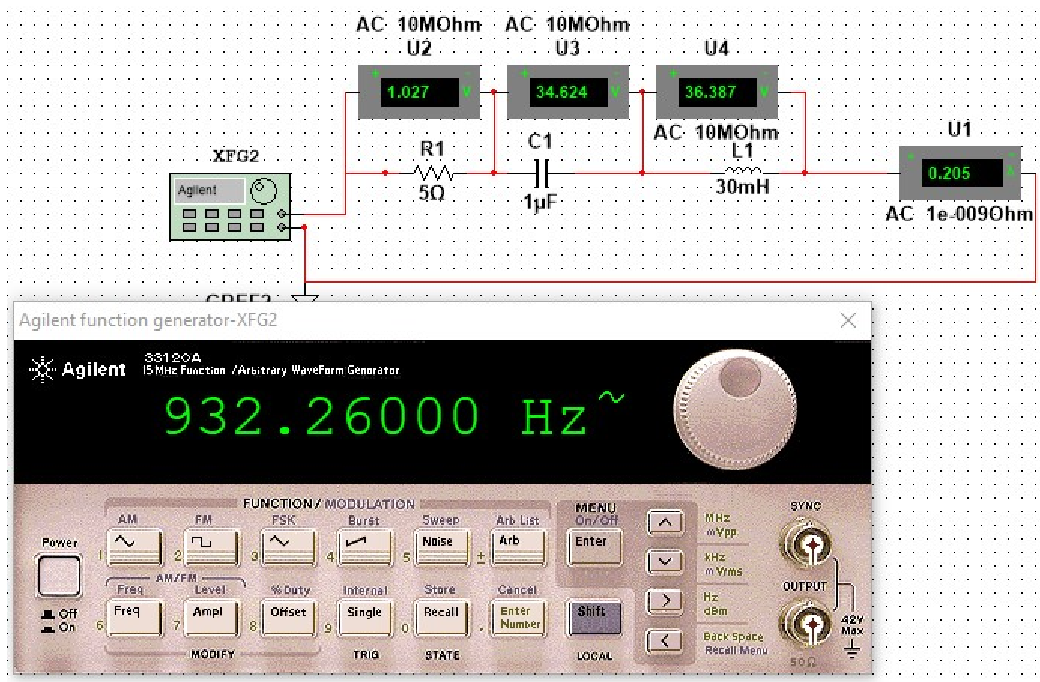
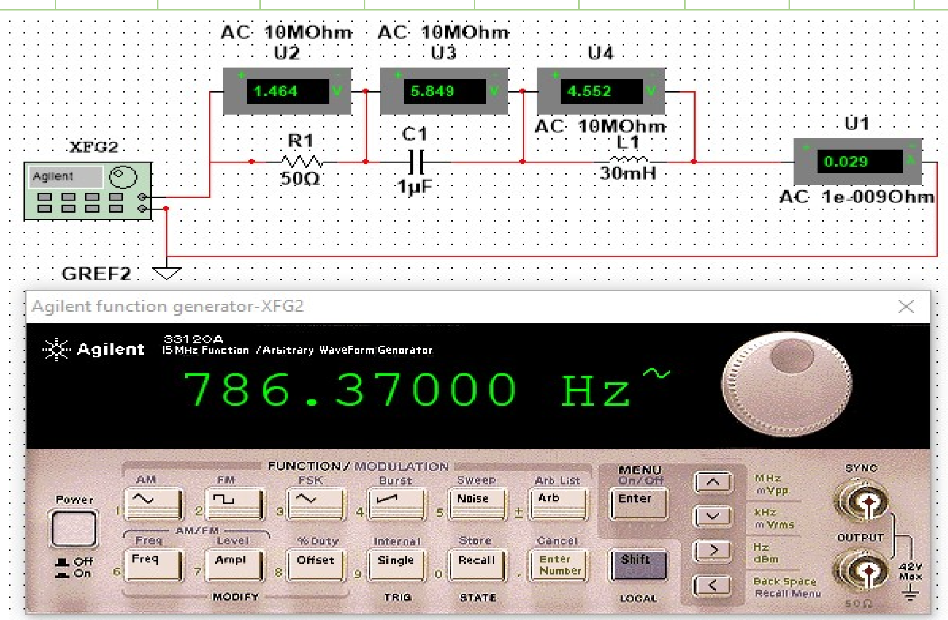
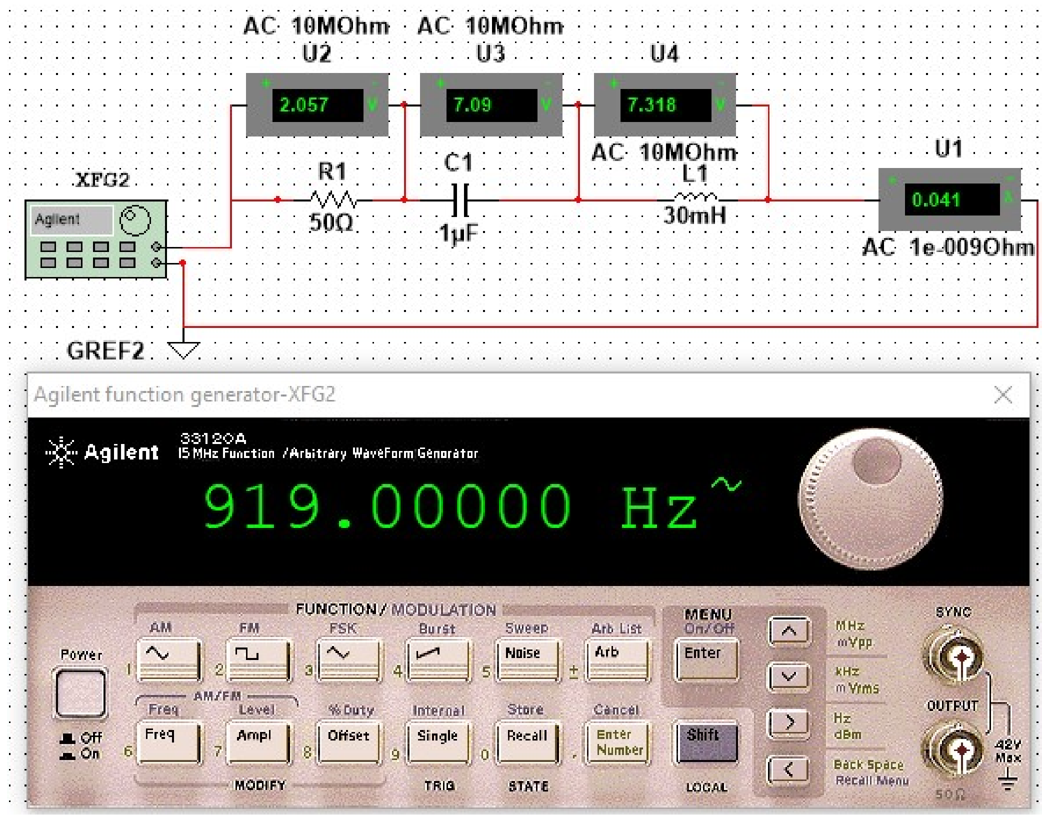


