15ECE381 Circuits and Communication Laboratory /

15ECE383 Linear Integrated Circuits Laboratory

B. Tech (ECE and EIE) – V Semester

Experiment 3

Instrumentation Amplifier

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SECTION : ECE-C

GROUP : C2

Objective :

To build and understand the operation of an instrumentation amplifier.

Instructions:

1. All resistors used in your design should be from the E24 series
2. You may make use power supplies of ±10 V.
3. **Please ensure proper polarity for the connections to the power supply pins (4 and 7) of the opamp. Wrong polarity may cause the opamp to explode**.

Procedure:

1. Consider the circuit shown in Fig. 1. Choose R = 100 kΩ; R_1 = 2 kΩ and R_2 = 47 kΩ. (i) Obtain an expression

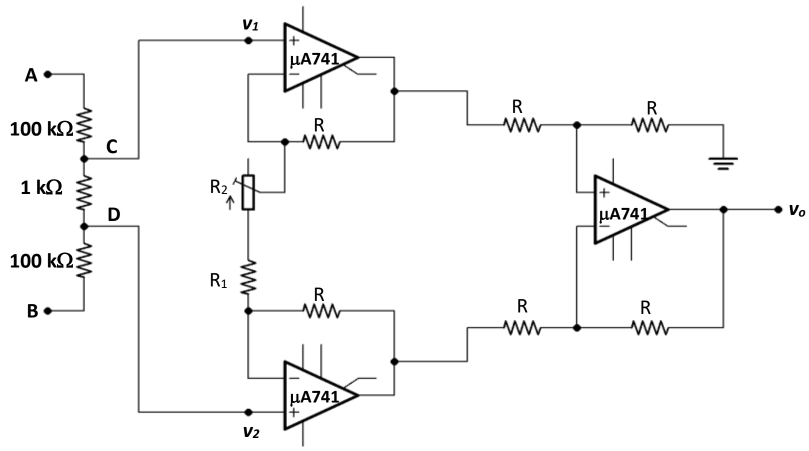


Fig. 1

indicating the variation in CMRR with the tolerance of the resistors (consider the difference amplifier alone); (ii) What should be the tolerance of the resistors so that the CMRR is 100 dB ? (iii) What are the minimum and maximum values of the voltage gain (A_v) for the instrumentation amplifier of Fig. 1 ?

2. Set up the circuit. Adjust the amplitude of the output from the function generator, such that V_A = 10 V and frequency = 1 kHz. Measure the voltage at C (V_c).

3. Keeping the potentiometer setting at the minimum (corresponding to maximum gain), measure the output, v_o. Determine the differential gain (A_D) $A_D = \frac{v_o}{5*10^{-3}V_A}$ (It should be approximately 101).

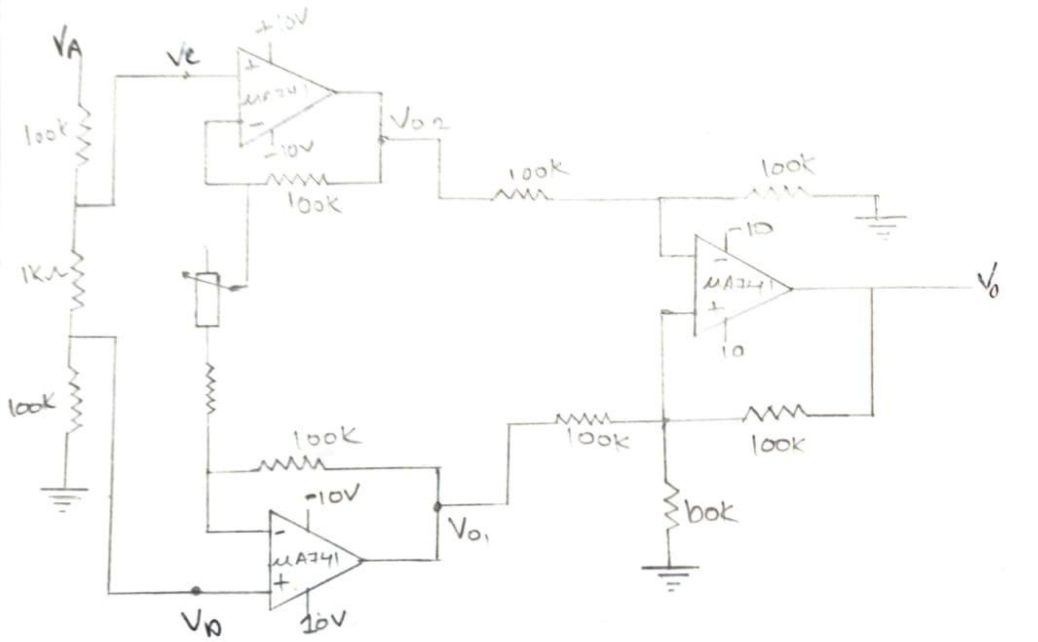
4. Connect V_1 and V_2 to C. With V_A = 10 V and frequency = 1 kHz, Measure the amplitude of the input and output at C and v_o respectively. Determine the common voltage gain A_{CM} as $A_{CM} = \frac{v_o}{V_C}$.

