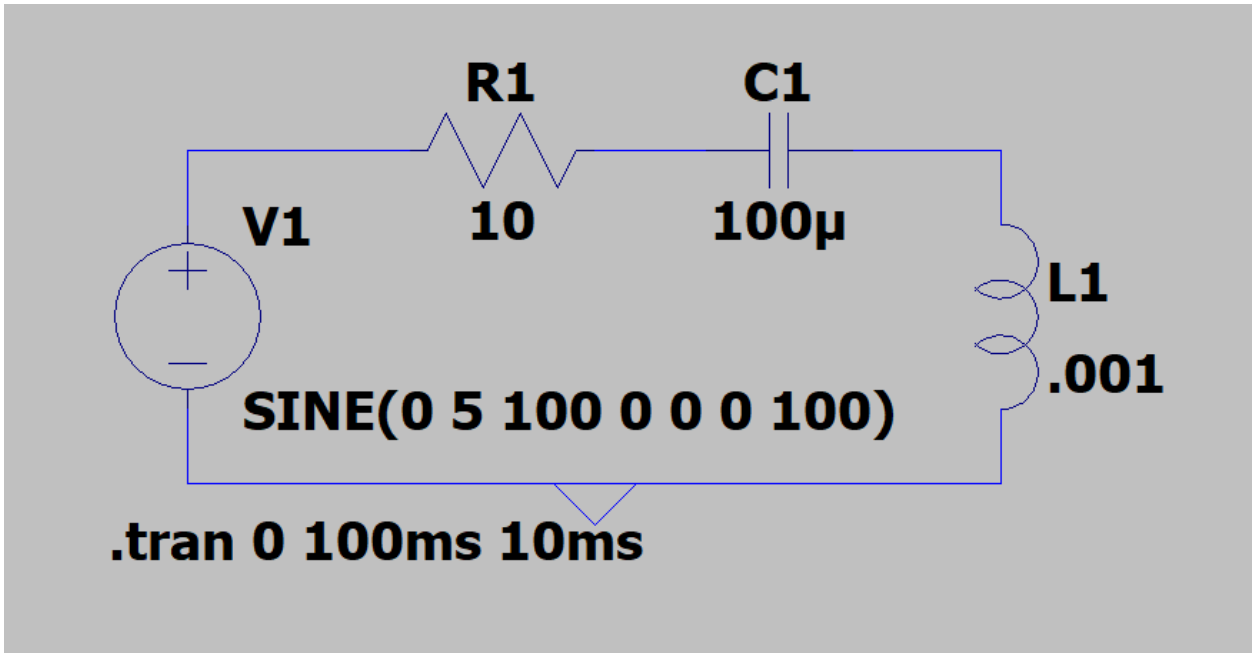
ECE113|BASIC ELECTRONICS
Dr. S.S.Jamuar
Lab_5:
Student Name : Shivam Agarwal
Roll No. : 2020123
Date : 31/7/2021

AIM 1 : To draw the phasor diagram of a series RLC circuit and compare the experimental and theoretical results.

Components Used : voltage source ,resistor ,inductor, capacitor , wires.

Software used : LTspice

Circuit Diagram



Theoretical calculations(for ideal inductor**) :**

1) For f = 100Hz

For frequency = 100 Hz.

$\omega = 2\pi\nu = 2\pi \cdot 100 = 628$.

$R = 10\Omega$, $L = 0.001H$, $C = 100\mu f$.

$X_L = j\omega L = j(0.628)\ \Omega$.

$X_C = -j\frac{1}{\omega C} = -j\left(\frac{1\times10^6}{628\times100}\right)$.

$= -j(15.923)\ \Omega$.

$Z = R + X_L + X_C$

$= 10 - j(15.29)$

$= 18.27\angle -56.81^\circ\ \Omega$

$\phi = -56.81^\circ$

$I = \frac{V}{Z} = \frac{5\angle 0^\circ}{18.27\angle -56.81}$

$= 0.273\angle 56.81^\circ A$.

$I_{RMS} = \frac{0.273}{\sqrt{2}}\angle 56.81\ A$

$= 0.193\angle 56.81 A$

$V_L = I \cdot X_L = I \cdot j\omega L$

$= |I\omega L| \angle 90°$

$= 0.273 \times (0.628) \angle 90°$

$= 0.1714 \angle 90° \text{ V}.$

$V_{L\,RMS} = \frac{0.1714}{\sqrt{2}} \angle 90°$

$= 0.1212 \angle 90°.$

$V_C = IX_C = I\left(\frac{-j}{\omega C}\right)$

$= 0.273\,(15.923) \angle -90°$

$= 4.346 \angle -90° \text{ V}$

$V_{C\,RMS} = \frac{4.346}{\sqrt{2}} \angle -90°$

$= 3.07 \angle -90°$

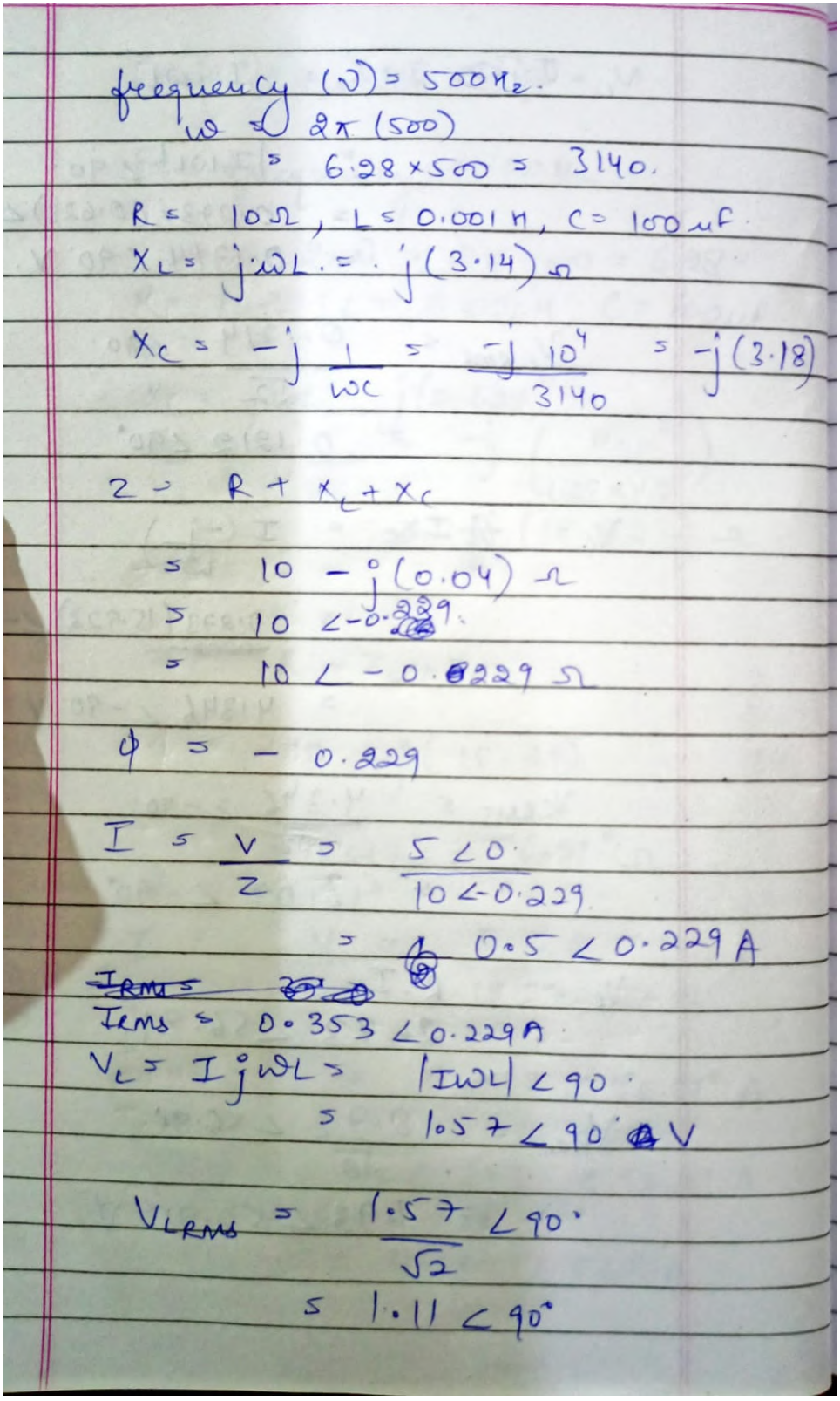
$V_R = R \cdot I.$

$= 2.73 \angle 56.81°.$

$V_{R\,RMS} = \frac{2.73}{\sqrt{2}} \angle 56.81°$

$= 1.93 \angle 56.81° \text{ V}$

2) For f = 500Hz



frequency (ν) = 500Hz.