Table 6

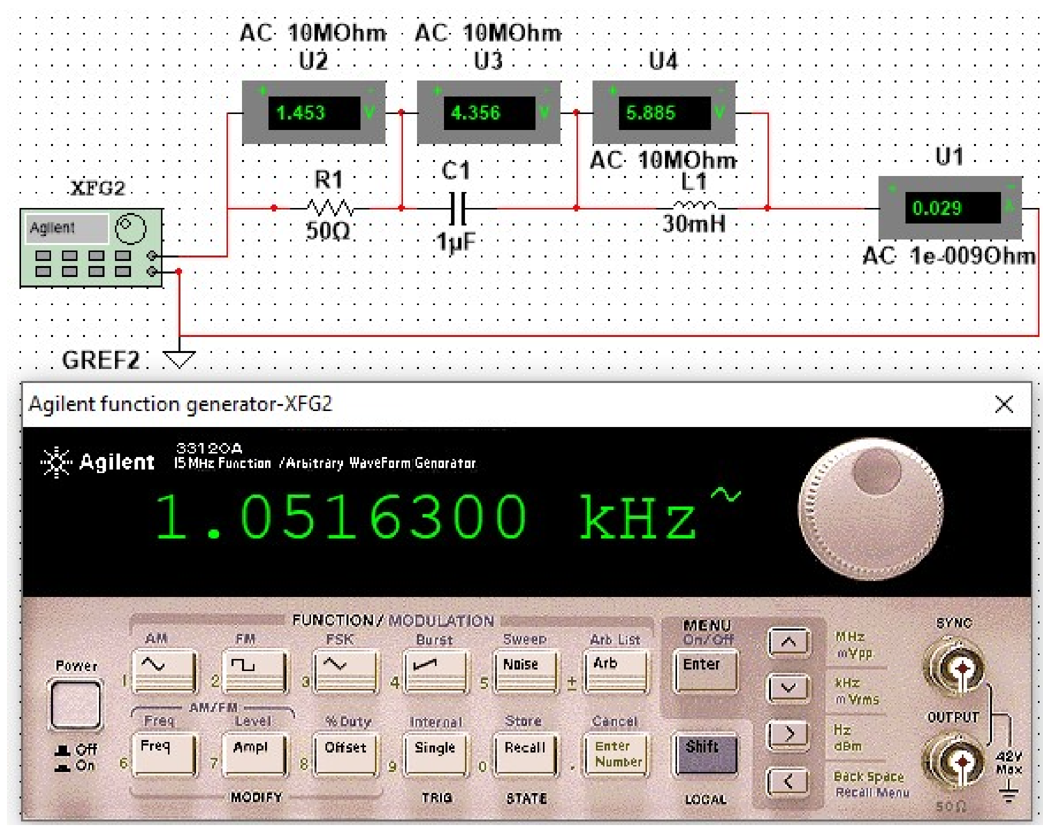
R=50-ohm, L=30mH, C= 1uF

f/Hz			**f_1**	**786.37**	**f_0**	**919**	**f_2**	**1051.63**	
I_R/A			I_{R1}	0.029	I_{R0}	0.041	I_{R2}	0.029	
U_R/V			U_{R1}	1.464	U_{R0}	2.057	U_{R2}	1.453	
U_L/V			U_{L1}	4.552	U_{L0}	7.318	U_{L2}	5.885	
U_C/V			U_{C1}	5.849	U_{C0}	7.09	U_{C2}	4.356	





AC 10MOhm
U2
2.057
AC 10MOhm
U3
7.09
U4
7.318
AC 10MOhm
XFG2
R1
50Ω
C1
1µF
L1
30mH
U1
0.041
AC 1e-009Ohm
GREF2
Agilent function generator-XFG2
Agilent
33120A
15 MHz Function / Arbitrary WaveForm Generator
919.00000 Hz



AC 10MOhm
U2
1.453
AC 10MOhm
U3
4.356
U4
5.885
AC 10MOhm
XFG2
R1
50Ω
C1
1µF
L1
30mH
U1
0.029
AC 1e-009Ohm
GREF2
Agilent function generator-XFG2
Agilent
33120A
15 MHz Function / Arbitrary WaveForm Generator
1.0516300 kHz