5. Compute the Common Mode Rejection Ratio (in dB) as $CMRR = 20*log\left(\frac{A_D}{A_{CM}}\right)$.

6. Repeat steps 4 and 5, for different values of V_A, say, 1 V, 2V and 4 V. Compute the CMRR in each instance.

7. With V_A = 10 V and frequency = 1 kHz, vary the potentiometer to its maximum value (minimum gain). Measure the differential gain, $A_D = \frac{v_o}{5*10^{-3}V_A}$. Verify that it is approximately 5.

Instrumentation Amplifier



For minimum gain 10V/V - 20log(10) = 20 dB

For maximum gain 25V/V - 20log25 = 27.95dB

we know that

For minimum gain $10 V/V - 20\log(10) = \underline{20\ dB}$

For maximum gain $25 V/V - 20\log 25 = \underline{27.95\ dB}$

we know that

$$Gain = \frac{R_4}{R_3}\left(1 + \frac{2R_2}{R_1}\right)$$

from the above circuit

$$R_4 = R_3 = R_2 = 100k\Omega$$

and $R_1 = R + R_p$ where R_p is potential-meter

$$\therefore Gain = 1 + \frac{200K}{R+R_p}$$

$$\Rightarrow Gain - 1 = \frac{200K}{R+R_p}$$

Gain = 10

$$1+\left(\frac{2(100k)}{R+R_p}\right) \geq 10$$

$$\frac{200k}{R+R_p} \geq 9$$

$$R+R_p \leq \frac{200k}{9}$$

$$R+R_p \leq 22.2K$$

Gain = 25

$$1+\left(\frac{2(100k)}{R+R_p}\right) \leq 25$$

$$\frac{200k}{R+R_p} \leq 24$$

$$R+R_p \geq \frac{100k}{12}$$

$$R+R_p \geq 8.3k$$

$$\therefore \boxed{8.3k \leq R+R_p \leq 22.2k}$$

Potential meter has to start from zero ohms.

