INDRAPRASTHA INSTITUTE *of*
INFORMATION TECHNOLOGY
DELHI

Department
of
Electronics & Communication Engineering

Circuit Theory and Devices

Dr. Shobha Sundar Ram

Lab_3: Filters
Week_3

Mohammad Shariq
2020220
12-Oct-2021

Objective:

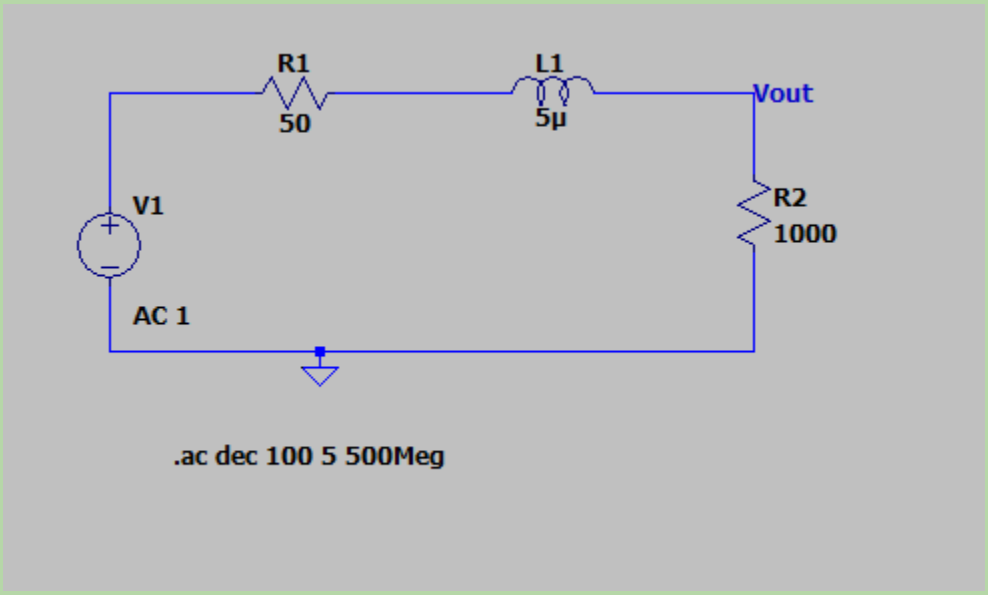
1. Design first, second and third order low pass filters in LTSpice.
2. Plot the magnitude and phase response of the filters in a Bode plot.
3. Observe how the filters reduce the ripples on the pulsating DC output of the rectifier circuit.

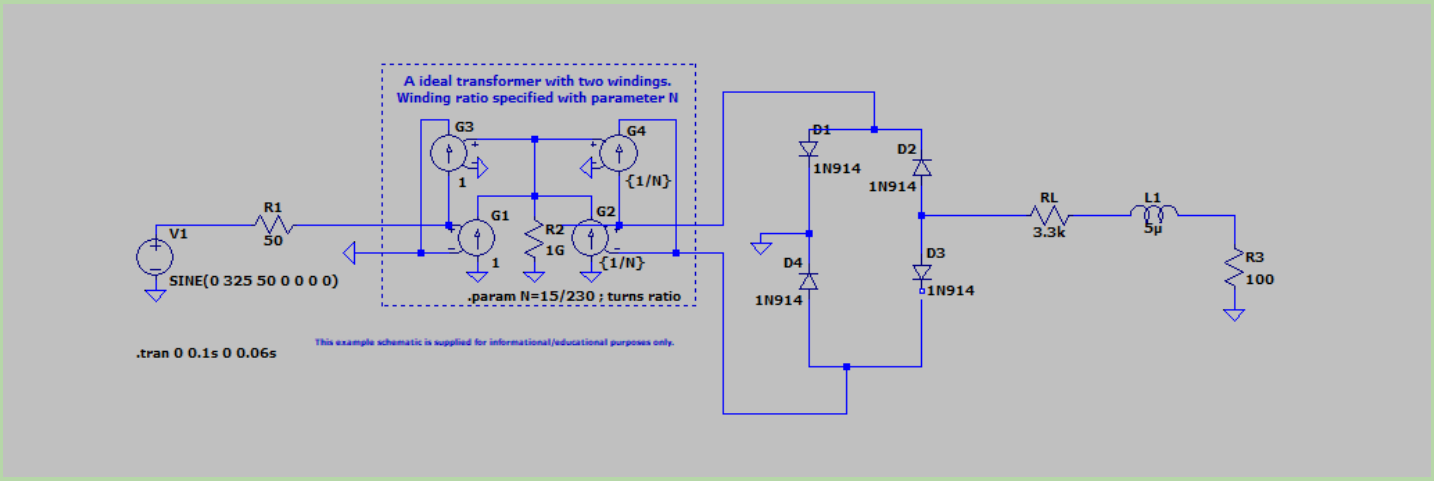
Components Used:

- LTSpice as Simulation Software
- Transformer
- Diode
- Inductor
- Capacitor
- Voltage Source
- Resistors

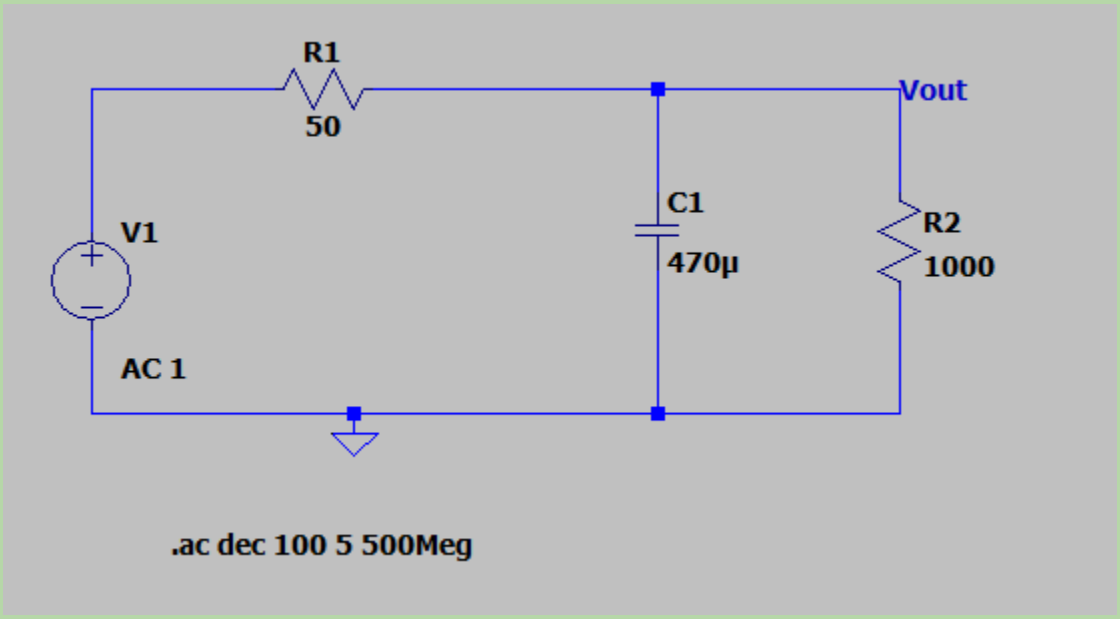
Diagram:

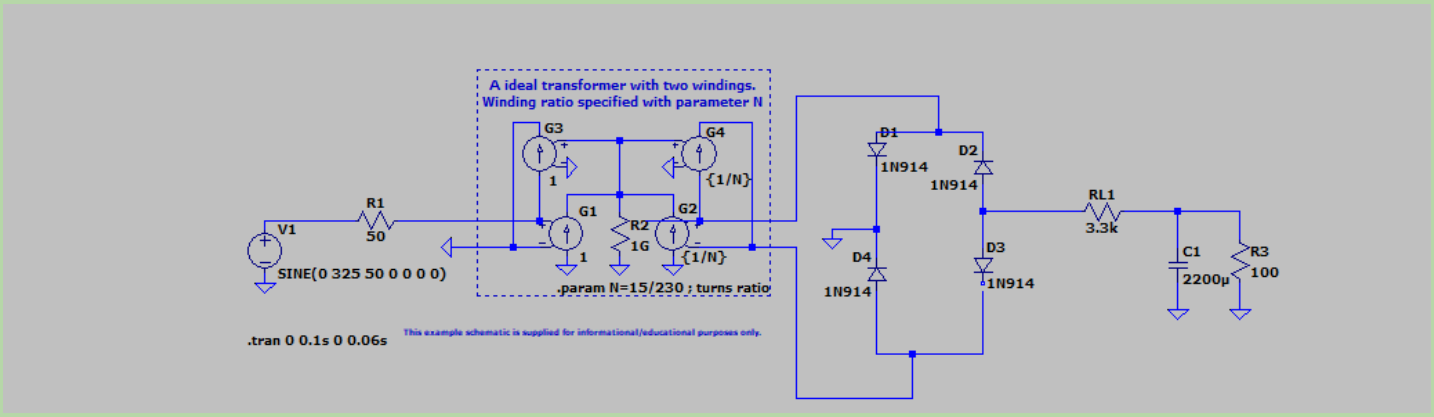
- **Series Inductor filter**





- **Shunt Capacitor filter**





- **LC filter circuit**

A second order LPF filter circuit can be obtained by connecting a series inductance followed by a shunt capacitor as shown below.