Electric Circuit Experiments

Basic Concept and Laws

First Order Circuit Analysis

Vital information,

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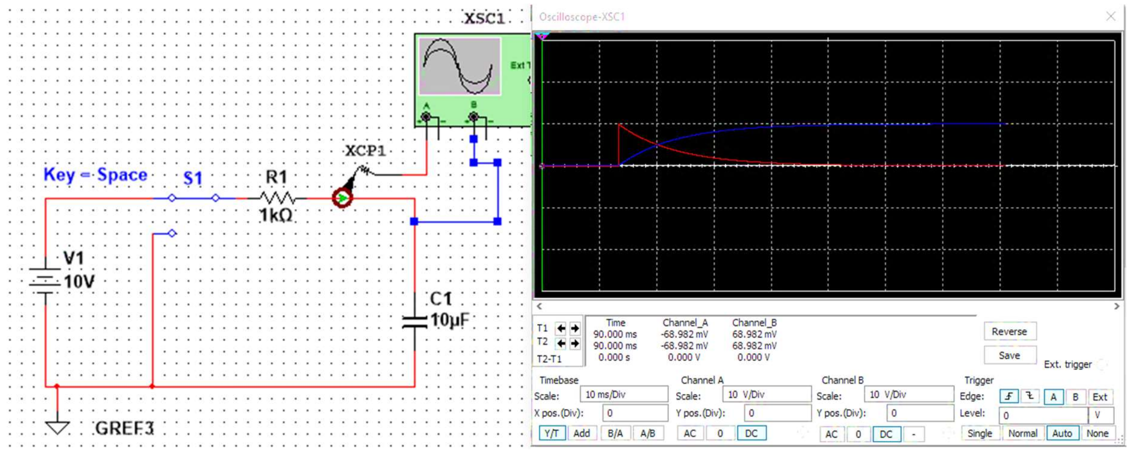
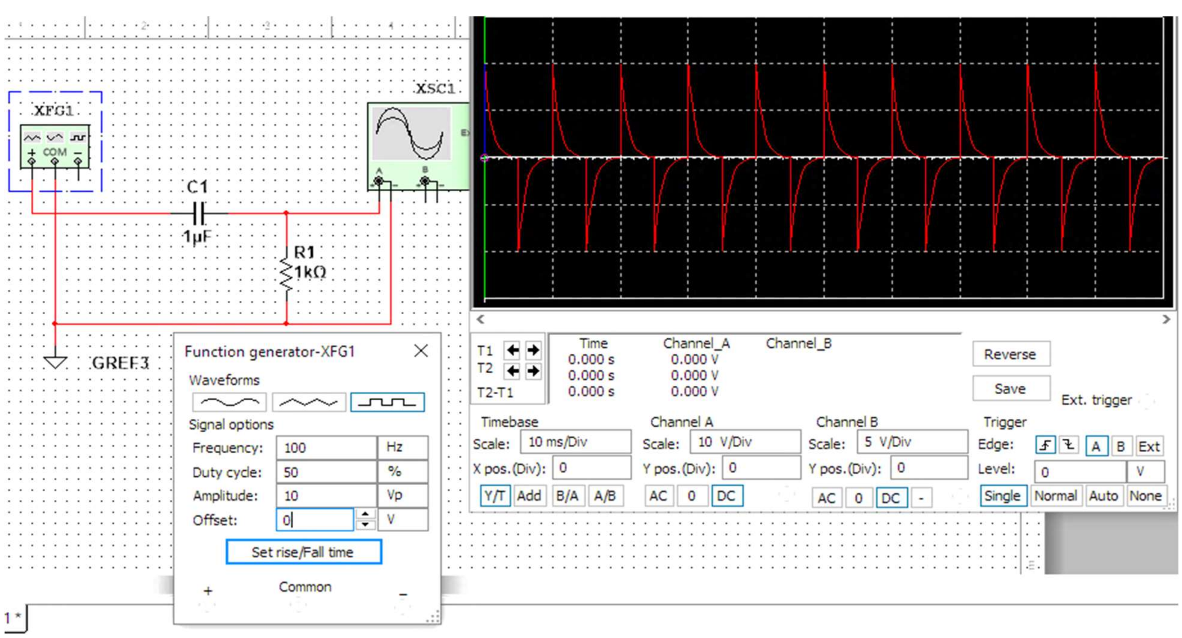
1. Use oscilloscope to obtain charging time constant and discharging time constant τ, and compare them with the theoretic values. (Circuit and simulation curves are necessary)



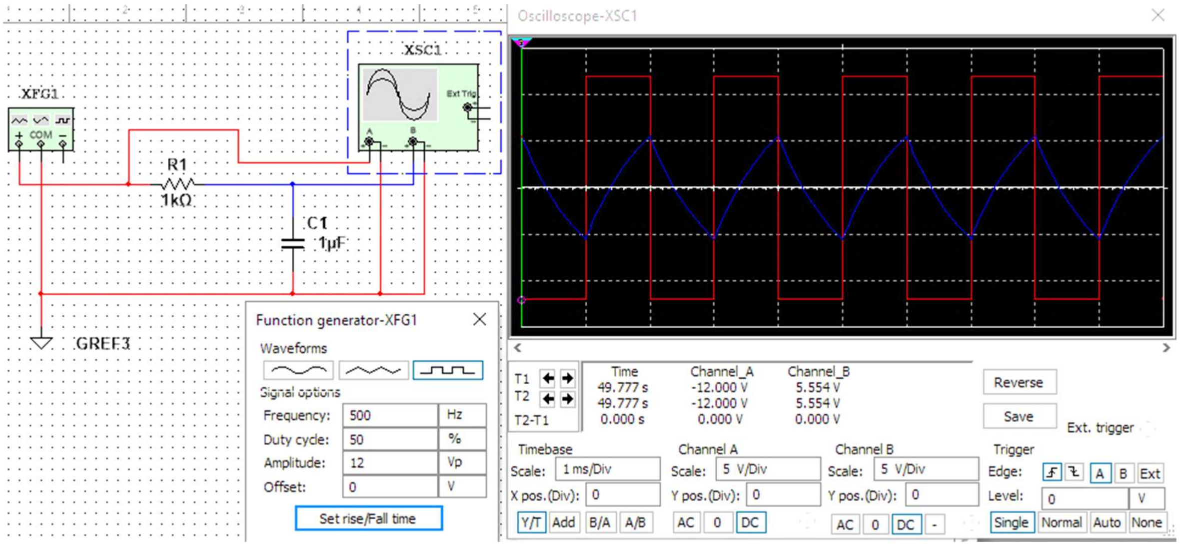
2. What is differential circuit? What is integral circuit? List conditions of differential circuit and integral circuit, and testify these conditions. (Circuit and simulation curves are necessary)

