North South University
Department of Electrical & Computer Engineering

LAB REPORT

Course Code : EEE/ETE 241 L

Course Title: Electrical Circuit 2

Course Instructor: NNP

Experiment Number: 06 Experiment Name:

Eperiment on RLC Resonance, Bandwidth and Quality Factor

Date of Experiment: 30th of April, 2020

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Section: 02

Group Number: 04

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Lab 6: RLC Resonance, Bandwidth and Quality Factor

A. Objectives:-

To investigate and verify the resonan phenomena in RLC circuit. Analyze the Resonant Frequency and Bandwidth of given circuit and regulate the effect of the load resistance.

B. Background:-

B.1 Resonance in a Series RLC circuit:

The resonance of a series RLC circuit occurs when the inductive and capacitive reactances are equal in magnitude but cancel eachother becau they are 180 degrees apart in phase.

Here, both X_C and X_L are frequenc dependent. However X_C is inversely propotional to frequency and X_L is

Resonant frequency Q = quality factor. A high Q resonant circuit has a narrow bandwidth as compared to a lo Q. Bandwidth is measured between the 0.707 current amplitude points.

Equipment :-

- Bread board
- Function Generator
- Digital storage oscilloscope
- connecting wires
- Resistors
- capacitors
- Inductor.

circuit :-

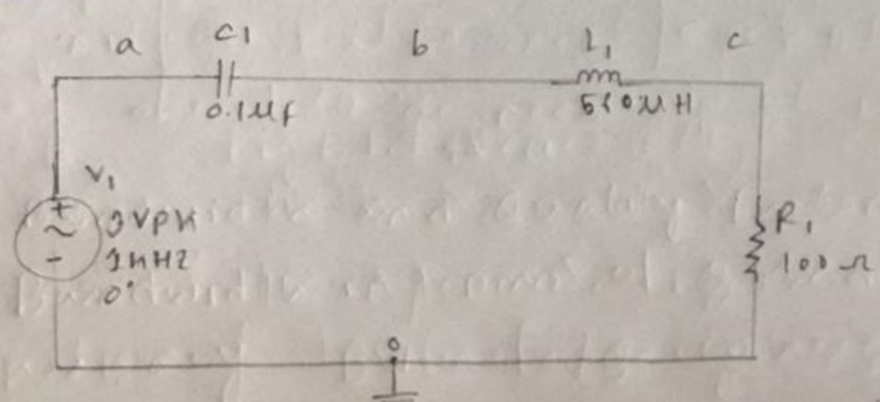


Fig B.1.1: Series RLC circuit

directly propotional. When frequency is increased, X_C decreases and X_L increases. That means, $X_C = X_L$. According to the resonance condition $X_C = X_L$ which means $\frac{1}{j\omega C} = j\omega L$ and the resonance frequency is f_0.

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

Now, the impedance in the below circuit can be expressed as $Z = R + jX_L - jX_C$

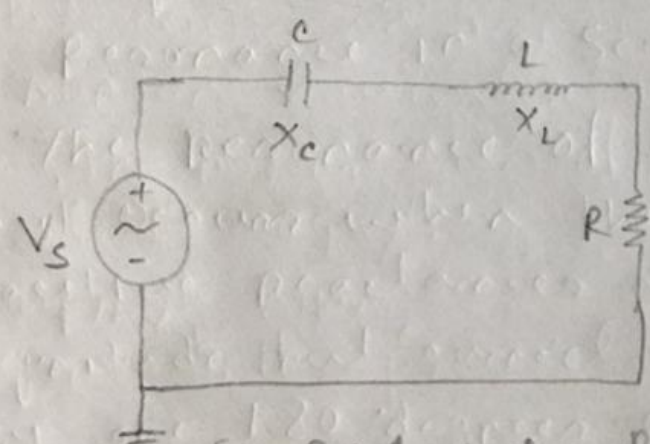


Fig B.1.1: Series RLC circuit

B.2 Bandwidth and Quality factor:-

Bandwidth in terms of Q and resonant frequency $BW = f_c/Q$ where f_c =

Table 1.1 : Component Values:

	R_1 (Ω)	R_2 (Ω)	C_1 (F)	L_1 (H).
Nominal	100 Ω	200	1×10^{-7}	5.6×10^{-4}
Measured	100 Ω	200	1×10^{-7}	5.6×10^{-4}

Table 1.2 : The magnitude of V_c, V_L, V_R at different frequencies for a high Q circuit.

Frequency (f) kHz	Peak Voltage, V_R (V)	Peak Voltage, V_c (V)	Peak voltage, V_L (V)
1	0.19	3.0	6.68×10^{-3}
10	1.89	2.997	0.67
20	2.99	2.37	2.11
30	2.65	1.4	2.8
40	2.107	0.83	2.[illegible]97
50	1.71	0.[illegible]154	3.0
60	1.424	0.[illegible]38	3.02
70	1.22	0.28	3.02
80	1.07	0.[illegible]21	3.02
90	0.95	0.17	3.01
100	0.85	0.[illegible]14	3.01

Table 1.3: Resonant frequency, Quality factor & Bandwidth for a high Q circuit

	Theoretical (a)	Experimental (b)	Deviation (%) $\frac{a-b}{a} \times 100$
f_0	21.27	20	5.97
f_1	11.8	14	18.64
f_2	40.21	38	5.496
Bandwidth $(f_2 - f_1)$	28.41	24	15.52
Q-factor (f_0/Bandwidth)	0.75	0.833	11.07

Table 1.4: The magnitudes of V_C, V_L & V_R at different frequencies for a low Q circuit.