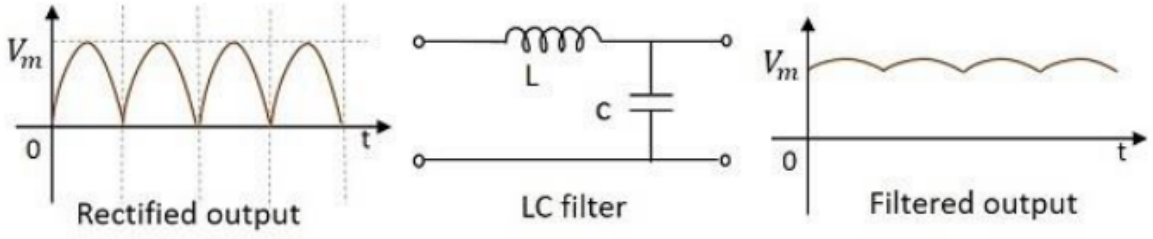
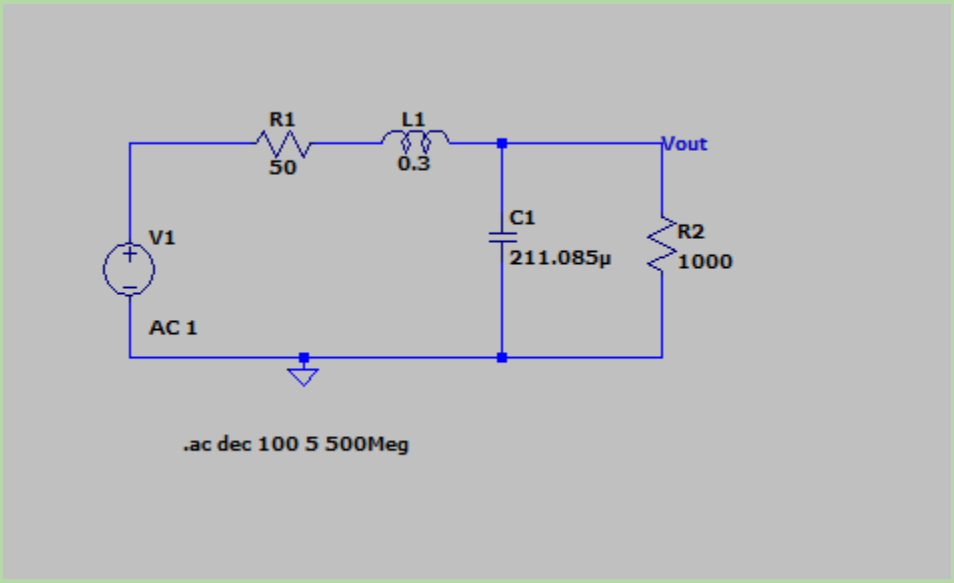


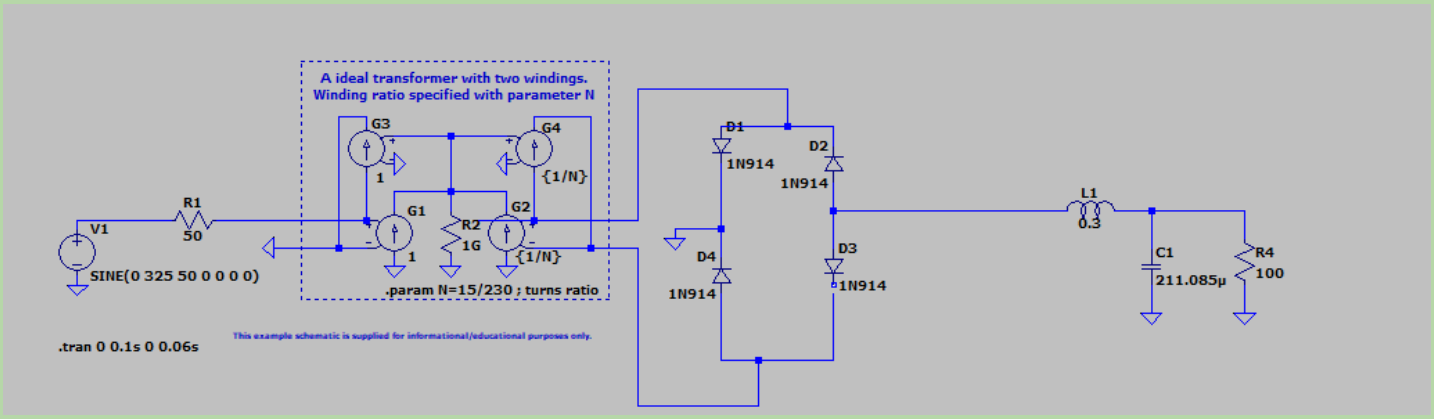
Fig.1. Rectifier output is fed to the input of an LC filter in order to obtain a filtered output (web link)

The cut-off frequency of this filter is determined by the L and C.

$$f = 1/2\Pi\sqrt{LC}$$

With the increased hardware complexity, we may obtain smoother DC output.





- **PI Filter**

A third order circuit can be configured for obtaining an even smoother response as shown below.

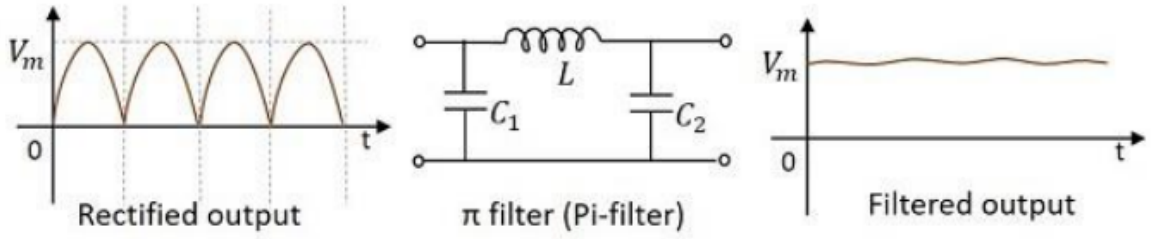
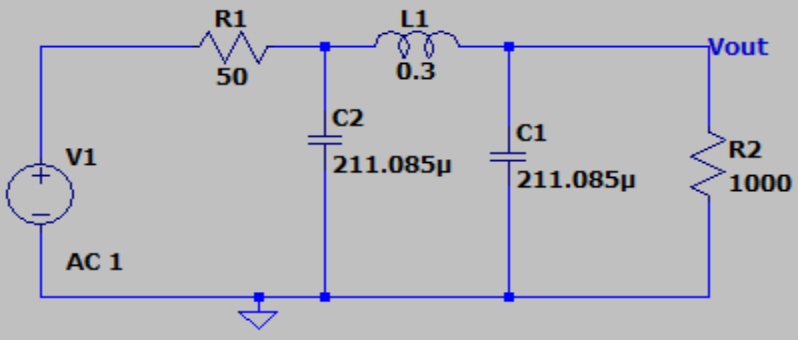
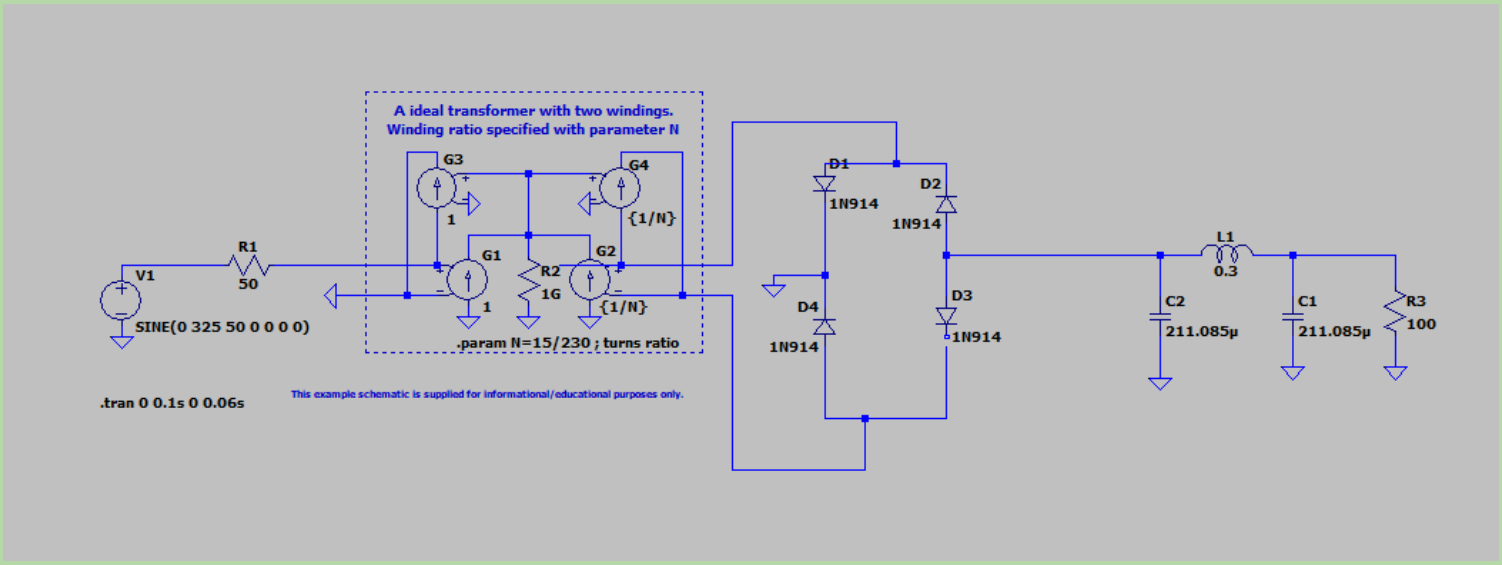


Fig.2 Rectifier output is fed to the input of a Pi filter in order to obtain a filtered output Pi Filter (web link)