So, $R_p = 0$

then minimum resistance i.e $\boxed{R = 8.3k}$

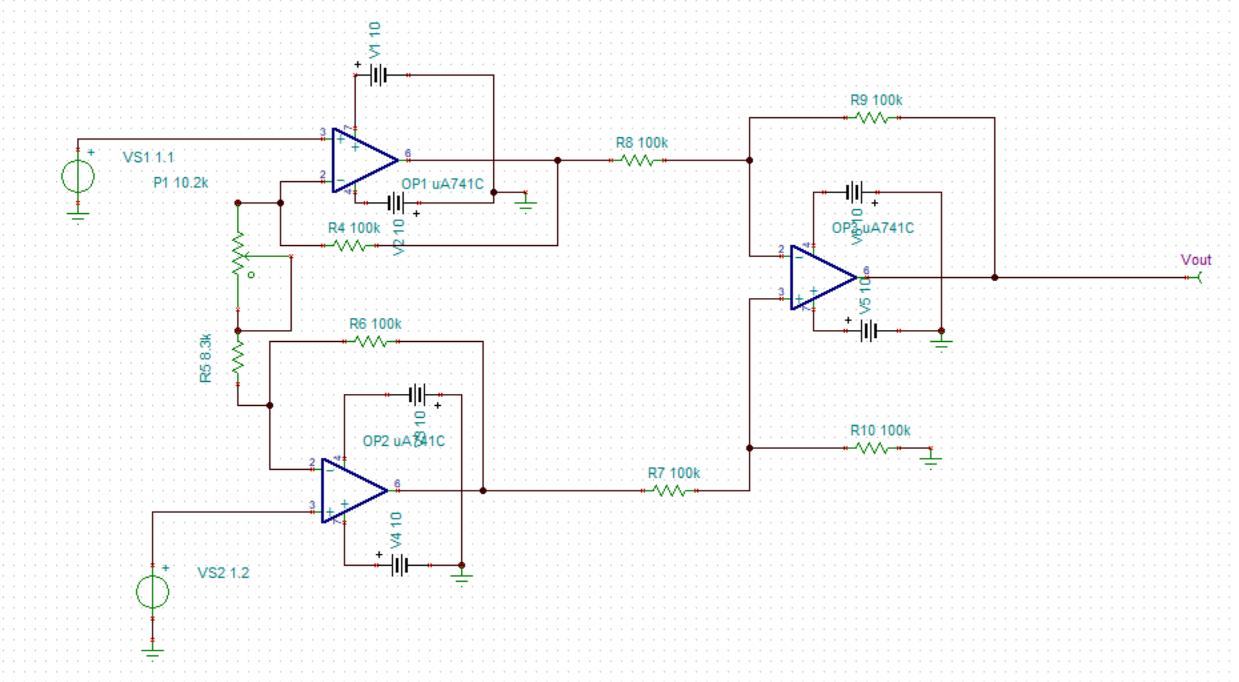
$$\therefore 8.3k + R_p \leq 22.2k$$

So, potential meter can vary a maximum of upto $(22.2k - 8.3k)$

$$\therefore \boxed{R_p \leq 13.9k}$$

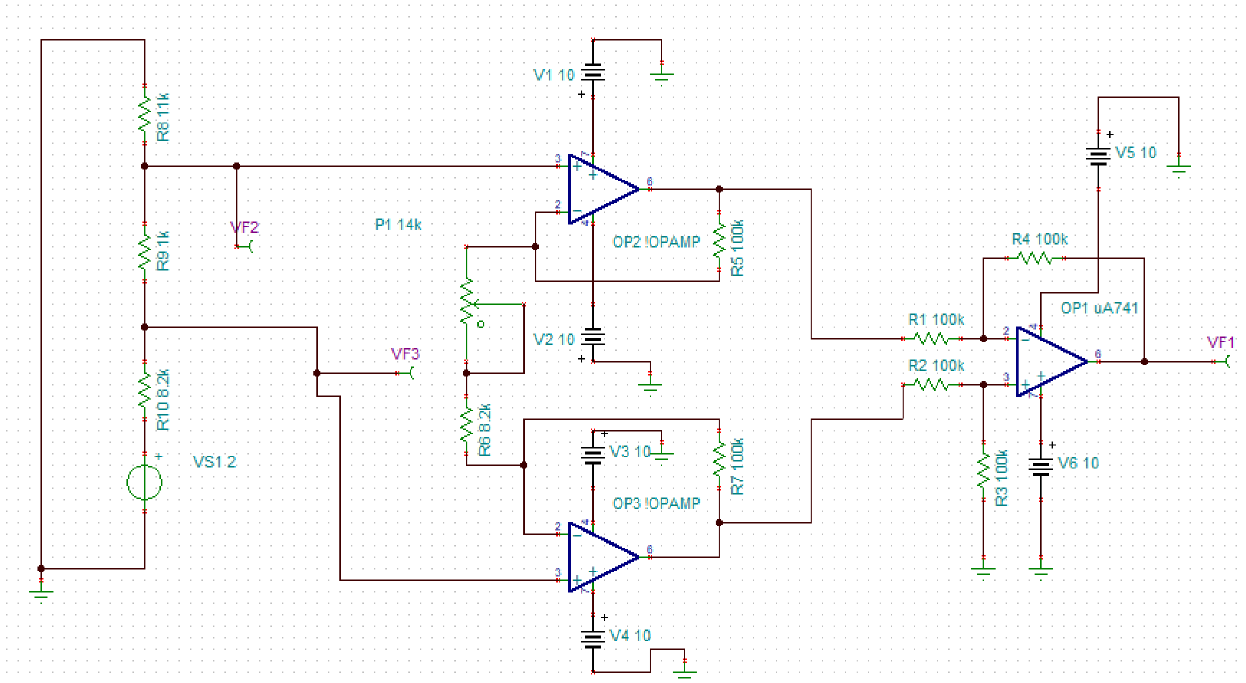
INSTRUMENTATIONAL AMPLIFIER