RC differentiator: RC differentiator is a series connected resistor and capacitor network that produces an output signal which corresponds to the mathematical process of differentiation. Differential circuit condition:

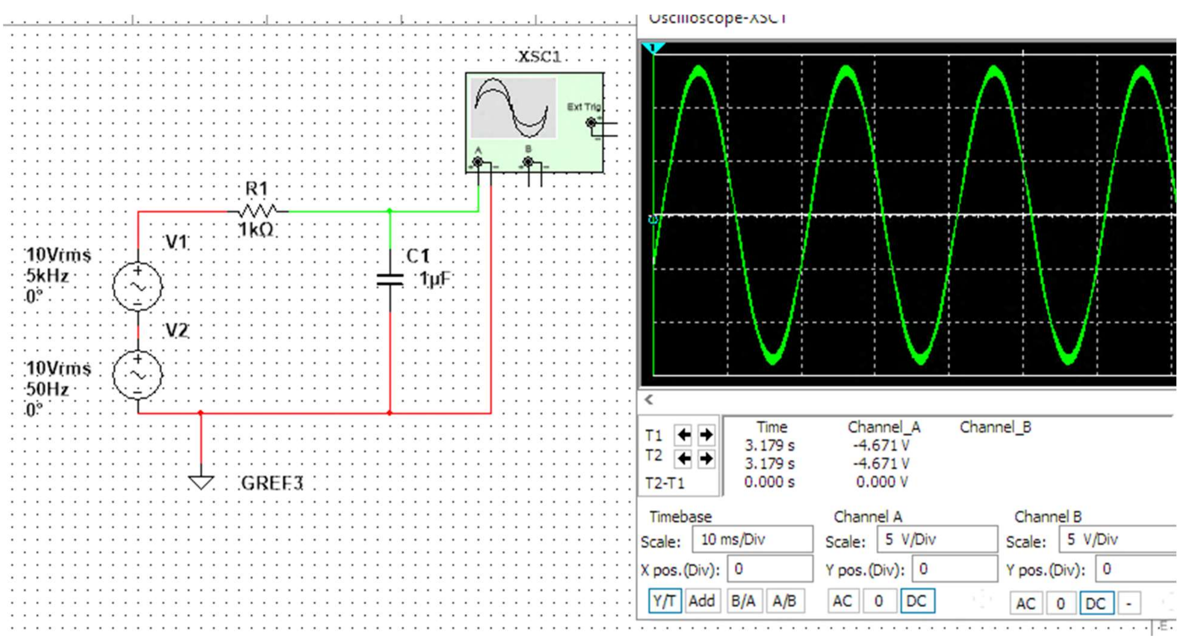
- T(Tau) =RC>> T/2
- Differential voltage can be found across the resistor's terminals.



RC Integral Circuit: RC integrator is a series connected RC network that produces an output signal which corresponds to the mathematical process of integration.



An integral circuit is highly used as a low pass filter which means it will only pass the lower frequency signal at the output terminal. An example circuit is shown below.

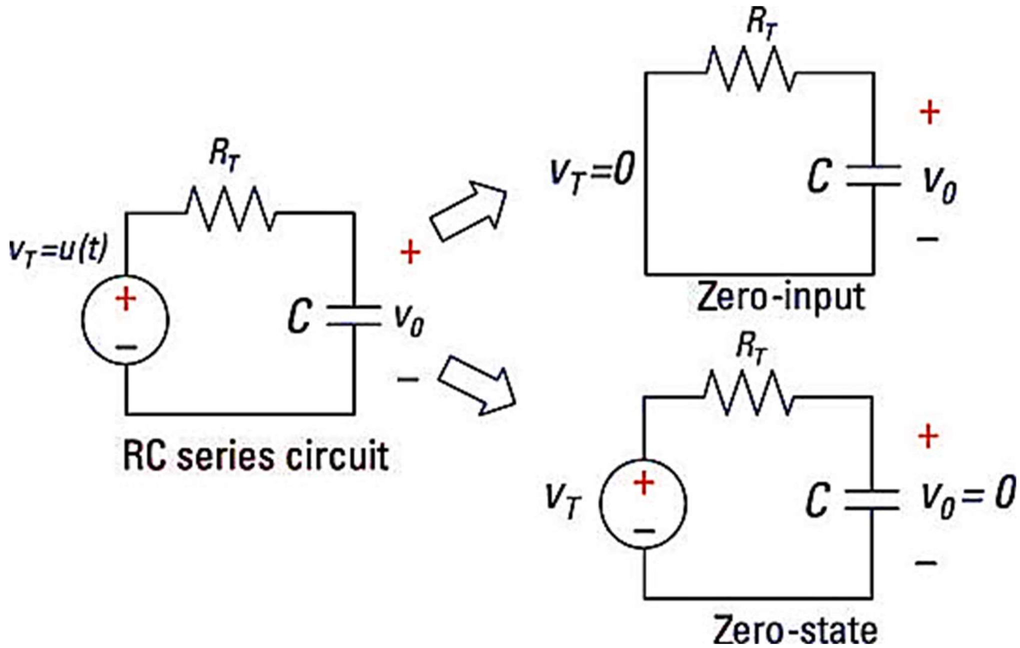


From the circuit above it is seen that only 50hz signal is passed in the output while the 5khz is blocked.

3. What kind of signal is very suitable to be the excitation signal to RC first order circuit to generate zero-input response, zero-state response and complete response？

To find the total response of an RC series circuit, we need to find the zero-input response and the zero-state response and then add them together. A first-order RC series circuit has one resistor (or network of resistors) and one capacitor connected in series.