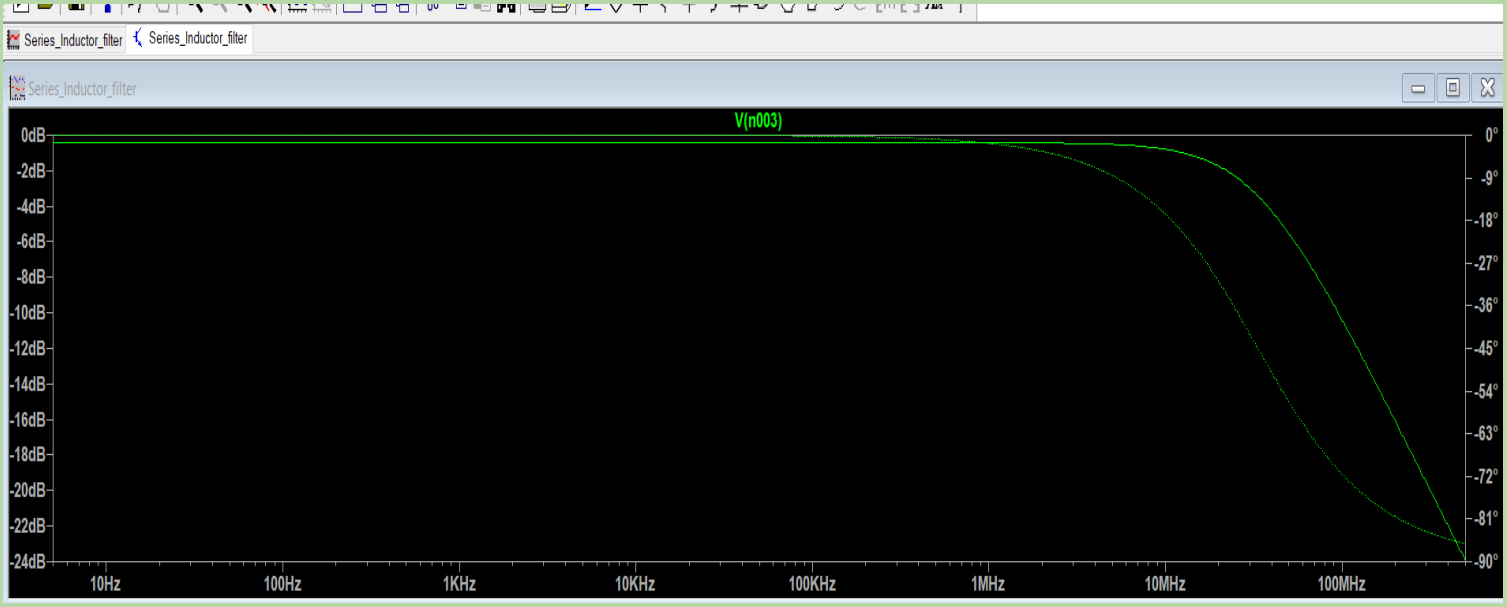


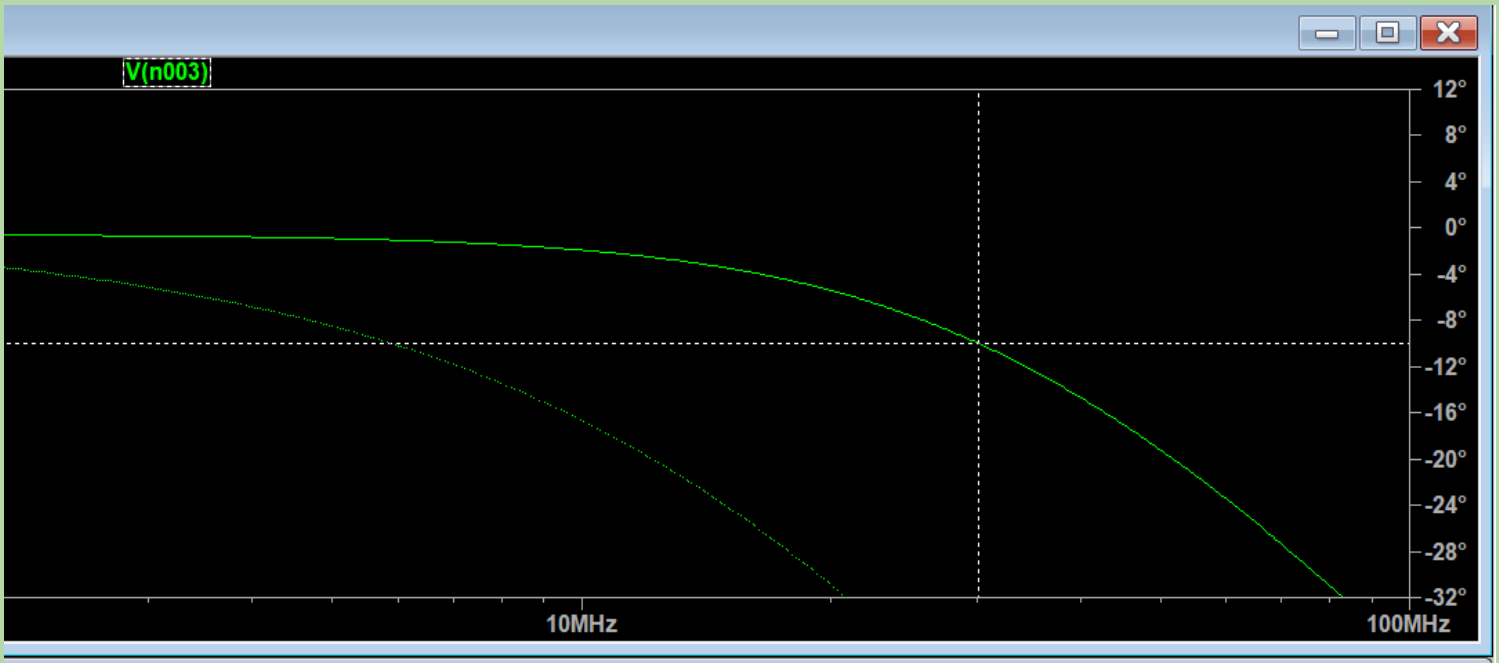
.ac dec 100 5 1Meg

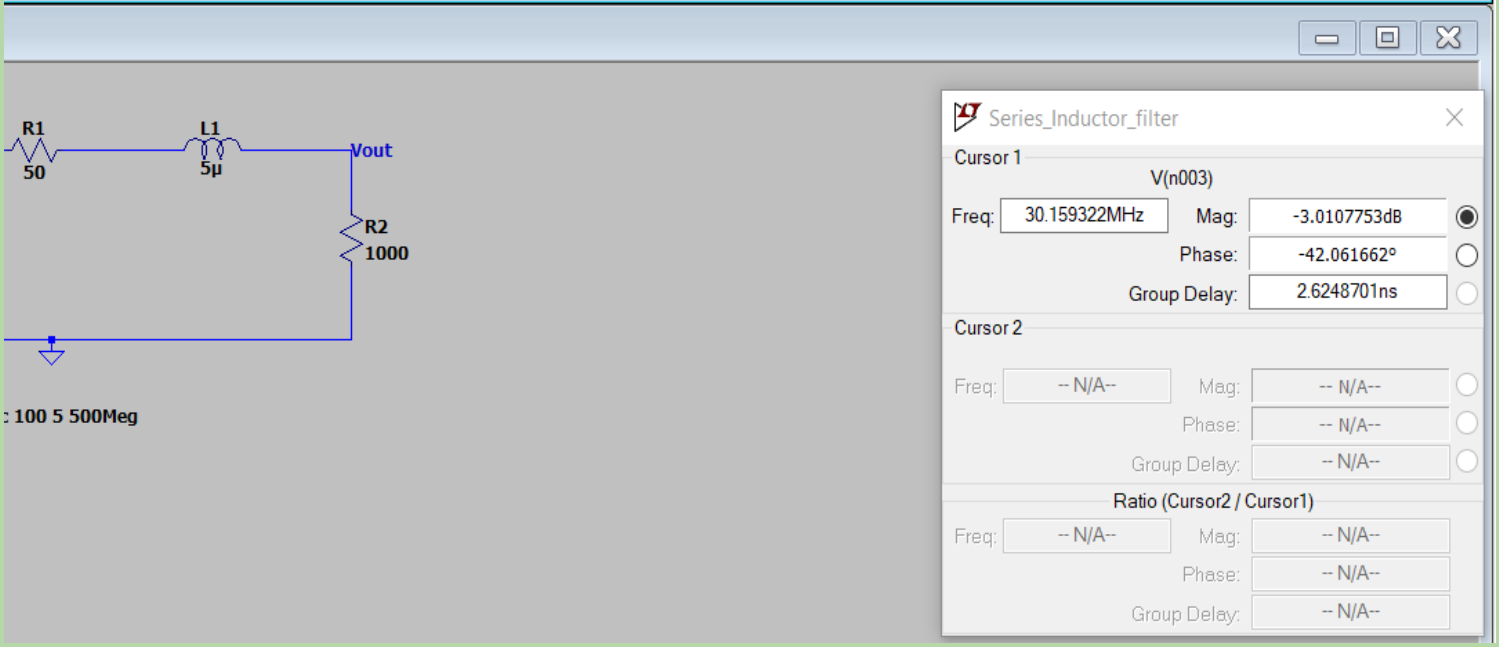


Plots:

- **Series Inductor filter**







Series_Inductor_filter

Cursor 1

V(n003)

Freq:	30.159322MHz	Mag:	-3.0107753dB
		Phase:	-42.061662°
		Group Delay:	2.6248701ns