$\omega = 2\pi(500)$

$= 6.28 \times 500 = 3140.$

$R = 10\Omega$, $L = 0.001\,H$, $C = 100\,\mu F$.

$X_L = j\omega L = j(3.14)\,\Omega$

$X_C = -j\frac{1}{\omega C} = \frac{-j\,10^4}{3140} = -j(3.18)$

$Z = R + X_L + X_C$

$= 10 - j(0.04)\,\Omega$

$= 10 \angle -0.229.$

$= 10 \angle -0.229\,\Omega$

$\phi = -0.229$

$I = \frac{V}{Z} = \frac{5\angle 0}{10\angle -0.229}$

$= 0.5 \angle 0.229\,A$

~~$I_{RMS} = \frac{0.5}{\sqrt{2}}$~~

$I_{rms} = 0.353 \angle 0.229\,A$

$V_L = I j\omega L = |I\omega L| \angle 90.$

$= 1.57 \angle 90^\circ\,V$

$V_{LRMS} = \frac{1.57 \angle 90^\circ}{\sqrt{2}}$

$= 1.11 \angle 90^\circ$

$$V_C = I\left(\frac{-j}{\omega C}\right) = \left|\frac{I}{\omega C}\right| \angle -90^\circ$$

$$= 1.59 \angle -90^\circ$$

$$V_{C\,rms} = \frac{1.59}{\sqrt{2}} \angle -90^\circ$$

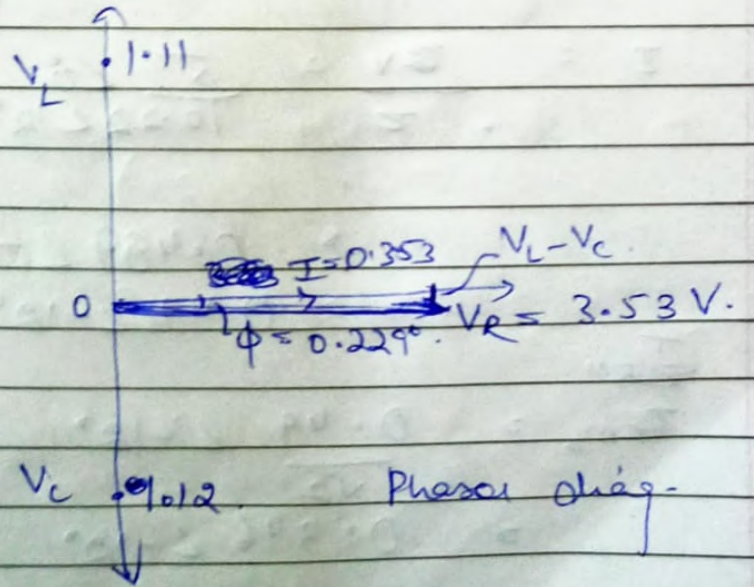
$$= 1.124 \angle -90^\circ$$

$$V_R = I \cdot R = 5 \angle 0.229\ V$$

~~$V_{R\,rms} = \frac{5}{\sqrt{2}} \angle 0^\circ$~~

$$V_{R\,rms} = \frac{5}{\sqrt{2}} \angle 0.229\ V$$

$$= 3.53 \angle 0.229 V.$$



Phasor diag.

3) For f = 700 Hz

Frequency (f) = 700 Hz.

$\omega = 2\pi(700) = 4396$

$R = 10\,\Omega$, $L = 10^{-3}$ H, $C = 10^{-4}$ F.

$X_L = j\omega L = j(4.396)$

$X_C = -j\frac{1}{\omega C} = -j\left(\frac{10^4}{4396}\right)$

$= -j(2.274)$

$Z = 10 + j(2.12)\ \Omega$.

$= 10.22 \angle 12°$.

$\phi = 12°$.

$I = \frac{V}{Z} = \frac{5\angle 0°}{10.22\angle 12°}$

$= 0.489 \angle -12°$.

$\approx 0.49 \angle -12°$

$I_{rms} = \frac{0.49\angle -12°}{\sqrt{2}}$

$= 0.346 \angle -12°$.

$V_L = I X_L = (0.49)(4.396) \angle 90°$

$= 2.15 \angle 90° V$

$V_{L,RMS} = \frac{2.15}{\sqrt{2}} \angle 90°$

$= 1.52 \angle 90° V$

$V_C = I \cdot X_C = (0.49)(2.274) \angle -90°$

$= 1.11 \angle -90° V$

$V_{C,RMS} = \frac{1.4}{\sqrt{2}} \angle -90°$

$= 0.787 \angle -90° V$

(B) $V_R = I \cdot R$

$= 4.9 \angle -12°$

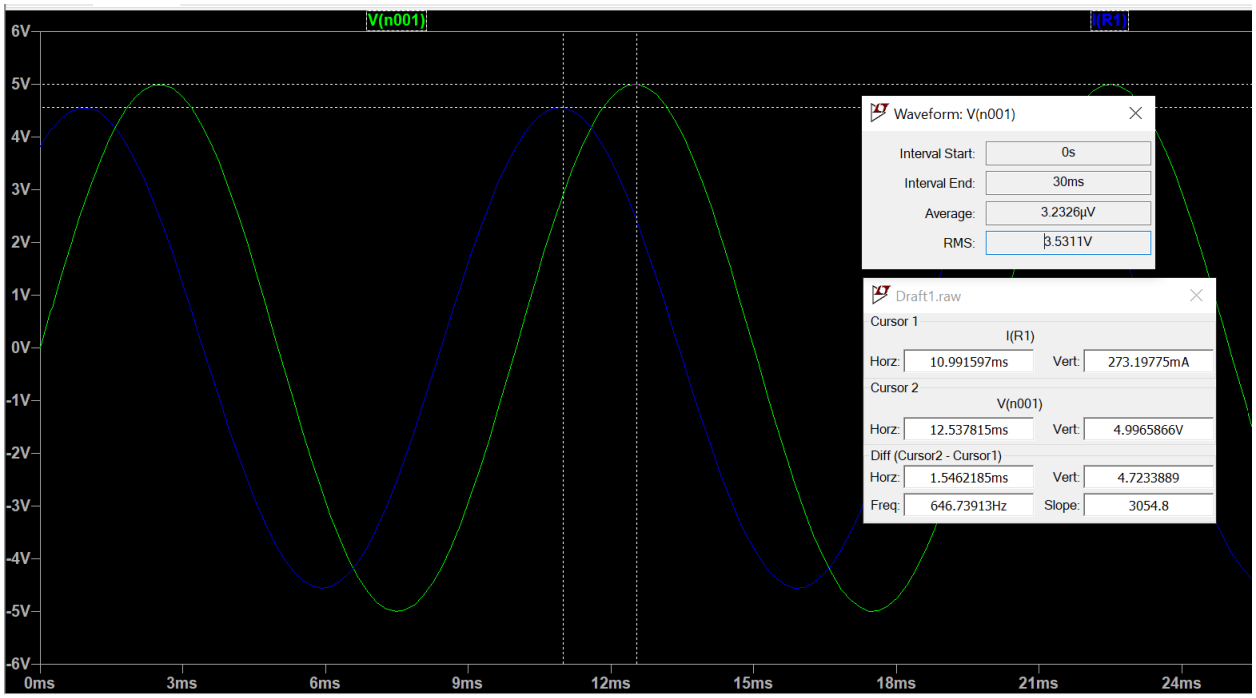
$V_{R,RMS} = \frac{4.9}{\sqrt{2}} \angle -12°$