Here is an RC series circuit broken up into two circuits. The top-right diagram shows the zero-input response, which you get by setting the input to 0. The bottom-right diagram shows the zero-state response, which you get by setting the initial conditions to 0.



We, at first want to find the zero-input response for the RC series circuit. The top-right diagram here shows the input signal $v_T(t)$ equal to 0. Zero-input voltage means you have zero . . . nada . . . zip . . . input for all time. The output response is due to the initial condition V_0 (initial capacitor voltage) at time $t = 0$. The first-order differential equation reduces to

$$v_T(t) = 0 = RC\frac{dv_{zI}(t)}{dt} + v_{zI}(t) \text{ or } v_{zI}(t) = -RC\frac{dv_{zI}(t)}{dt}$$

Here, $v_{ZI}(t)$ is the capacitor voltage. For an input source set to 0 volts as shown here, the capacitor voltage is called a *zero-input response* or *free response*. No external forces (such as a battery) are acting on the circuit, except for the initial state of the capacitor volt.

Remarks and Grade (by the instructor)

Instructor Signature:

Grading Date:

Electric Circuit Experiments

Basic Concept and Laws

Operational Amplifier

Vital information,

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Use op amp to realize the expression below u1, u2 and u3 are input voltage, and make sure u1, u2 and u3 are variable.

uo=3u1-7u2+5u3

At first, let's identify the op amplifier, it's known to be A DC-coupled high-gain electronic voltage amplifier with a differential input and a single-ended output. The op-amp produces an output potential that is larger than the potential difference between its input terminals. And as we know, the purpose it that it's used as a voltage amplifying device designed to be used with external feedback components such as resistors and capacitors between its output and input terminals.

It is known to be a high-gain electronic voltage amplifier with a differential input and a single-ended output.

To calculate the expression given above, we will create the following circuit, we will use a non-inverting op amplifier to calculate the sum. As the beginning we will create 3 different circuits for each part, one is for 3U,
one is for - 7U2,
and one is for 5U3.

Let's begin,
For the first circuit, 3U.
For the second circuit, - U2.
For the third circuit, 5U3.

At the end you will get this result, we will find the result at the end, which is going to be:

Uo = 3u1-7u2+5u
= 3V – 7V + 2.5V = 3V

Remarks and Grade (by the instructor)

Instructor Signature:

Grading Date:

Electric Circuit Experiments

Basic Concept and Laws

Audio Amplification Circuit Design

Vital information,

RAIHAN MD RAKIBUL ISLAM

Student ID: 2020380029

WeChat: theraihanrakib

E-mail: raihan.npu.cst@gmail.com

Apparatus:

Multism simulation software

Theory:

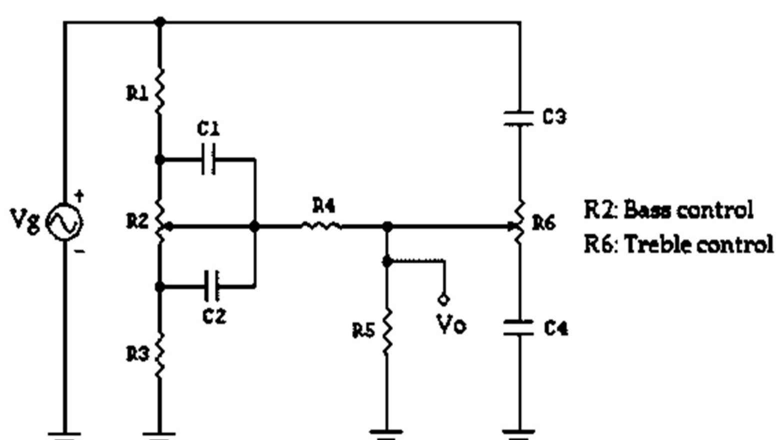
Amplifier is the generic term used to describe a circuit which produces and increased version of its input signals. However, not all amplifier circuits are the same as they are classified according to their circuit configurations and modes of operation.

In "Electronics", small signal amplifiers are commonly used devices as they have the ability to amplify a relatively small input signal, for example from a Sensor such as a photo-device, into a much larger output signal to drive a relay, lamp or loudspeaker for example.

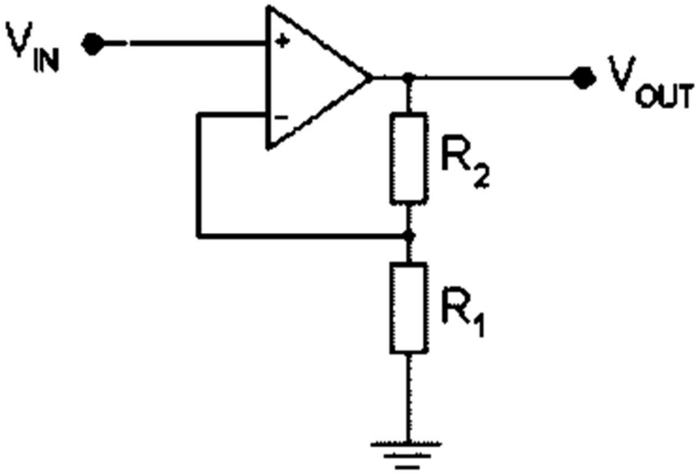
There are many forms of electronic circuits classed as amplifiers, from Operational Amplifiers and Small Signal Amplifiers up to Large Signal and Power Amplifiers. The classification of an amplifier depends upon the size of the signal, large or small, its physical configuration and how it processes the input signal, that is the relationship between input signal and current flowing in the load.

An Audio amplifier is an electronic amplifier that amplifies low power electronic audio signals such as the signal from a radio receiver to a level that is high enough for driving loud speakers or headphones. It turns low voltage signals from source equipment into a signal with enough gain to be used to power a pair of speakers. It is also known as a power amplifier. Below is flow chart illustrating what goes on in an audio amplifier.

