INDIAN INSTITUTE OF TECHNOLOGY BHUBANESWAR

Introduction to Electronics Laboratory

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EXPERIMENT 2

MEASUREMENT TECHNIQUES FOR ELECTRONIC CIRCUITS

Aim of the Experiment:

- *Familiarize ourselves with working of the function generator.*
- Familiarize ourselves with the working of Cathode Ray Oscilloscope(CRO).
- Set up a circuit to measure the behavior of a Low-pass RC circuit.
- Set up a circuit to measure the behavior of a High-pass RC circuit.
- And obtain important information from the measurements

Materials & Equipment:

- Required resistor value-1kΩ(x1)
- Required capacitor value-0.1µF(x1)
- Connecting wires
- Bread board
- A laptop with open MS excel sheet to note your readings

Theory:

LOW PASS FILTER:-

A low pass filter is a filter that passes signals with a frequency lower than a selected cut-off frequency and alternates signals with frequencies higher than cut-off frequency. The exact frequency response of the filter depends on the filter design.

HIGH PASS FILTER: -

A High pass filter is an electronic that passes signals with frequency higher than a certain cutoff frequency and alternates signals with frequencies lower than the cutoff frequency. The amount of alteration for each frequency depends on filter design.

- Low pass filter is the type of frequency domain filter that is used for smoothening the image
- High pass filter is the type of frequency domain that is used for sharpening the image

Part 1

Familiarization with Function Generator and CRO

Function Generator:

This is the function generator that we use in the lab to generate waveforms .It has two channels so that we can generate two waveforms with two channels. We can customize our waveform by adjusting the Amplitude, Frequency and Nature of Curve (i.e Sine , Square , Pulse , Ramp , Noise)
. To view the generated waveform we use CRO (Cathode ray Oscilloscope).

We adjust the amplitude and frequency by using the number panel and we use course to adjust them to near values. To get the we graph which is required we have to press the Output Button. And if we have plotted the curve in CH1 display then we must insert the probe in CH1 pin.
Similarly for the CH2 pin.

Cathode Ray Oscilloscope (CRO):

This is the cathode ray oscilloscope we use in our laboratory. It is mainly classified into five parts

1. Display.
2. Power, Calibration and Display controls.
3. Vertical axis controls .
4. Horizontal axis controls.
5. Trigger controls.

Now Let us see the functions of some important controls in CRO.

- *Volts/division (voltage base) and time/division (time base):*

To adjust volts/cm and time/cm we rotate the nob with labeling VOLTS/DIV and TIME/DIV and set the required time base and voltage base

- *DC, AC and Ground coupling modes:*

Coupling refers to the method used to connect an electrical signal from one circuit to another. In this case, the input coupling is the connection from your test circuit to the oscilloscope. We can see three buttons labeled AC, DC and GND just above the channel pin. To change the coupling mode we have to press the required button.

- *Triggering and trigger level control, trigger source and trigger lock*

An oscilloscope's trigger function synchronizes the horizontal sweep at the correct point of the signal. This is essential for clear signal characterization. Trigger controls allow you to stabilize repetitive waveforms and capture single-shot waveforms. The trigger makes repetitive waveforms appear static on the oscilloscope display by repeatedly displaying the same portion of the input signal.

The trigger level and slope controls provide the basic trigger point definition and determine how a waveform is displayed.

The oscilloscope does not necessarily need to trigger on the signal being displayed. Several sources can trigger the sweep:

- Any input channel
- An external source other than the signal applied to an input channel
- The power source signal
- A signal internally defined by the oscilloscope, from one or more input channels

Most of the time, you can leave the oscilloscope set to trigger on the channel displayed. Some oscilloscopes provide a trigger output that delivers the trigger signal to another instrument. The oscilloscope can use an alternate trigger source, whether or not it is displayed, so you should be careful not to unwittingly trigger on channel 1 while displaying channel 2

- *Single and dual channel operation, and appropriate triggering:*

  To do a single channel operation we must set CH1 or CH2 in mode option. If we want to do dual channel operation then only we must set to dual in mode option. And if we want to add the both channel curves then we have to set the option to add in mode.

- Sweep mode and X-Y mode:

  To display events with unchanging or slowly (visibly) changing waveforms, but occurring at times that may not be evenly spaced, modern oscilloscopes have triggered sweeps. Compared to older, simpler oscilloscopes with continuously-running sweep oscillators, triggered-sweep oscilloscopes are markedly more versatile.

  A triggered sweep starts at a selected point on the signal, providing a stable display. In this way, triggering allows the display of periodic signals such as sine waves and square waves, as well as nonperiodic signals such as single pulses, or pulses that do not recur at a fixed rate.

  In X-Y mode the curve in channel-1 will be assumed as X-axis and curve in channel-2 is assumed as Y-axis.

- *Difference between Signal coupling and Trigger coupling*

  Trigger coupling can be chosen depending on the signal type used for oscilloscope synchronization. The description of every coupling types is as follows:

DC (direct current) – input type is open. Both constant and variable input signal components can be passed through.

AC (alternating current) – Input type is closed. Only variable input signal component can be passed through.

HF Reject (high-frequency filter) – signal high-frequency attenuation, attenuation of signals with high frequency, e.g. 140 KHz

LF Reject (low-frequency filter) – signal low-frequency attenuation, attenuation of signals with low frequency, e.g. 7 KHz

The signal coupling or input coupling selection determines how the signal on the input is passed on.

DC coupling allows for both the AC and the DC components of the input signal to pass.AC coupling rejects the DC component of the input signal and only the AC component is measured.

Before using the function generator, ensure its output load option is set to 'High Z' i.e. high impedance. Why is this necessary? Explain in your report.

The High Z or 1 Megohm mode makes the oscilloscope's input impedance very high so that negligible current is drawn from the circuit being tested. The term High Impedance is relative however, and in the case that the circuit being observed has an output impedance greater than 1 Megohm, more current will flow through the probes and into the oscilloscope (through the path of least resistance), than through the circuit itself.

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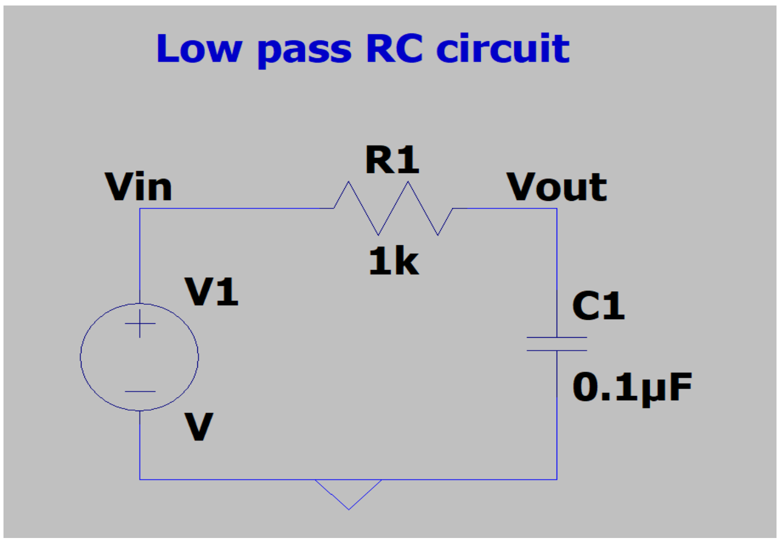
Part 2

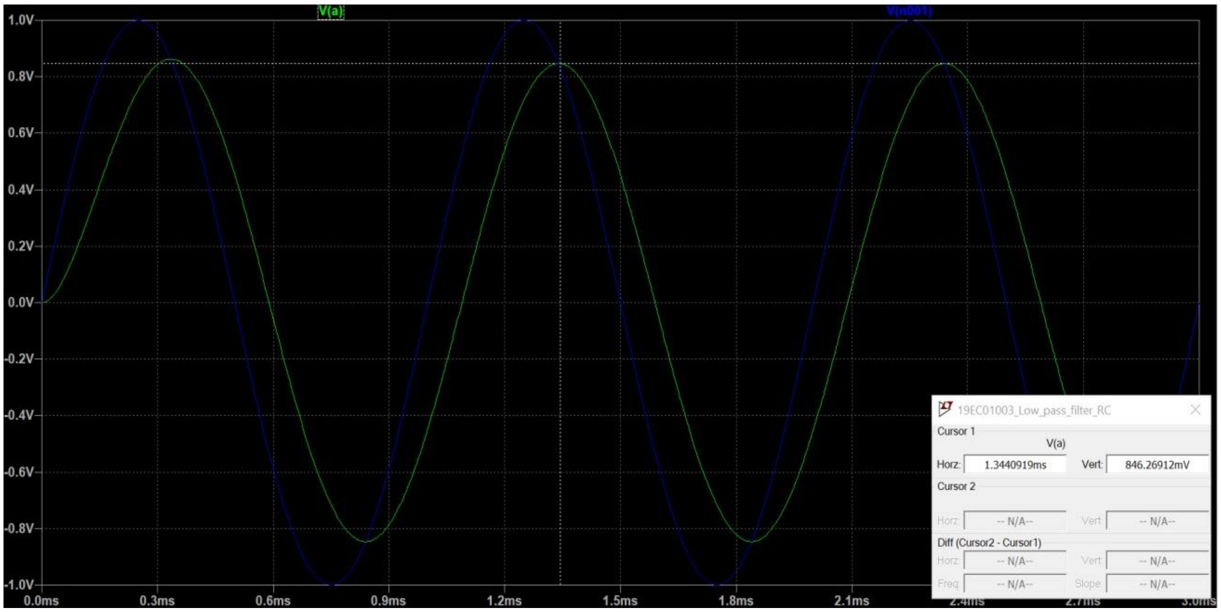
Low Pass RC-Circuit

Circuit Diagram



Graphs:

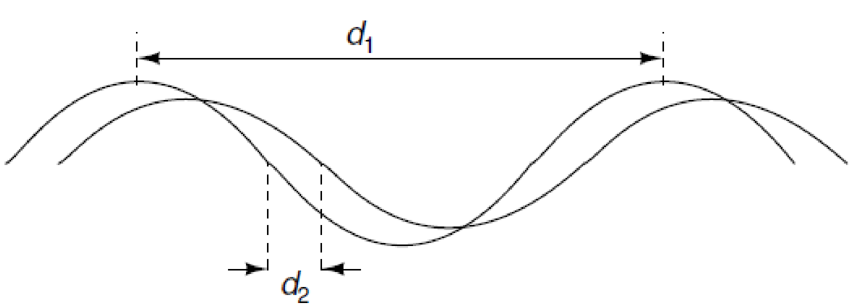
As we know V1 max = 1.0V.