$= 3.46 \angle -12° V$

Practical observations(ideal inductor**):**

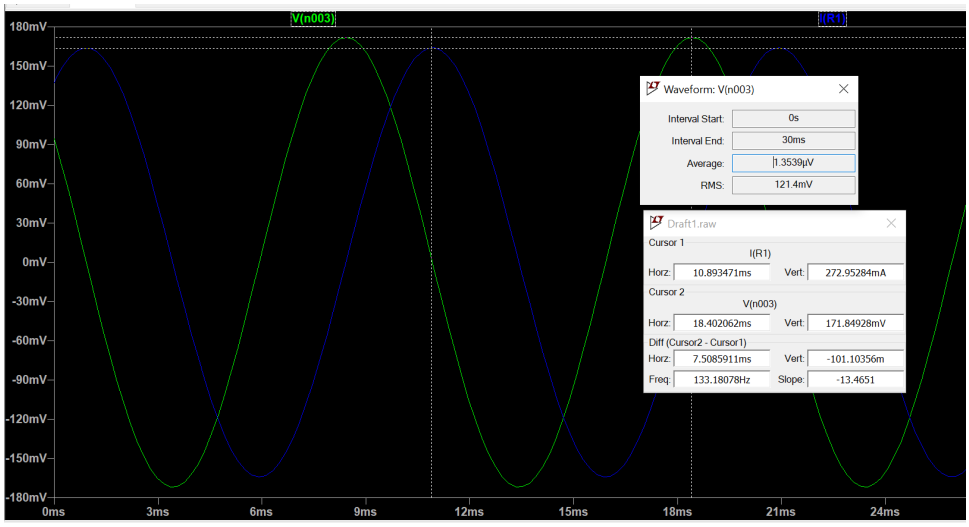
1) For 100 Hz frequency:

For V



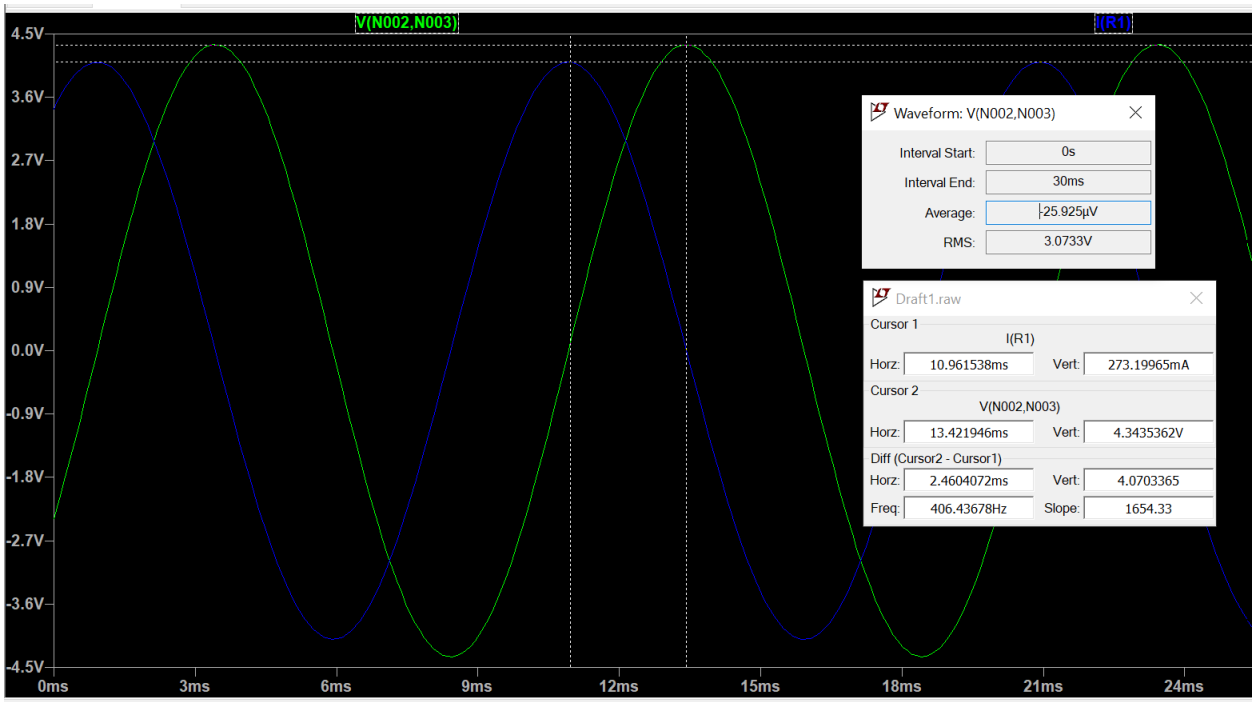
Phase diff = 1.579ms * 360 * 100 = 56.88

For VL



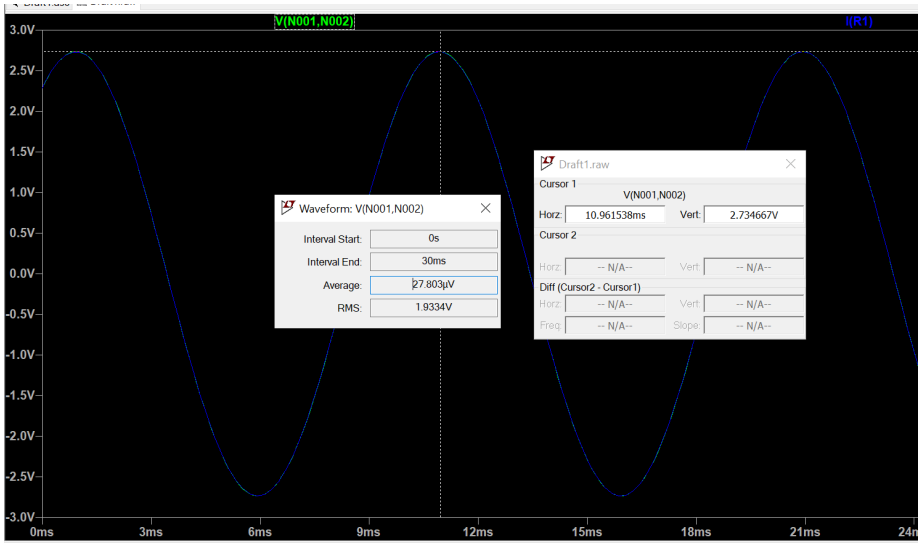
Phase diff = 7.508ms * 360 * 100 = 270.288

For Vc



Phase diff = 2.4608ms * 360 * 100 = 91.2

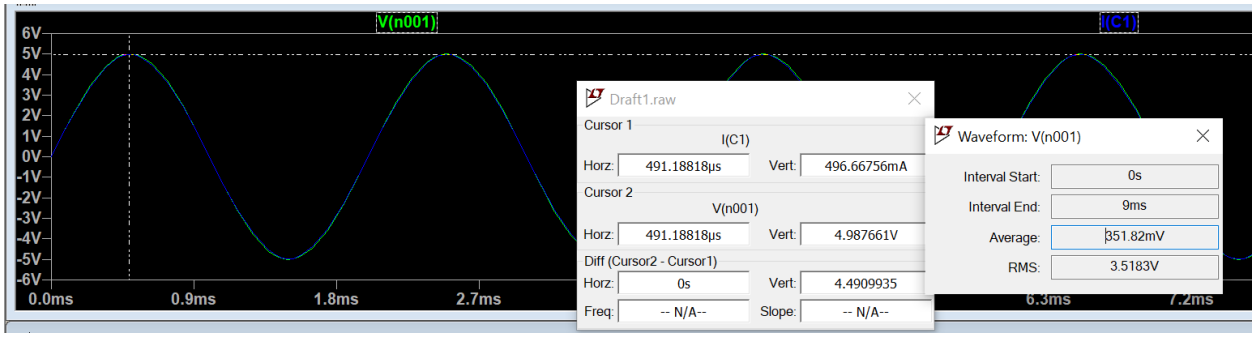
For Vr



Phase diff = 0

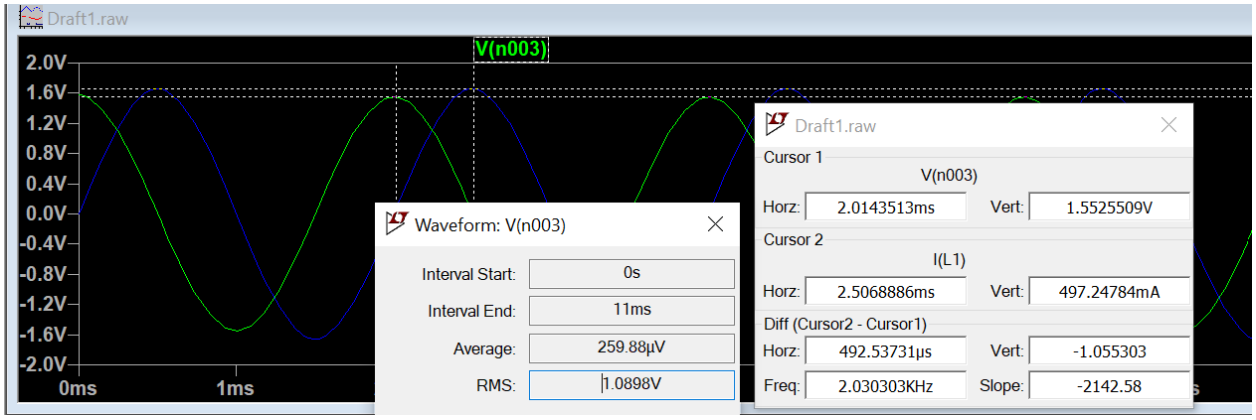
2) For 500 Hz frequency:

For V



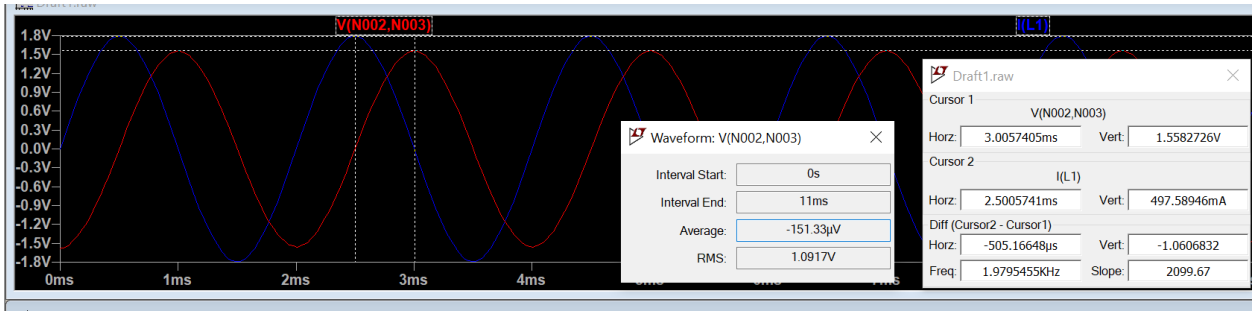
Phase diff = 0

For VL



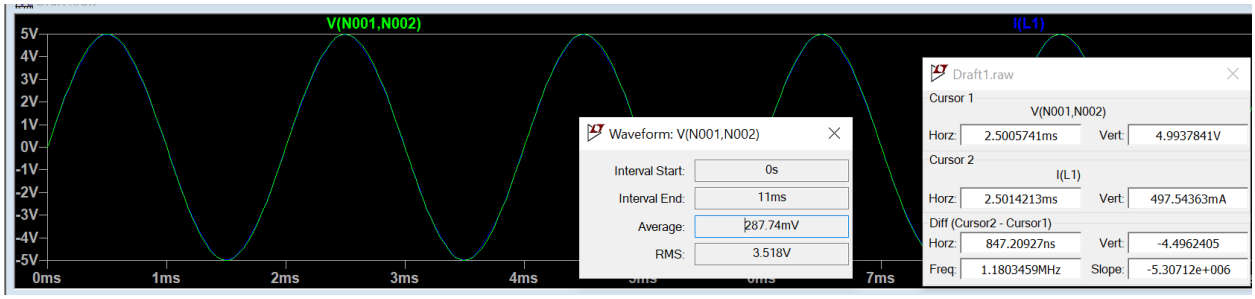
Phase diff = -88.56

For Vc



Phase diff = 90.9

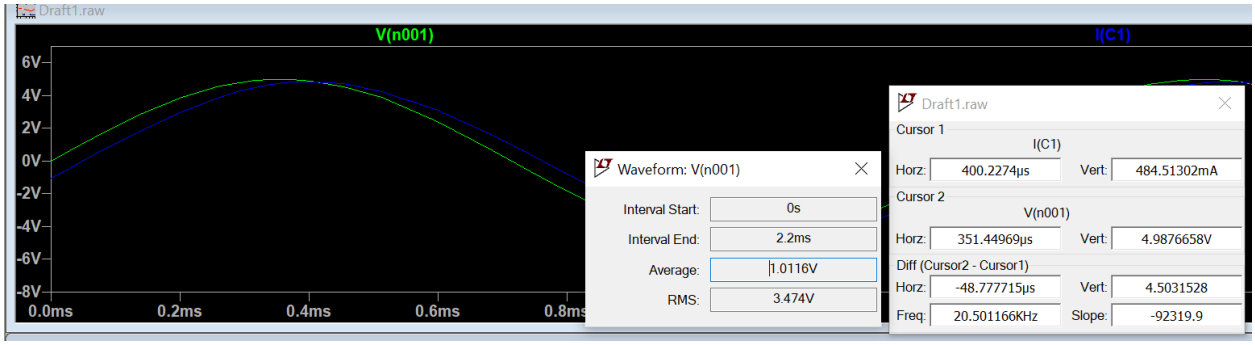
For Vr



Phase diff = 0

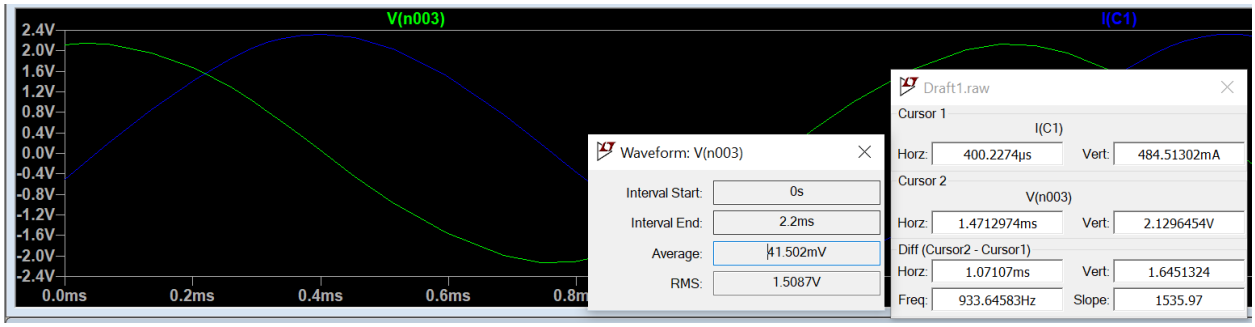
3) For 700 Hz frequency:

For V



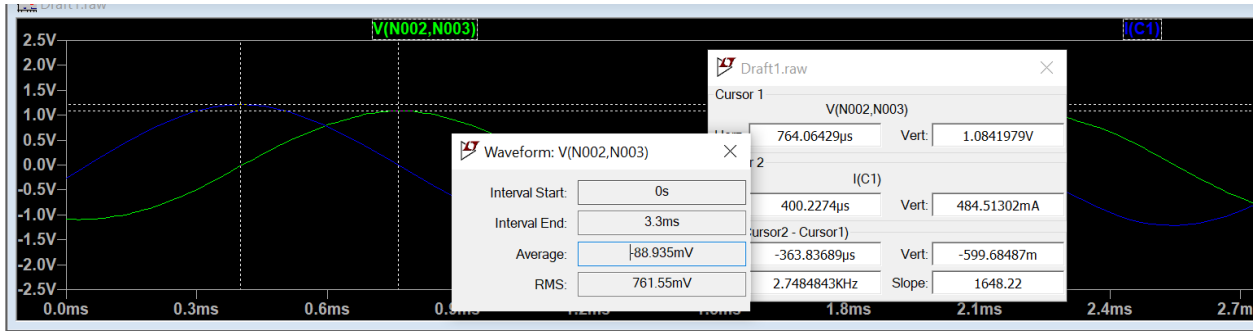
Phase diff = 12.1

For VL



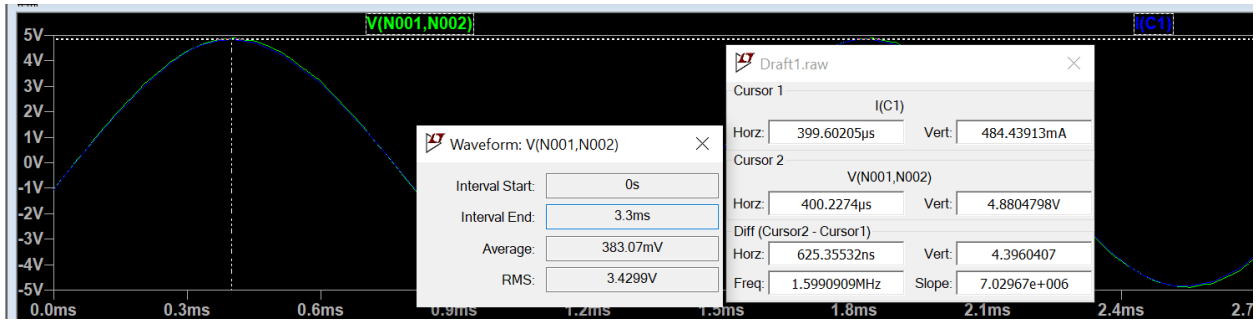
Phase diff = 269.6

For Vc



Phase diff = 91.4

For Vr



Phase diff = 0

<u>Theoretical calculations(</u><u>for practical inductor</u>**<u>) :</u>**

1) For f = 100Hz

Practical for Inductor.

for $\nu = 100$ Hz.