Frequency (f) kHz	Peak Voltage, V_R (V)	Peak Voltage, V_C (V)	Peak Voltage V_L (V)
1	0.37	2.98	6.64×10^{-3}
10	2.55	2.03	0.45
20	2.997	1.189	1.06
30	2.899	0.77	1.54
40	2.67	0.530	1.89
50	2.43	0.386	2.14
60	2.20	0.29	2.33
70	1.995	0.226	2.47
80	1.82	0.18	2.567
90	1.66	0.147	2.64
100	1.53	0.121	2.70

Table 1·5: Resonant frequency, Quality factor & Bandwidth for a Low Q-circuit

	Theoretical (a)	Experimental (b)	Deviation (%) $\frac{a-b}{a} \times 100$
f_0	21·27	21	1·27
f_1	7·6	7	7·89
f_2	64·42	64	0·65
Bandwidth ($f_2 - f_1$)	~~28·41~~ 56·82	57	0·32
Q-factor (f_0/Bandwidth)	0·37	0·368	0·54

Questions :-

1. Explain why the load voltage in RLC circuit is maximum at resonance condition.

Ans:- Since the RLC circuit is driven by a variable frequency and $Z = R + jX_L - jX_C$, at resonance condition, $jX_L = jX_C$ resulting $(Z = R)$ the circuit to be purely resistive. As the magnitude of the voltage V is directly proportional to the impedence Z, the entire source voltage acts across R. Thus the ~~lod~~ load voltage is maximum at resonance condition.

2. If a 5mH inductor was used instead of 560μH one, what capacitance value would be required to keep the resonant frequency (f_0) the same as the value obtained from the experiment.

Ans: $f_0 = \frac{1}{2\pi\sqrt{LC}}$

$\Rightarrow 21268 = \frac{1}{2\pi\sqrt{5\times10^{-3}\,C}}$

$\Rightarrow C = \frac{1 \times 5\times10^{-3}}{\sqrt{21268 \times 2\pi}}$

$= 1.37 \times 10^{-5}$ F

$= 13.7\ \mu F$

5. Is it possible to have a resonance condition in a parallel ~~circuit~~ RLC circuit? If so, briefly discuss a possible experimental set up which could be used to investigate resonance in a parallel RLC circuit.

Ans: It is possible to have a resonance condition in a parallel RLC circuit where energy will constantly be transferred back and forth between the indicator and the capacitor resulting in zero current and energy being absorbed from the supply. The experiment setup should be similar to the series RLC component wise except the resistor, inductor and capacitor should be connected in parallel respectively to frequency generator. Change the frequency until maximum peak of voltage is obtained. That will be the resonant frequency for the parallel RLC circuit.

6. Do the practical value of of the resonant frequency bandwidth and quality factor obtained from confirm with the theoretical values. if any percentage ~~is~~ difference are above 10% suggest 3 possible reasons for the discrepancy.

3. How would the resonant frequency of the circuit given in figure B. 11 change if the 100Ω resistor was replaced with a 50Ω one? explain.

Ans: No change will occur on the resonant frequency. Since resonant frequency depends wholly on the capacitance and inductance of the circuit, $f_0 = \frac{1}{2\pi\sqrt{LC}}$, any change in the value of the resistor will not affect the value of the Resonant frequency. It will only affect the peak of the resonance ~~as the current will~~ in the oscilloscope as $V = IR$.

4 Use your experimental results and the graph obtained from the simulations to explain the concept of high and low Quality factors in series RLC circuits.

Ans: Quality factor is the ratio of resonant frequency to bandwidth.

Answer No:4.

As per experimental value, we obtain a low-Q due to a high resistance in series RLC circuit. And, we obtain high Q is due to a low resistance in series. ~~wit~~

Answer to question No:6.

For the first part of the experiment deviation percentage for Bandwidth & quality factor are above 10. Other measured values are close to theoreticatical values where deviation is less than 10%. Three possible reasons for the ~~dispe~~ discrepancy:

(I) We could not ~~measure~~ determine the exact values from graph.