1. Design and implement a 3-opamp instrumentation amplifier of gain varying from 10 to 25

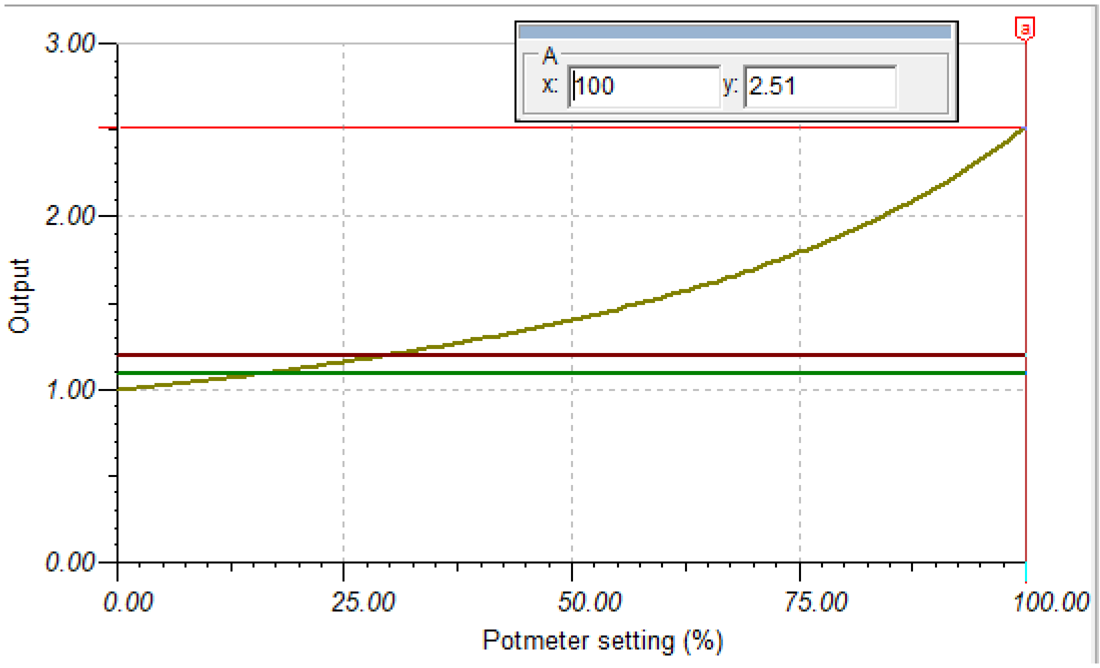


2. If the two inputs are 1.1 V and 1.2 V, find the output of the amplifier.

Design

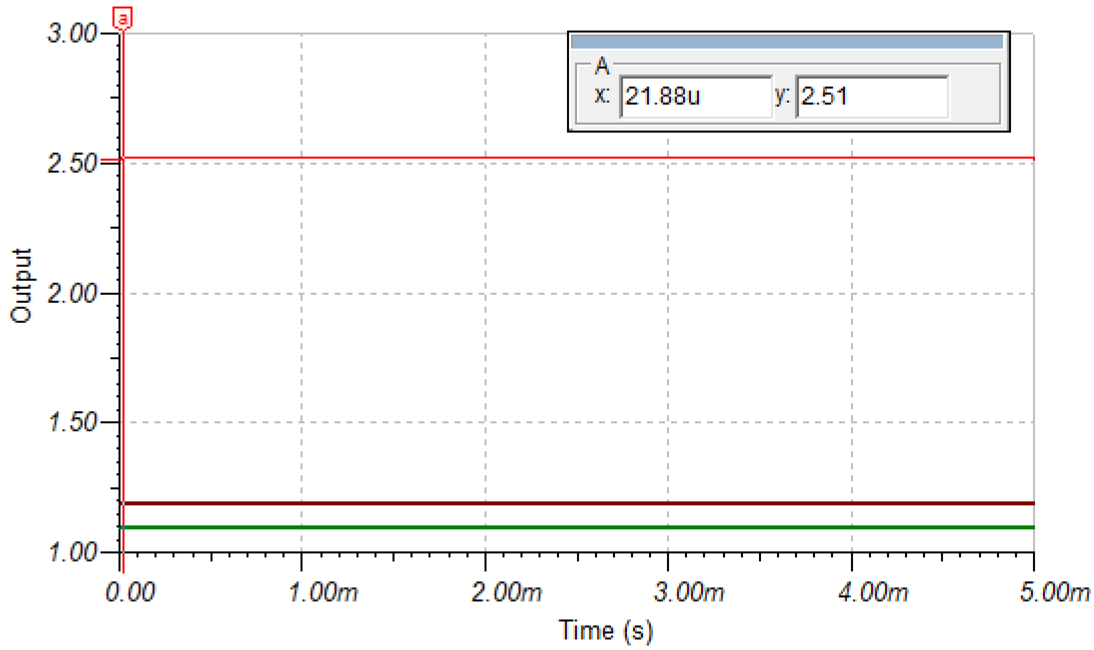


OUTPUT



3. Determine the common mode and differential mode gains and the CMRR of the designed amplifier.