A pre-amplifier is required to amplify the signal from various audio sources which include a microphone, record player, CD etc. More importantly different voltages are provided for different audio sources from millivolt to hundreds of millivolts but the input sensitivity of the amplifier is constant. If different audio sources input into the audio amplifier errors will be experienced.



❖ ***The diagram below is an example of a pre-amplifier:***



The Tonality Control Unit controls the frequency response of the audio system to be adjusted to compensate for the response of speakers and their enclosures. The most common of all modern tone control circuits was named after P.J Baxandall who came up with the idea in the 1950s.

❖ ***Voltage Amplifier Gain:***

$$Voltage\,Gain\,(A_v) = \frac{Output\ Voltage}{Input\ Voltage} = \frac{Vout}{Vin}$$

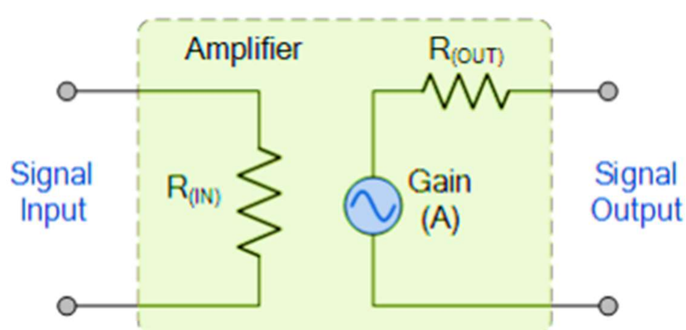
❖ ***Current Amplifier Gain:***

$$Current\,Gain\,(A_i) = \frac{Output\ Current}{Input\ Current} = \frac{Iout}{Iin}$$

❖ ***Power Amplifier Gain:***

$$Power\,Gain\,(A_p) = A_v\ x\ A_i$$

Procedure:



The amplified difference between the input and output signals is known as the Gain of the amplifier. Gain is basically a measure of how much an amplifier "amplifies" the input signal. For example, if we have an input signal of 1 volt and an output of 50 volts, then the gain of the amplifier would be "50". In other words, the input signal has been increased by a factor of 50. This increase is called Gain.

Amplifier gain is simply the ratio of the output divided-by the input. Gain has no units as it's a ratio, but in Electronics it is commonly given the symbol "A", for Amplification. Then the gain of an amplifier is simply calculated as the "output signal divided by the input signal".

To build a complete circuit for an audio amplifier (power amplifier), three units are needed and these are the pre-amplifier unit, tonality control unit and the power amplifier unit.

Data Collection and Analysis

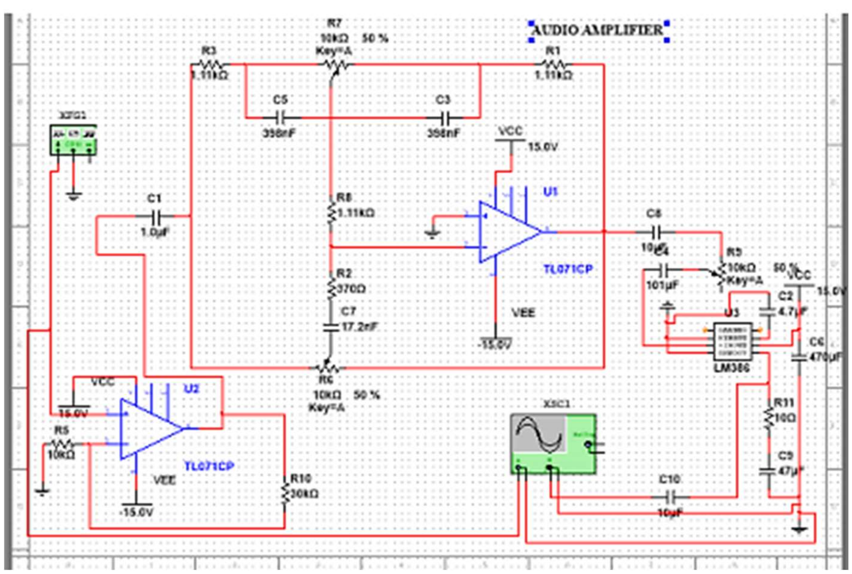
➢ ***Audio Amplifier Design:***

LM368 is a powerful amplifier that can be used in low voltage circuits and looking at the fact that it has not been installed in the current version of Multism a duplicate had to be made using the components section of the toolbar. The voltage gain of it can change from 20 to 200 and its low distortion feature can make the total audio power amplifier better.