When we zoom the graph we get Va(max) = 0.846volts.

Calculation

Sinusoidal wave method.



Now let us measure d1 and d2 . To measure d1 we measure time period of sinusoidal curve of V1 which is equal to d1.

Time period of graph is 1ms which is equal to d1.

Now to measure d2 we must measure the time gap between both curves as 0volts. As we know we are measuring d2 to calculate phase difference both waves. As V1 started at 0volts to measure the phase difference first we have to calculate how much time it has taken for Va to reach 0volts and that time is d2.

Now to calculate d2 we are going to zoom the graph.

From the graph we can say that d2 ≈ 0.089ms.

Now we can calculate the phase difference

from d1 and d2 We Know that, d1> 360

degrees

d2 -- > phase difference, from this we say

phase difference = (d2 x 360) / d1.

= (0.000089 x 360) / (0.001)

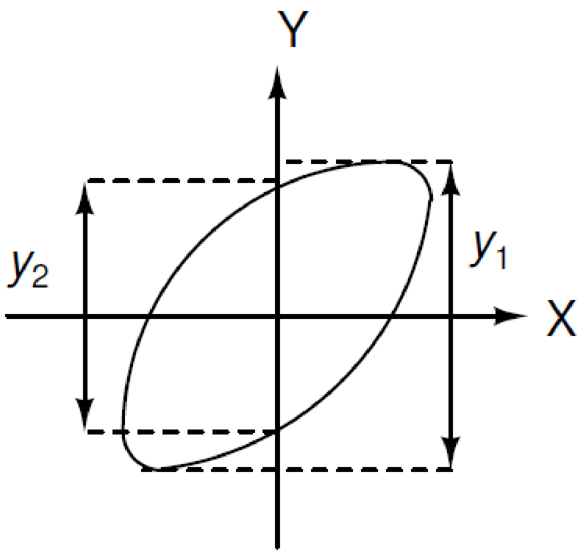
= 32.04degrees.

Therefore, phase difference = 32.04degrees.

Ellipse method:

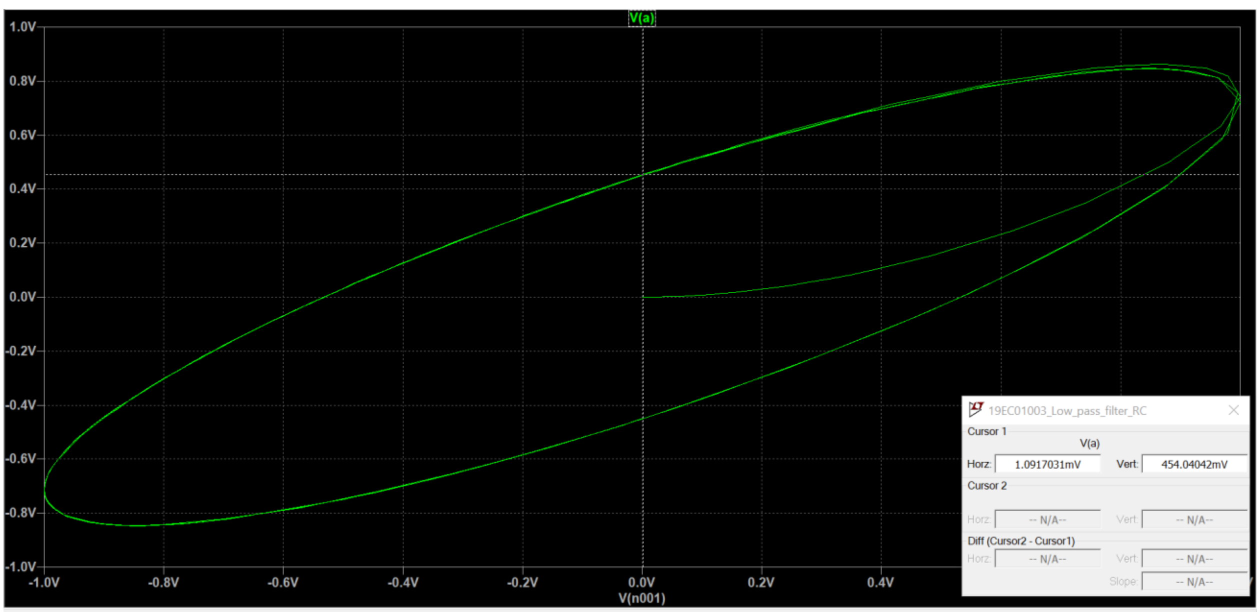
Now we are going to plot V1 as X-axis and Va as Y-axis and calculate phase.

In this case we get an inclined ellipse now to calculate phase difference we must do in the following way.



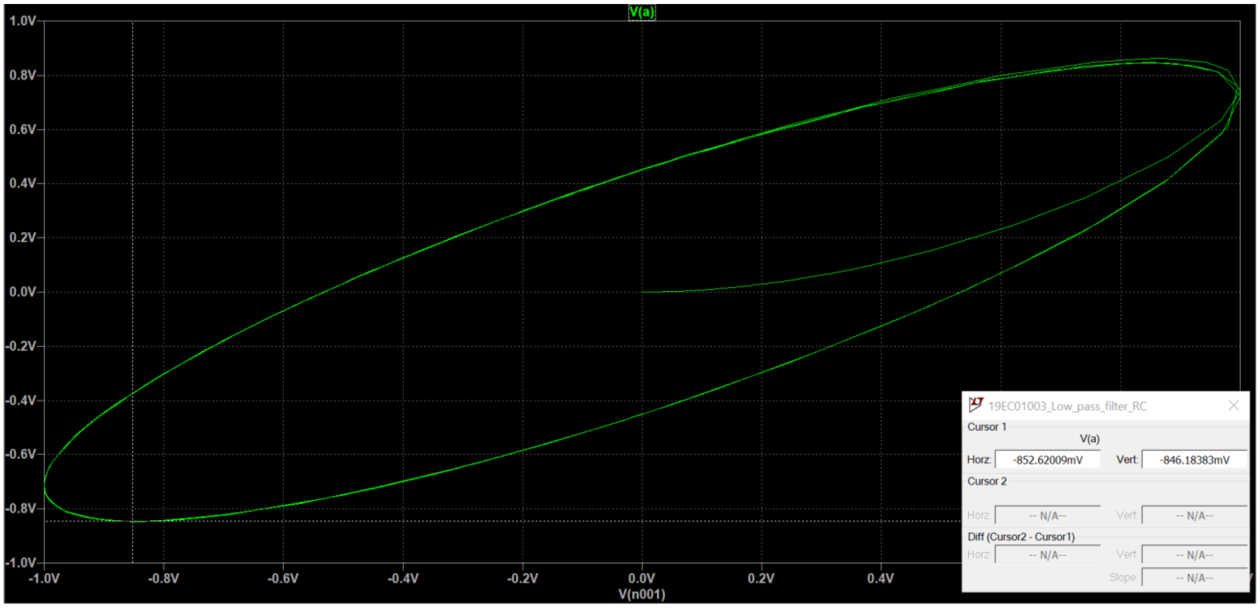
Measure the quantities y1 and y2, and the phase angle = sin -1 (y2/y1)

Graph from circuit diagram.



From the graph we can clearly say that y2 = 0.45-(-0.45) =

0.9V Now to calculate y1 we must zoom the graph.



Observing the cursor we can say the min vertical value of curve is -0.846V As the graph is symmetric about origin the value of y1 is 2 x 0.846.

The y1 = 1.689V

Now we have y1 = 1.689V and y2 = 0.9V Then phase difference = sin -1 (0.9 / 1.689)

= sin -1 (0.5325)

= 32.17 degrees.

Therefore phase difference = 32.17 degrees . Which is very near to first method.

Verifying the phase difference Analytically.