$\omega = 628$

$R = 10\,\Omega$, $L = 10^{-3}$ H, $C = 10^{-4}$ F

$r = 12.5\,\Omega$.

~~$Z = (R+r) + j\left(\omega L - \frac{1}{\omega C}\right)$~~

$X_L = 12.5 + j(0.628)\,\Omega$.

$= 12.51 \angle 2.876\,\Omega$.

$X_C = \frac{-j}{\omega C} = -j\left(\frac{10^4}{628}\right)$

$= -j(15.92)\,\Omega$

$Z = R + X_L + X_C$

$= 22.5 - j(15.29)\,\Omega$.

$= 27.2 \angle -34.2°$.

$I = \frac{V}{Z} = \frac{5 \angle 0}{}$

$I_{rms} = \frac{0.183}{\sqrt{2}} \angle 34.2°$

$= 0.13 \angle 34.2°$

$V_L = I \cdot X_L$

$= 0.183 \times 12.51 \angle 2.876$

$= 2.28 \angle 2.87° V$

$V_{L_{RMS}} = \frac{2.28}{\sqrt{2}} \angle 2.87° V$

$= 1.618 \angle 2.87° V$

$V_L = I \cdot X_C$

$= 0.183 \times (15.92) \angle -90°$

$= 2.91 \angle -90°$

$V_{C_{RMS}} = 2.06 \angle -90°$

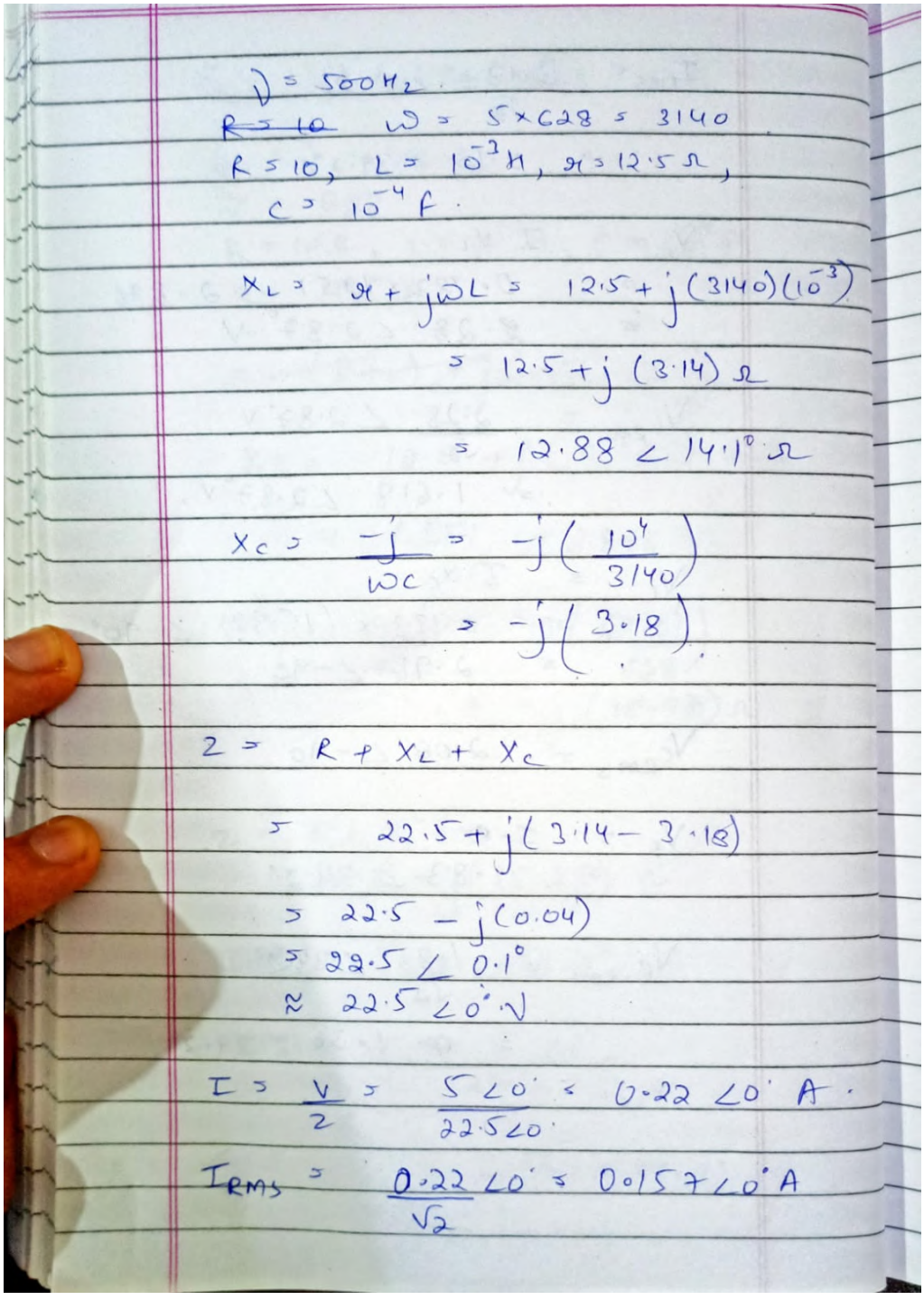
$V_R = I \cdot R$

$= 1.83 \angle 34.2°$

$V_{R,RMS} = \frac{1.83}{\sqrt{2}} \angle 34.2°$

$= 1.30 \angle 34.2°$

2) For f = 500Hz



$f = 500\,Hz$

$R = 10, \quad \omega = 5 \times 628 = 3140$

$R = 10, \; L = 10^{-3}\,H, \; r = 12.5\,\Omega,$

$C = 10^{-4}\,F.$

$$X_L = r + j\omega L = 12.5 + j(3140)(10^{-3})$$

$$= 12.5 + j(3.14)\,\Omega$$

$$= 12.88 \angle 14.1^\circ\,\Omega$$

$$X_C = \frac{-j}{\omega C} = -j\left(\frac{10^4}{3140}\right)$$

$$= -j(3.18)$$

$$Z = R + X_L + X_C$$

$$= 22.5 + j(3.14 - 3.18)$$

$$= 22.5 - j(0.04)$$

$$= 22.5 \angle 0.1^\circ$$

$$\approx 22.5 \angle 0^\circ\,\Omega$$

$$I = \frac{V}{Z} = \frac{5 \angle 0^\circ}{22.5 \angle 0^\circ} = 0.22 \angle 0^\circ\,A.$$

