15ECE381 Circuits and Communication Laboratory /

15ECE383 Linear Integrated Circuits Laboratory

B. Tech (ECE and EIE) – V Semester

Experiment 2

Operational Amplifier – Inverting and Non-inverting amplifier

NAME:- B Sumanth

ROLL.NO:- CB.EN.U4ECE18211

CLASS AND GROUP:-ECE-C, C2

Aim :

To design and implement a inverting and a non-inverting amplifier, using the given opamp.

Instructions:

1. **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. Download the datasheet of the µA741 from the link: http://www.ti.com/lit/ds/symlink/lm741.pdf
2. Note down the answer to the following questions before you come to the lab: (a) What does the letter 'M' in the model µA741M represent ? (b) What is the temperature range over which the model µA741C can be used ? (c) What is the typical input offset voltage of the µA741 ? (d) What is the open loop gain of this operational amplifier? (e) What is its input impedance? (f) What is the maximum power supply that can be given ? What is the Gain-Bandwidth product of this operational amplifier?

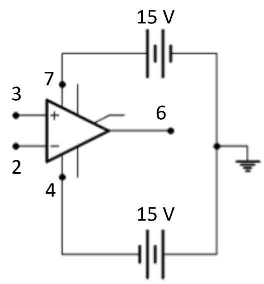


Fig. 1

3. Connect up the operational amplifier as shown in Fig. 1. Though the power supplies are not explicitly shown, they need to be connected as shown in Fig. 1

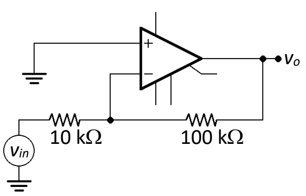


Fig. 1

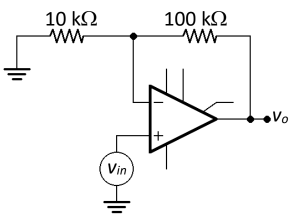


Fig. 2

4. (a) Let v_{in} be a sinusoid of amplitude 50 mV and frequency 1 kHz. Plot the input and output (pin 6) waveforms. What is the gain of the amplifier?

   (b) Vary the frequency from 10 Hz to 1 MHz, with ten readings each in the range 10 Hz – 10 kHz, 100 kHz - 500 kHz and 500 kHz to 1 MHz. Measure the gain (A_v) at each frequency. Plot the frequency response. What is the bandwidth of the amplifier ?

5. Now, change the 100 kΩ to 22 kΩ and repeat 2. Determine the bandwidth of the amplifier.

6. (a) Now, connect the op-amp as shown in Fig. 2. What is the gain of this amplifier ?

7. (b) Vary the frequency from 10 Hz to 1 MHz, with ten readings each in the range 10 Hz – 10 kHz, 100 kHz - 500 kHz and 500 kHz to 1 MHz. Measure the gain (A_v) at each frequency. Plot the frequency response. What is the bandwidth of the amplifier ?