We know that analytically phase difference is = tan -1 (R / Xc)

= tan -1 (R x wC) (as Xc = 1/wC)

= tan -1 (1000 x 2 x pi x 0.0000001)

= tan -1 (0.628)

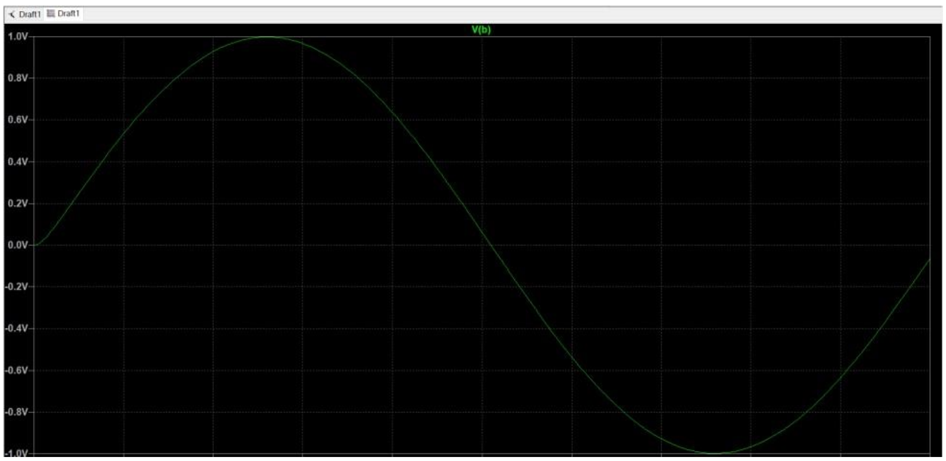
= 32.129 degrees.

Therefore, phase difference = 32.129degrees. Which is equal to both the methods that are done in LTspice.

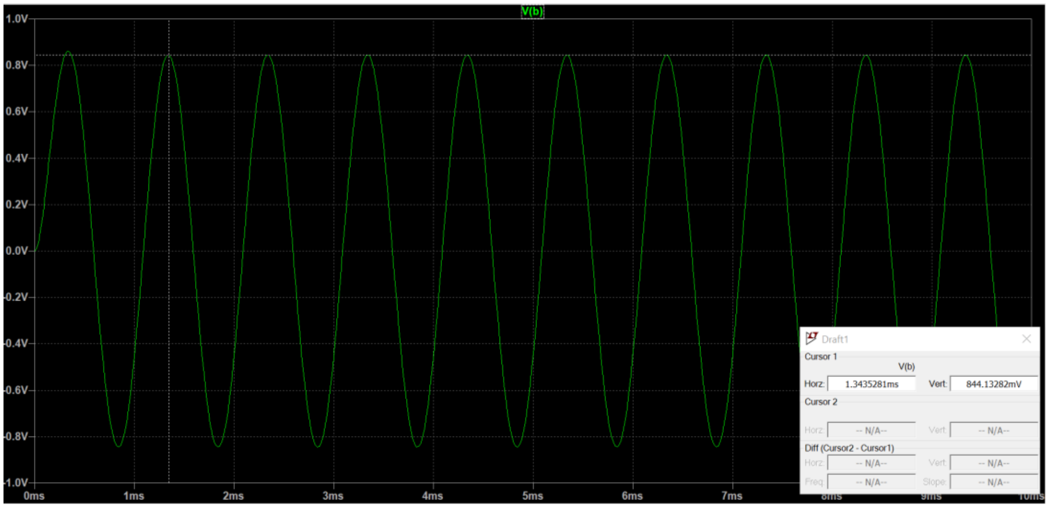
Observations:

Now Keeping Vpp = 2 as constant I'm changing frequency from 100Hz to 1Mz by **randomly collecting 9 frequency values.**