$$I_{RMS} = \frac{0.22 \angle 0^\circ}{\sqrt{2}} = 0.157 \angle 0^\circ\,A$$

$V_L = I \cdot X_L = |I \cdot X_L| \angle 14.1^\circ$

$= (0.22)(12.88) \angle 14.1^\circ$

$= 2.83 \angle 14.1^\circ$ V

$V_{L\,rms} = \frac{2.83}{\sqrt{2}} \angle 14.1$

$= 2 \angle 14.1$ V

$V_C = |I \cdot X_C| \angle -90^\circ$

$= (0.22)(3.18) \angle -90^\circ$

$= 0.7 \angle -90^\circ$ V

$V_{C\,rms} = \frac{0.7}{\sqrt{2}} \angle -90^\circ$ V

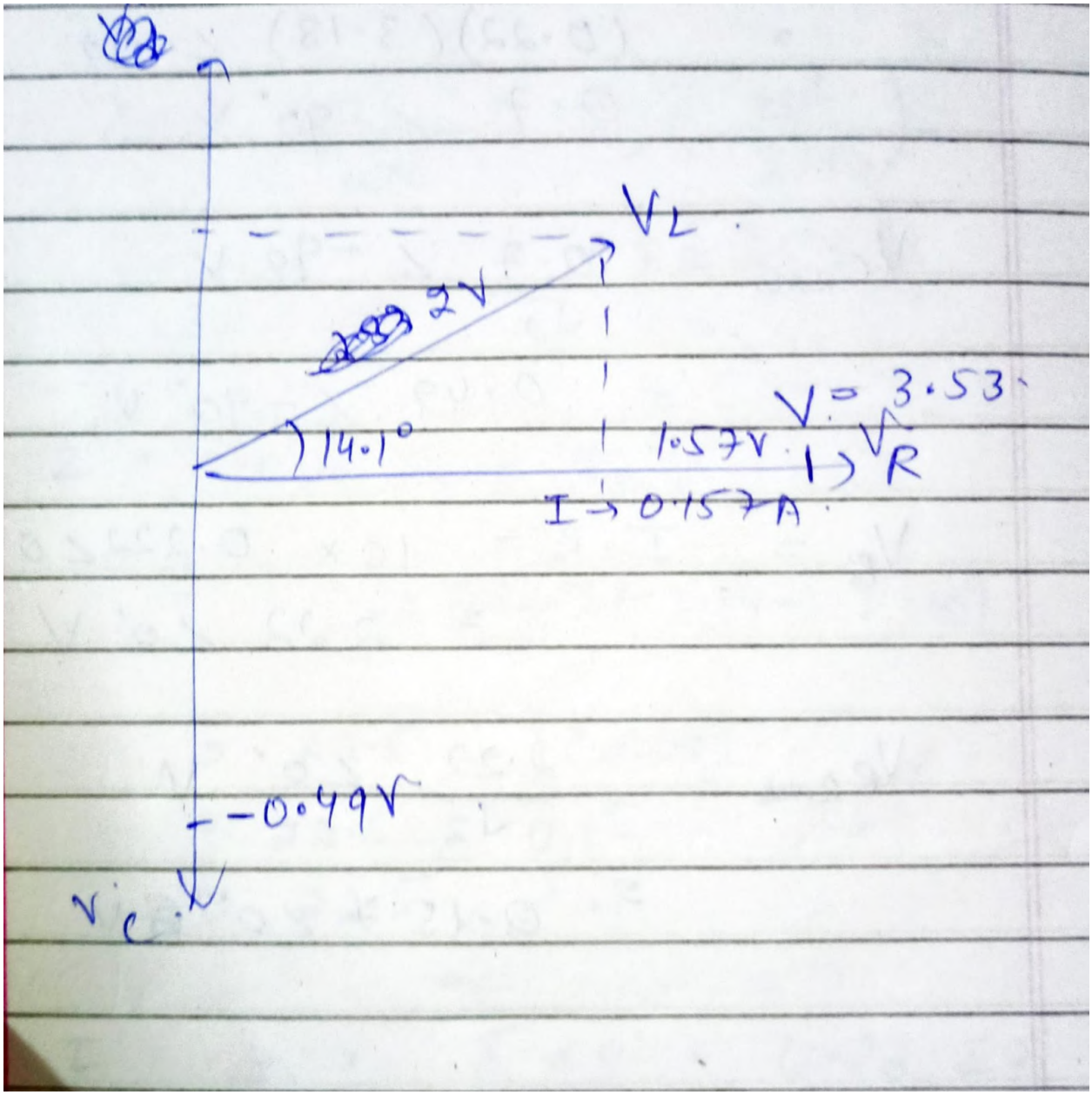
$= 0.49 \angle -90^\circ$ V.

$V_R = I \cdot R = 10 \times 0.222 \angle 0^\circ$

$= 2.22 \angle 0^\circ$ V

$V_{R\,rms} = \frac{2.22}{\sqrt{2}} \angle 0^\circ$ V

$= 0.157 \angle 0^\circ$ V



3) For f = 700 Hz

$f = 700\ Hz$

$\omega = 4396$

$R = 10\ \Omega$, $L = 10^{-3}\ H$, $r = 12.5\ \Omega$

$C = 10^{-4}\ F$

$$X_L = j\omega L + r = 12.5 + j(4.396)$$

$$= 13.25 \angle 19.37^\circ$$

$$X_C = \frac{-j}{\omega C} = -j\left(\frac{10^4}{4396}\right)$$

$$= -j(2.274)\ \Omega.$$

$$Z = 10 + 12.5 + j(4.396 - 2.274)$$

$$= 22.5 + j(2.12)$$

$$= 22.6 \angle 5.38^\circ$$

$$\phi = \angle 5.38^\circ$$

$$I = \frac{V}{Z} = \frac{5 \angle 0^\circ}{22.6 \angle 5.38^\circ}$$

$$= 0.221 \angle -5.38^\circ$$

$$I_{rms} = \frac{0.221 \angle -5.38^\circ}{\sqrt{2}}$$

$I_{RMS} = 0.156 \angle -5.38$ A.

$V_L = |I \cdot X_L| \angle \tan^{-1}\left(\frac{\omega L}{R}\right)$

$= (0.221)(13.25) \angle 19.37°$

$= 2.928 \angle 19.37°$ V.

$V_{L_{RMS}} = \frac{2.928}{\sqrt{2}} \angle 19.37$

$= 2.07 \angle 19.37°$ V.

$V_C = |I \cdot X_C| \angle -90°$

$= (0.221)(2.274) \angle -90°$

$= 0.502 \angle -90°$

$V_{C_{RMS}} = \frac{0.502}{\sqrt{2}} \angle -90°$

$= 0.355 \angle -90°$

$V_R = I \cdot R = 0.221 \times 10 \angle -5.38$

$= 2.21 \angle -5.38$ V

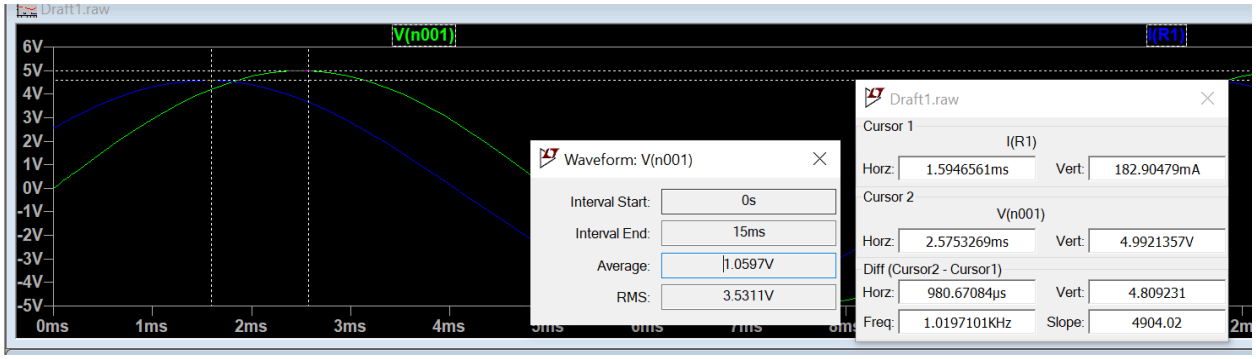
$V_{R_{RMS}} = \frac{2.21}{\sqrt{2}} \angle -5.38$

$= 1.56 \angle -5.38$ V.