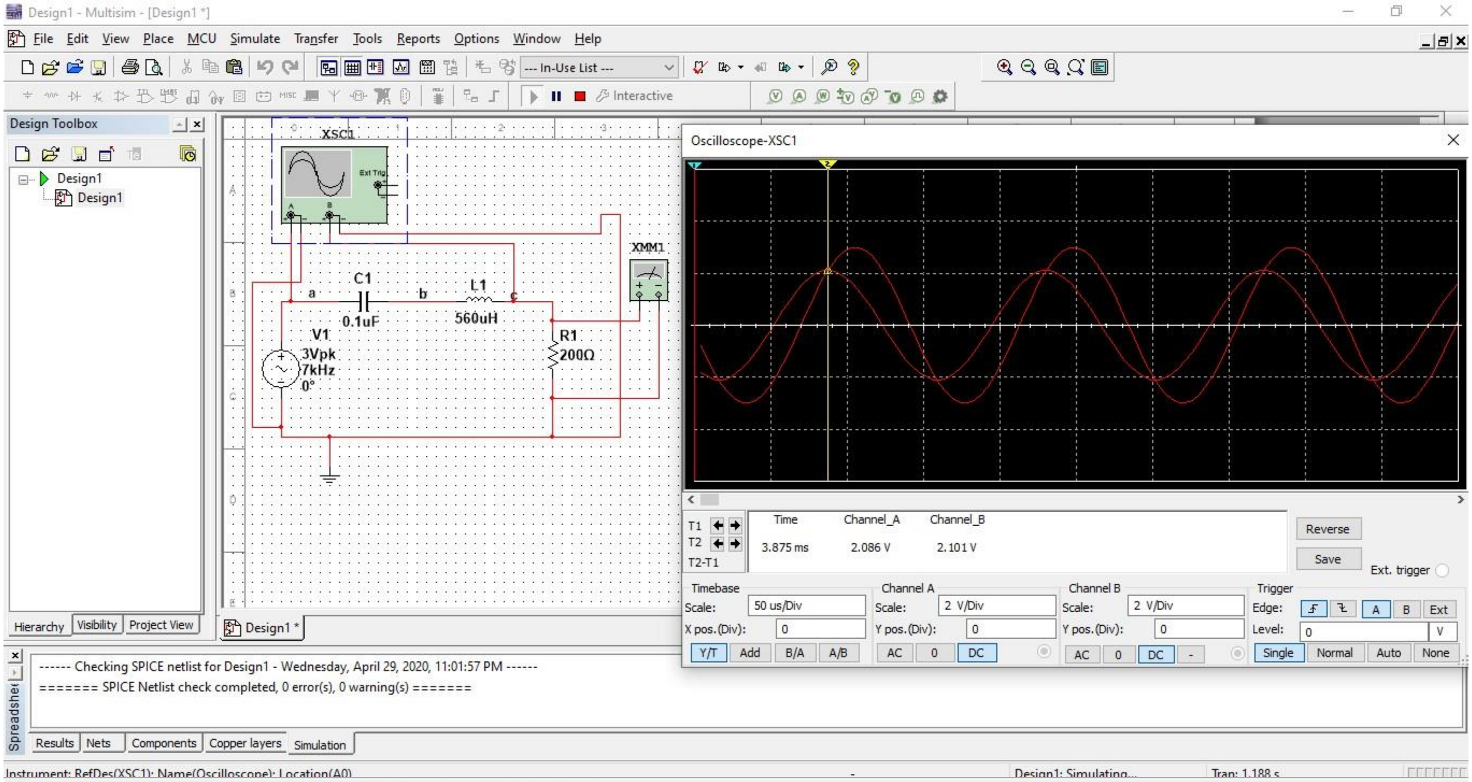
(II) Instruments are not precised as desired.

(III) There might be some systemetic error.

Discussion:

For the first part of experiment our theoretical & practical value deviated ~~sli~~ slightly larger than the second part where a larger resistand has been used. But, deviation percentage were never larger than 20%. In some cases it was only 0.3%. Cause of errors might be instrumental, error procedural, & human. To determine the peak voltage we faced slight difficulty as the ~~e~~ value was fluctuation too quickly. Thus, we took average value in some cases.