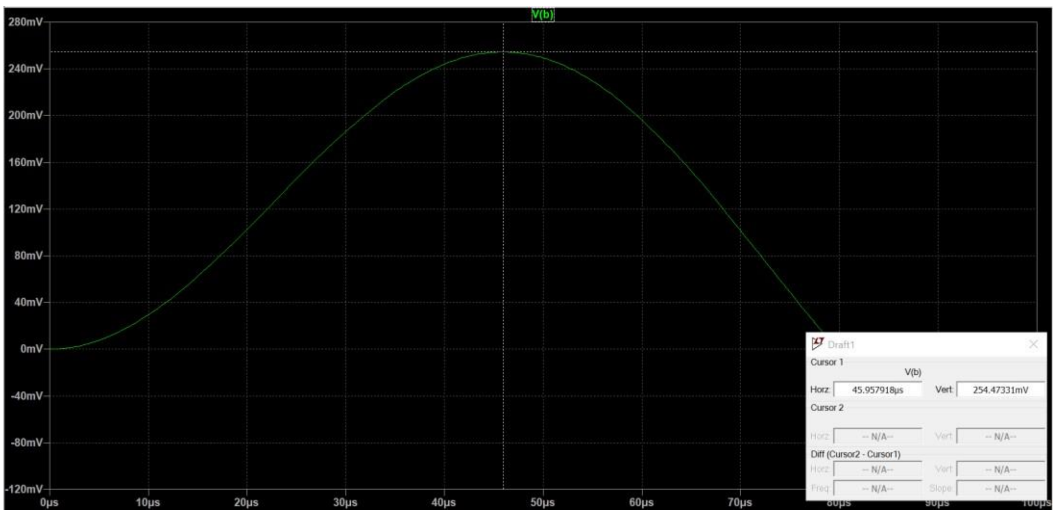
- At f = 100Hz , V(b) ≈ 1.0volts



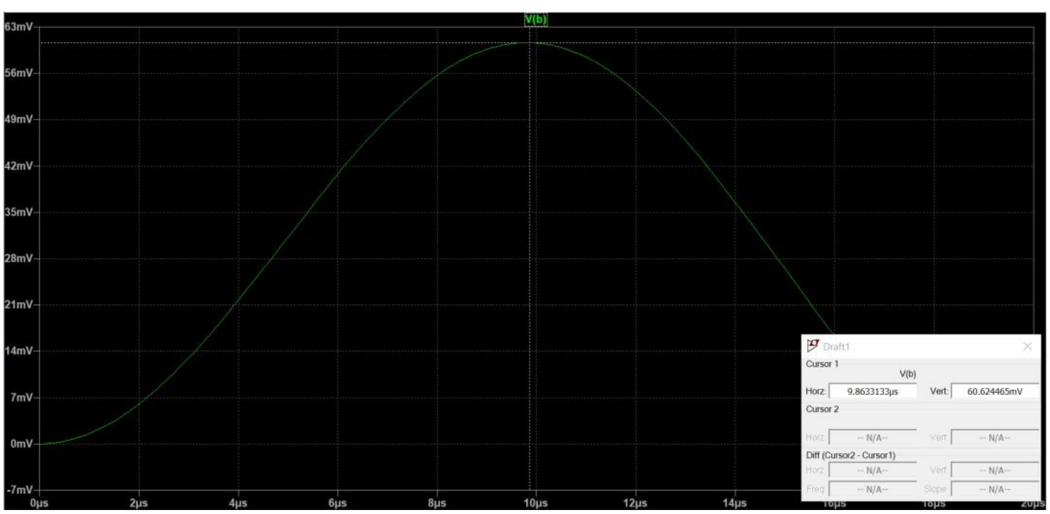
- At f = 1000Hz , V(b) = 0.844volts



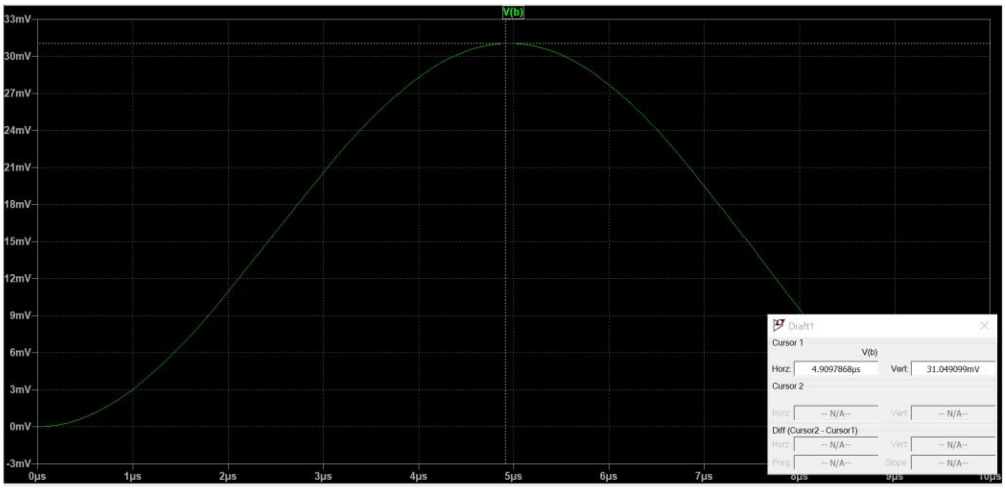
- At f = 10000Hz , V(b) = 0.254volts



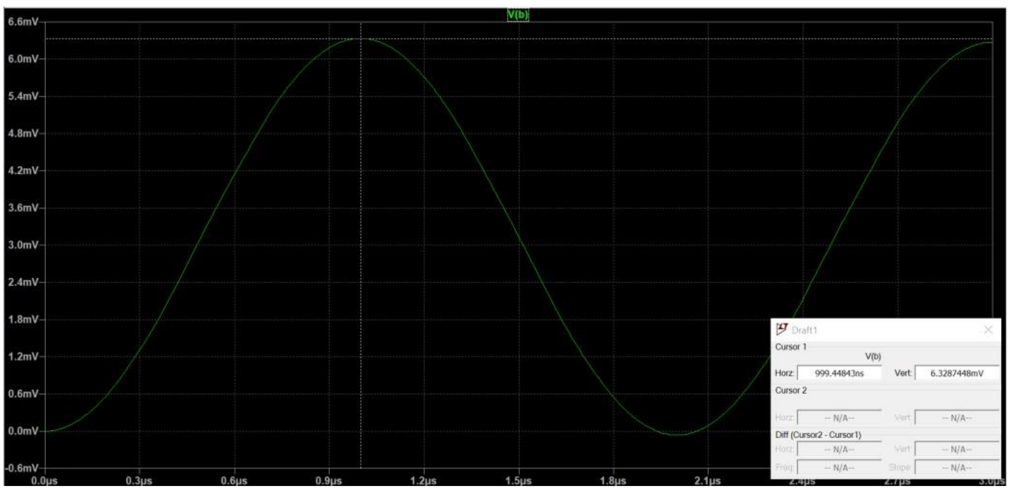
- At f = 50000Hz , V(b) = 0.060volts



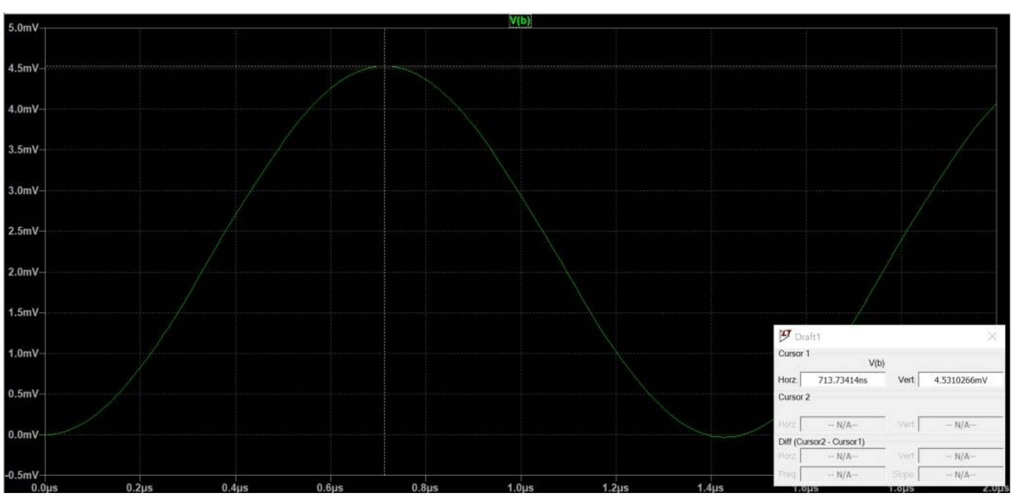
- At f = 100000Hz , V(b) = 0.031volts



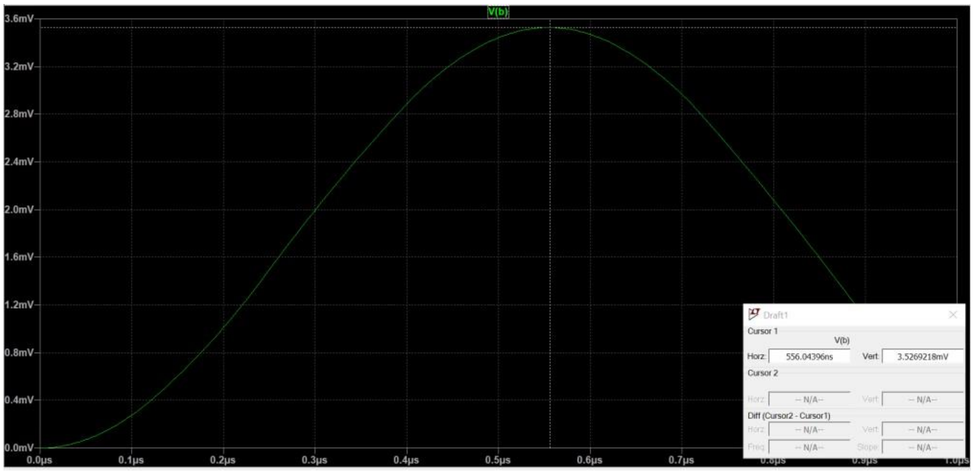
- At f = 500000Hz , V(b) = 0.0063volts.



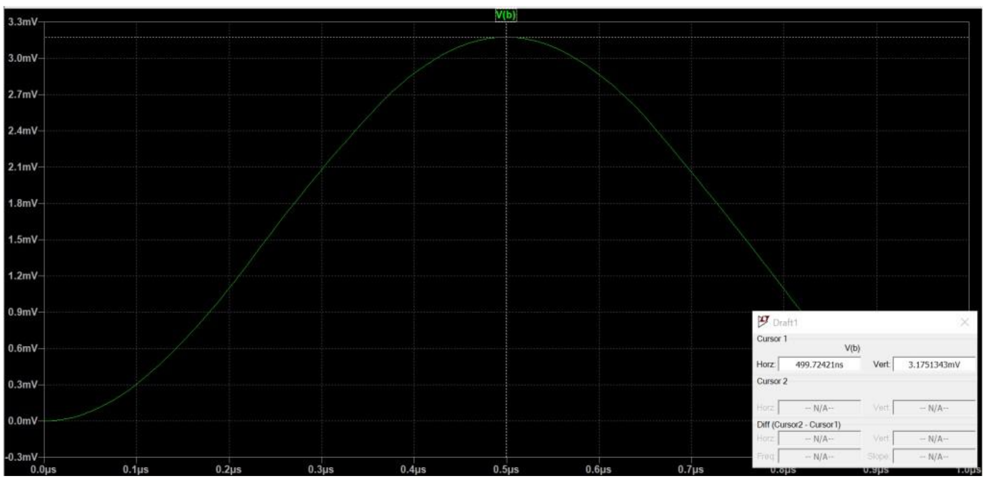
- At f = 700000Hz , V(b) = 0.004volts.



➢ At f = 900000Hz , V(b) = 0.0035volts.



➢ At f = 1000000Hz , V(b) = 0.003175volts



Here we are observing that as frequency increases the output voltage is decreasing this is called as low pass filter.

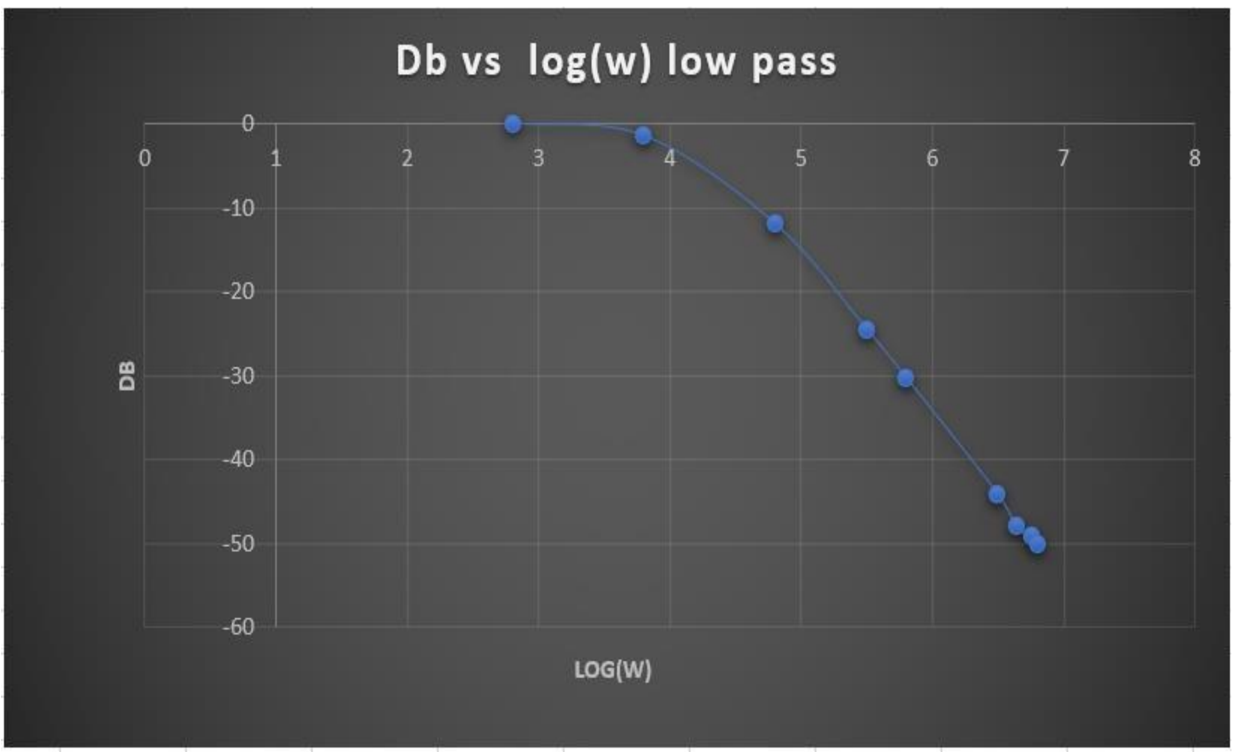
From these values now we are going to enter these values in excel and calculate Gain and we are going to plot the graphs in excel.

frequency	Vin p-p in volts	Vout p-p in volts	Gain	Gain in DB	log(w)
100	2	2	1	0	2.79796
1000	2	1.688	0.844	-1.47315	3.79796
10000	2	0.508	0.254	-11.9033	4.79796
50000	2	0.12	0.06	-24.437	5.49693
100000	2	0.062	0.031	-30.1728	5.79796
500000	2	0.0126	0.0063	-44.0132	6.49693
700000	2	0.008	0.004	-47.9588	6.64306
900000	2	0.007	0.0035	-49.1186	6.7522
1000000	2	0.00635	0.00318	-49.9651	6.79796