Practical observations(practical inductor**):**

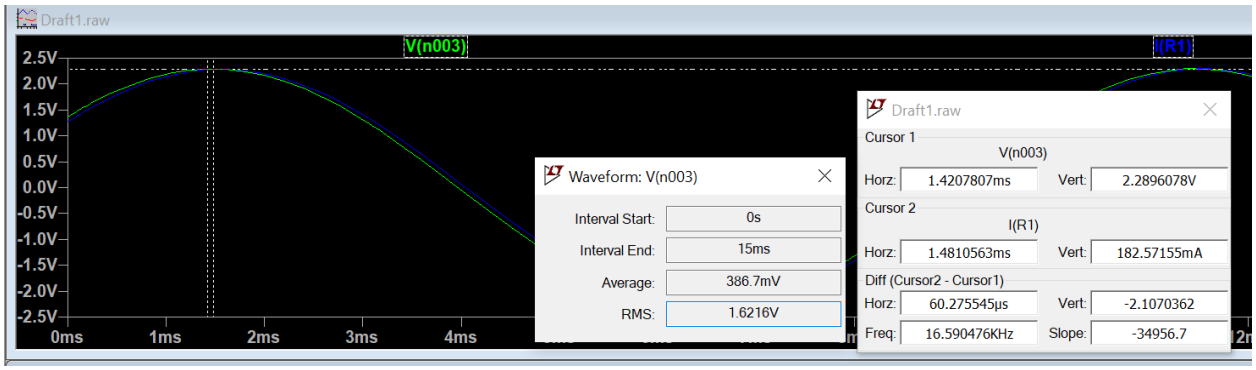
1) For 100 Hz frequency:

For V



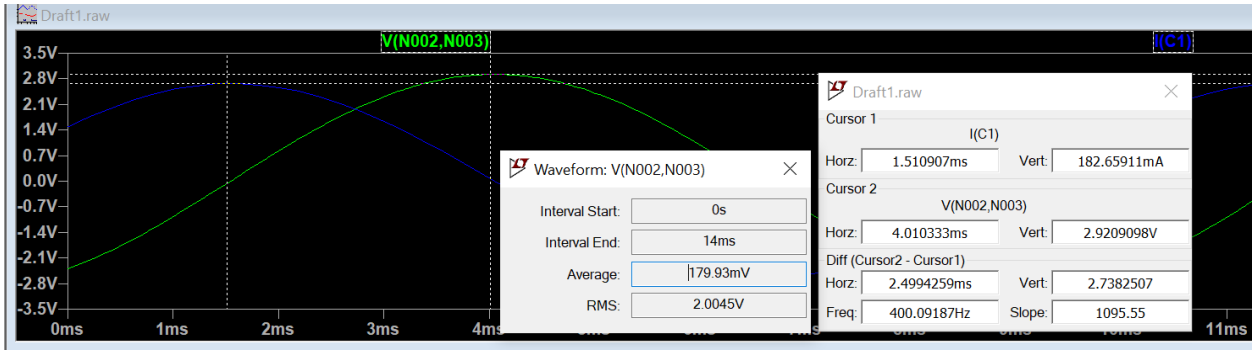
Phase diff = 35.2

For VL



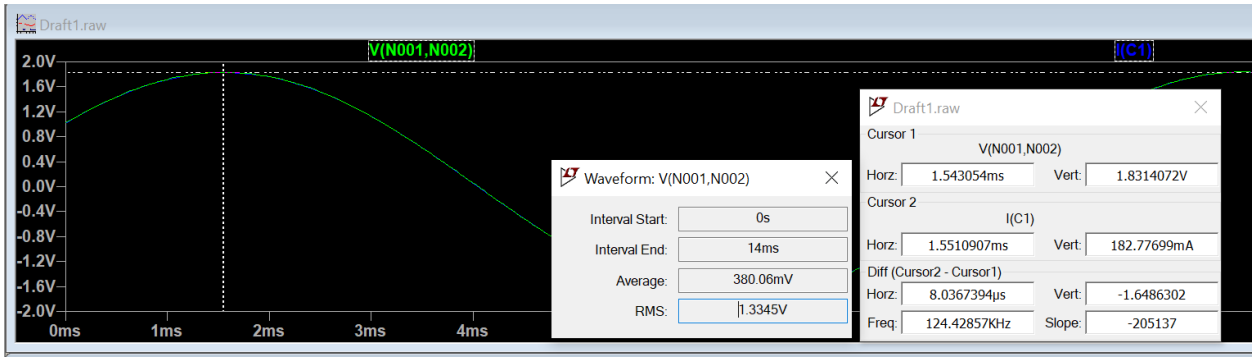
Phase diff = -2.16 or (360- 2.16)

For Vc



Phase diff = 89.64

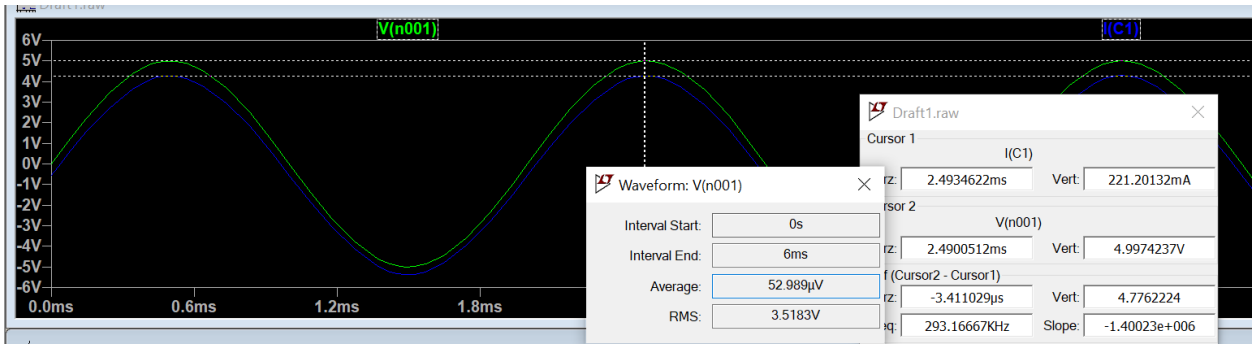
For Vr



Phase diff = 0

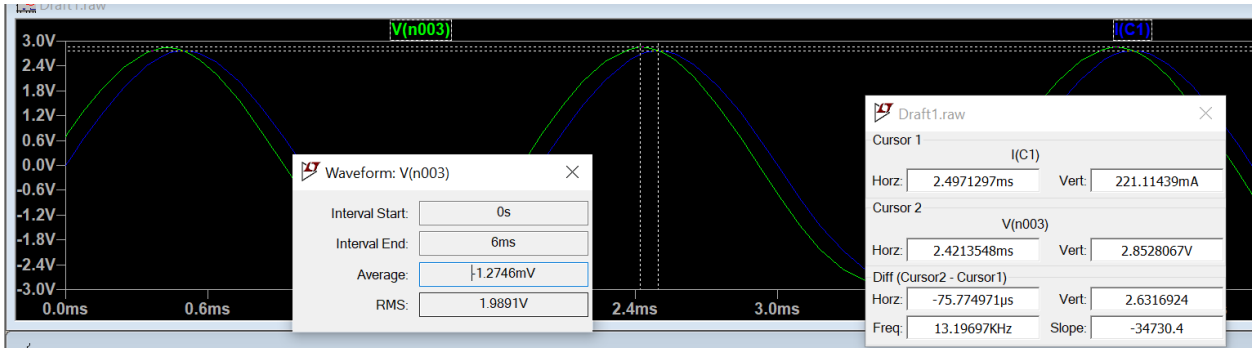
2) For 500 Hz frequency:

For V



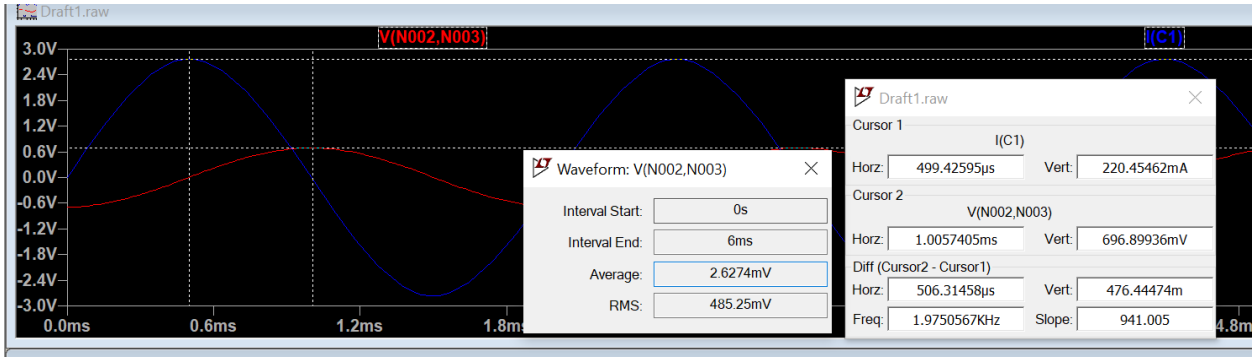
Phase diff = 0

For VL



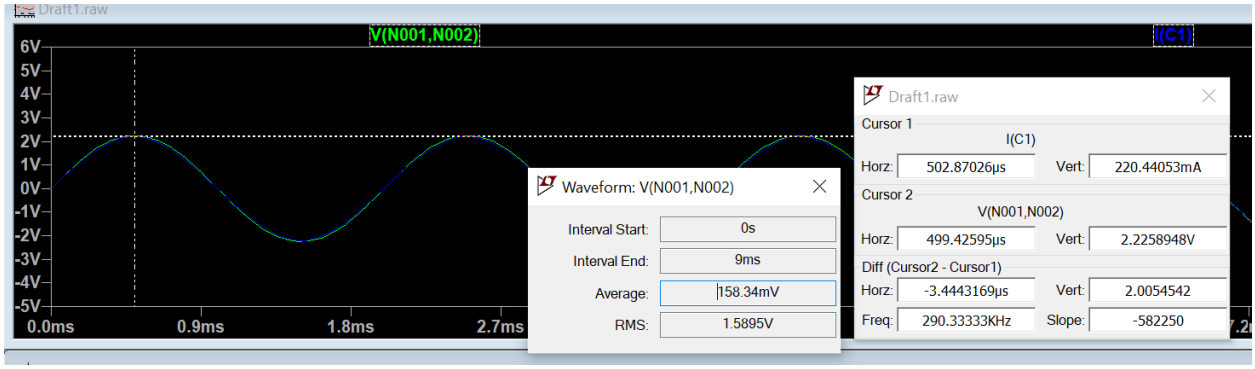
Phase diff = -13.5 or (360- 13.5)