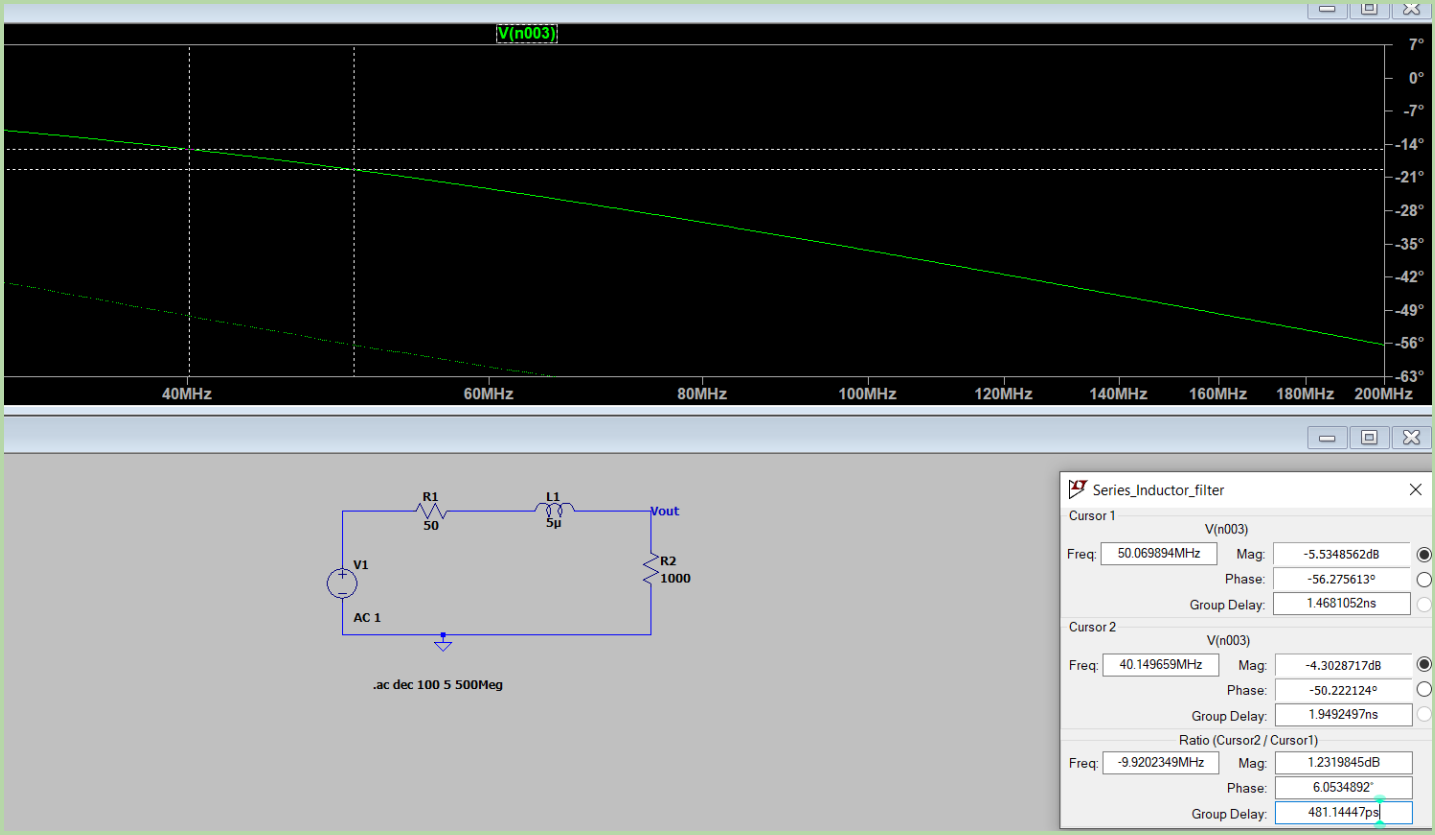
Cursor 2

Freq:	-- N/A--	Mag:	-- N/A--
		Phase:	-- N/A--
		Group Delay:	-- N/A--

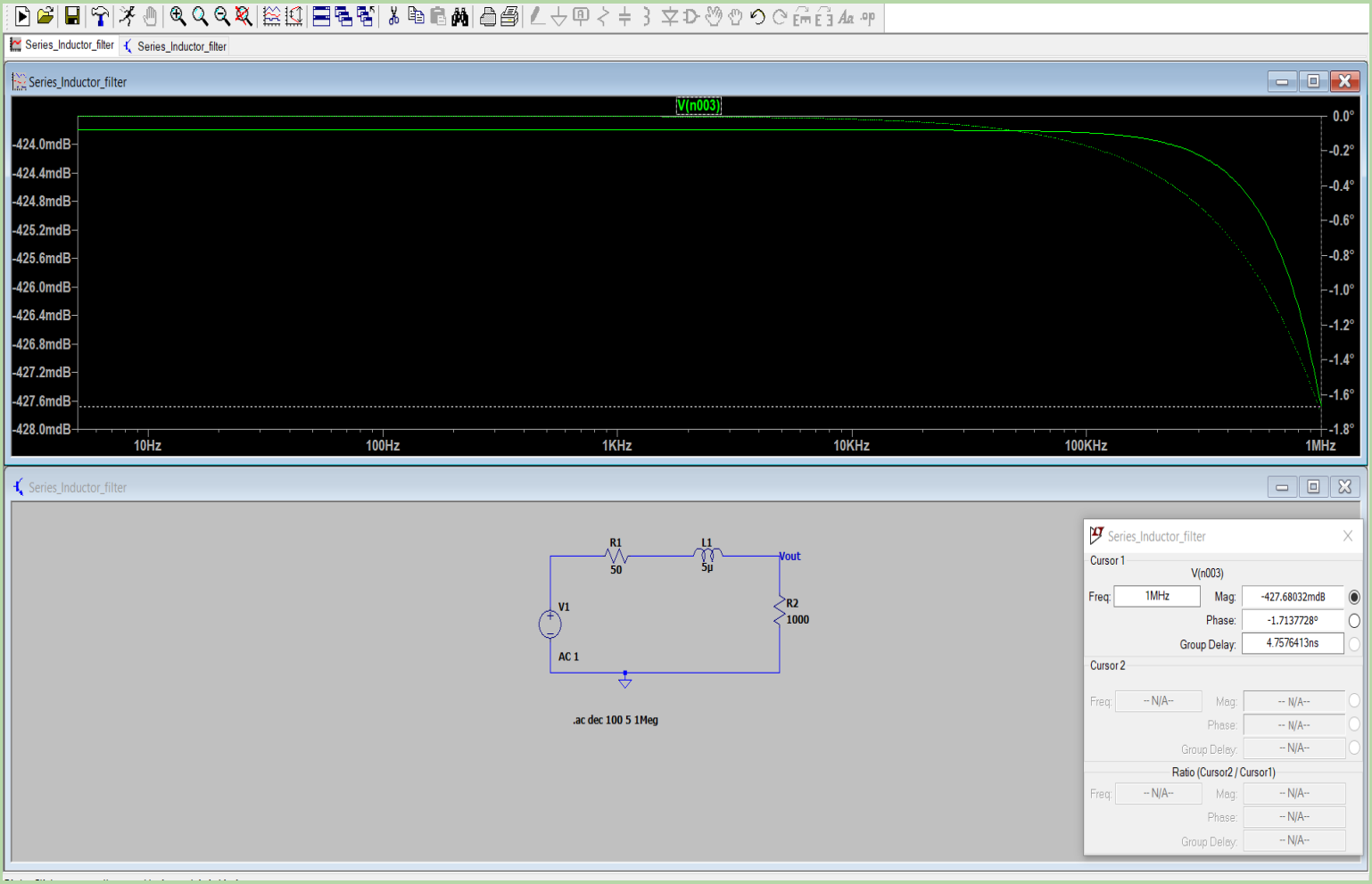
Ratio (Cursor2 / Cursor1)

Freq:	-- N/A--	Mag:	-- N/A--
		Phase:	-- N/A--
		Group Delay:	-- N/A--

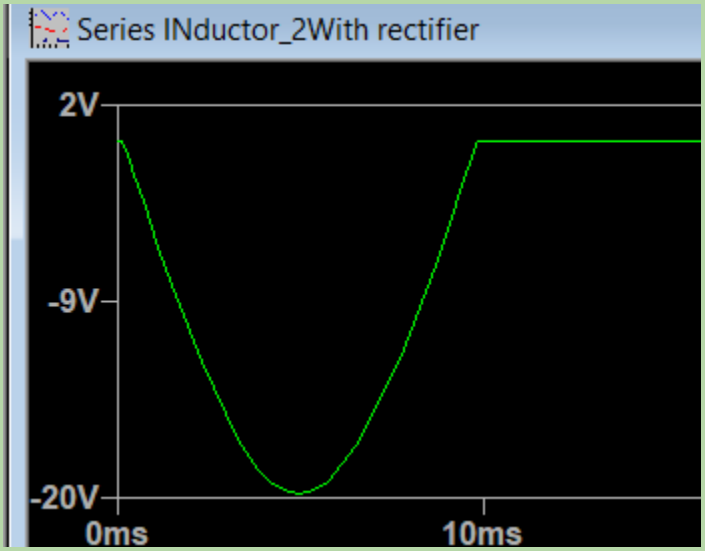
Roll off Rate:



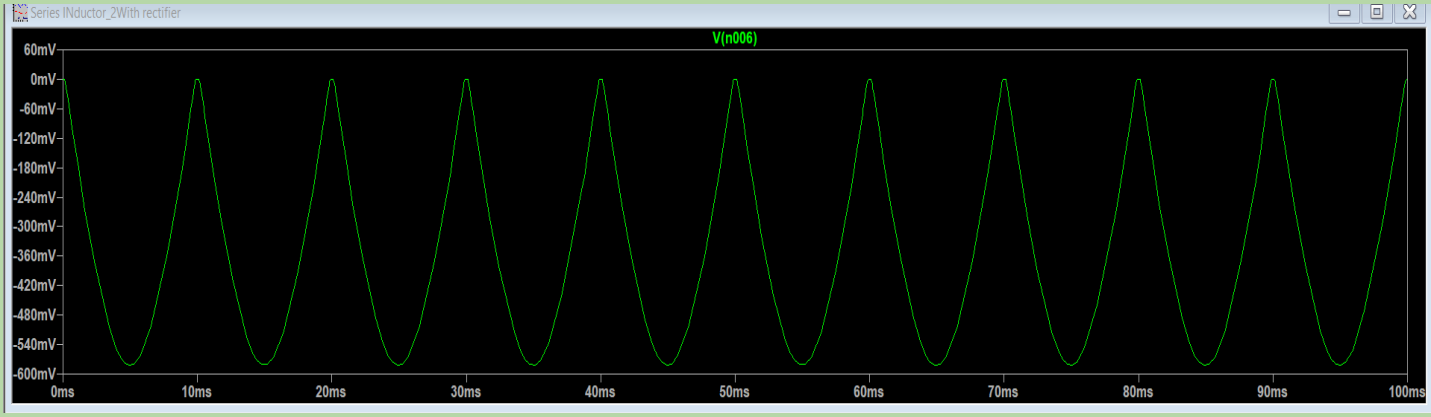
plot the phase response of the filter circuit from 5Hz to 1MHz. :