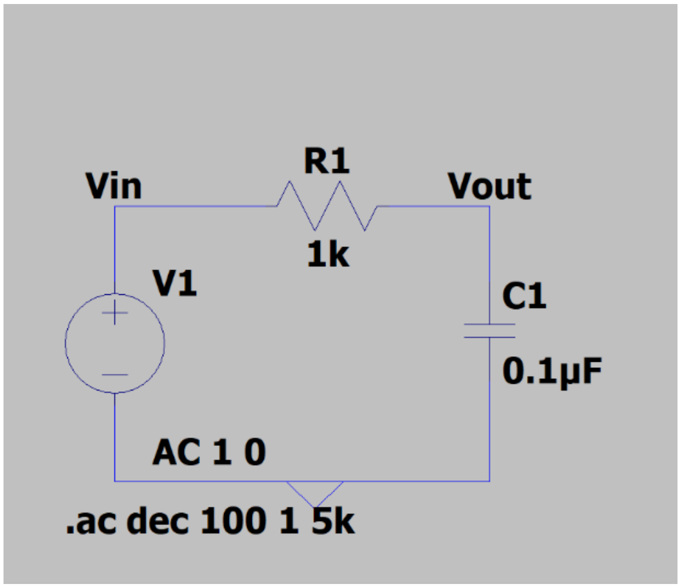
This is for low pass filter

Result

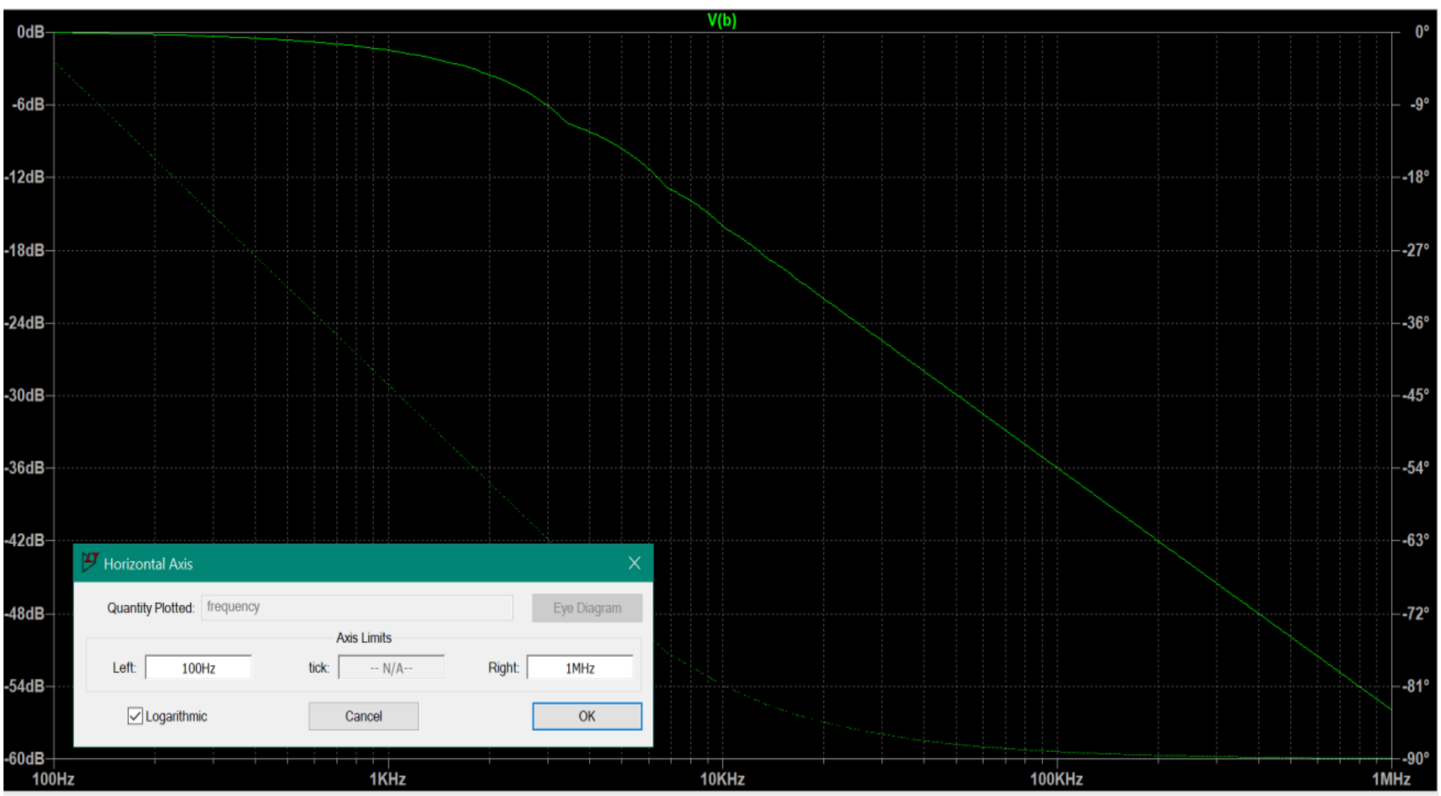
Graph from Excel:



Now Let us see the actual behaviour of low pass circuit in one graph



Output:



Here we can clearly observe the function of low pass circuit.

Discussion:

Now we can clearly observe that , when the frequency is low then amplitude of output voltage is high. As soon as the frequency of input increases then the amplitude of the output voltage decreases.

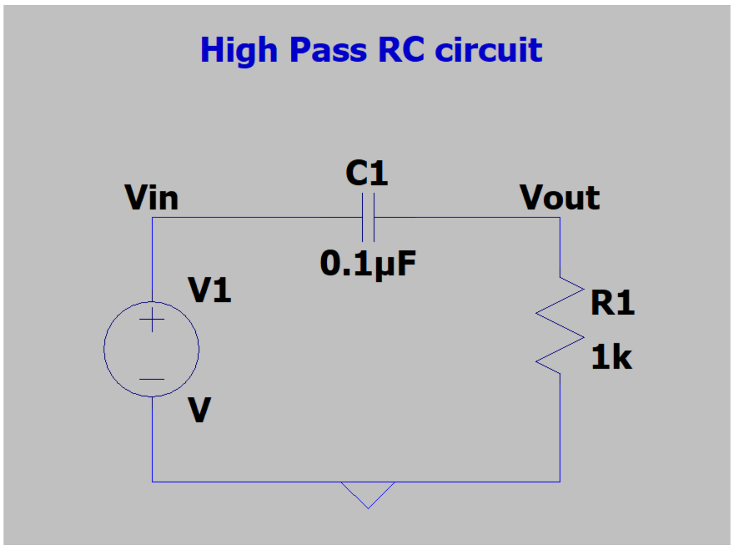
Conclusion:

The RC low pass filter always gives a considerable output for input with low frequency. As the frequency of output tend to i

Part 2

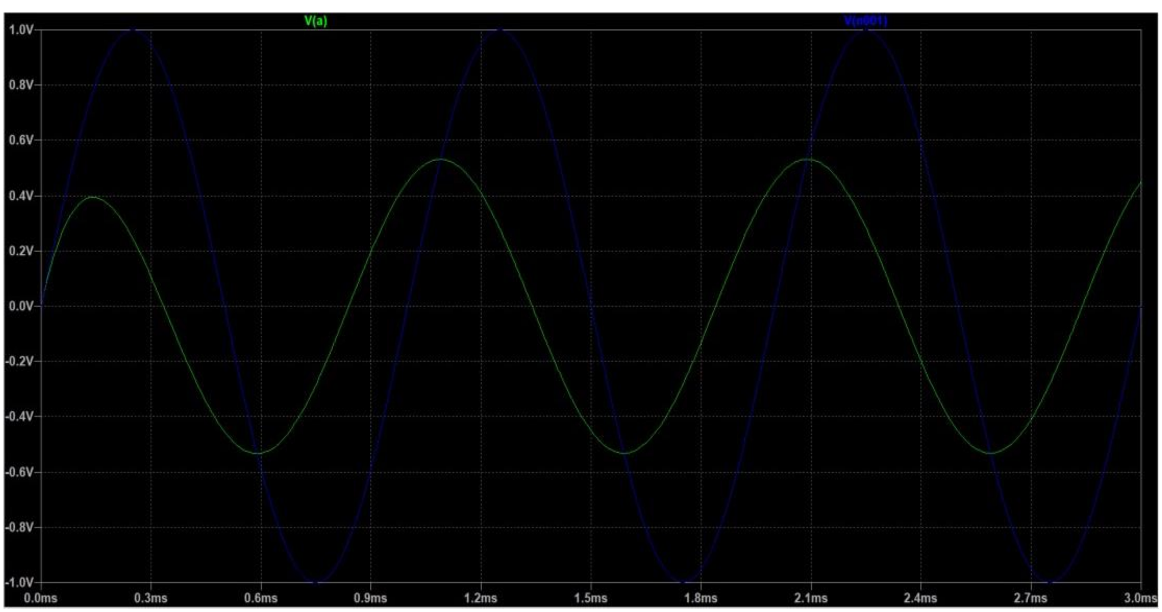
High Pass RC-Circuit

Circuit Diagram

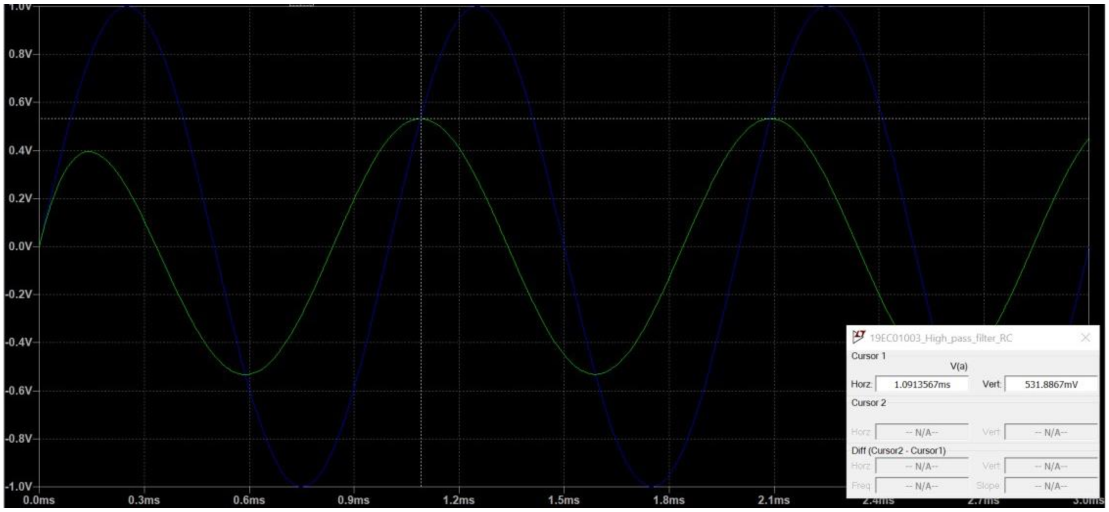


Graphs:

The output for above circuit is….



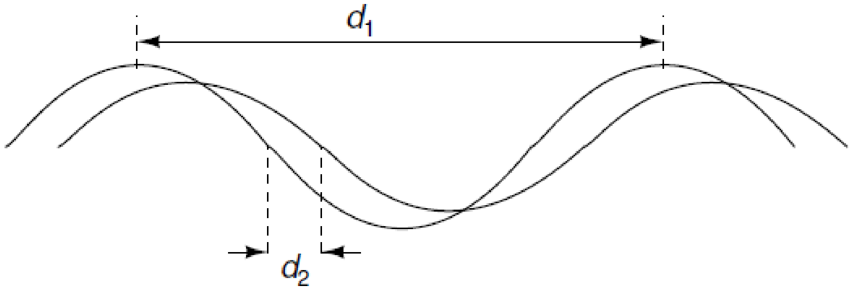
From the graph we can say that V1 = 1volts.



And (Vout)max = 0.531Volts

CALCULATION:-

Sinusoidal wave method:



Now let us measure d1 and d2 . To measure d1 we measure time period of sinusoidal curve of V1 which is equal to d1.

Time period of graph is 1ms which is equal to d1.

Now to measure d2 we must measure the time gap between both curves as 0volts. As we know we are measuring d2 to calculate phase difference both waves. As V1 started at 0volts to measure the phase difference first we have to calculate how much time it has taken for Va to reach 0volts and that time is d2.

Now to calculate d2 we are going to zoom the graph.

From the graph we can say that d2 ≈ 0.159ms.

Now we can calculate the phase difference from d1 and

d2 We Know that, d1 > 360 degrees

d2-----> phase difference , From this we say

phase difference = (d2 x 360) / d1.

= (0.000159 x 360) / (0.001)

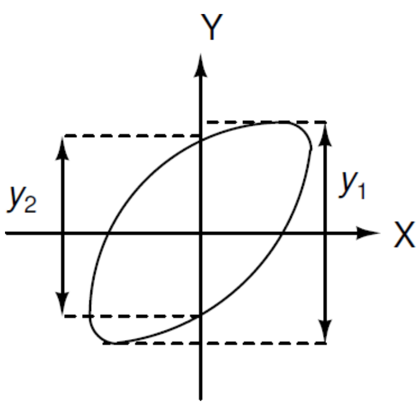
= 57.24degrees.

Therefore phase difference = 57.24degrees.

Ellipse method:

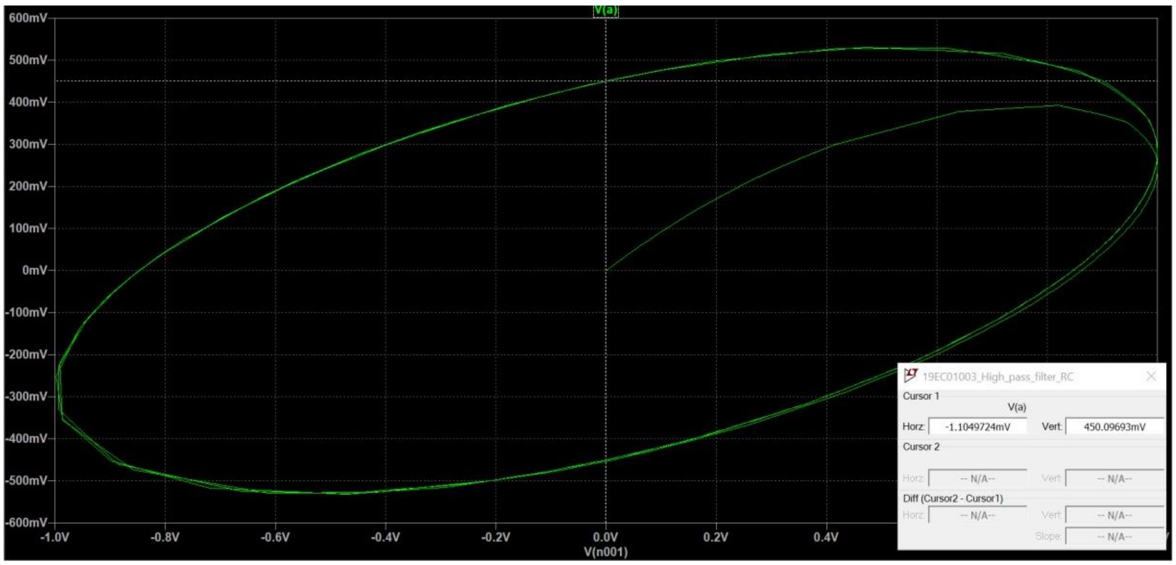
Now we are going to plot V1 as X-axis and Va as Y-axis and caluculate phase.

In this case we get an inclined ellipse now to calculate phase difference we must do in the following way.



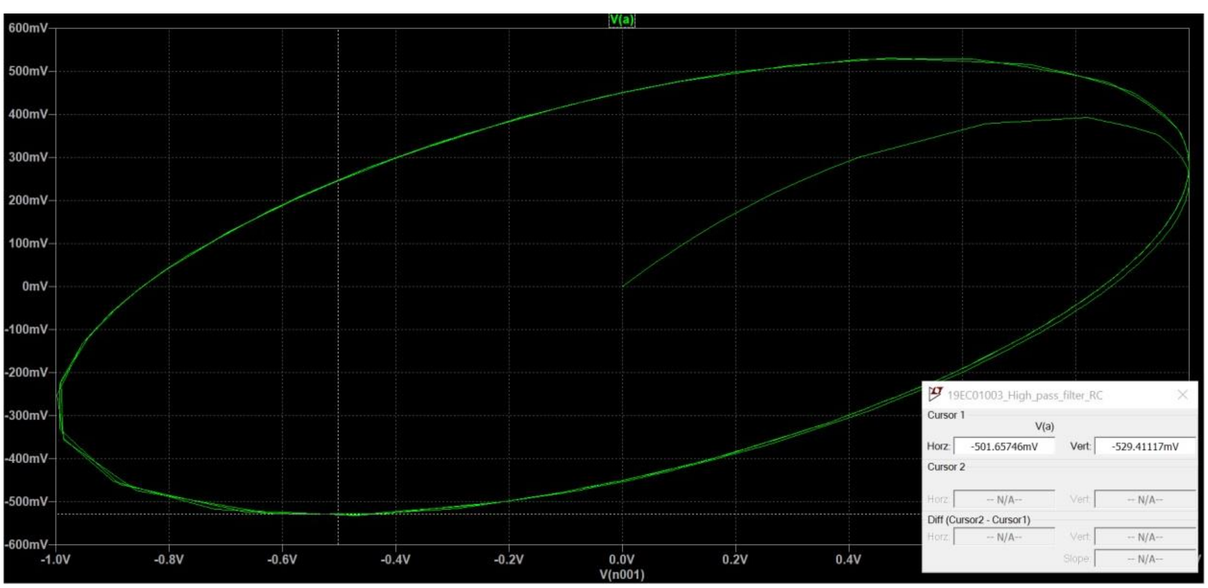
Measure the quantities y1 and y2, and the phase Angle = sin -1

(y2/y1) Graph from circuit diagram.



From the graph we can clearly say that y2 = 0.45-(-0.45) =

0.9V Now to calculate y1 we must zoom the graph.



Observing the cursor we can say the min vertical value of curve is -

0.530V As the graph is symmetric about origin the value of y1 is 2 x

0.530.

The y1 = 1.06V.
Now we have y1 = 1.06V and y2 = 0.9V

Then phase difference = sin -1 (0.9 /

1.06)

= sin -1 (0.84)

= 57.140 degrees.

Therefore phase difference = 57.140 degrees . Which is very near to first method.

Verifying the phase difference Analytically.

We know that analytically phase difference is = tan -1 (Xc / R)

= tan -1 (1 / R x wC) (as Xc = 1/wC)

= tan -1 (1 / 1000 x 2 x pi x 0.0000001)

= tan -1 (1.56)

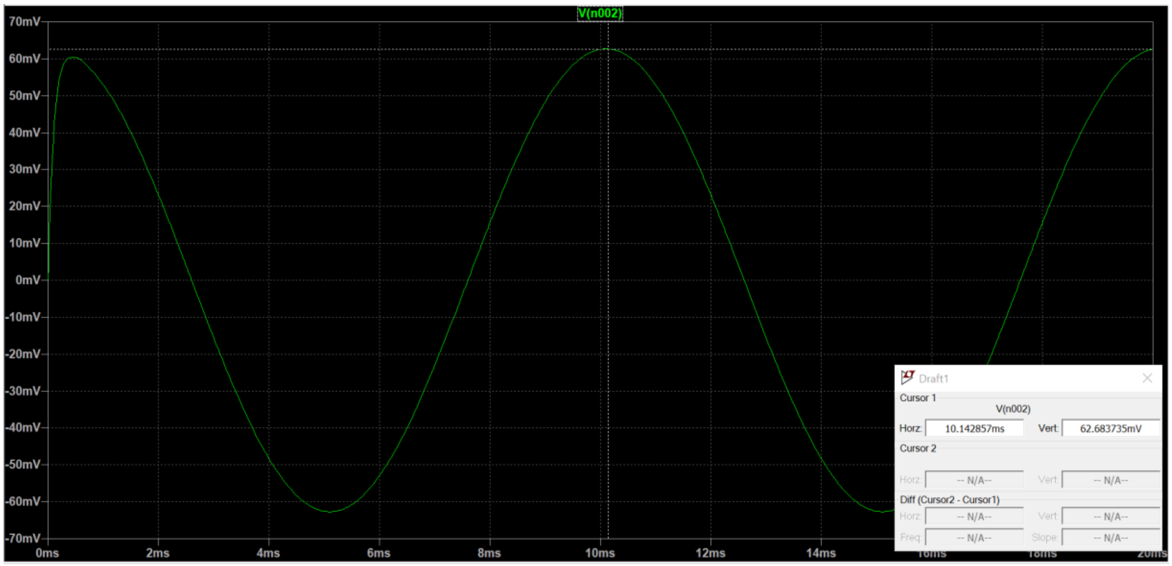
= 57.33 degrees.

Therefore, phase difference = 57.33degrees. Which is equal to both the methods that are done in LTspice.

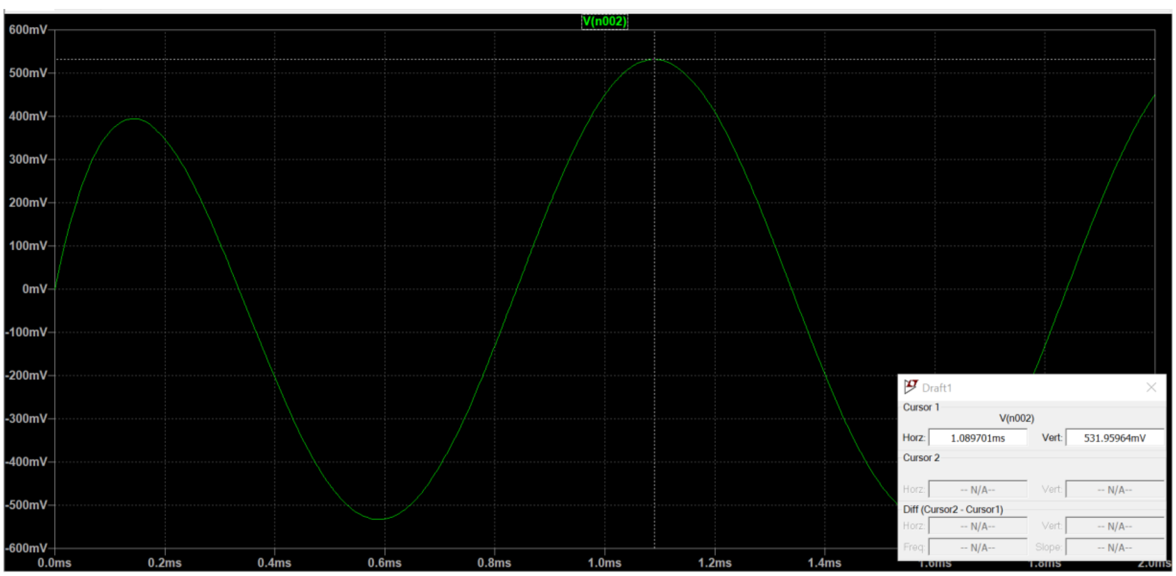
Observations:

Now Keeping Vpp = 2 as constant I'm changing frequency from 100Hz to 1Mz by randomly collecting 5 frequency values.

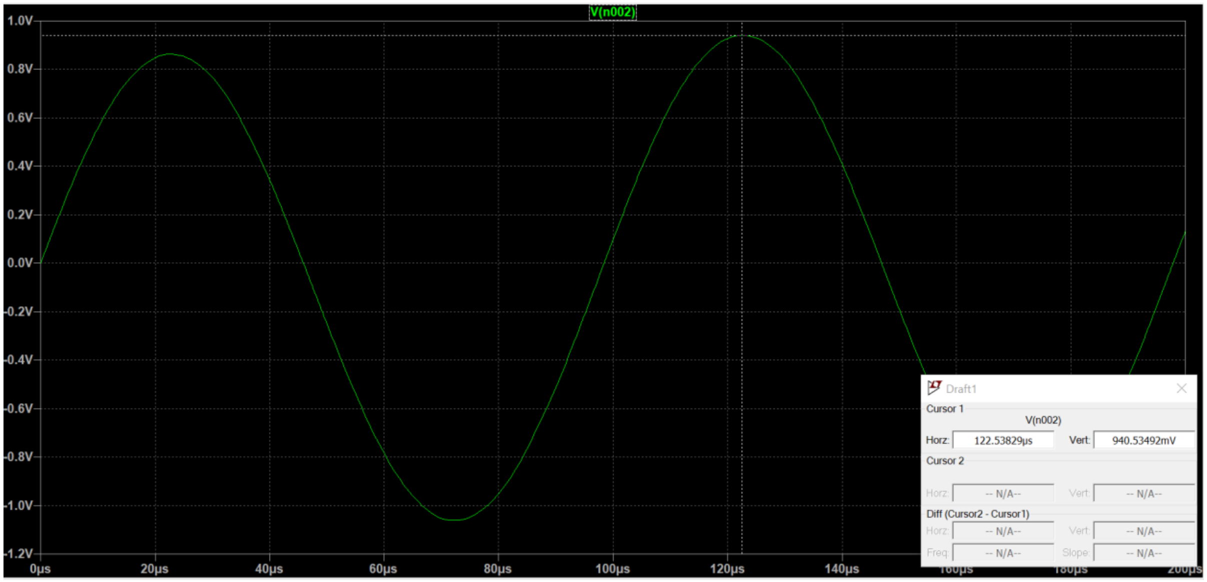
- At f = 100Hz , (Vout) = 0.062volts.



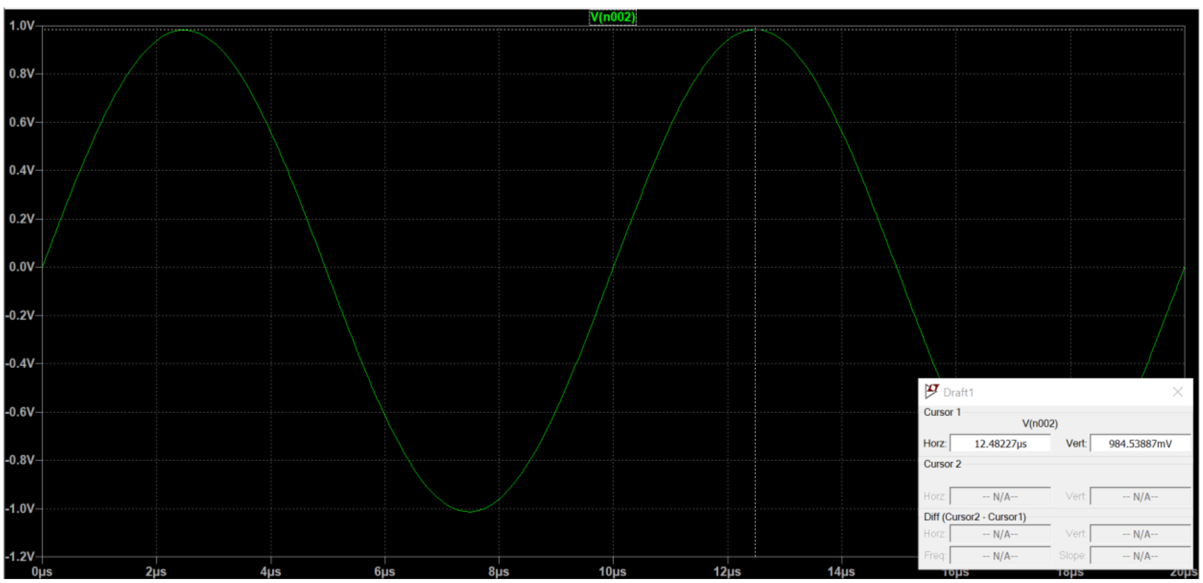
- At f = 1000Hz , Vout = 0.531volts.



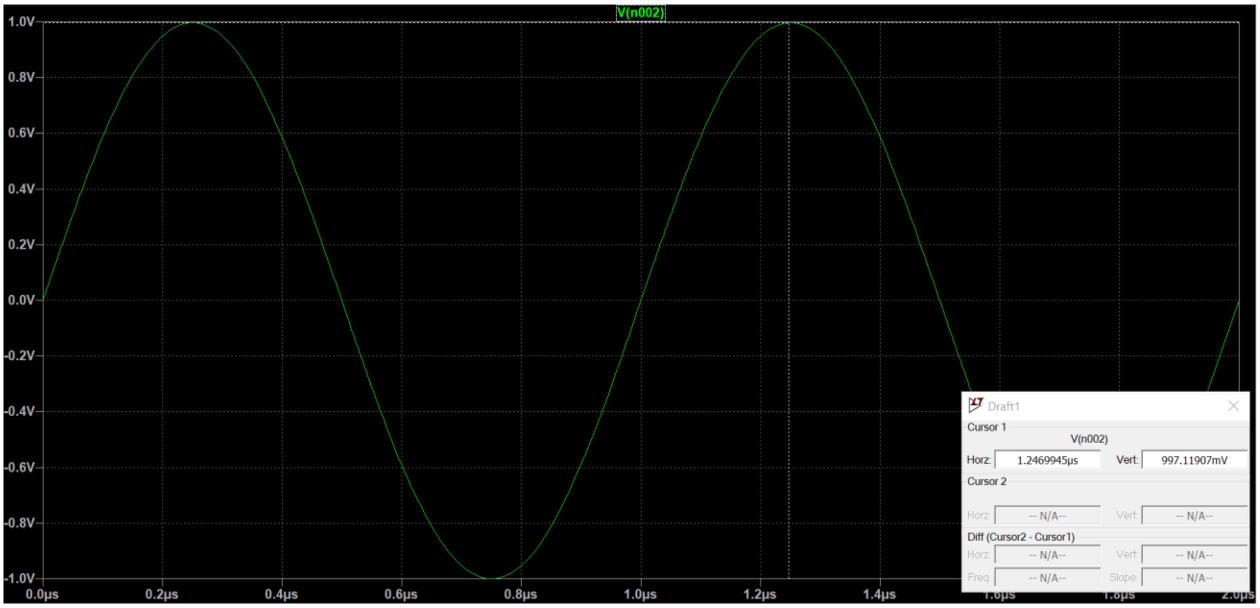
➢ At f = 10000Hz , Vout = 0.940volts.



➢ At f = 100000Hz , Vout = 0,984volts.



➢ At f = 1000000Hz , Vout = 0.997volts.



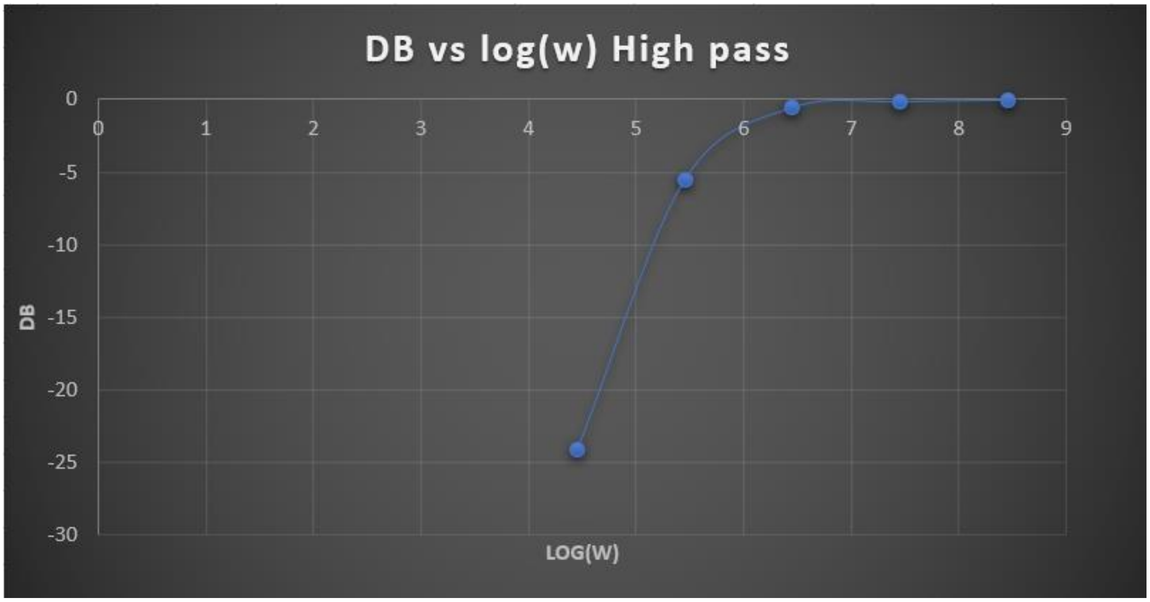
Here we are observing that as frequency increases the output voltage is increasing this is called as High pass filter.

From these values now we are going to enter these values in excel and calculate Gain and we are going to plot the graphs in excel.

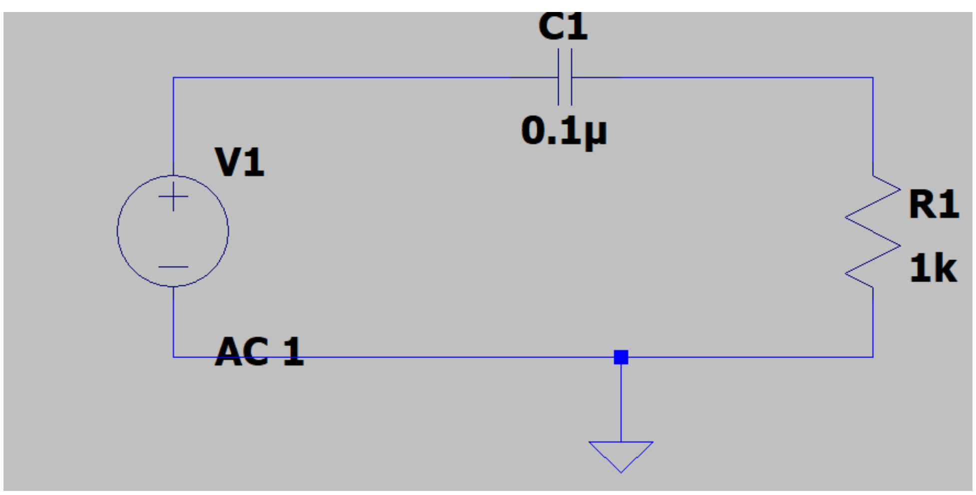
frequency		Vin p-p in volts		Vout p-p in volts		Gain		Gain in DB		log(w)
100			2		0.124		0.062		-24.1522	4.452
1000			2		1.062		0.531		-5.49811	5.452
10000			2		1.88		0.94		-0.53744	6.452
100000			2		1.968		0.984		-0.1401	7.452
1000000			2		1.994		0.997		-0.0261	8.452
		This is for high pass filter								

Result

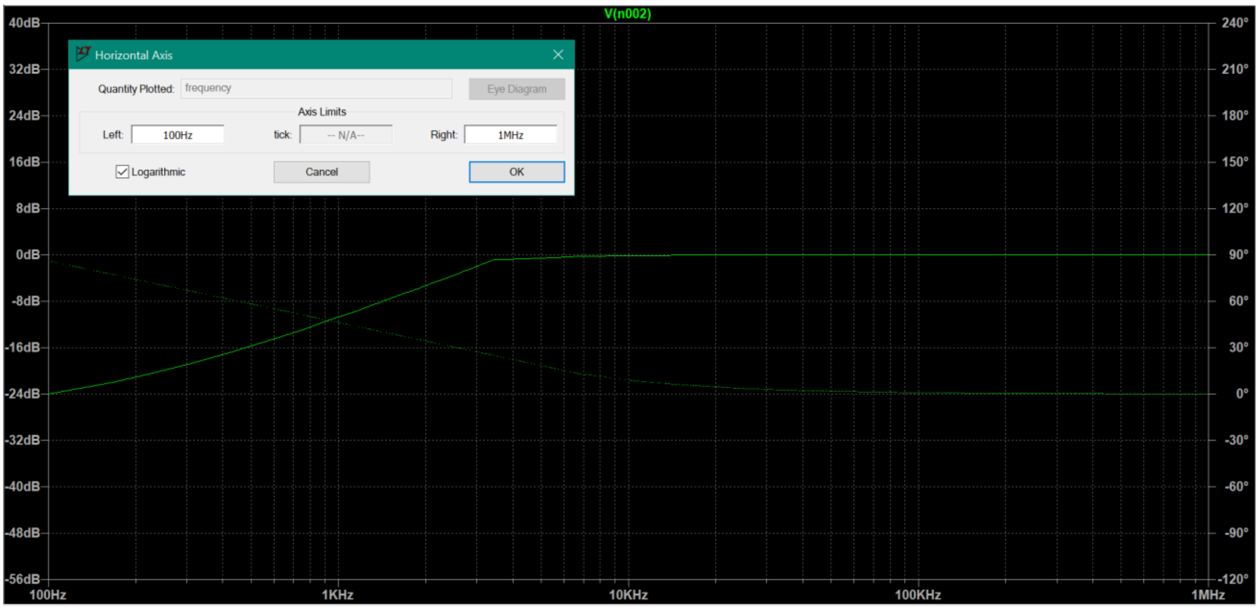
Graph from Excel:



Now Let us see the actual behaviour of low pass circuit in one graph.



Output:



Here we can clearly observe the function of High pass circuit.

<u>Discussion:</u>

Now we can clearly observe that , when the frequency is low then amplitude of output voltage is Low. As soon as the frequency of input increases then the amplitude of the output voltage increases.

<u>Conclusion</u>:

The RC low pass filter always gives a Negligible output for input with Low frequency. As the frequency of output tend to infinity then amplitude of output becomes equal to that of input.