For Vc



Phase diff = 91.1

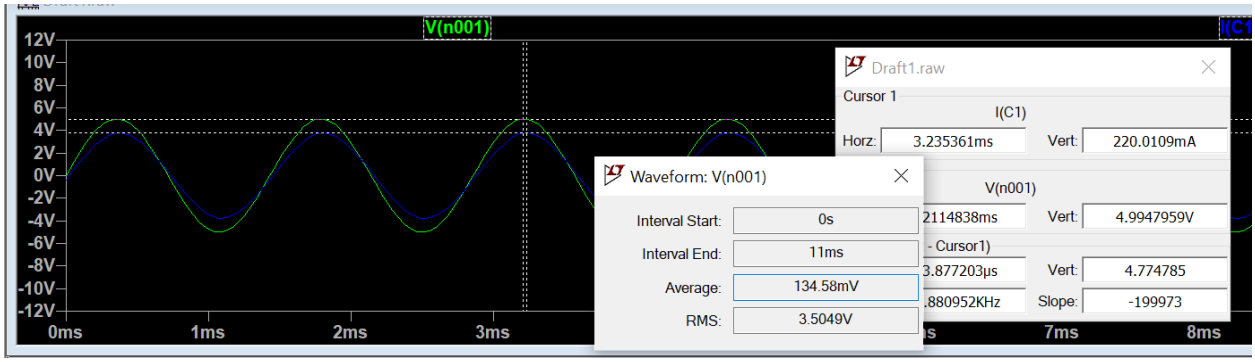
For Vr



Phase diff = 0

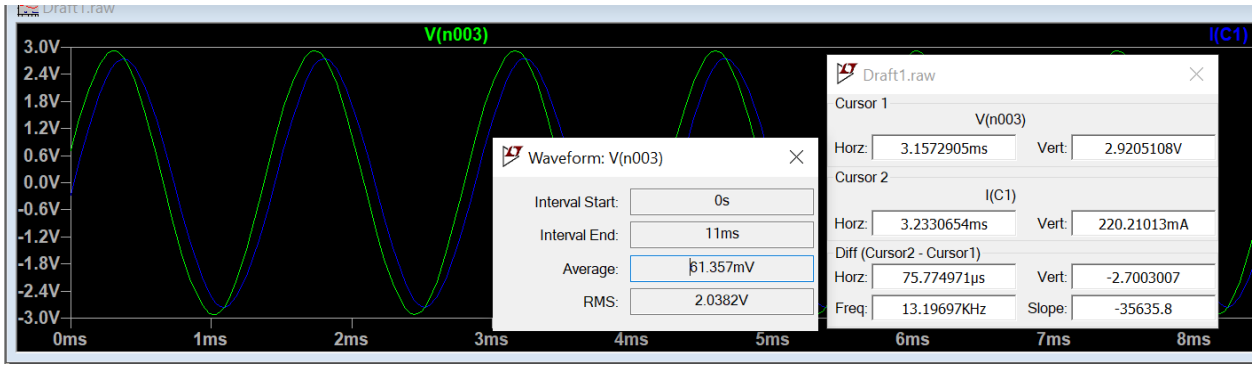
3) For 700 Hz frequency:

For V



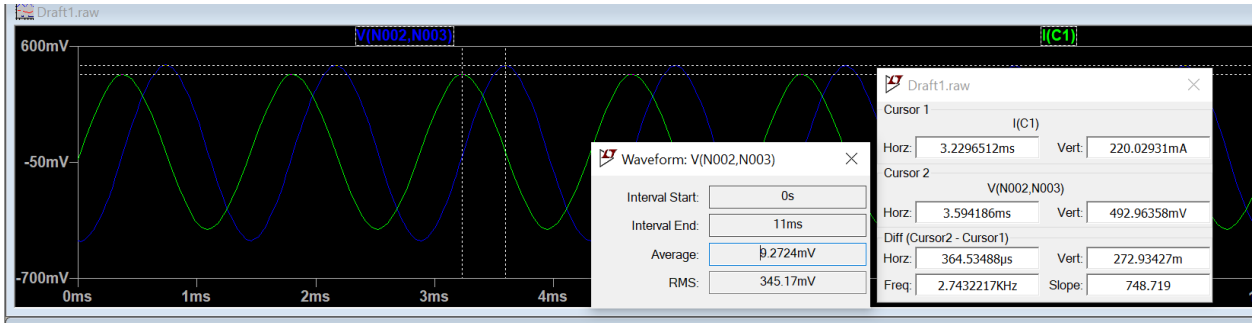
Phase diff = 5.8

For VL



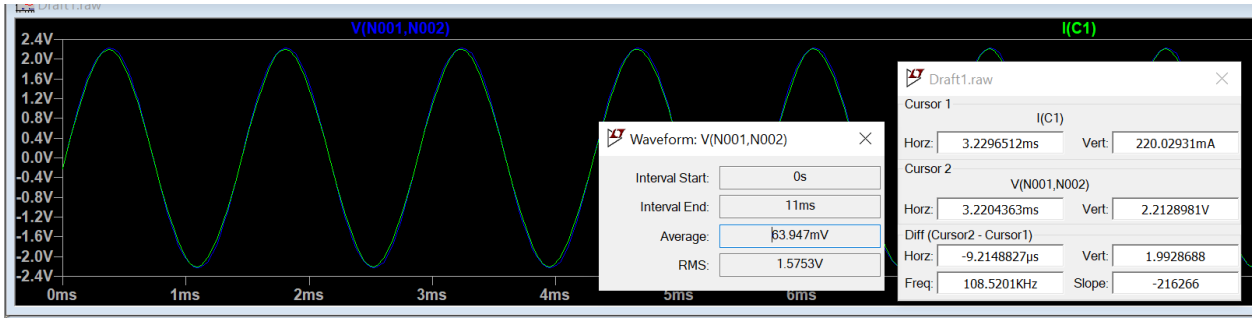
Phase diff = -19 or (360- 19)

For Vc



Phase diff = 90.8

For Vr



Phase diff = 0

Observations :

For ideal inductor

Input Freq	Mention phase (lag or lead) of the voltage waveforms w.r.t input current along with the rms values of the voltages.							
	Vr		VL		Vc		V	
	theoretical	practical	theoretical	practical	theoretical	practical	theoretical	practical
100Hz	1.93	1.933	.1212	0.1214	3.07	3.07	3.53	3.53
500Hz	3.53	3.518	1.11	1.09	1.12	1.09	3.53	3.53
700Hz	3.46	3.43	1.52	1.51	0.787	0.761	3.53	3.53

For practical inductor

Input Freq	Mention phase (lag or lead) of the voltage waveforms w.r.t input current along with the rms values of the voltages.							
	Vr		VL		Vc		V	
	theoretical	practical	theoretical	practical	theoretical	practical	theoretical	practical
100Hz	1.3	1.33	1.618	1.62	2.06	2	3.53	3.53

500Hz	1.57	1.589	2	2	0.49	.485	3.53	3.53
700Hz	1.56	1.57	2.07	2.03	0.355	.345	3.53	3.53

Applications :

1. RLC circuits have many applications as oscillator circuits.
2. They are used in television sets and radio receivers for tuning purposes.