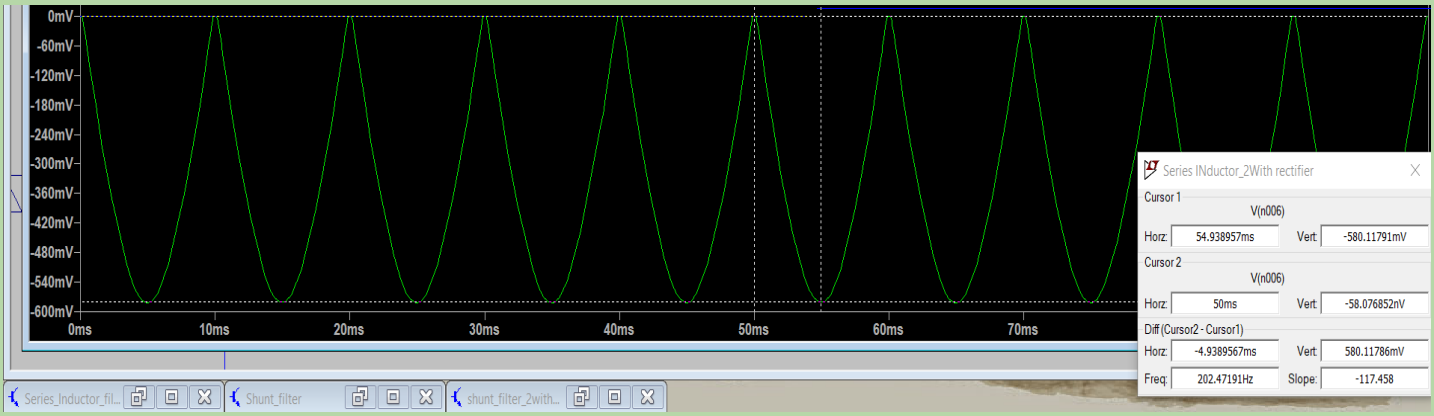


Lab.2 rectifier circuit in the absence of the filter.The difference between the maximum and minimum provides the ripple voltage of the circuit.

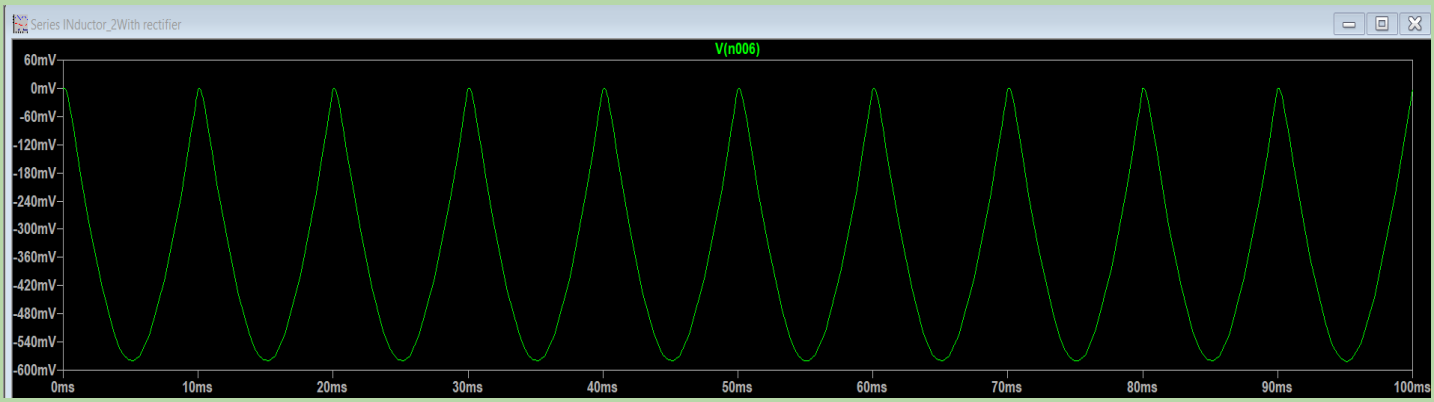


Insert the series L filter with the output from load resistance in the rectifier circuit. Again, run the transient simulation and plot the time-domain output voltage. Compute the ripple voltage of this output. For a frequency of 50Hz, compute the impedance offered by this inductance.

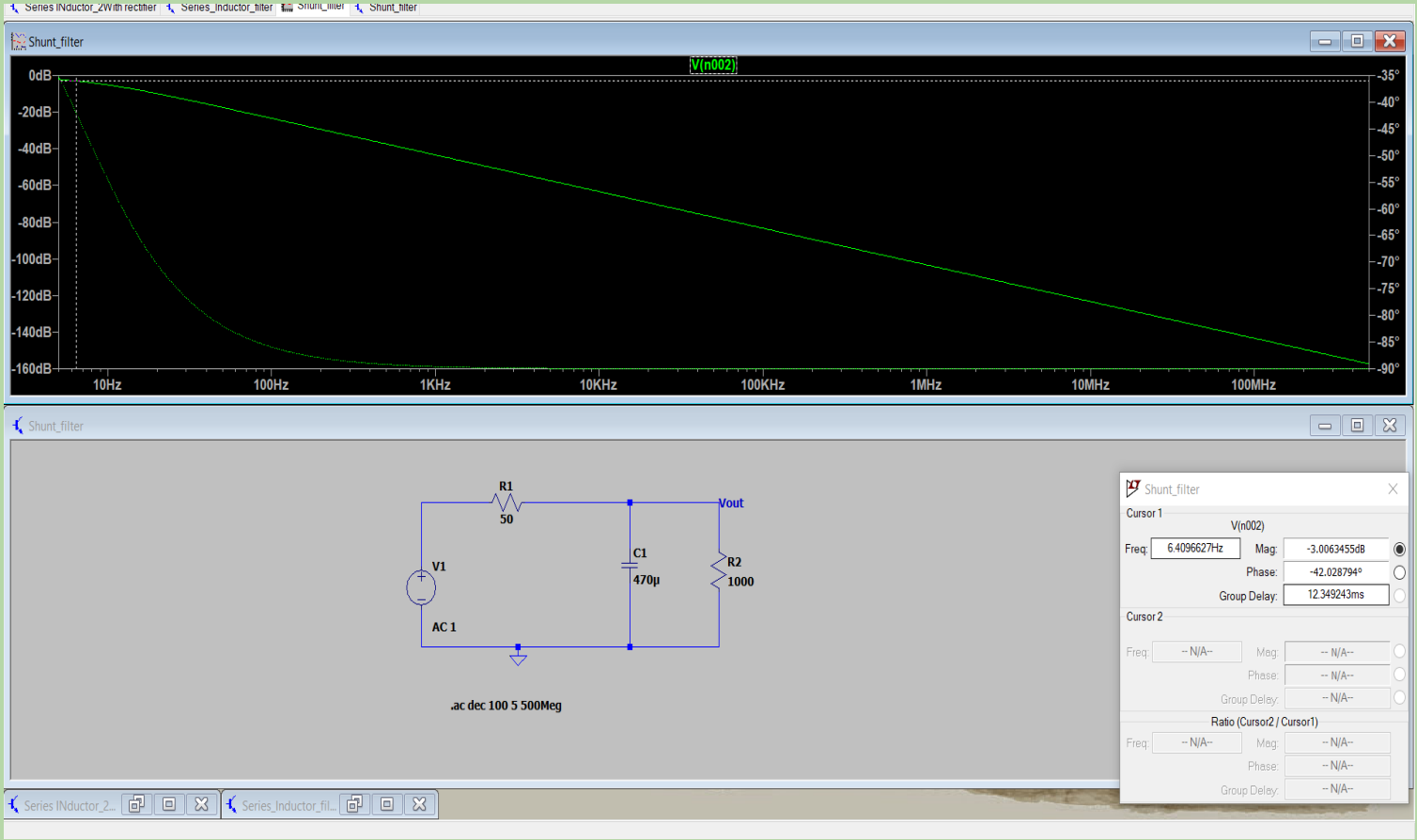


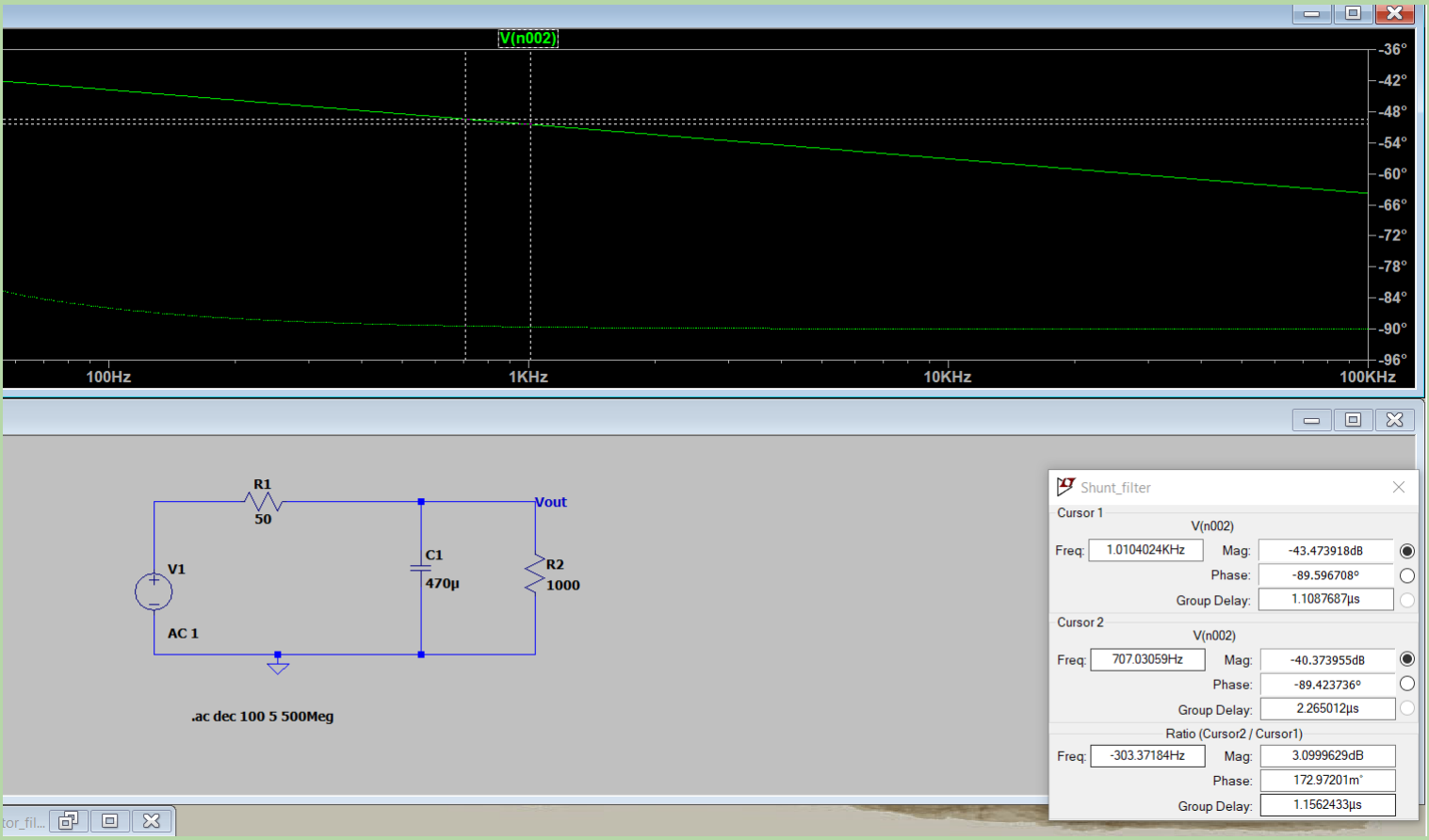


Increase the inductance value to 500mH. Repeat previous step.