This experiment helped us to complete the gap between our theoretical learning & experimental learning. We learned about the resonance, Bandwidth & Quality factor & learned how to calculate them.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Design Toolbox
Design1
Design1
XSC1
Ext Trig
XMM1
a
C1
b
L1
c
0.1uF
560uH
V1
3Vpk
7kHz
0°
R1
200Ω
Oscilloscope-XSC1
T1
T2
T2-T1
Time
Channel_A
Channel_B
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2.086 V
2.101 V
Reverse
Save
Ext. trigger
Timebase
Scale: 50 us/Div
X pos.(Div): 0
Y/T Add B/A A/B
Channel A
Scale: 2 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
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Instrument: RefDes(XSC1); Name(Oscilloscope); Location(A0)
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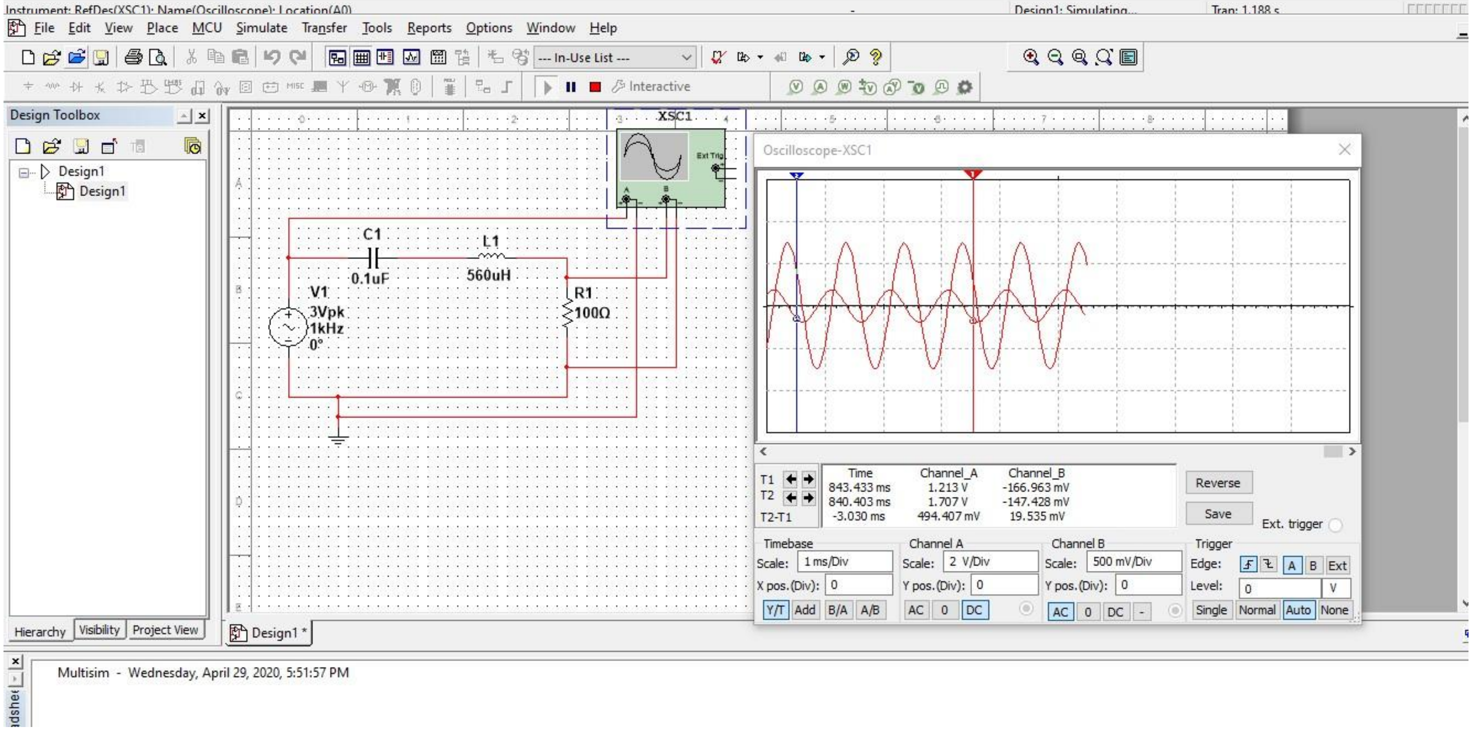
