INDIAN INSTITUTE OF TECHNOLOGY BHUBANESWAR

Introduction to Electronics Laboratory

School of Electrical Sciences

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Part 1

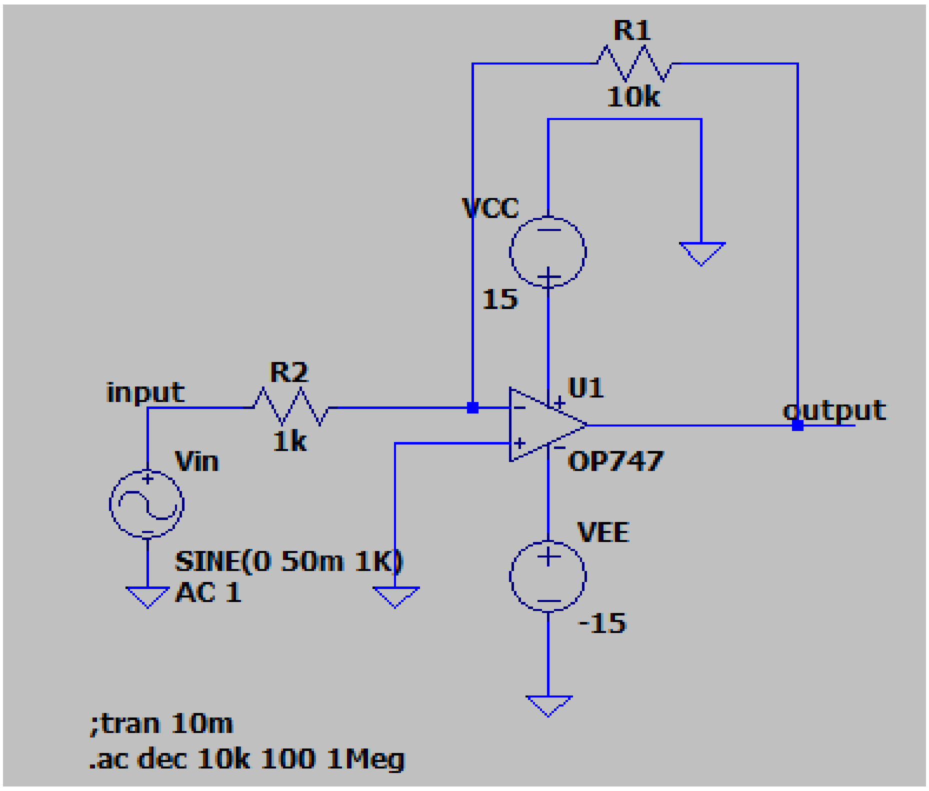
Aim:

Analyzing an Inverting amplifier through Op-amp

Theory:

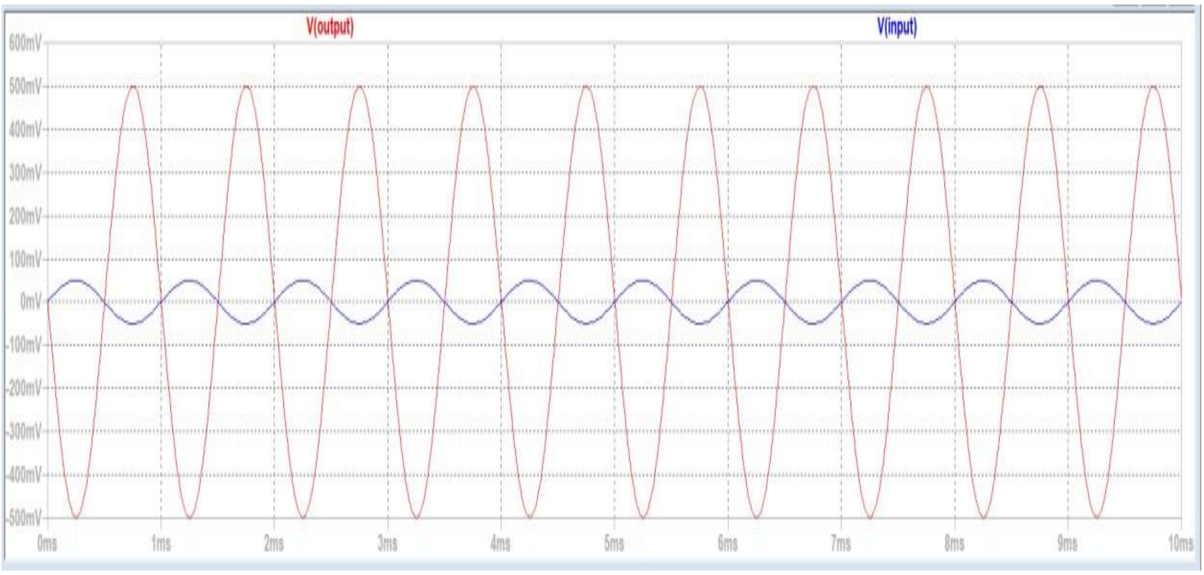
An inverting amplifier using opamp is a type of amplifier using opamp where the output waveform will be phase opposite to the input waveform. The input waveform will be amplifier by the factor Av (voltage gain of the amplifier) in magnitude and its phase will be inverted.

Circuit Diagram:

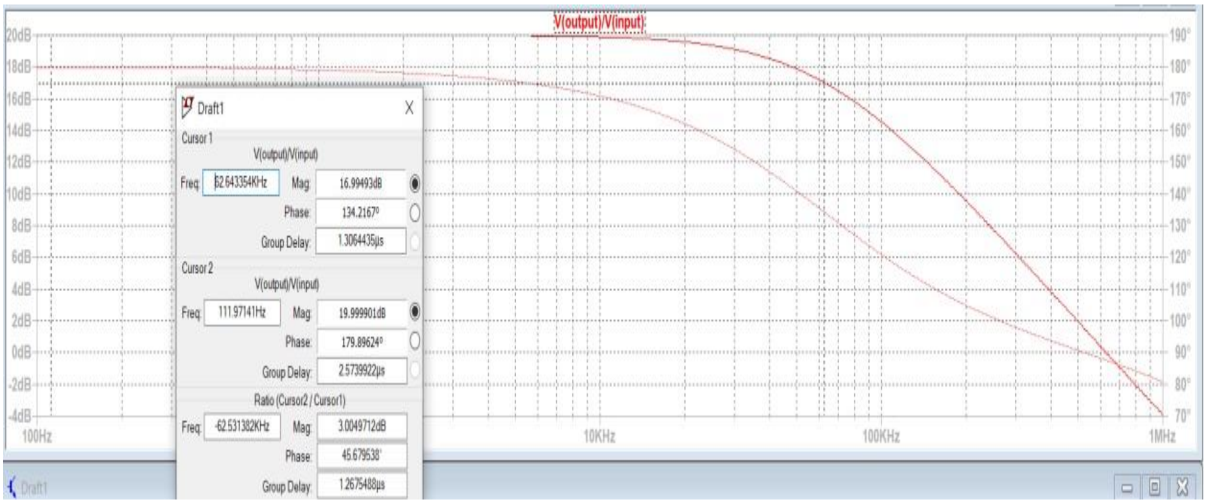


Graphs:

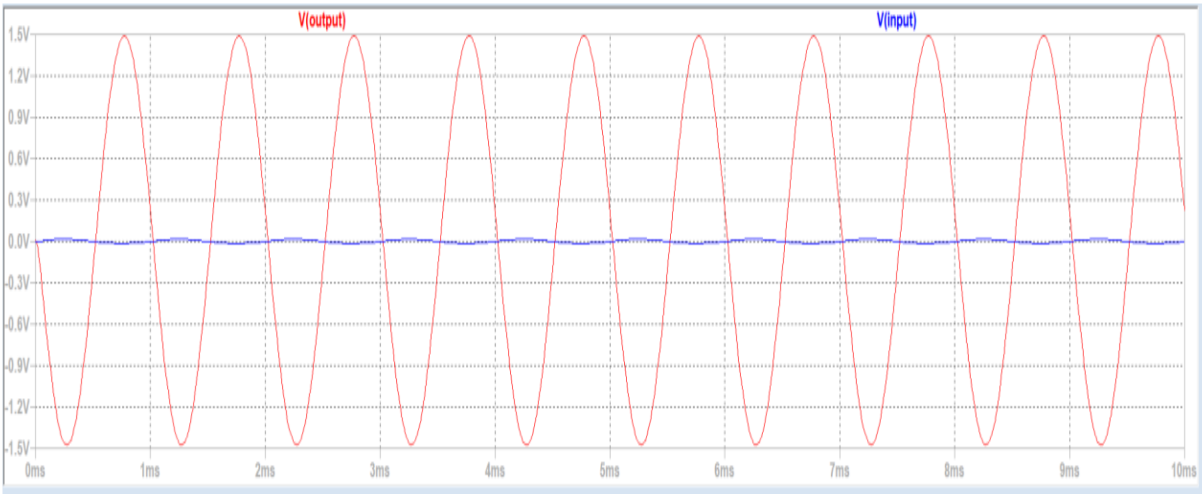
a) Output and Input (R2=10kΩ,Vin=100mVpp at 1kHz)



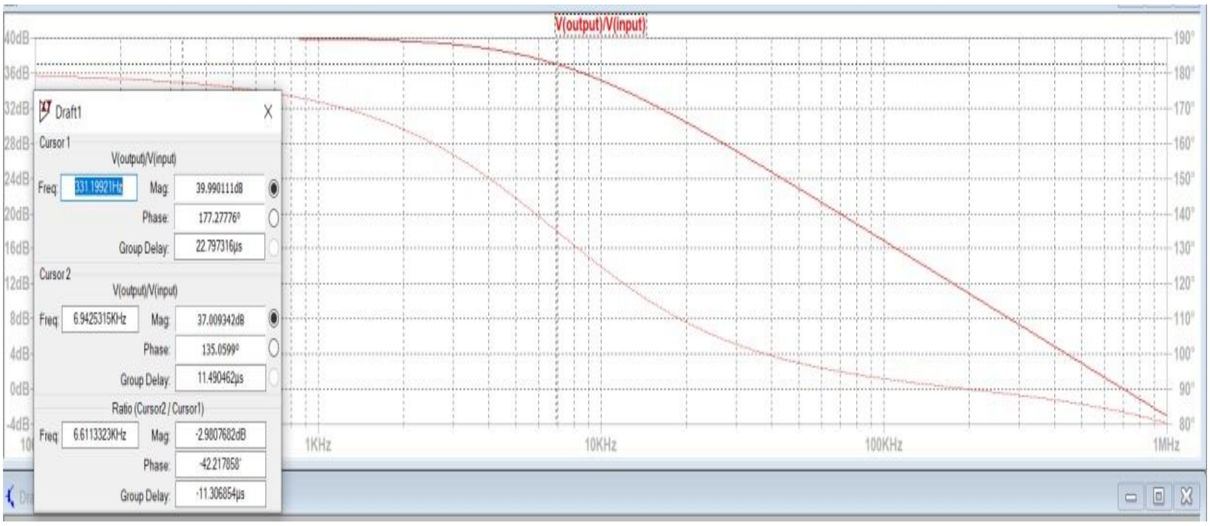
Gain vs frequency plot(in dB):



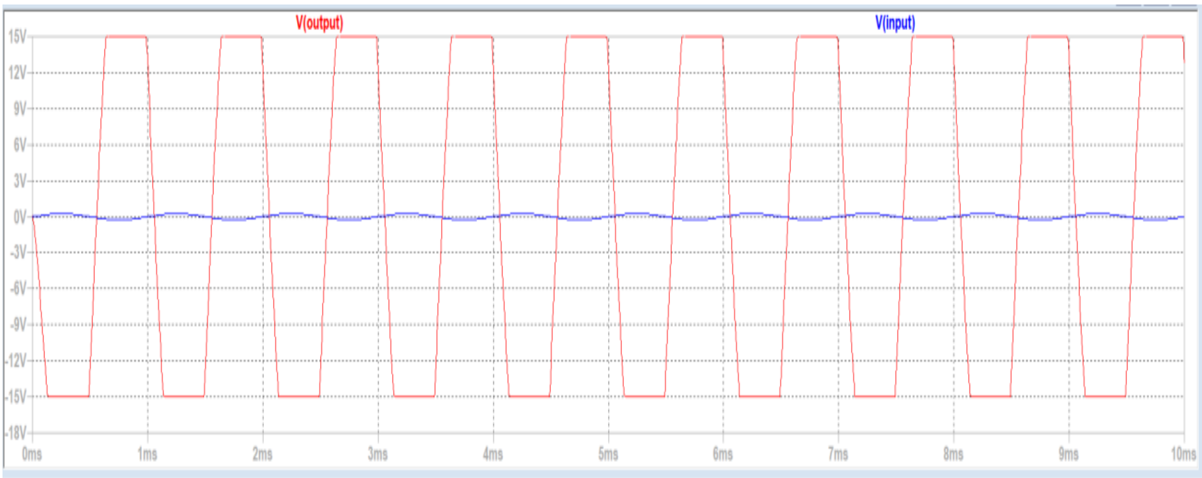
b) Output and Input(R2=100kΩ,Vin=30mVpp at 1kHz)



Gain vs frequency plot(in dB):



c)Output and Input(R2=100kΩ,Vin=500mVpp at 1kHz)



Results:

- For R2=10kΩ,Vin=100mVpp,Vout max=500mV
  3dB cutoff frequency=62.64kHz,
  Av=Vout/Vin=500mV/50mV=-10V/V(due to phase difference of 180 degrees)

- For R2=100kΩ,Vin=30mVpp,Vout max=1.5V
  3dB cutoff frequency=6.94kHz,
  Av=Vout/Vin=1500/15=-100V/V(due to phase difference of 180degrees)

Part 2

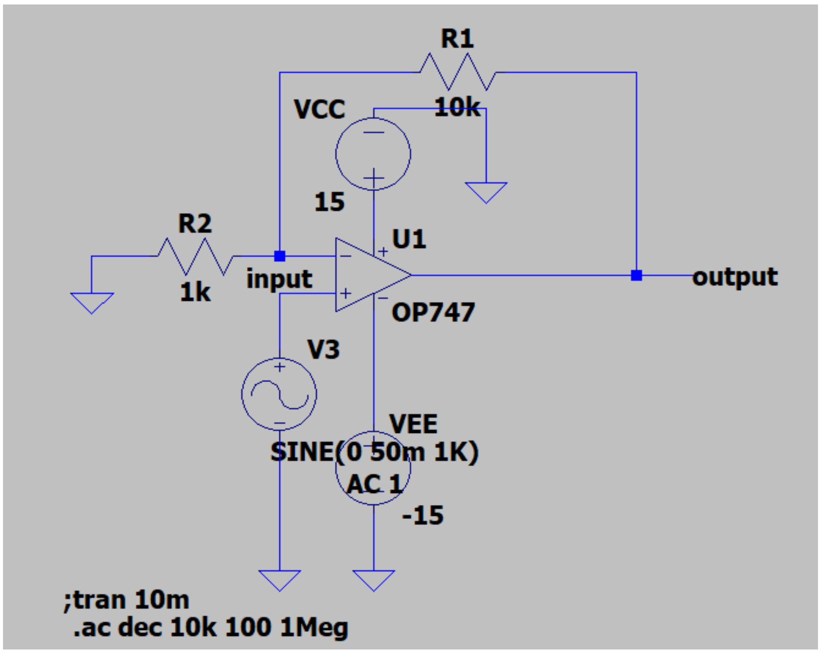
Aim:

Analyzing a Non-Inverting Amplifier using Op-amp

Theory:

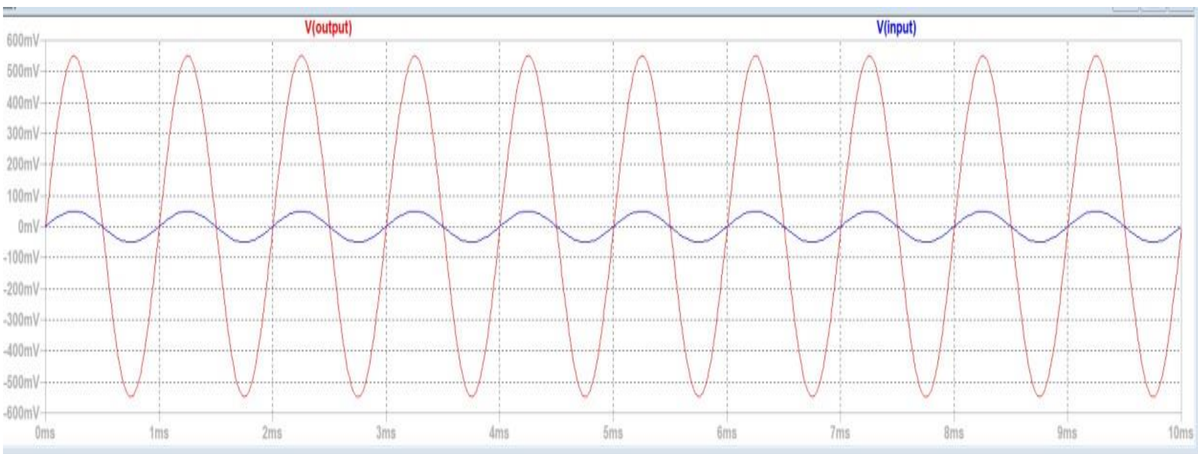
A non-inverting amplifier is an op-amp circuit configuration that produces an amplified output signal. This output signal of the non-inverting op-amp is in-phase with the input signal applied. In other words, a non-inverting amplifier behaves like a voltage follower circuit.

Circuit Diagram:

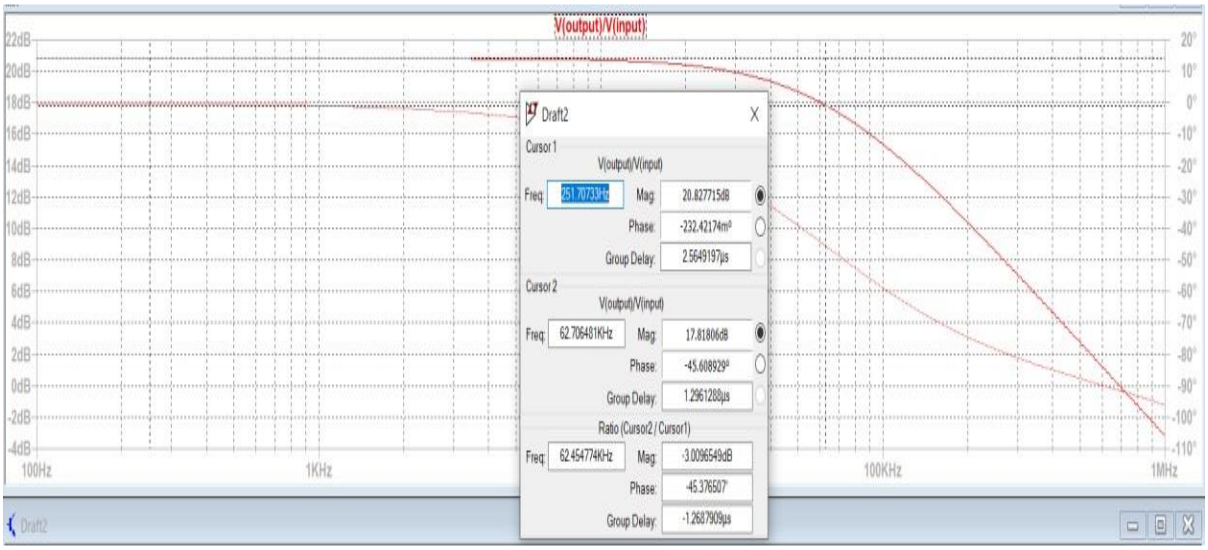


Graphs:

Output and Input



Gain vs Frequency(in dB):



Results:

For R1=10kΩ,Vin=100mVpp at 1kHz,Vout max=550mV

3dB cutoff frequency=62.45kHz,

Av=Vout/Vin=550mV/50mV=11V/V

Part 3

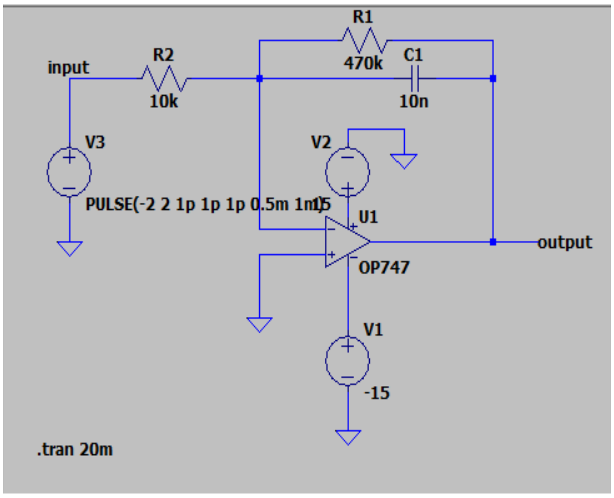
Aim:

Analyzing an Integrator Circuit using Op-amp.

Theory:

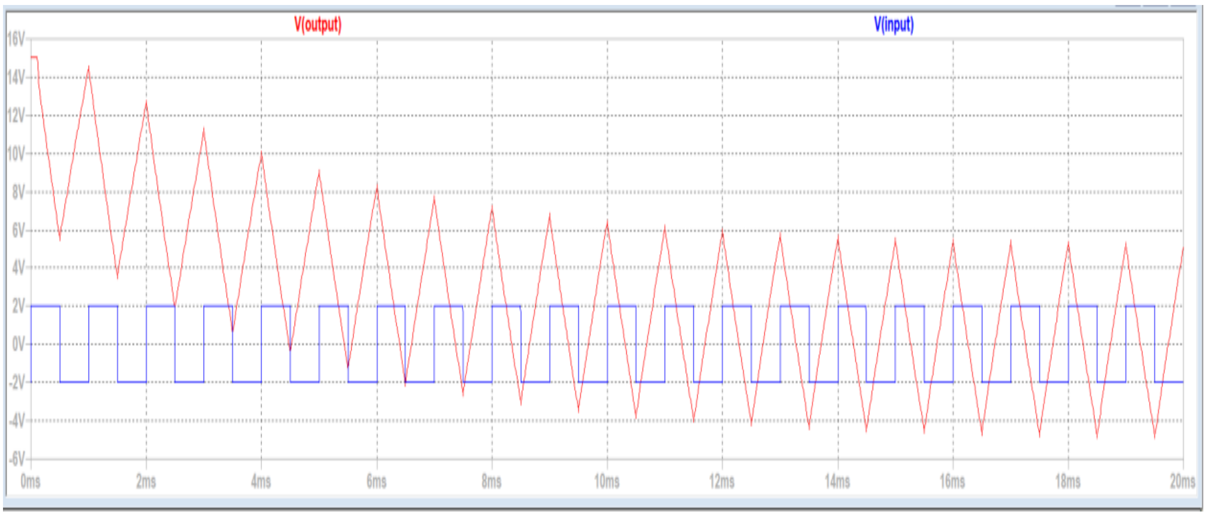
The integrator Op-amp produces an output voltage that is both proportional to the amplitude and duration of the input signal.

Circuit Diagram:

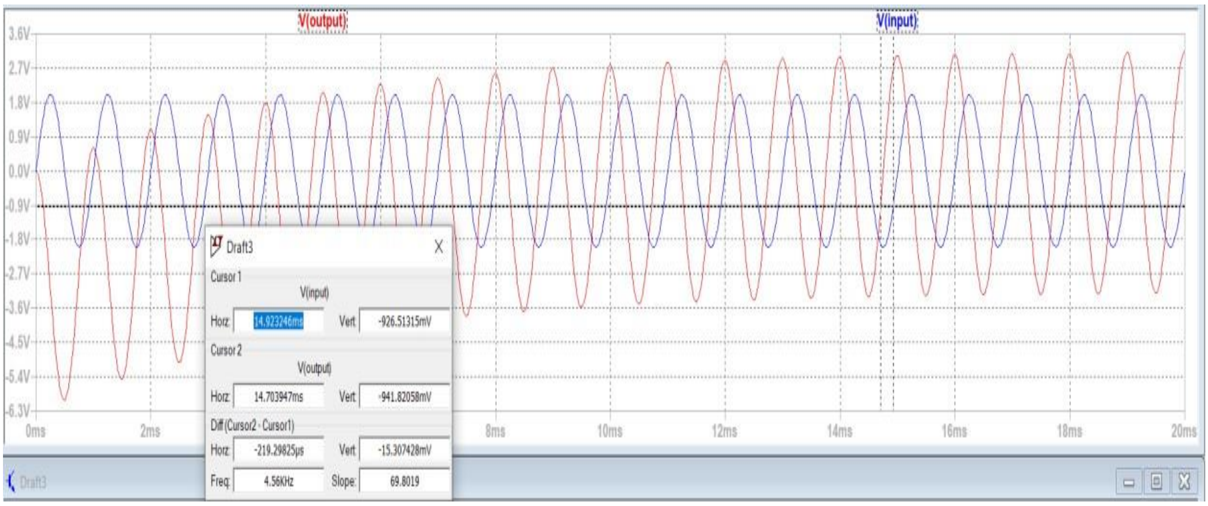


Graphs:

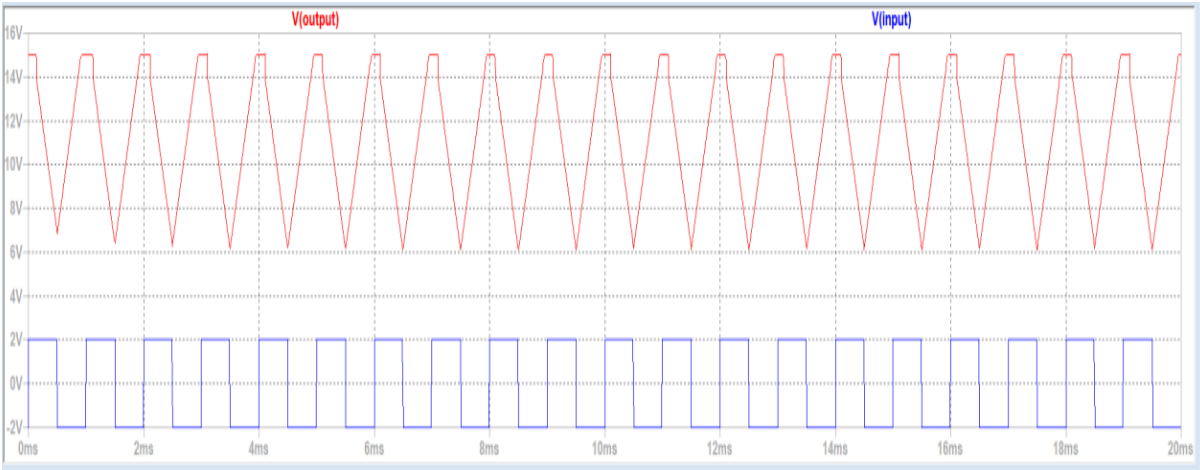
With Square wave and resistor 470kΩ



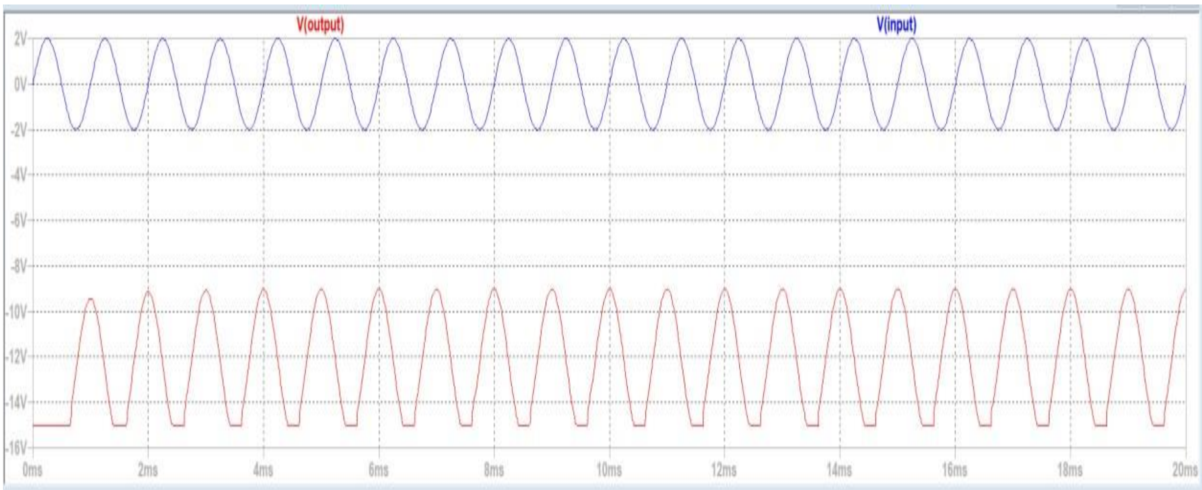
With Sine wave and resistor 470kΩ



Without resistor and with square wave



Without resistor and with sine wave



Results:

- For square wave and resistor 470kΩ, we obtained a triangular wave.

- For input signal as sine wave and resistor 470 kΩ, phase shift from graph=219.29µs;
  Phase difference=2*pi*(219.29 µs)/1m=pi/2.28
  We get a sine signal with a phase difference of pi/2.28.

- Without resistor 470 kΩ, for input square wave we obtained a triangular wave clipped at +15V.

- Without resistor 470 kΩ, for input sine wave we obtained a sine wave clipped at -15V.

Part 4

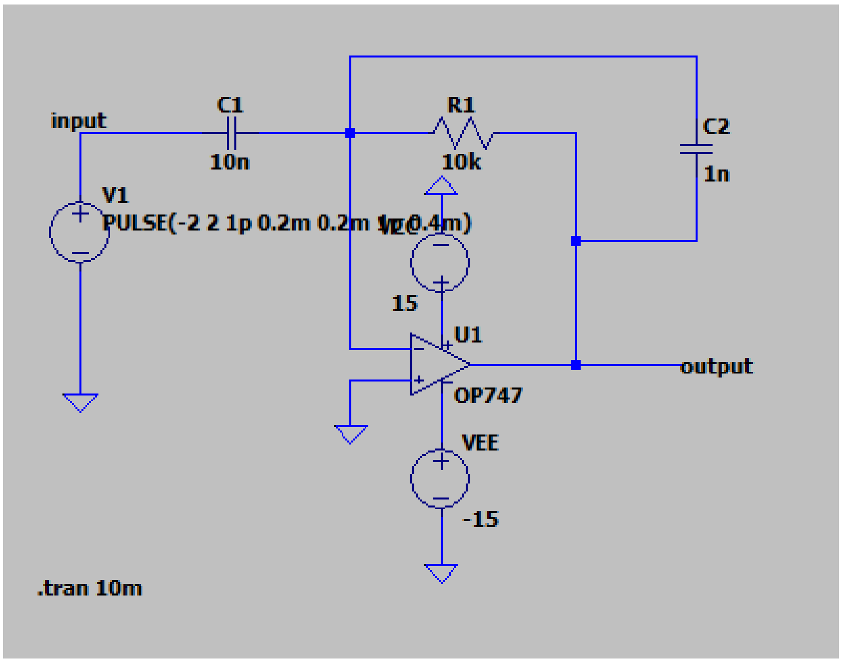
Aim:

Analyzing a differentiator circuit using Op-amp

Theory:

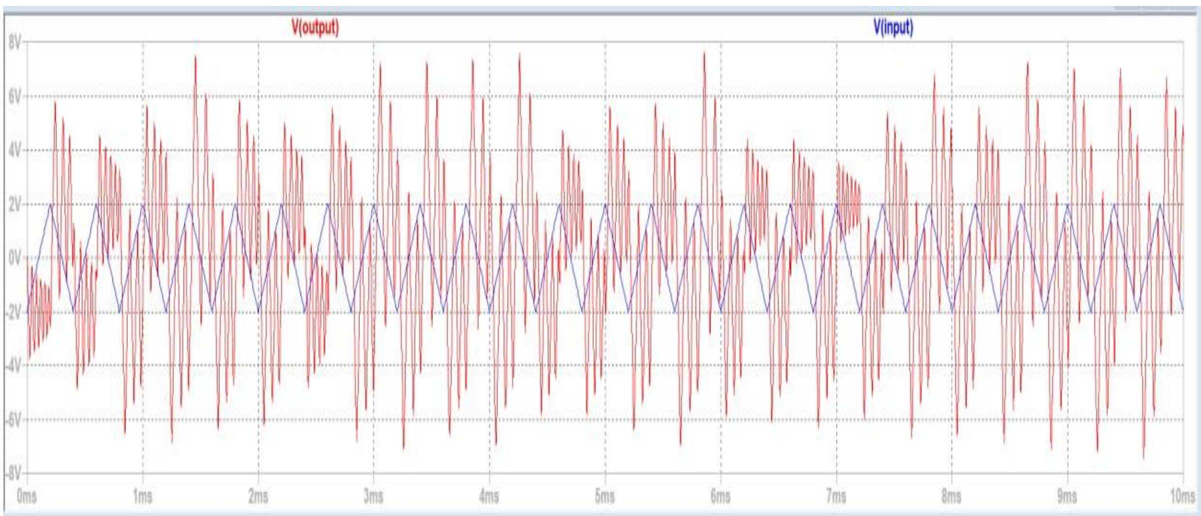
An op amp differentiator is basically an inverting amplifier with a capacitor of suitable value at its input terminal. The figure below shows the basic circuit diagram of an op amp differentiator.

Circuit Diagram:

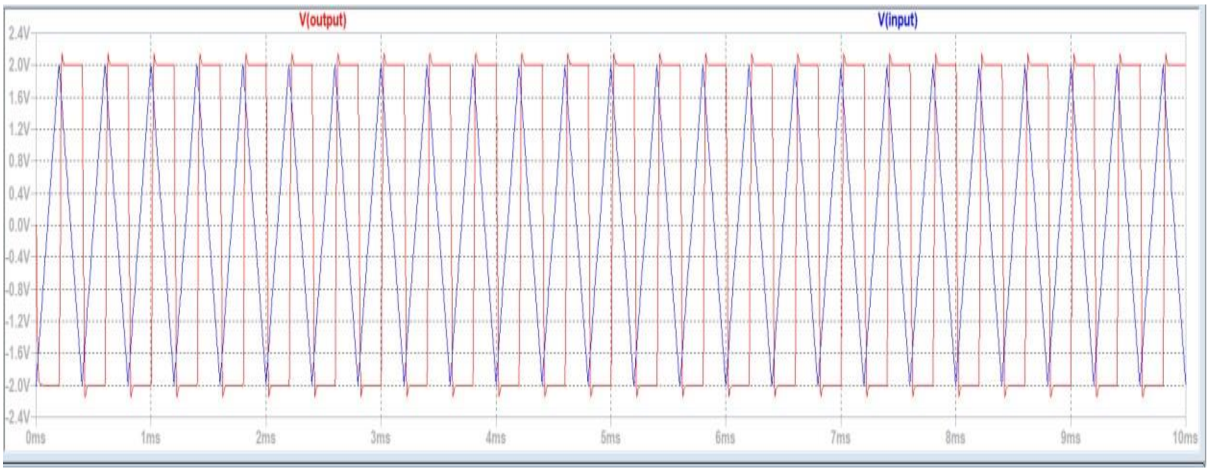


Graphs:

Without Capacitor:



With Capacitor=1nF



Discussion

- ***NEED OF FEEDBACK RESISTOR IN INTEGRATOR CIRCUIT:***

At zero frequency (0Hz) or DC, the capacitor acts like an open circuit due to its reactance thus blocking any output voltage feedback. **As a result, very little negative feedback is provided from the output back to the input of the amplifier.**

Therefore, with just a single capacitor, C in the feedback path, at zero frequency the op-amp is effectively connected as a normal open-loop amplifier with very high open- loop gain. This results in the op-amp becoming unstable cause undesirable output voltage conditions and possible voltage saturation.

This circuit connects a high value resistance in parallel with a continuously charging and discharging capacitor. The addition of this feedback resistor, R2 across the capacitor, C gives the circuit the characteristics of an inverting amplifier with finite closed-loop voltage gain given by: R2/R1.

- ***NEED OF FEEDBACK CAPACITOR IN DIFFERENTIATOR CIRCUIT:***

The input signal to the differentiator is applied to the capacitor. The capacitor blocks any DC content so there is no current flow to the amplifier summing point, X resulting in zero output voltage. The capacitor only allows AC type input voltage changes to pass through and whose frequency is dependent on the rate of change of the input signal.

At low frequencies the reactance of the capacitor is “High” resulting in a low gain (Rf/Xc) and low output voltage from the op-amp. At higher frequencies the reactance of the capacitor is much lower resulting in a higher gain and higher output voltage from the differentiator amplifier.

However, at high frequencies an op-amp differentiator circuit becomes unstable and will start to oscillate. To avoid this the high frequency gain of the circuit needs to be reduced by adding an **additional small value capacitor across the feedback resistor**.

- In part 1, the source is connected at inverting terminal, and hence the phase difference between the output and input is 180 degrees. Even if Rf(R1) ids increased, the input resistance is very large and not a very good gain is possible. The 3dB cutoff frequency is more in first case than second. For very large input, the output will have maximum and minimum value of power supply, effectively clipping at 15V.

- In part 2, i.e non inverting amplifier, the phase difference is 0 degrees.

- In part 3, the output is a triangular wave for a Square wave as input. If the value is more than the saturated voltage, the output is itself the given power supply or the saturated voltage. On the other hand, for a sine wave as input, a cosine wave is observed at the output and the output is clipped off at the saturated voltage.

- In part 4, Differentiator circuit does the opposite of part3, it gives the differentiated input as the output. Like a square wave as output for a triangular input.

Conclusion

INVERTING OPERATIONAL AMPLIFIER:

- We see that the gain depends on the external resistors which is very efficient in designing amplifiers for required values of gain.
- The shape of the output remains the same but is out of phase with the input, hence the name inverting output.
- The theoretical and practical values almost match ensuring our assumptions are true to some extend and practical realization is possible.
- Feedback mechanism helps us to achieve this amplification configuration.
- The gain-bandwidth product helps us to account for the bandwidth according to the designed gain of the op-amplifier.

NON-INVERTING AMPLIFIER:

- We see that the gain depends on the external resistors which is very efficient in designing amplifiers for required values of gain. Gain obtained here is more than that of the inverting amplifier.
- The shape of the output remains the same and is in phase with the input, hence the name non-inverting output.

INTEGRATOR CIRCUIT:

- The resultant output waveform was the integration of the input signal as expected from the name of the circuit.
- The feedback capacitor helps to achieve this operation. Without this, there is a net dc value which leads the output values to saturate at the supply voltage value, thus giving undesirable output.

DIFFERENTIATOR CIRCUIT:

- The resultant output waveform was the differentiation of the input signal as expected from the name of the circuit.
- The feedback capacitor ensures this operation as without that, there are many high frequency components in the output which needs to be filtered out. This parallel capacitor along with a resistor acts as a low pass filter thus ensuring desirable output.