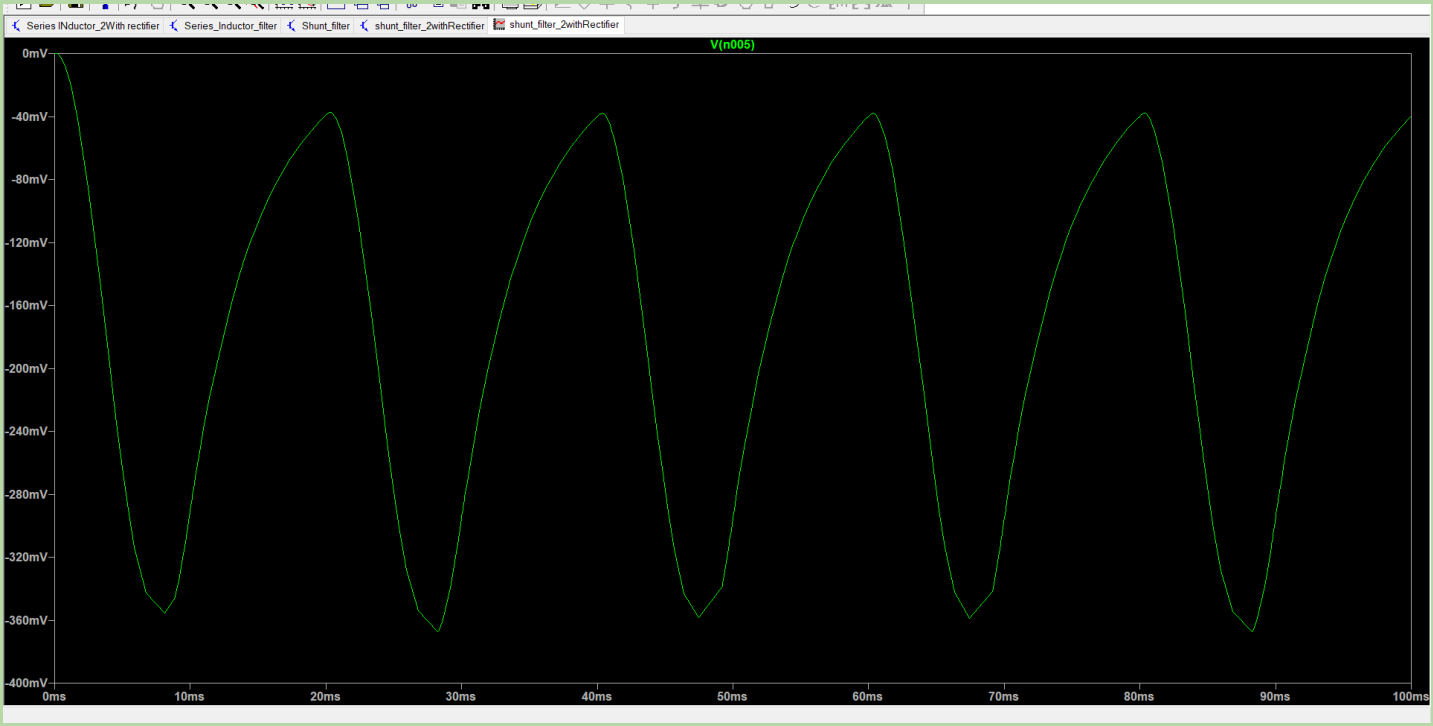


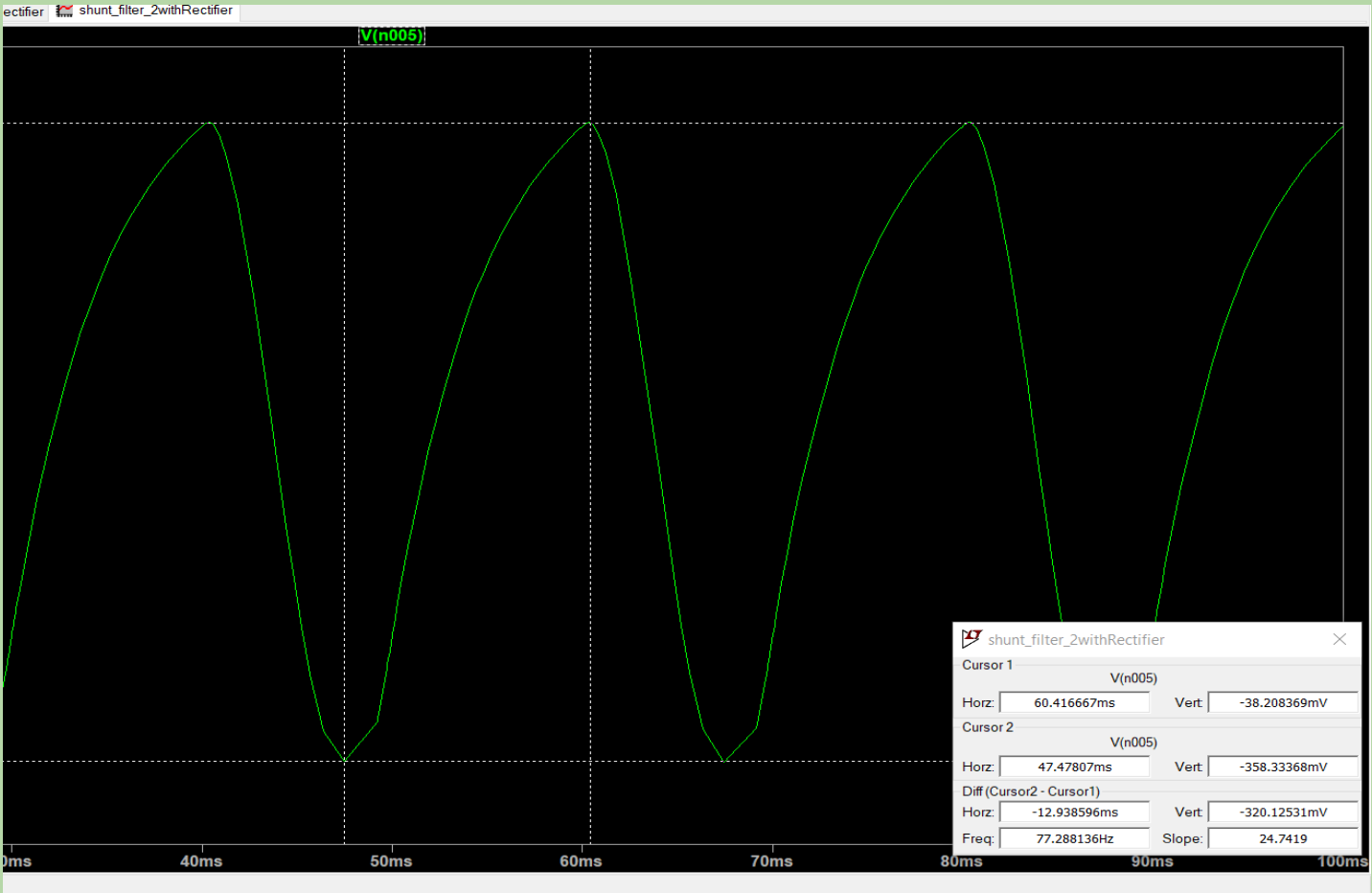
- Shunt Capacitor filter





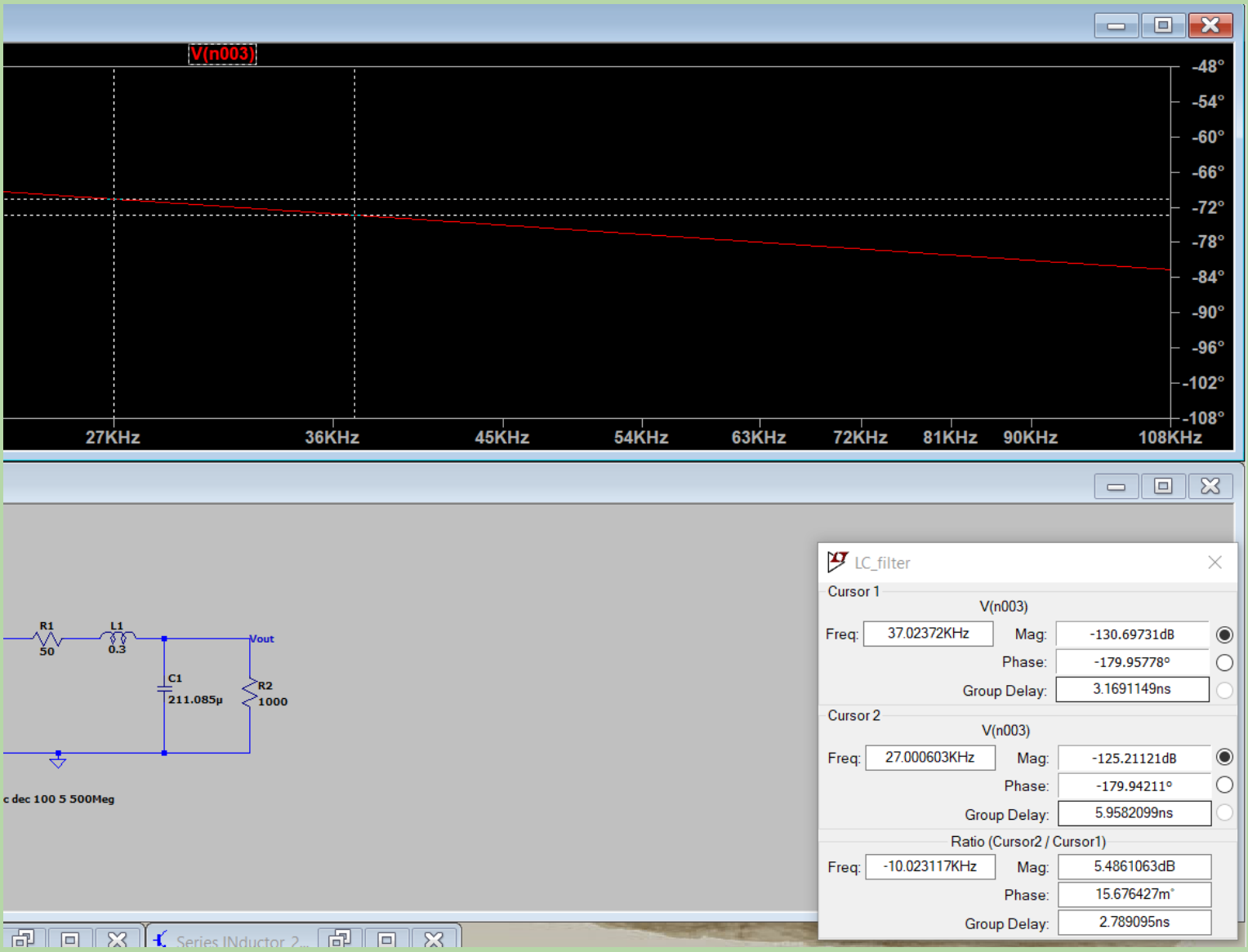
Insert a shunt capacitance of 50uF with the output from load resistance in the rectifier circuit. Again, run the transient simulation and plot the time-domain output voltage. Compute the ripple voltage of this output. For a frequency of 50Hz, compute the impedance offered by this capacitance.


Series INductor_2With rectifier
Series_Inductor_filter
Shunt_filter
shunt_filter_2withRectifier
shunt_filter_2withRectifier
V(n005)
0mV
-40mV
-80mV
-120mV
-160mV
-200mV
-240mV
-280mV
-320mV
-360mV
-400mV
0ms
10ms
20ms
30ms
40ms
50ms
60ms
70ms
80ms
90ms
100ms

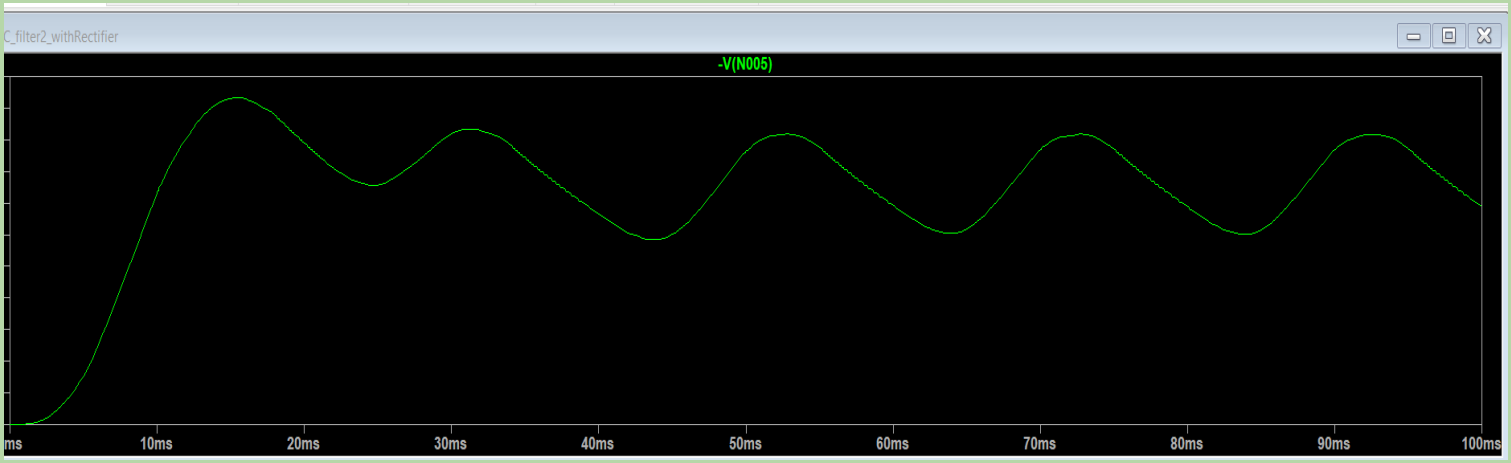

ectifier
shunt_filter_2withRectifier
V(n005)
0ms
40ms
50ms
60ms
70ms
80ms
90ms
100ms