DIFFERENTIAL GAIN



differential gain (A_D) $A_D = \frac{v_o}{5*10^{-3}V_A}$

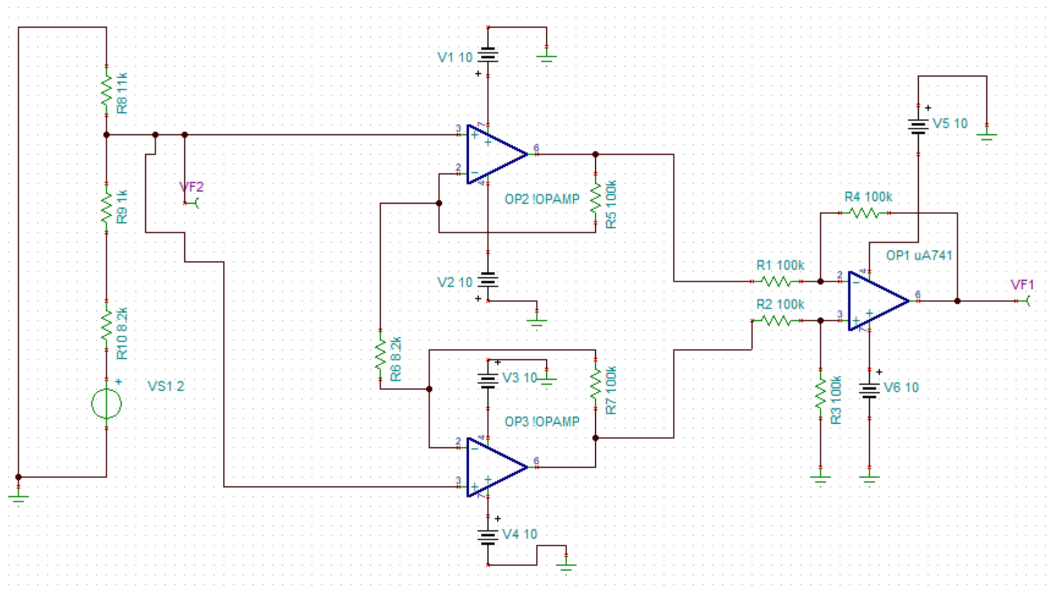
here Vo=2.5 volts

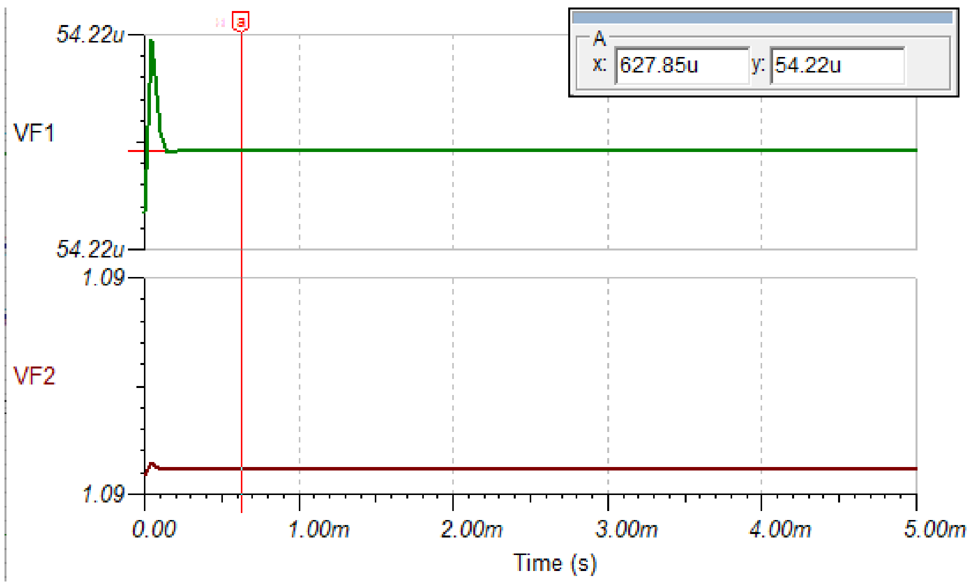
and Va=2 volts

A_D =2.5k/10 =250

So differential gain is 250 Volts

Common mode gain:





$A_{CM} = \frac{V_o}{V_C}$ =54.22µ/1.1 = 49.23µ

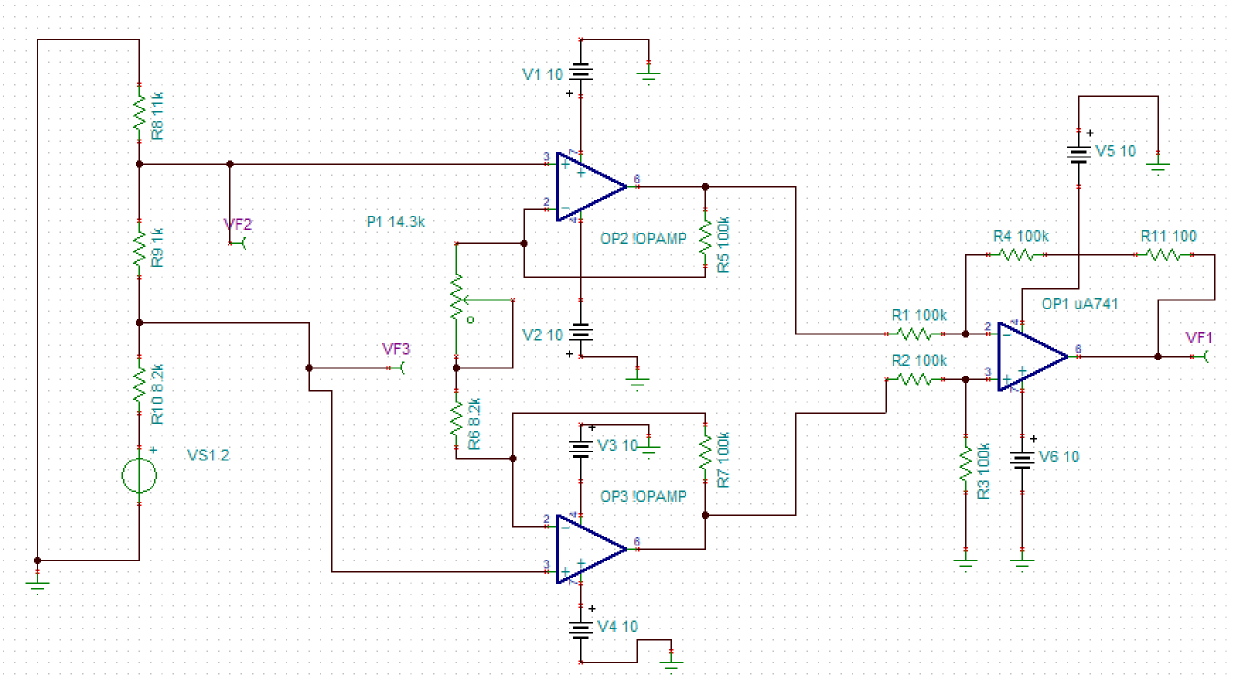
So common mode gain is 49.23µ

Common mode rejection ratio (CMRR):

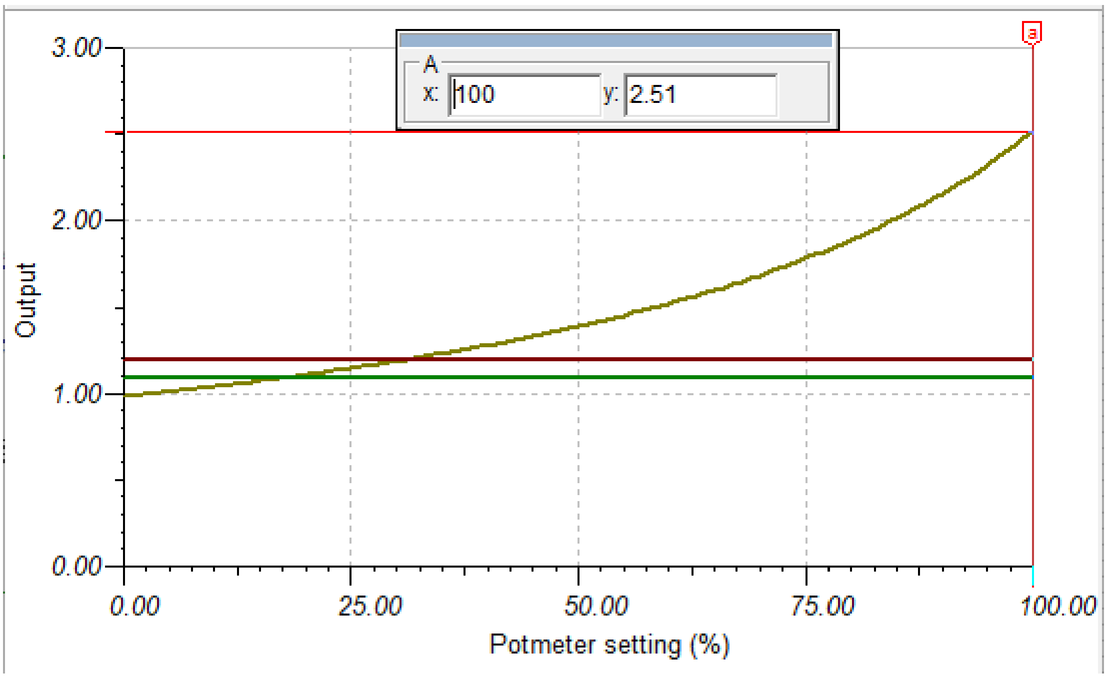
$CMRR = 20 * log\left(\frac{A_D}{A_{CM}}\right)$ =20log(250/49.23µ)= 6.7

So CMMR is 6.7

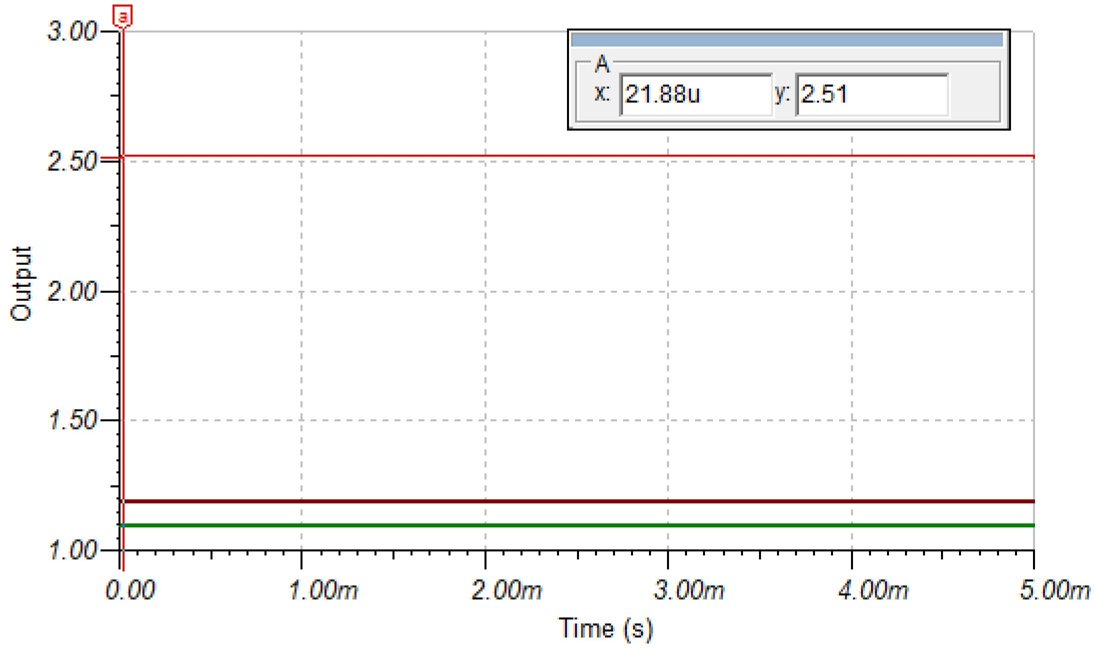
4. Now add a 100 Ω resistance in series with the resistance in the feedback loop of the difference amplifier (resistance connected to v_o).



5. Repeat steps 2 and 3.



DIFFERENTIAL GAIN



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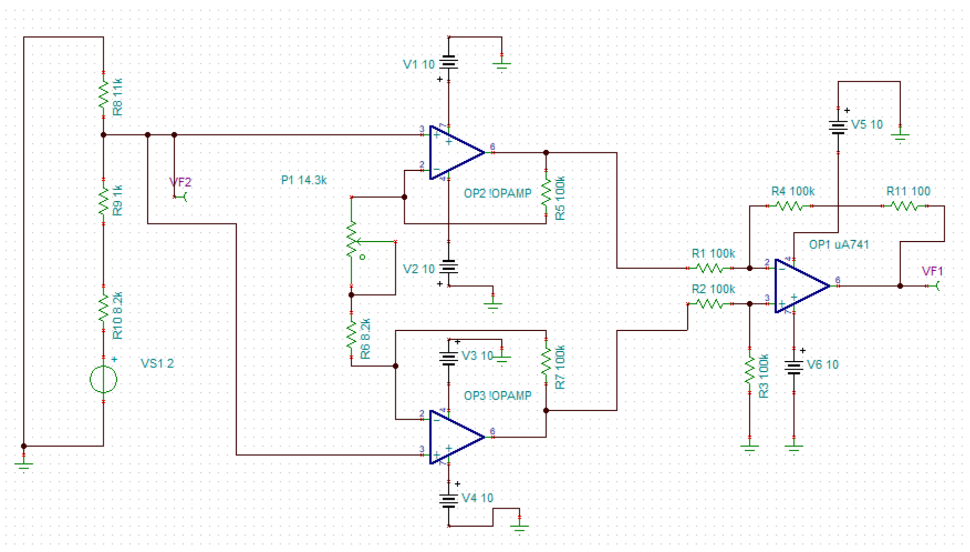

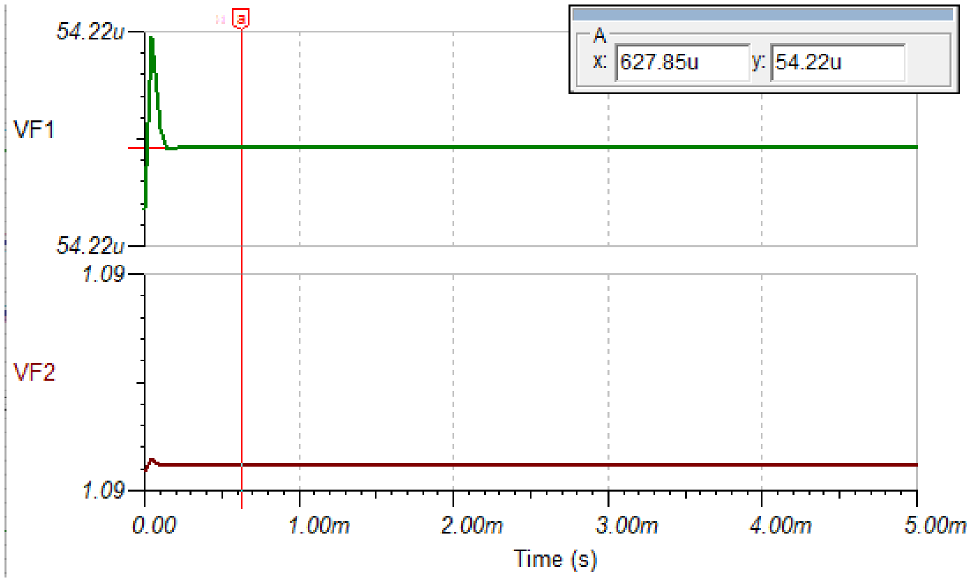

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INFERENCE

1. Why do we need the set up a voltage divider to generate a differential signal? Can the same effect be produced by means of two independent function generators ? If not, why not ?

ANS:

A voltage divider is used to ensure that the input terminals receive the same common more signal, two independent function generators cannot be used as they might or might not have the same common signals like noise, offset etc. We can use common supply to ensure uniformly in noise. This is applicable in ideal case .For non-ideal there will be noise distortion

2. Compare the results obtained before and after addition of the 100 Ω resistor (step 4). Explain your answer.

ANS:

Negligible. Because the results are same. because the overall resistance will be 100.1k Ω.so it is negligible.