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Design1
Design1
XSC1
Ext Trig
C1
L1
0.1uF
560uH
V1
3Vpk
1kHz
0°
R1
100Ω
Oscilloscope-XSC1
T1
T2
T2-T1
Time
Channel_A
Channel_B
843.433 ms
1.213 V
-166.963 mV
840.403 ms
1.707 V
-147.428 mV
-3.030 ms
494.407 mV
19.535 mV
Reverse
Save
Ext. trigger
Timebase
Scale: 1 ms/Div
X pos.(Div): 0
Y/T Add B/A A/B
Channel A
Scale: 2 V/Div
Y pos.(Div): 0
AC 0 DC
Channel B
Scale: 500 mV/Div
Y pos.(Div): 0
AC 0 DC -
Trigger
Edge:
A B Ext
Level: 0 V
Single Normal Auto None
Hierarchy Visibility Project View
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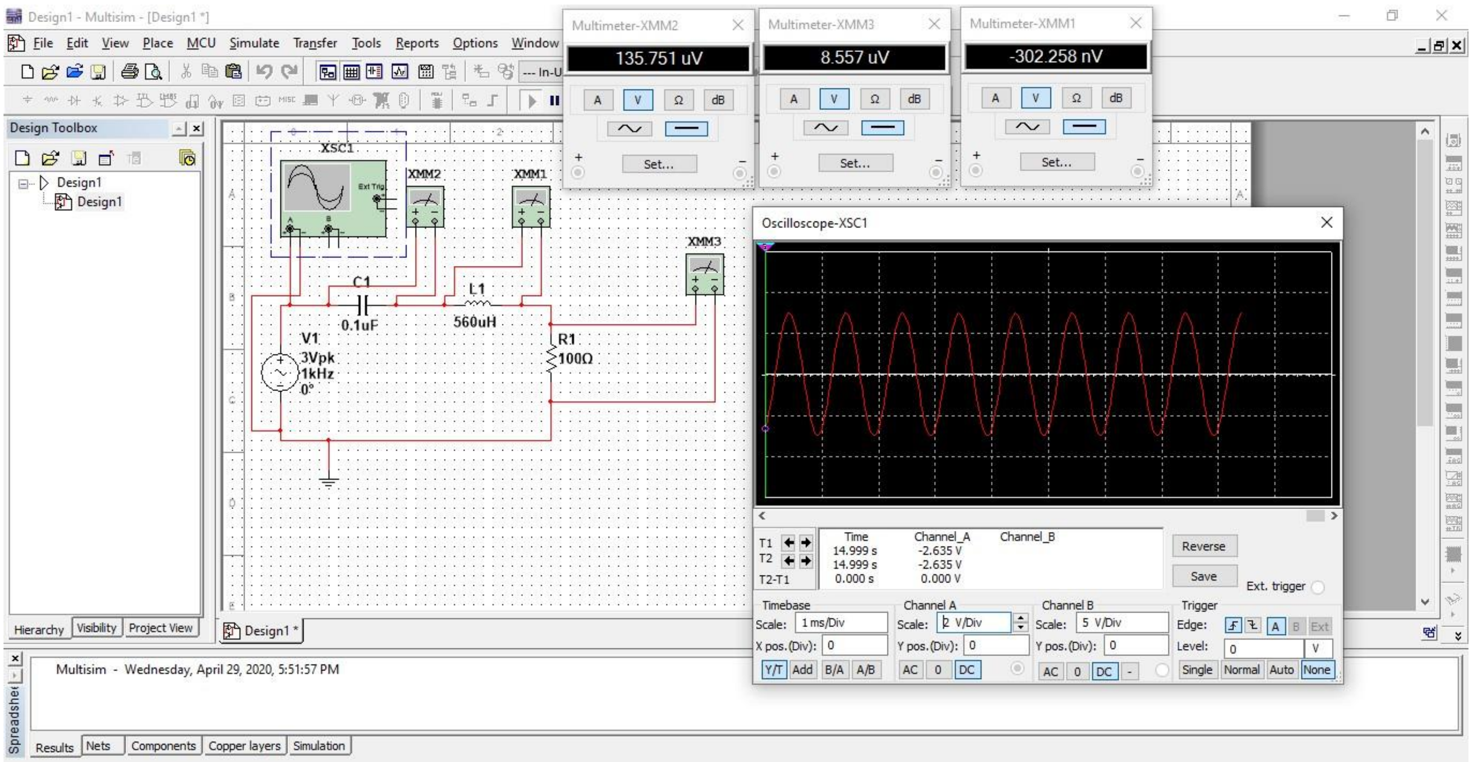
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Multimeter-XMM2
135.751 uV
Multimeter-XMM3
8.557 uV
Multimeter-XMM1
-302.258 nV
Design Toolbox
XSC1