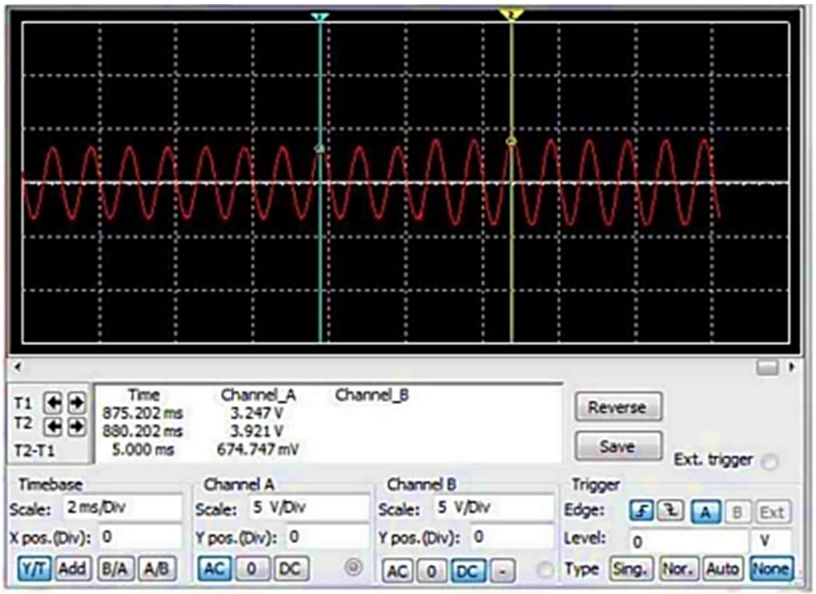
➢ ***Result:***

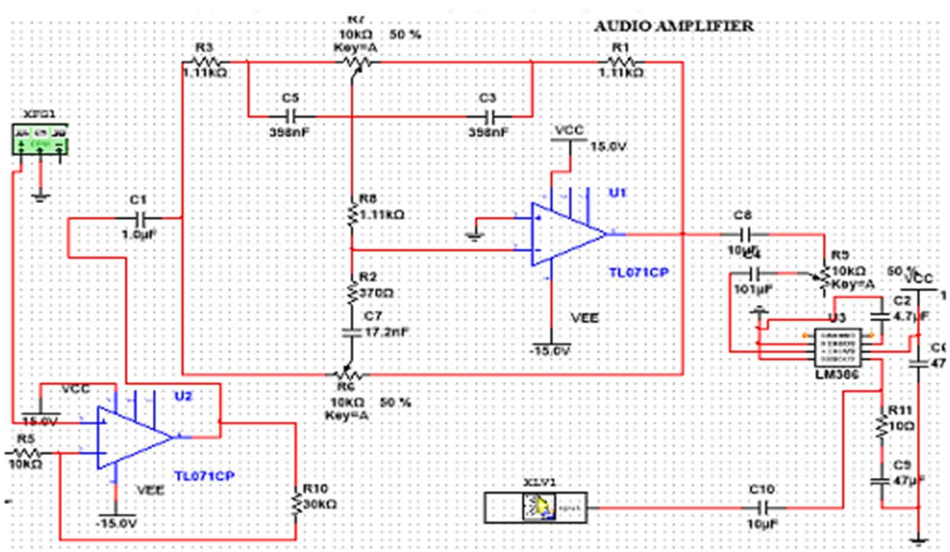
One part is obtained through simulation with Multism and by analyzing the figures of output waveform and frequency response got from the simulation, he designed audio power amplifier may be known. Then the circuit is built on the electronic elements needed and measures the output waveform, gain, power and distortion etc. Also connect the circuit with a true speaker at the same time and to check if the tonality control works normally the sound heard by ear is pure.

Simply connect the function generator and the Oscilloscope and set a sine wave with 50mVp and 1KHz but smaller than 10mVp as specified in the question. See the Figure below.

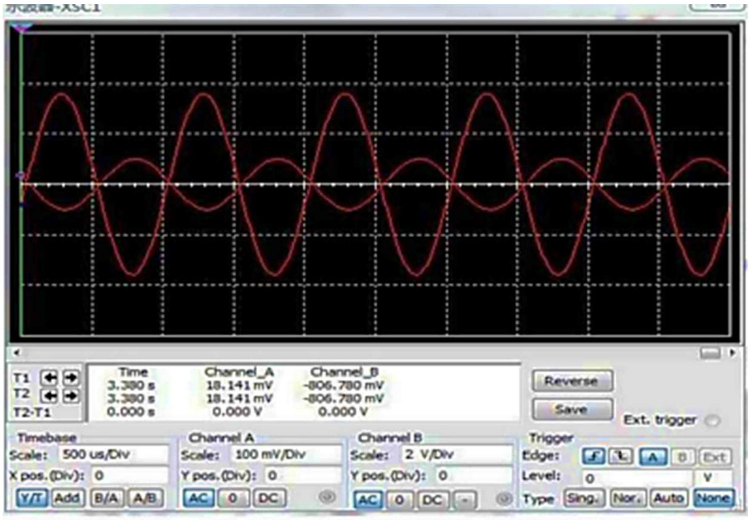


The diagram below is the same illustration as the one above but with the speaker connected instead of the oscilloscope. Kindly note that replacing the speaker with the multimeter gives the multimeter reading of the multimeter curve.

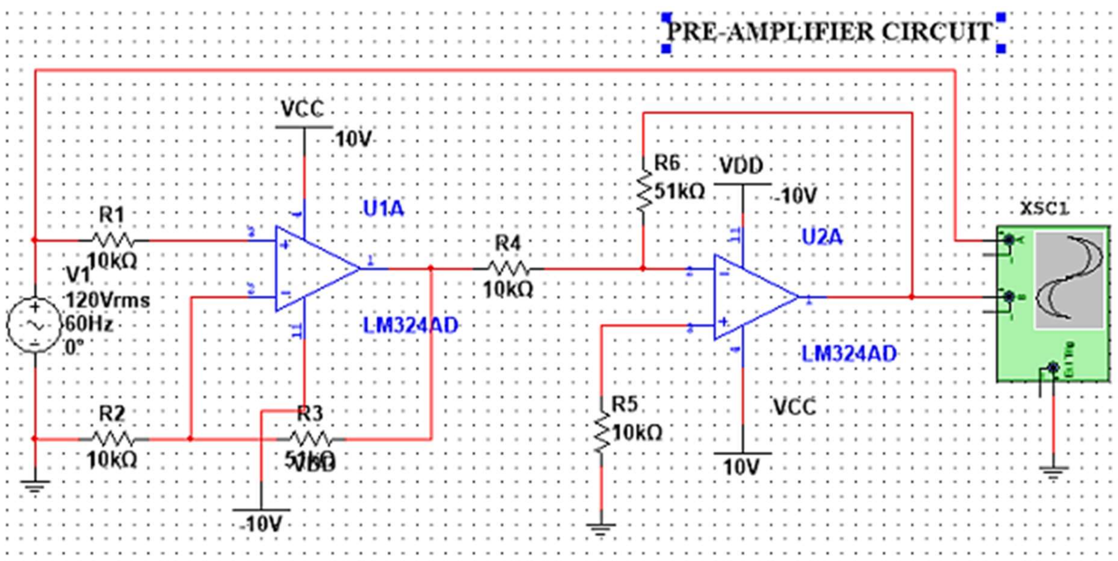




On condition that the arms of potentiometers are set to the position 50%, change the value of R9, and the volume increases. See Figure below. The output amplitude changes from 3.247V to 3.921V.