shunt_filter_2withRectifier
Cursor 1
V(n005)
Horz: 60.416667ms
Vert: -38.208369mV
Cursor 2
V(n005)
Horz: 47.47807ms
Vert: -358.33368mV
Diff (Cursor2 - Cursor1)
Horz: -12.938596ms
Vert: -320.12531mV
Freq: 77.288136Hz
Slope: 24.7419

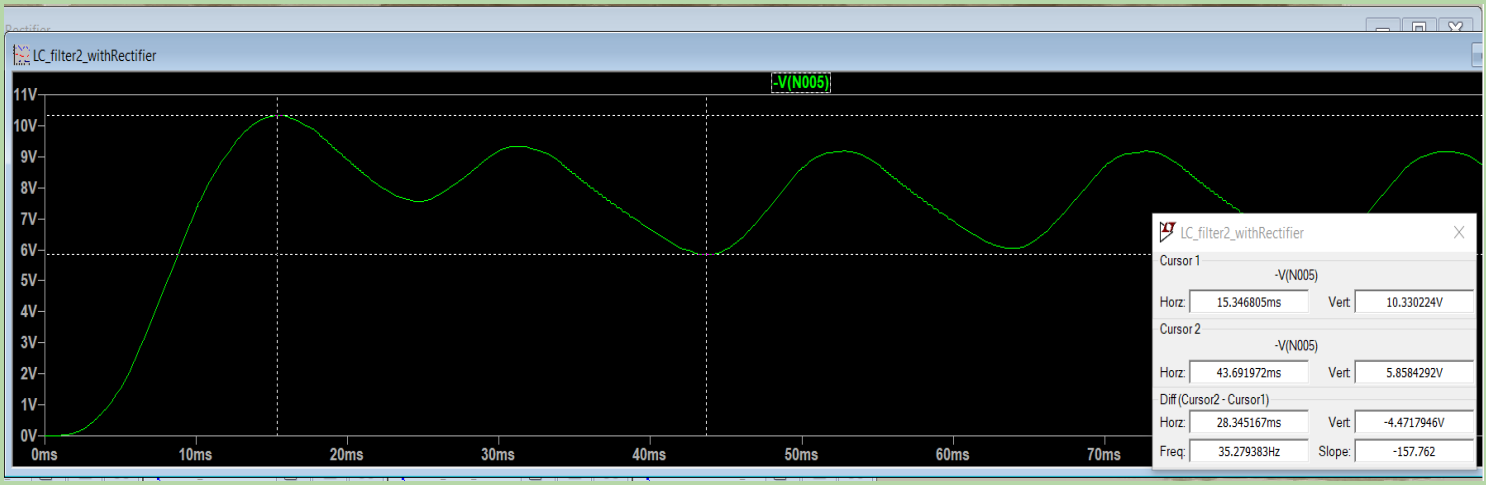
Increase the smoothing capacitance value to 2200uF and repeating previous step.

- L-C Filter :


V(n003)
-48°
-54°
-60°
-66°
-72°
-78°
-84°
-90°
-96°
-102°
-108°
27KHz
36KHz
45KHz
54KHz
63KHz
72KHz
81KHz
90KHz
108KHz
R1
50
L1
0.3
Vout
C1
211.085µ
R2
1000
c dec 100 5 500Meg
LC_filter
Cursor 1
V(n003)
Freq: 37.02372KHz
Mag: -130.69731dB
Phase: -179.95778°
Group Delay: 3.1691149ns
Cursor 2
V(n003)
Freq: 27.000603KHz
Mag: -125.21121dB
Phase: -179.94211°
Group Delay: 5.9582099ns
Ratio (Cursor2 / Cursor1)
Freq: -10.023117KHz
Mag: 5.4861063dB
Phase: 15.676427m°
Group Delay: 2.789095ns