XMM2
XMM1
XMM3
C1
0.1uF
L1
560uH
V1
3Vpk
1kHz
0°
R1
100Ω
Oscilloscope-XSC1
Time
Channel_A
Channel_B
T1
T2
T2-T1
14.999 s
14.999 s
0.000 s
-2.635 V
-2.635 V
0.000 V
Timebase
Scale: 1 ms/Div
Channel A
Scale: 2 V/Div
Channel B
Scale: 5 V/Div
Trigger
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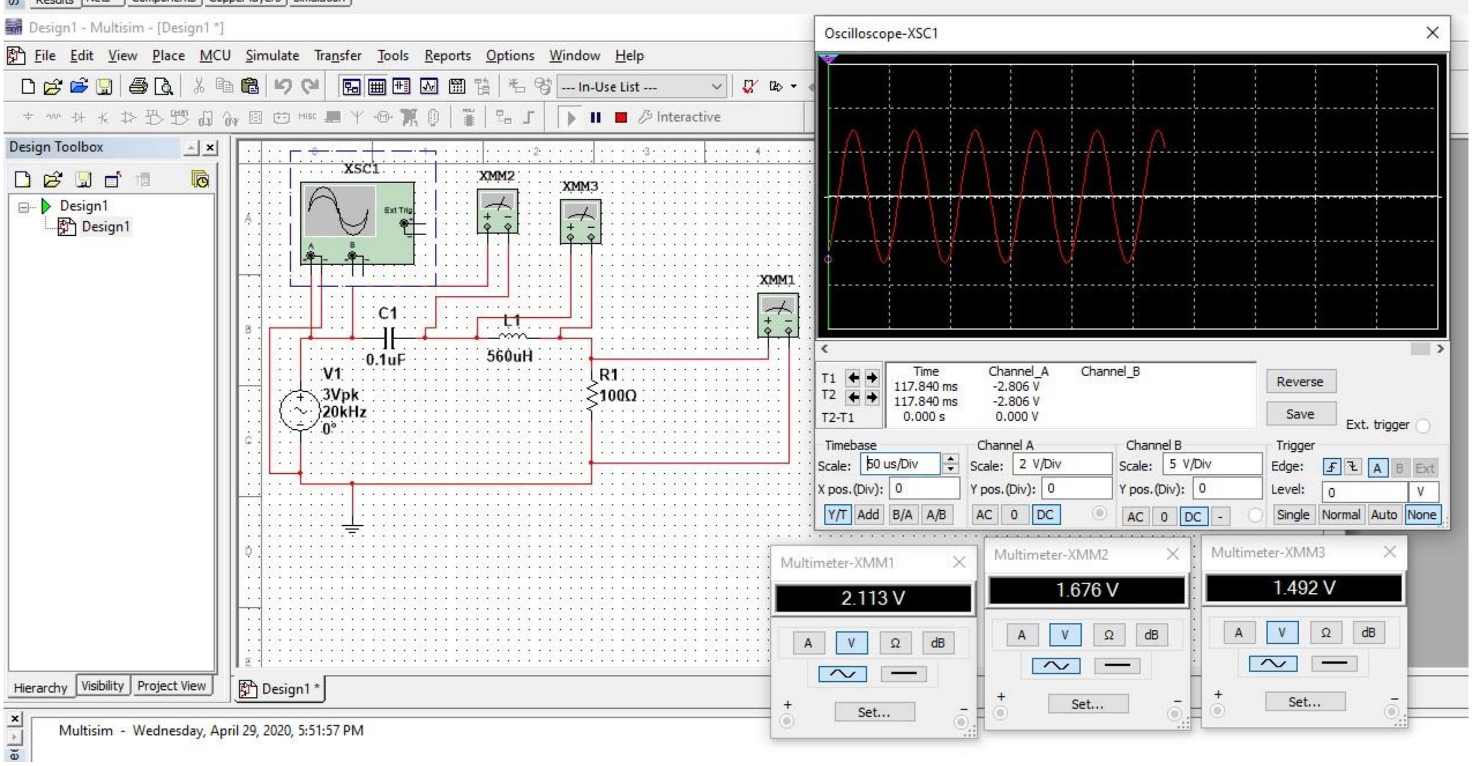
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Oscilloscope-XSC1
XSC1
XMM2
XMM3
XMM1
C1
0.1uF
L1
560uH
V1
3Vpk
20kHz
0°
R1
100Ω
Time
Channel_A
Channel_B
T1
T2
T2-T1
117.840 ms
117.840 ms
0.000 s
-2.806 V
-2.806 V
0.000 V
Timebase
Scale: 50 us/Div
Channel A
Scale: 2 V/Div
Channel B
Scale: 5 V/Div
Multimeter-XMM1
2.113 V
Multimeter-XMM2
1.676 V
Multimeter-XMM3
1.492 V
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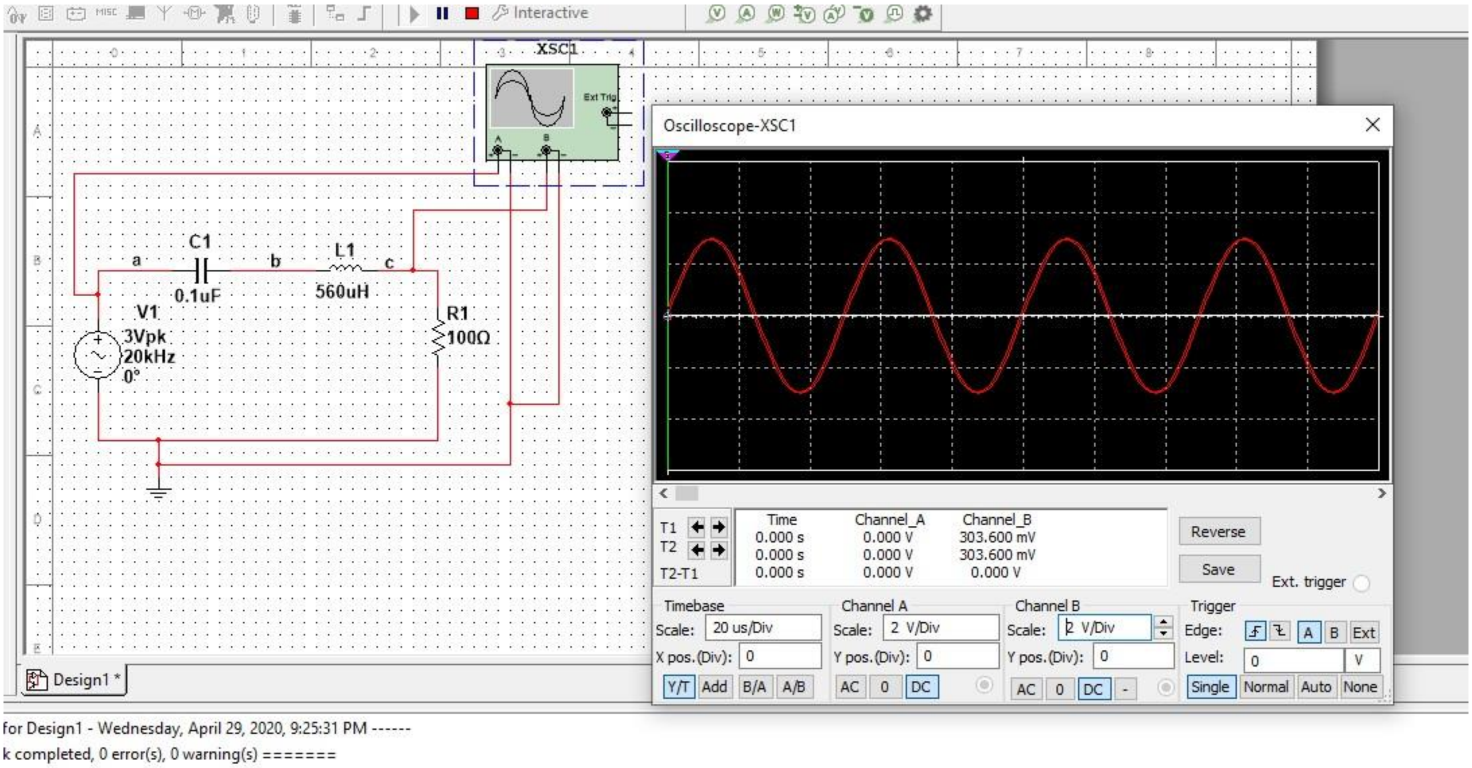