Input peak:
18.141mv
Output Peak:
606.780mv
Gain:
33.45



First stage amplifier：

Ui/R2=(Uo1-Ui)/R3 = (-10.561V+43.273V)/51 = 0.641V/Kohm

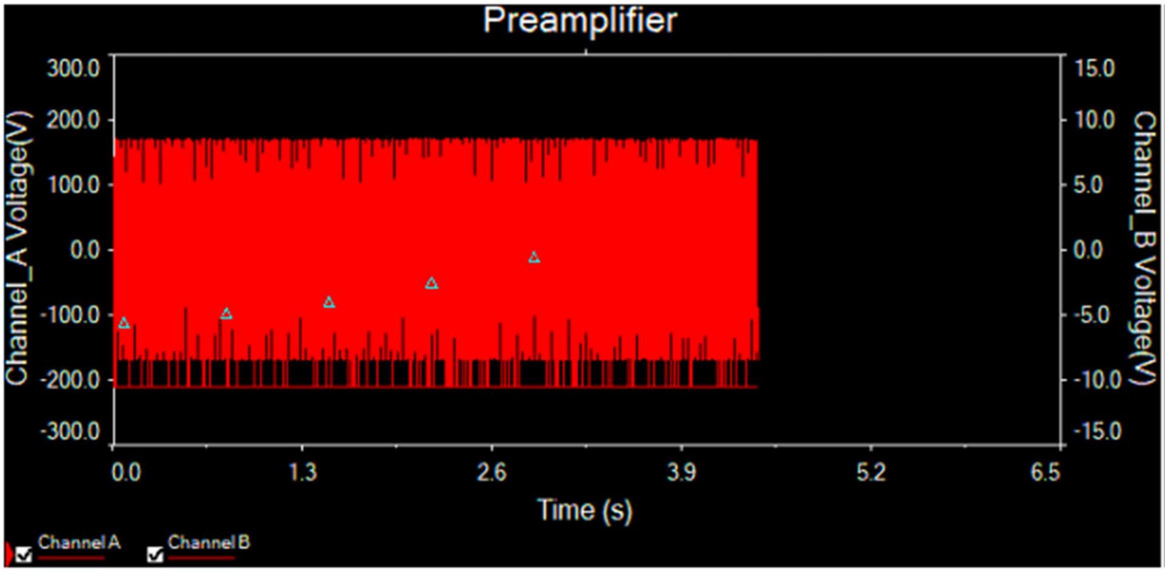
Second stage amplifier:
Uo1/R6=(0-Uo)/R5 = -10.561V/10kohm = - 1.0561V/Kohm

Uo= 1+ (R3/R2)*(-R5/R6)Ui = 1+51/10 * -51/10 *Ui = -31.11Ui = 328.6V

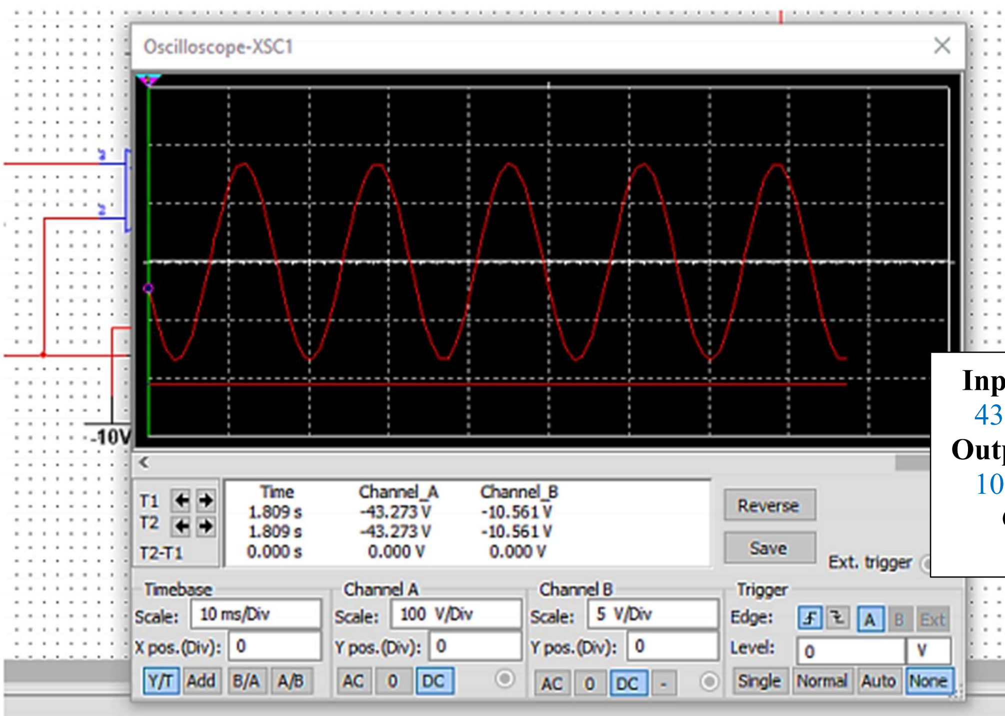
The gain： AUi=(1+R3/R2)*(-R5/R6) =(1+51/10)*(-51/10) = -31.11

Below is the curve illustrating the circuit above. The next diagram after this shows the oscilloscope reading of the same circuit.

- ***Graph***



- ***Oscilloscope reading:***



Input Peak:
43.273mV
Output Peak:
10.561mV
Gain:
0.245

Acknowledgment:

In summary, the above-mentioned circuit meets the requirements for the normal operation of the audio amplifier and the normal operation of the preamplifier circuit. I encountered some errors during the simulation because I had to replace these values every time, I restarted Multism to get the correct curves and graphs. It is hoped that the designed circuit is correct and meets the standard requirements of this experiment.

Remarks and Grade (by the instructor)

Instructor Signature:

Grading Date: