Department of Electrical Engineering
IIT Ropar
EE302 Analog Circuits Lab

Experiment 5

Design of adder and subtractor circuit using differential amplifier

Keshav Kishore
2018eeb1158

Submission Date: 10/04/2021

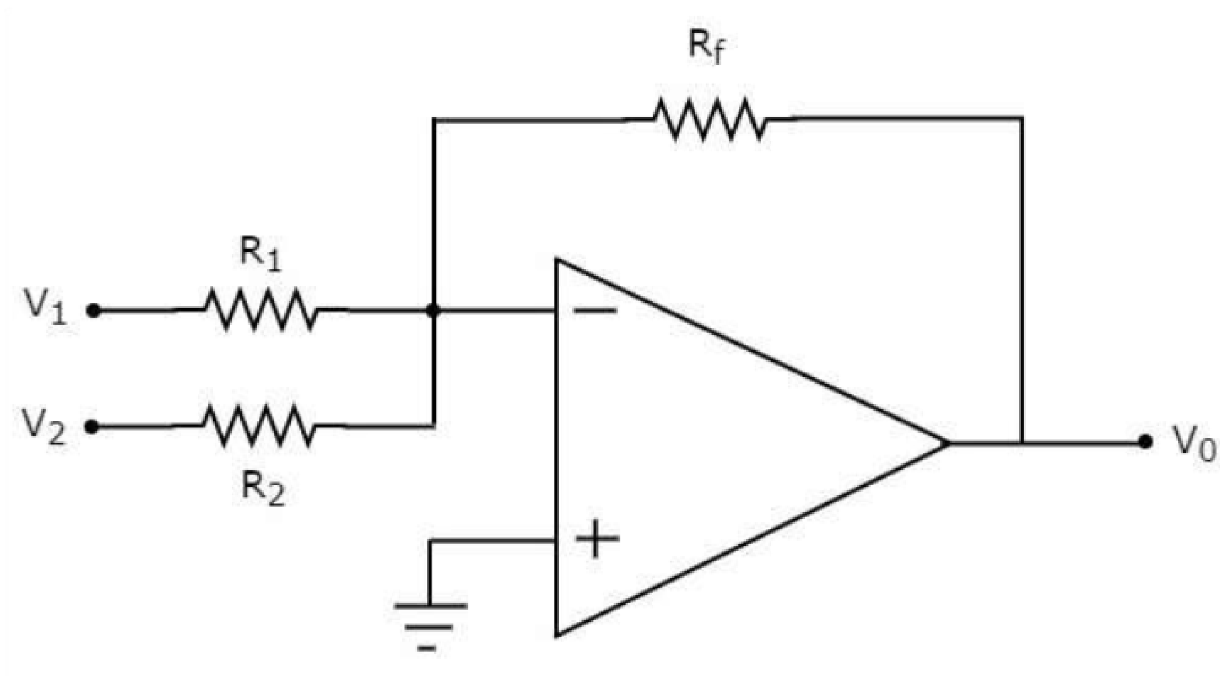
Objectives: To implement adder and subtractor circuits using differential amplifiers designed in the previous experiment and verify using sinusoidal input signals.

Components/Tools Required: Ltspice, Gdocs

Theory :

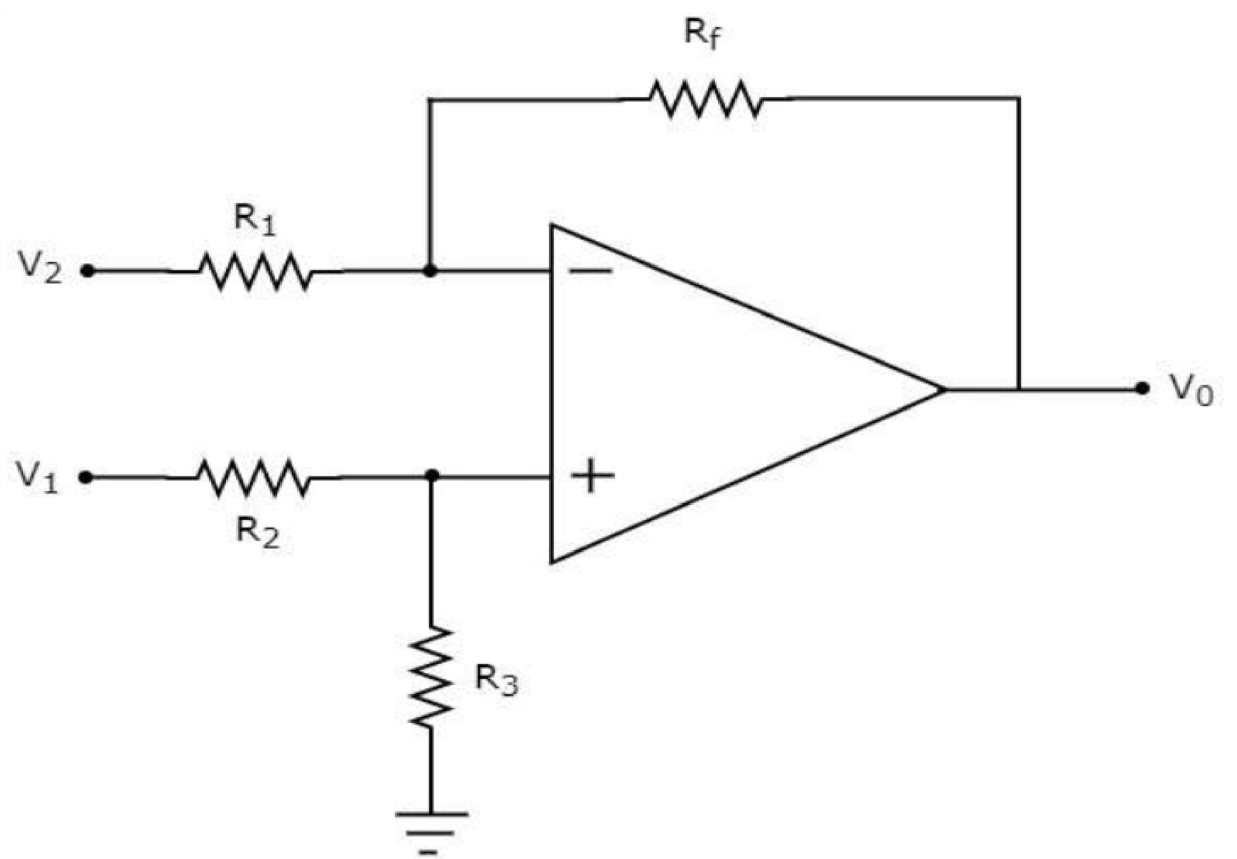
The electronic circuits, which perform arithmetic operations are called arithmetic **circuits**. Using op-amps, you can build basic arithmetic circuits such as an **adder** and a **subtractor**.

- An adder is an electronic circuit that produces an output, which is equal to the sum of the applied inputs. An op-amp based adder produces an output equal to the sum of the input voltages applied at its inverting terminal. It is also called a **summing amplifier**, since the output is an amplified one.



$$V_0 = -R_f\left(\frac{V1}{R1}+\frac{V2}{R2}\right)$$

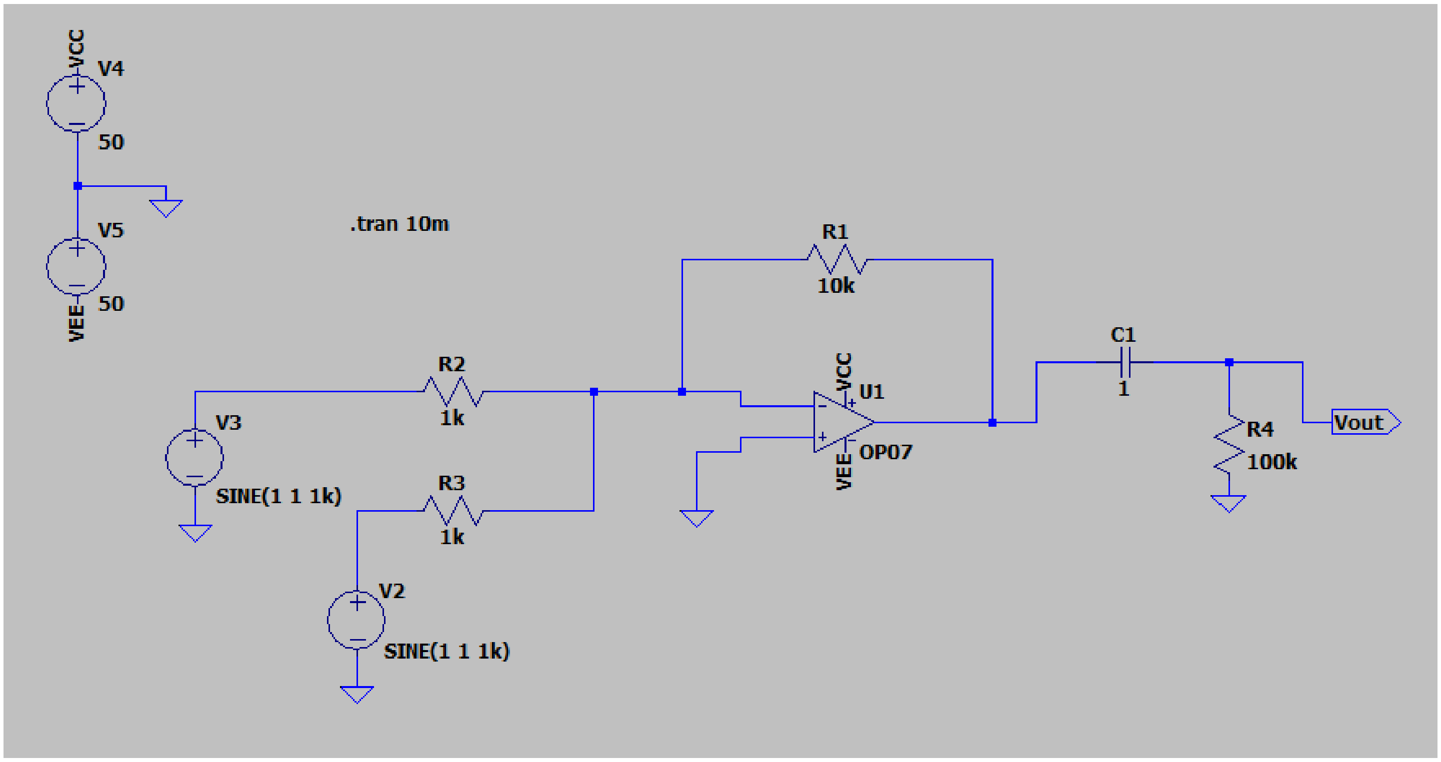
- A subtractor is an electronic circuit that produces an output, which is equal to the difference of the applied inputs. An op-amp based subtractor produces an output equal to the difference of the input voltages applied at its inverting and non-inverting terminals. It is also called a **difference amplifier**, since the output is an amplified one.



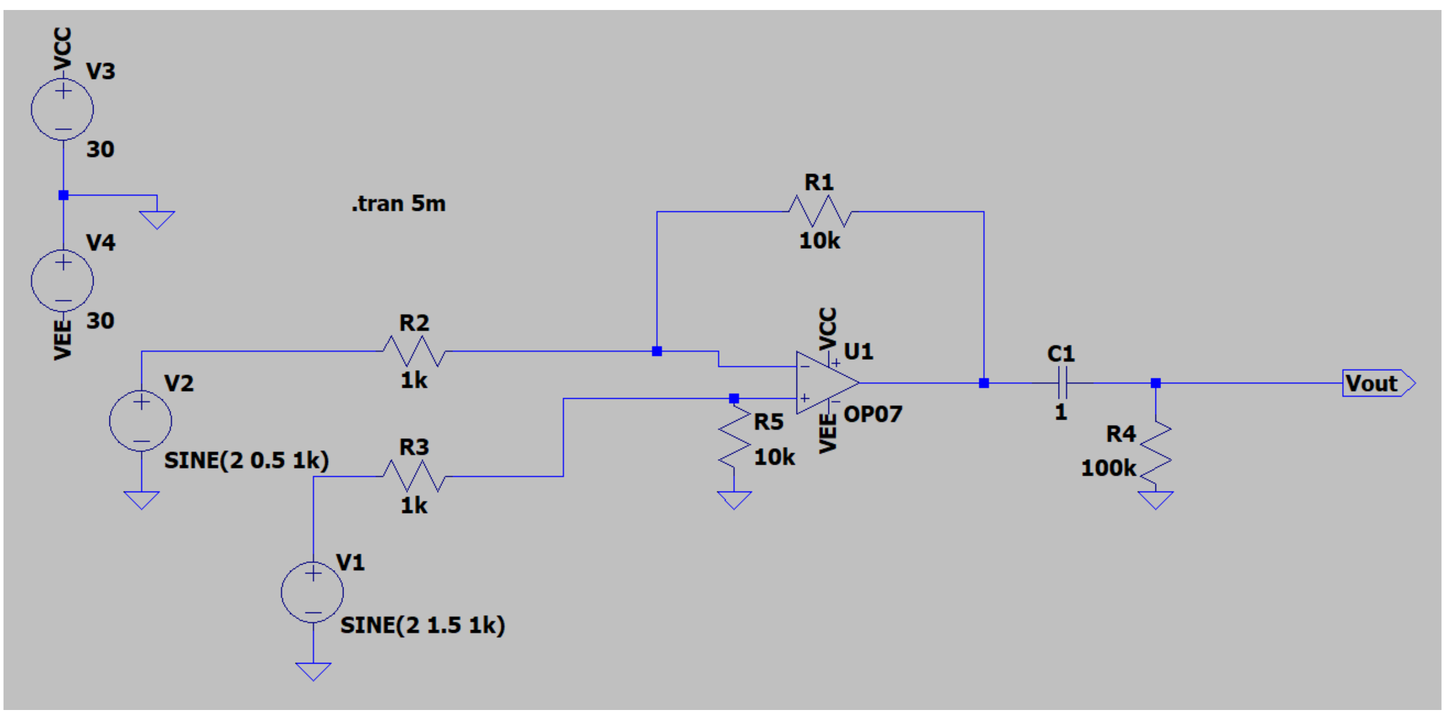
$$V_0 = V_1\left(\frac{R3}{R2+R3}\right)\left(1 + \frac{R_f}{R1}\right) - V_2\left(\frac{R_f}{R1}\right)$$

Circuit Diagram:

- Adder

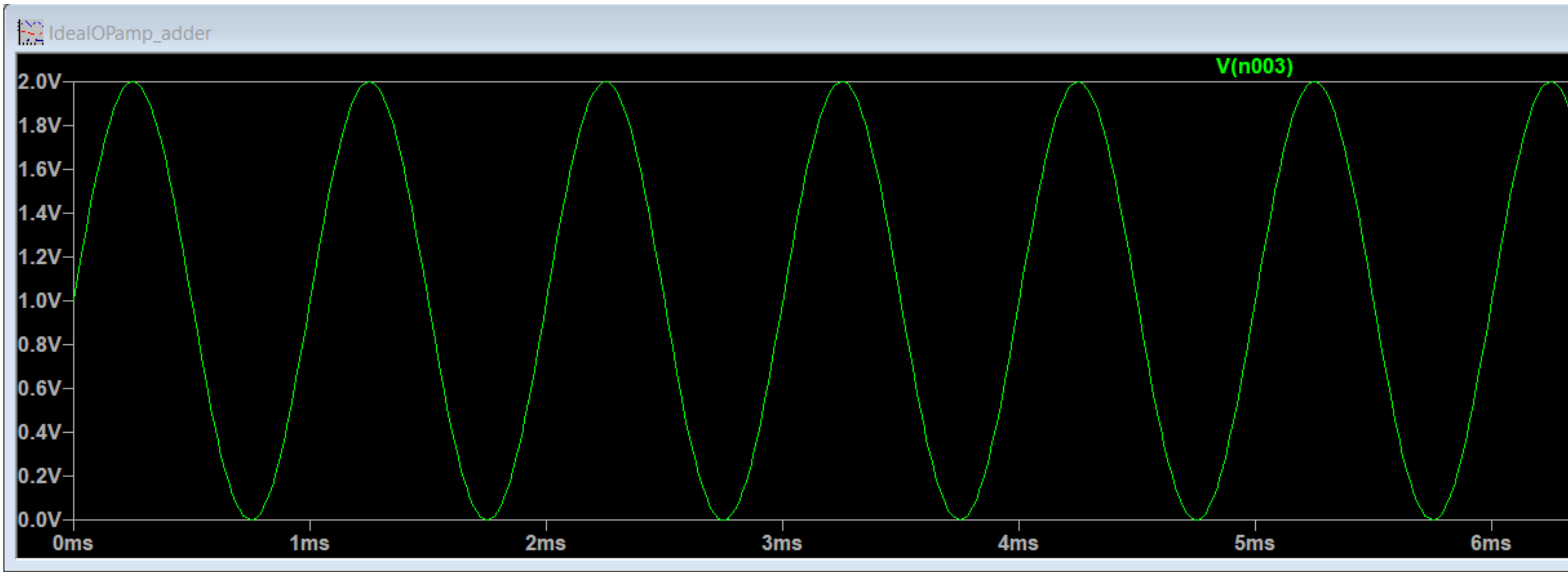


- Subtractor

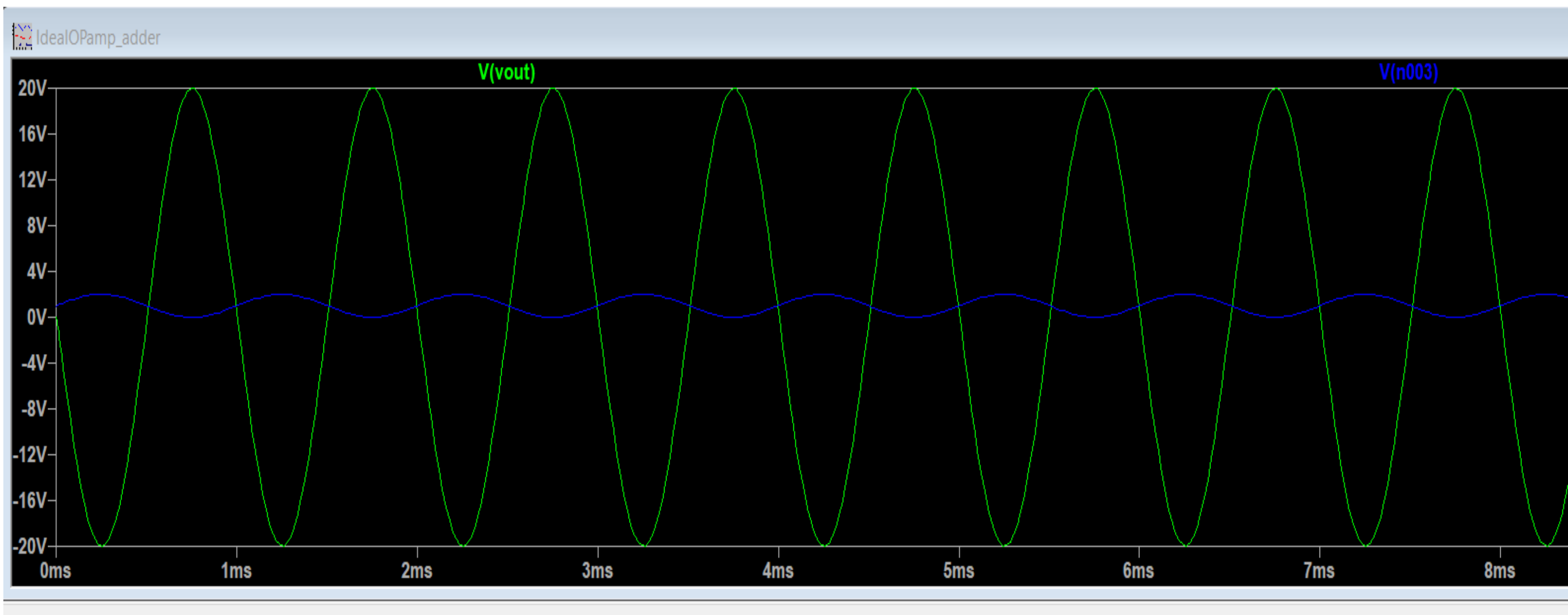


Waveforms:

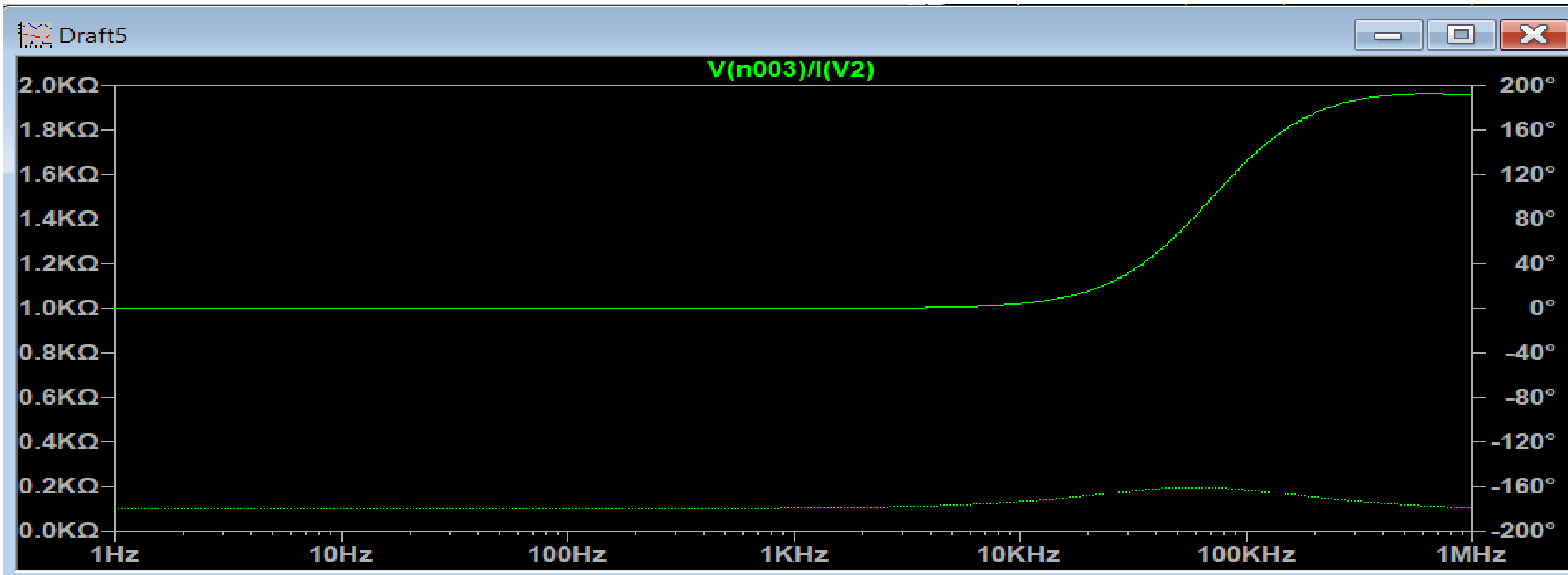
- Adder



$$V1 = V2 = 1 + 1Sinwt$$

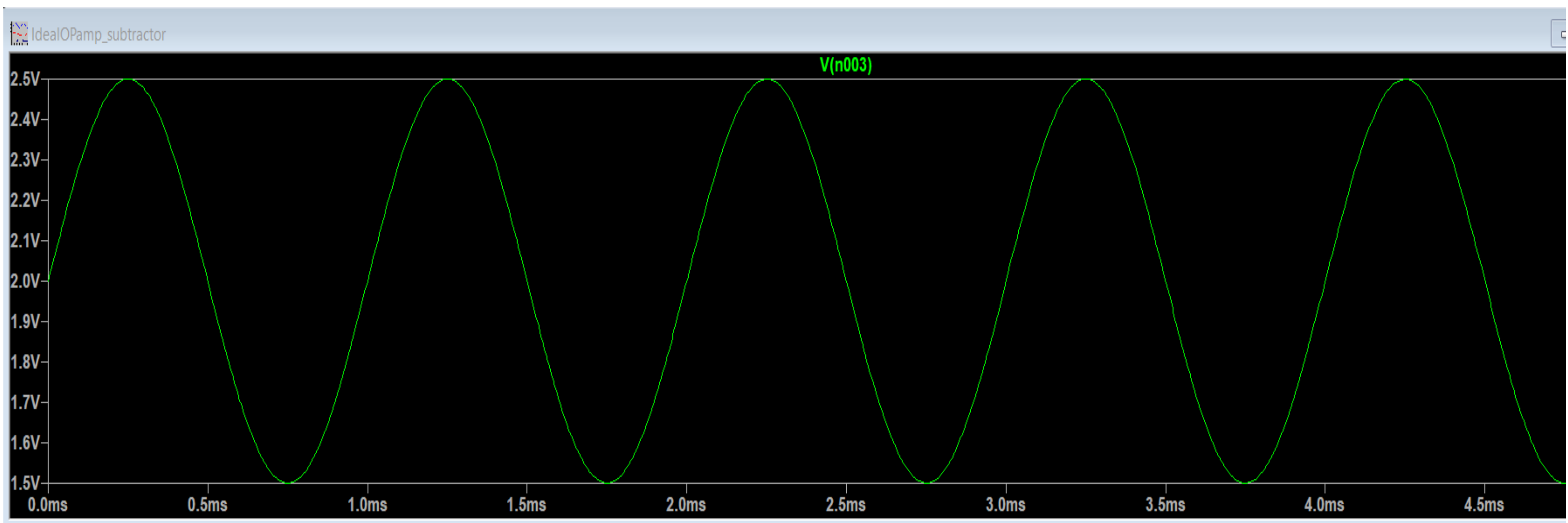


Gain = -10 V/V (without dc offset)

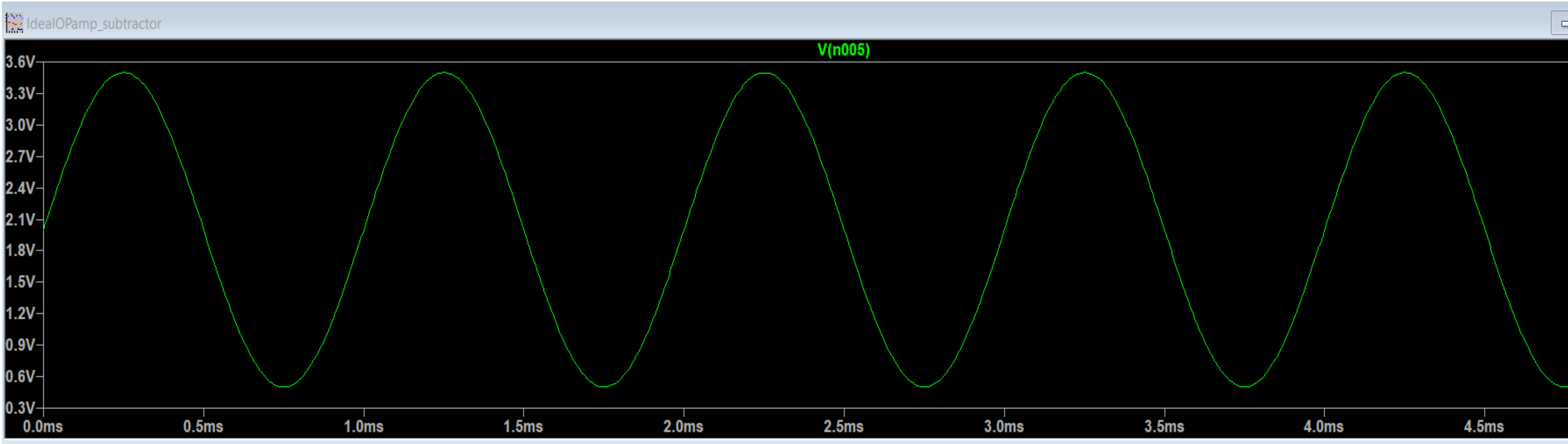


Rin = 1 Kohm(V3 and V2 as input)

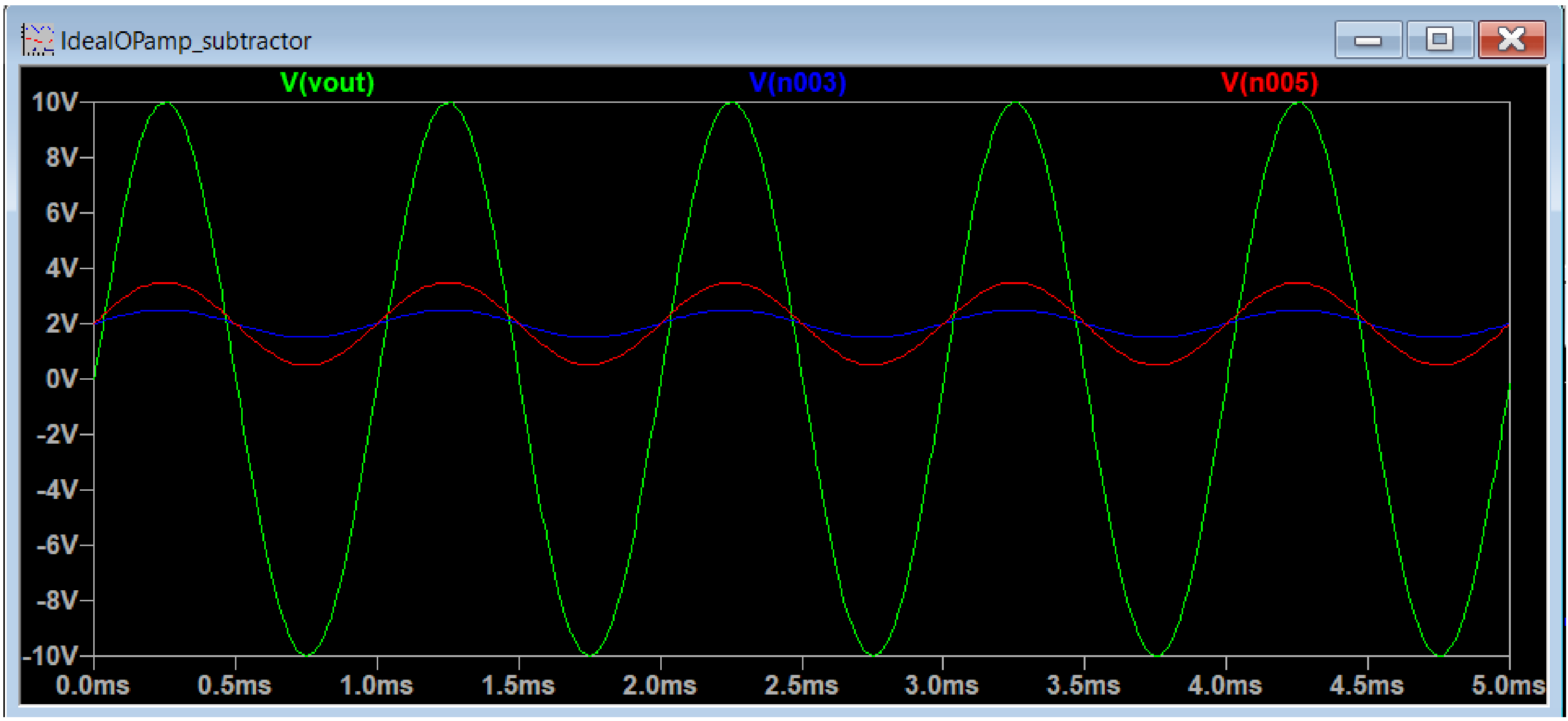
- Subtractor



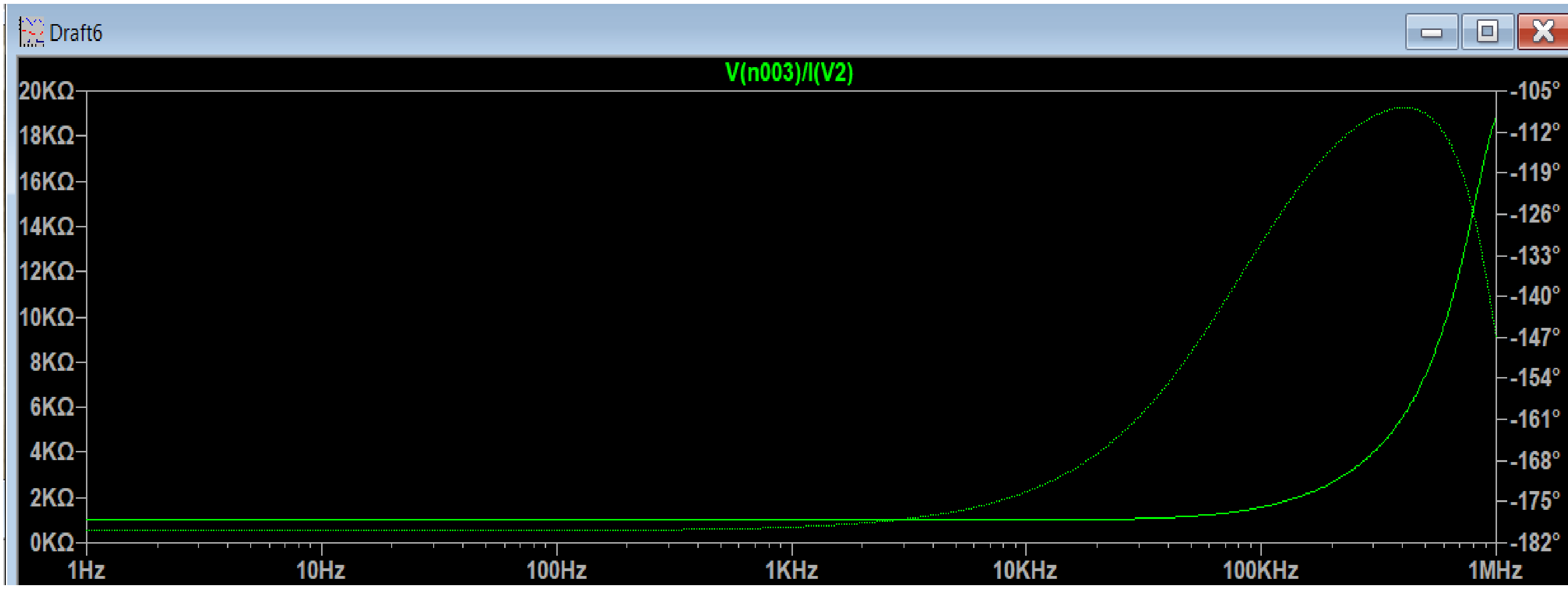
$V1 = 2 + 0.5\sin wt$



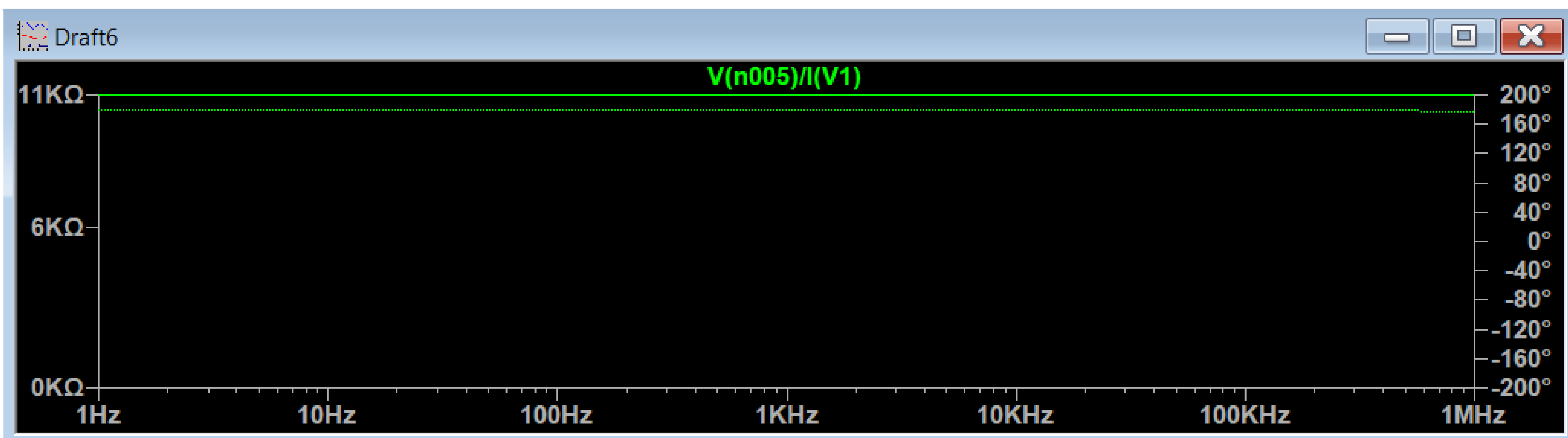
$V2 = 2 + 1.5\sin wt$



Gain $= 10$ V/V (without dc offset)



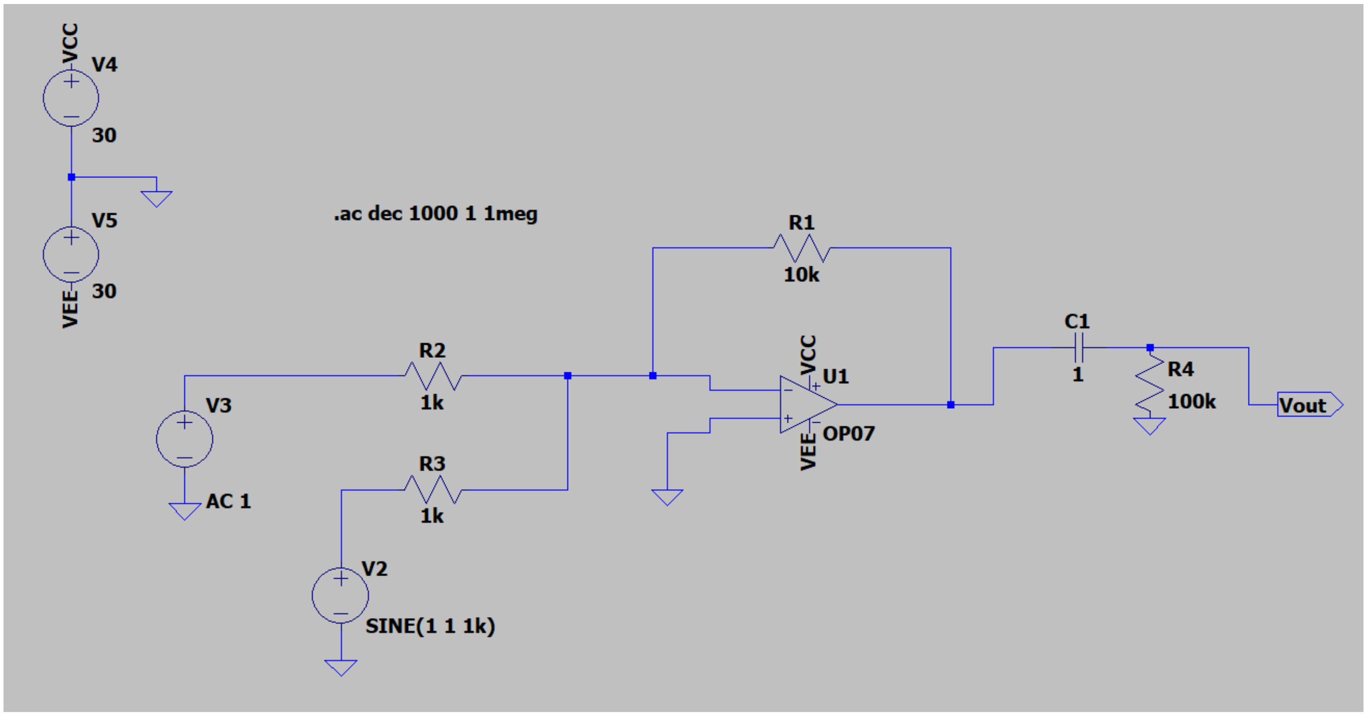
$\mathrm{Rin}(\mathrm{V2}) = 1\ \mathrm{Kohm}$



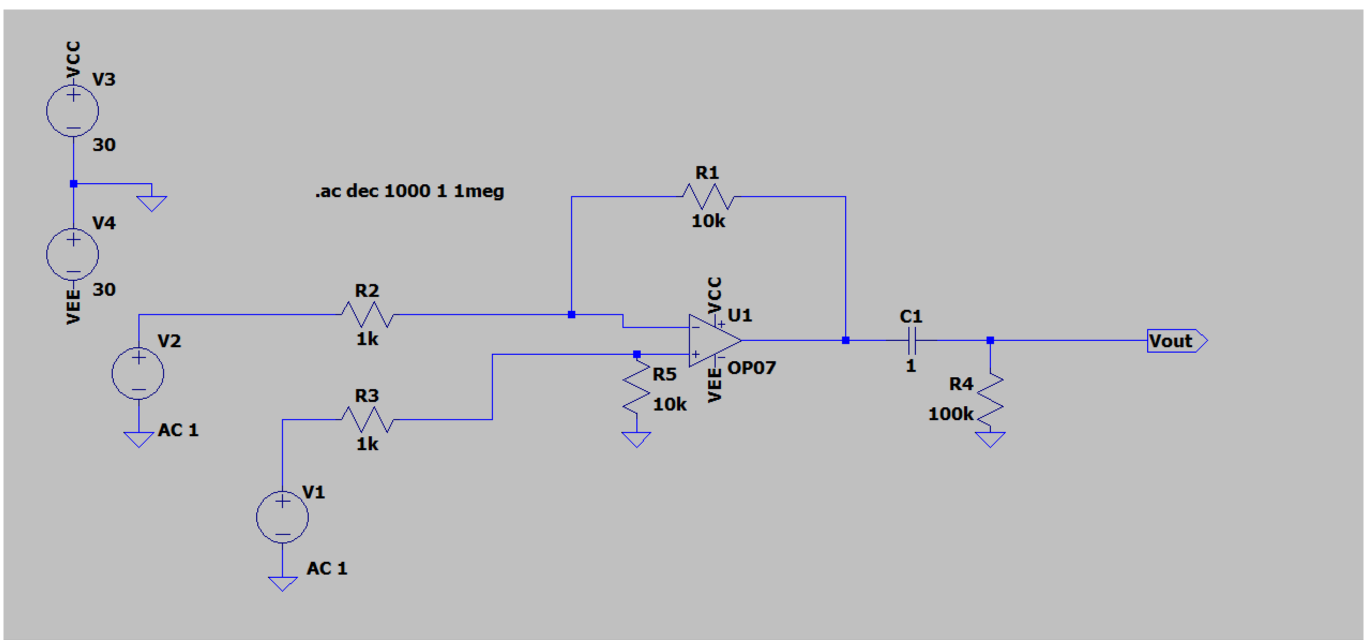
$\mathrm{Rin}(\mathrm{V1}) = 11\ \mathrm{Kohm}$

For input impedance, Ac analysis was done and V/I was calculated. Check below given schematic diagrams of Ac analysis.

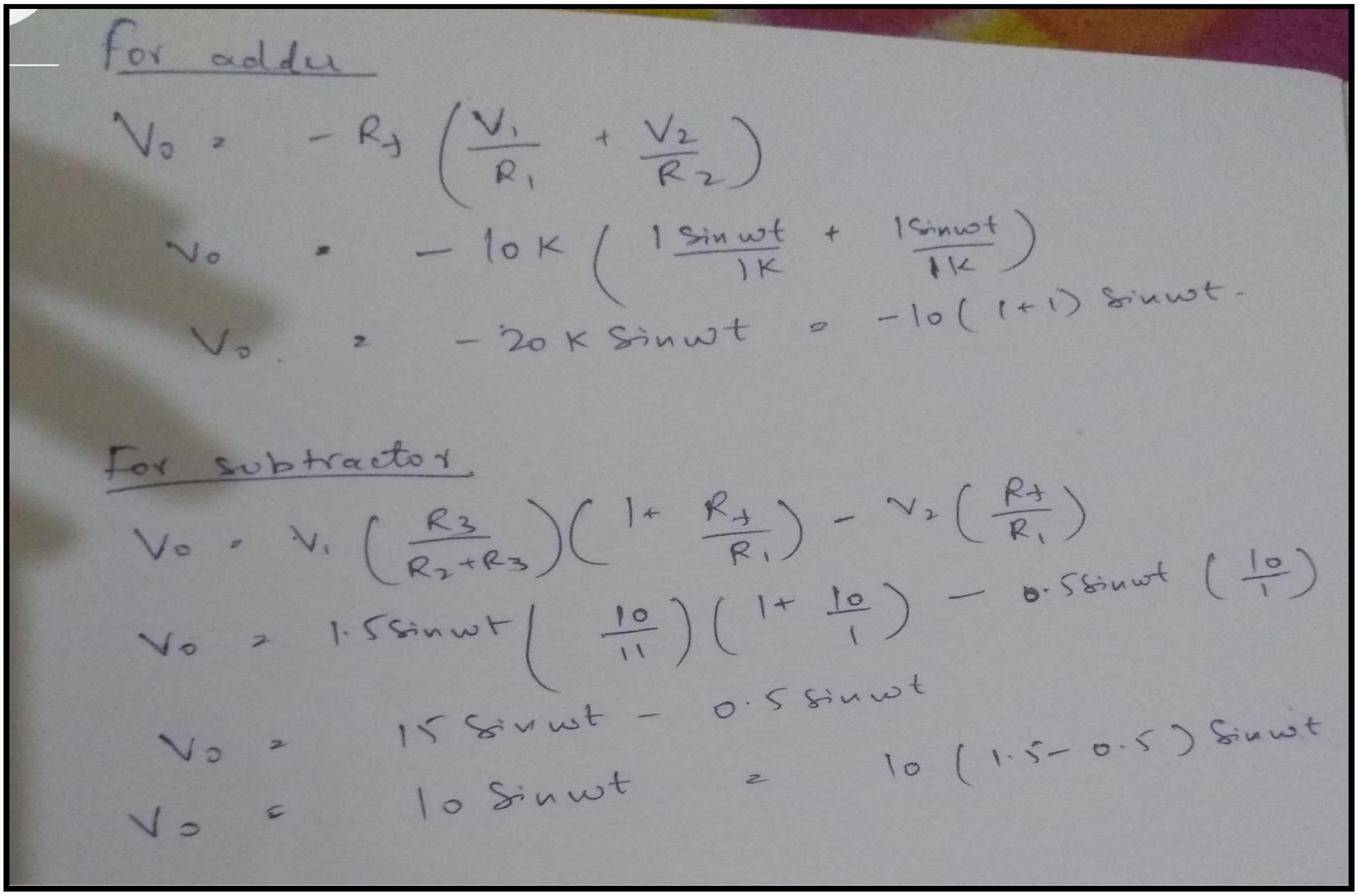
- Adder



- Subtractor



Hand Calculations :



For adder

$$V_o = -R_f\left(\frac{V_1}{R_1}+\frac{V_2}{R_2}\right)$$

$$V_o = -10K\left(\frac{1\sin wt}{1K}+\frac{1\sin wt}{1K}\right)$$

$$V_o = -20K\sin wt = -10(1+1)\sin wt.$$

For subtractor

$$V_o = V_1\left(\frac{R_3}{R_2+R_3}\right)\left(1+\frac{R_f}{R_1}\right) - V_2\left(\frac{R_f}{R_1}\right)$$

$$V_o = 1.5\sin wt\left(\frac{10}{11}\right)\left(1+\frac{10}{1}\right) - 0.5\sin wt\left(\frac{10}{1}\right)$$

$$V_o = 15\sin wt - 0.5\sin wt$$

$$V_o = 10\sin wt = 10(1.5-0.5)\sin wt$$

Vo = 15sinwt - 5sinwt (in above image)*

For filter circuit : R = 100 Kohm , C = 1 ohm