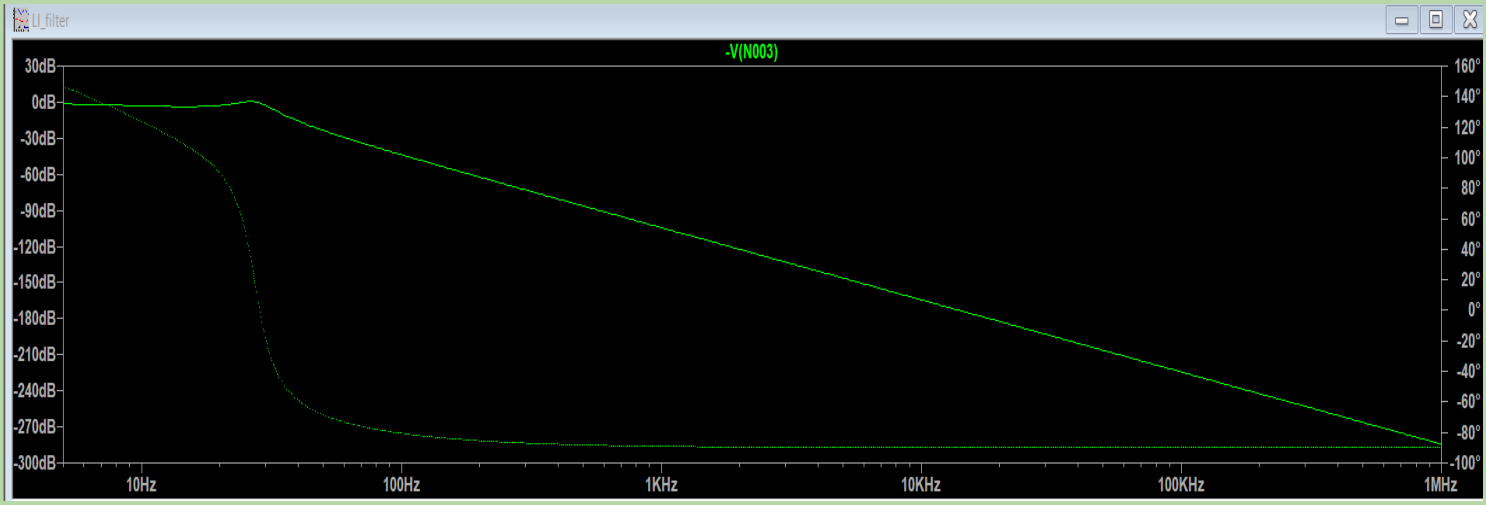
Insert a LC filter with the output from load resistance in the rectifier circuit. Again, run the transient simulation and plot the time-domain output voltage. Compute the ripple voltage of this output.

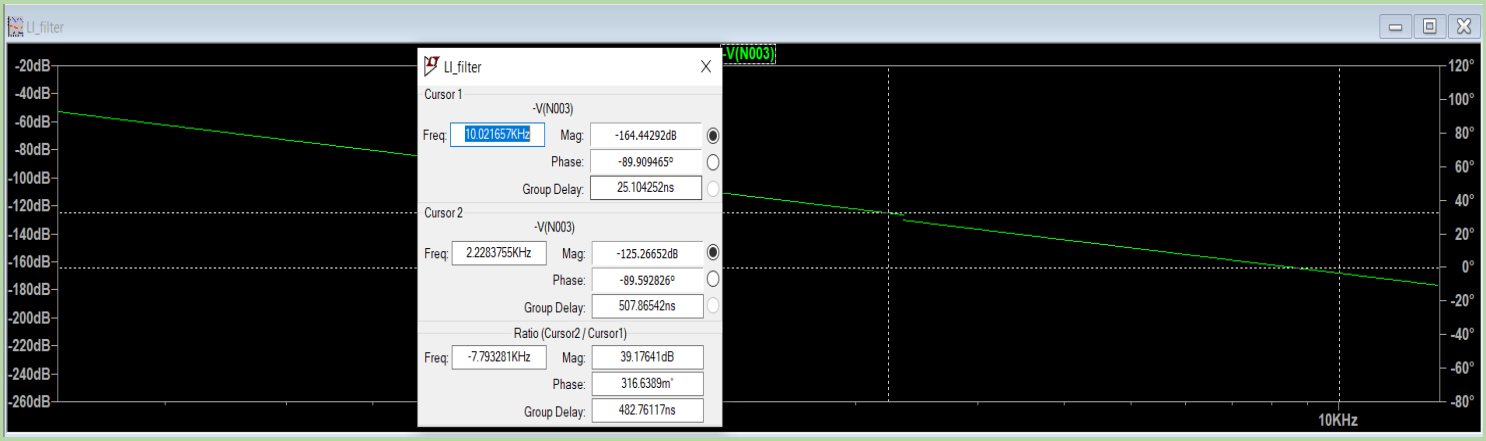




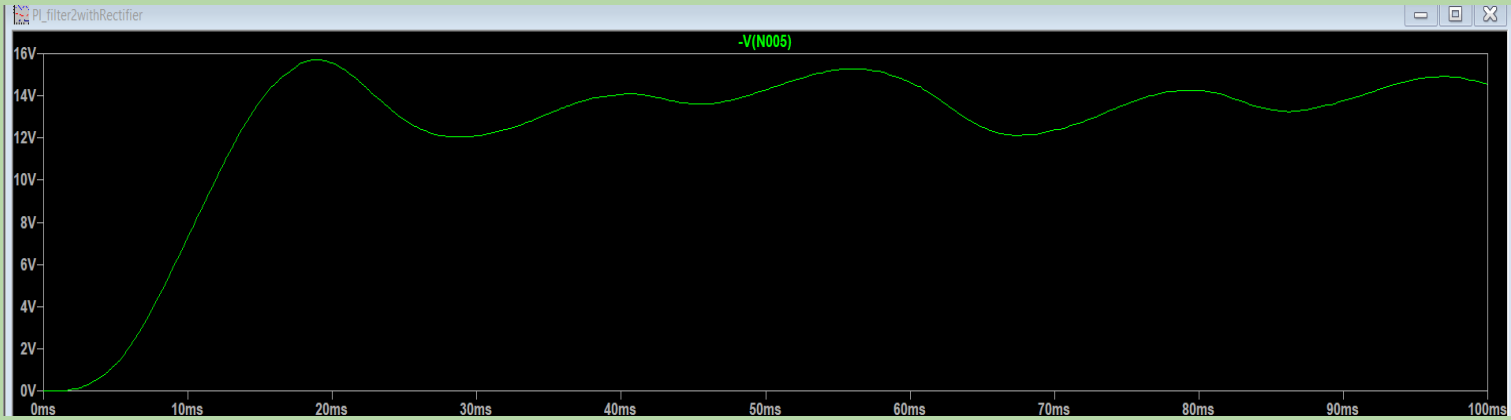
- **PI-Filter:**

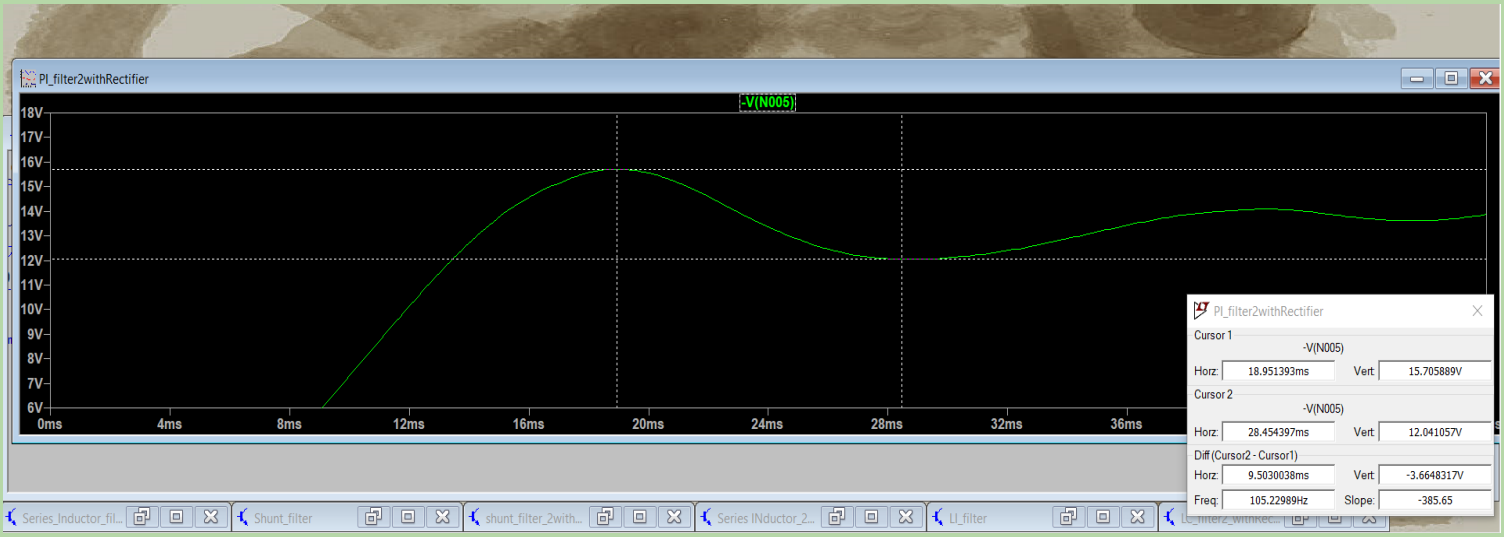

LI_filter
-V(N003)
40dB
0dB
-40dB
-80dB
-120dB
-160dB
-200dB
-240dB
-280dB
-320dB
-360dB
-400dB
-440dB
-480dB
160°
140°
120°
100°
80°
60°
40°
20°
0°
-20°
-40°
-60°
-80°
-100°
10Hz
100Hz
1KHz
10KHz
100KHz
1MHz
10MHz
100MHz


LI_filter
-V(N003)
30dB
0dB
-30dB
-60dB
-90dB
-120dB
-150dB
-180dB
-210dB
-240dB
-270dB
-300dB
160°
140°
120°
100°
80°
60°
40°
20°
0°
-20°
-40°
-60°
-80°
-100°
10Hz
100Hz
1KHz
10KHz
100KHz
1MHz


LI_filter
-V(N003)
-20dB
-40dB
-60dB
-80dB
-100dB
-120dB
-140dB
-160dB
-180dB
-200dB
-220dB
-240dB
-260dB
120°
100°
80°
60°
40°
20°
0°
-20°
-40°
-60°
-80°
10KHz
LI_filter
Cursor 1
-V(N003)
Freq: 10.021657KHz
Mag: -164.44292dB
Phase: -89.909465°
Group Delay: 25.104252ns
Cursor 2
-V(N003)
Freq: 2.2283755KHz
Mag: -125.26652dB
Phase: -89.592826°
Group Delay: 507.86542ns
Ratio (Cursor2 / Cursor1)
Freq: -7.793281KHz
Mag: 39.17641dB
Phase: 316.6389m°
Group Delay: 482.76117ns

Insert a Pi filter with the output from load resistance in the rectifier circuit. Again, run the transient simulation and plot the time-domain output voltage. Compute the ripple voltage of this output





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