Interactive
XSC1
Oscilloscope-XSC1
C1
0.1uF
a
b
L1
560uH
c
R1
100Ω
V1
3Vpk
20kHz
0°
T1
T2
T2-T1
Time
0.000 s
0.000 s
0.000 s
Channel_A
0.000 V
0.000 V
0.000 V
Channel_B
303.600 mV
303.600 mV
0.000 V
Reverse
Save
Ext. trigger
Timebase
Scale: 20 us/Div
X pos.(Div): 0
Y/T Add B/A A/B
Channel A
Scale: 2 V/Div
Y pos.(Div): 0
AC 0 DC
Channel B
Scale: 2 V/Div
Y pos.(Div): 0
AC 0 DC -
Trigger
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Level: 0 V
Single Normal Auto None
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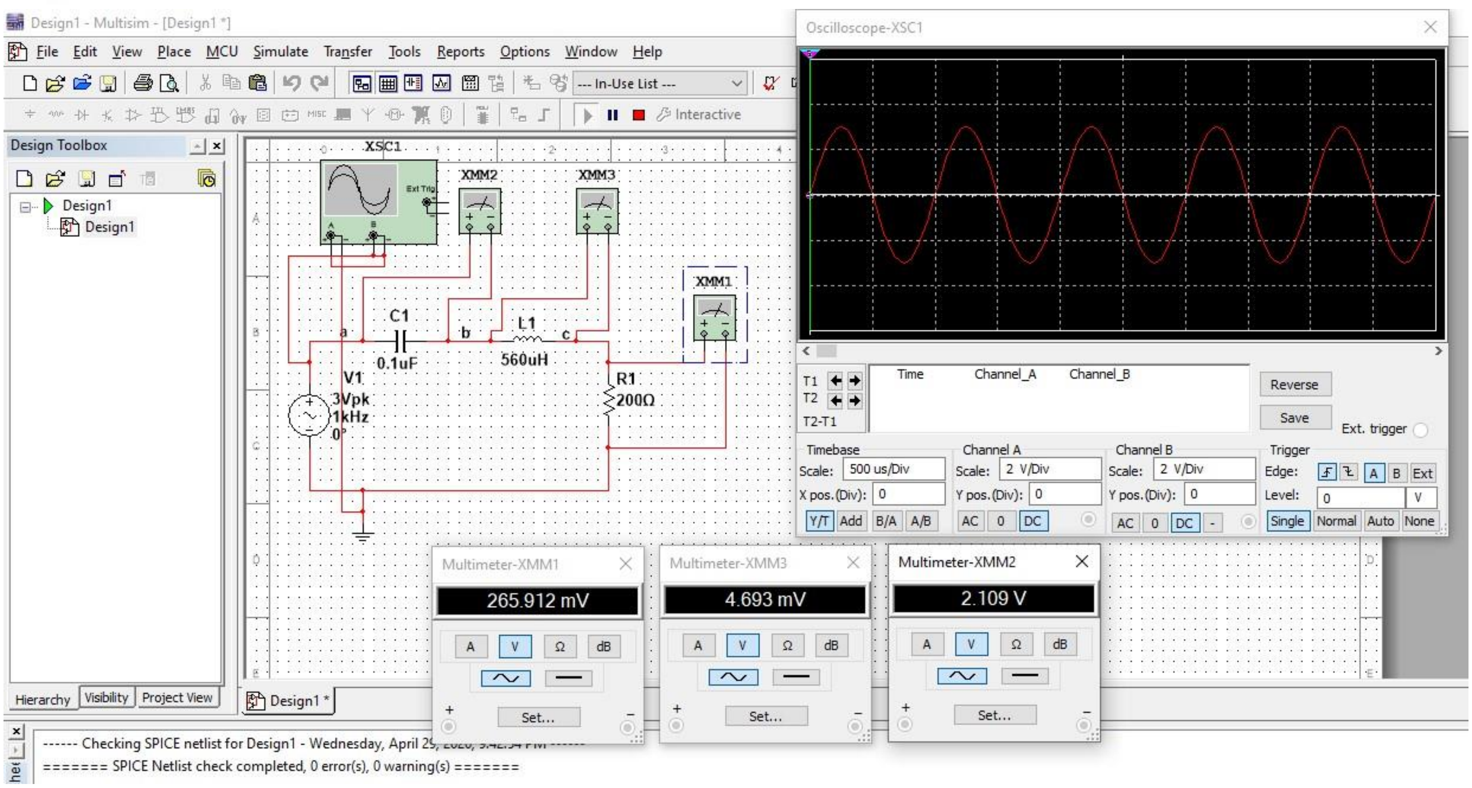

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Design1
Design1
XSC1
XMM2
XMM3
XMM1
C1
0.1uF
a
b
L1
560uH
c
R1
200Ω
V1
3Vpk
1kHz
0°
Oscilloscope-XSC1
T1
T2
T2-T1
Time
Channel_A
Channel_B
Reverse
Save
Ext. trigger
Timebase
Scale: 500 us/Div
X pos.(Div): 0
Y/T Add B/A A/B
Channel A
Scale: 2 V/Div
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
Multimeter-XMM1
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Multimeter-XMM3
4.693 mV
Multimeter-XMM2
2.109 V
A V Ω dB
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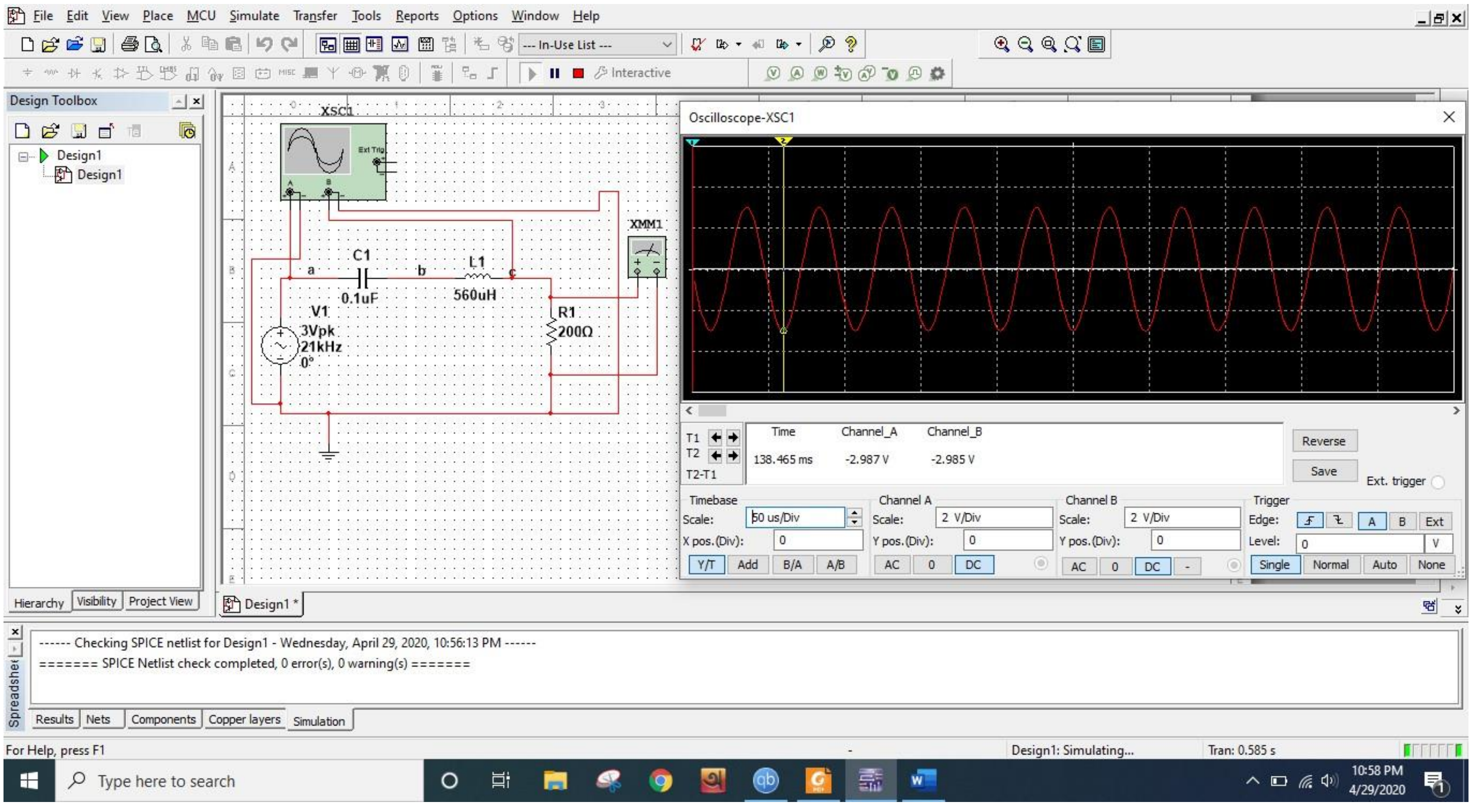
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Design1
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L1
560uH
a
b
c
V1
3Vpk
21kHz
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R1
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Oscilloscope-XSC1
Time
Channel_A
Channel_B
T1
T2
T2-T1
138.465 ms
-2.987 V
-2.985 V
Reverse
Save
Ext. trigger
Timebase
Scale:
50 us/Div
X pos.(Div):
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Y/T
Add
B/A
A/B
Channel A
Scale:
2 V/Div
Y pos.(Div):
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DC
Channel B
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2 V/Div
Y pos.(Div):
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Components
Copper layers
Simulation
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Type here to search
10:58 PM
4/29/2020