8. Now, change the 100 kΩ to 22 kΩ and repeat 2. Determine the bandwidth of the amplifier.

9. Increase the amplitude of your input to 10 mV and set its frequency to 500 kHz. Determine the gain of your amplifier.

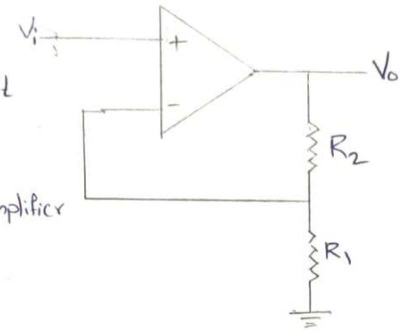
NON-INVERTING AMPLIFIER

GAIN=12

Analysis:→

① Gain = 12

as the phase shift is 360°. So it is an non-inverting Amplifier



wkT,

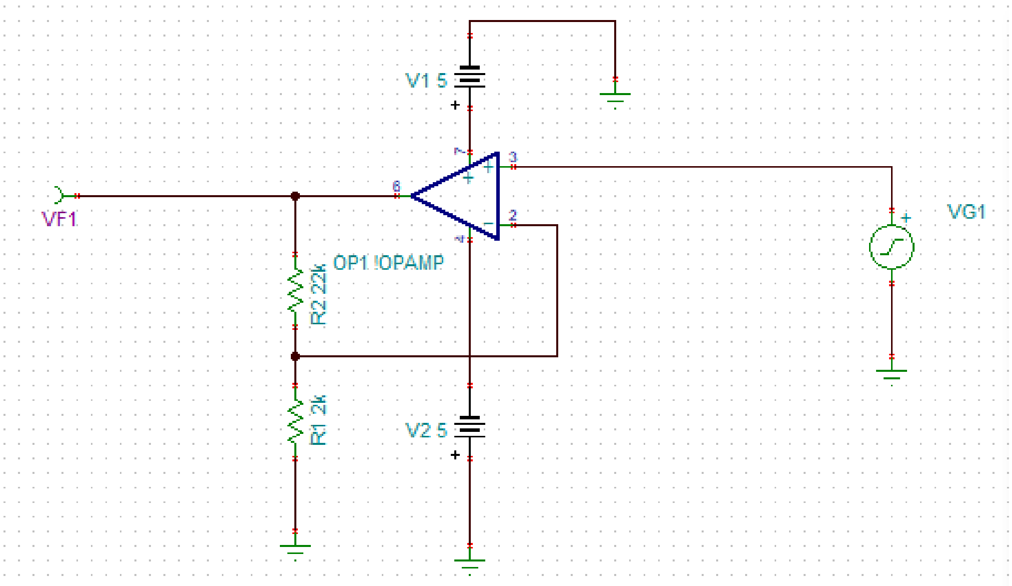
$$V_o = V_i\left(1 + \frac{R_2}{R_1}\right)$$

$$\frac{V_o}{V_i} = 1 + \frac{R_2}{R_1} \qquad \left(\text{wkT, } \frac{V_o}{V_i} = 12\right)$$

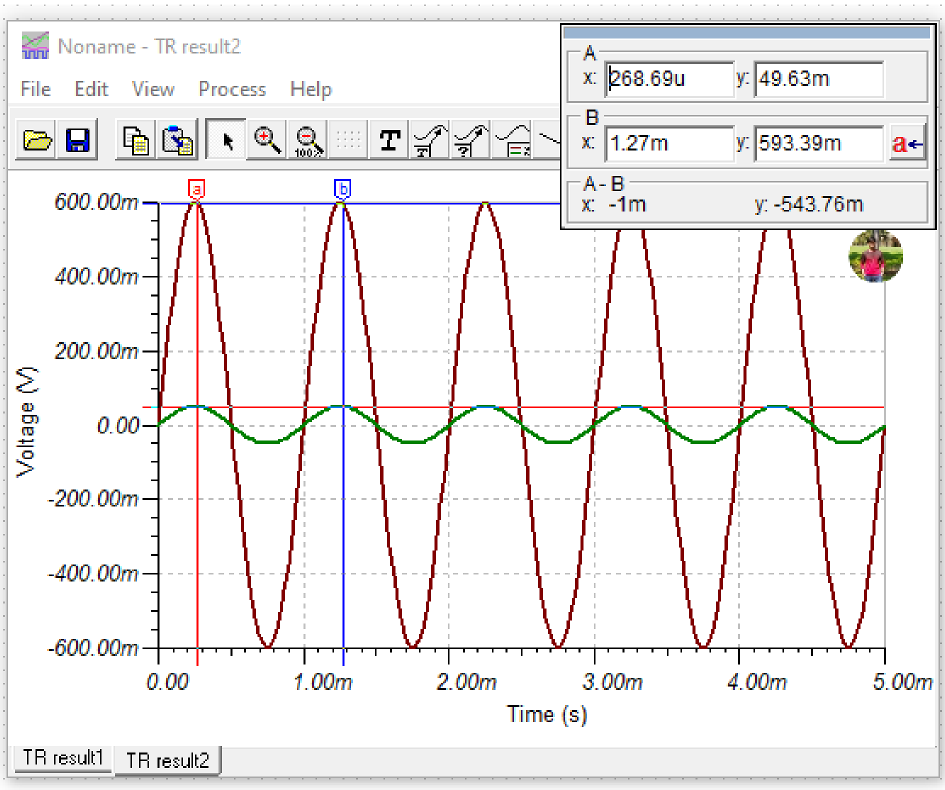
$$11 = \frac{R_2}{R_1}$$

$$\Rightarrow R_2 = 11R_1$$

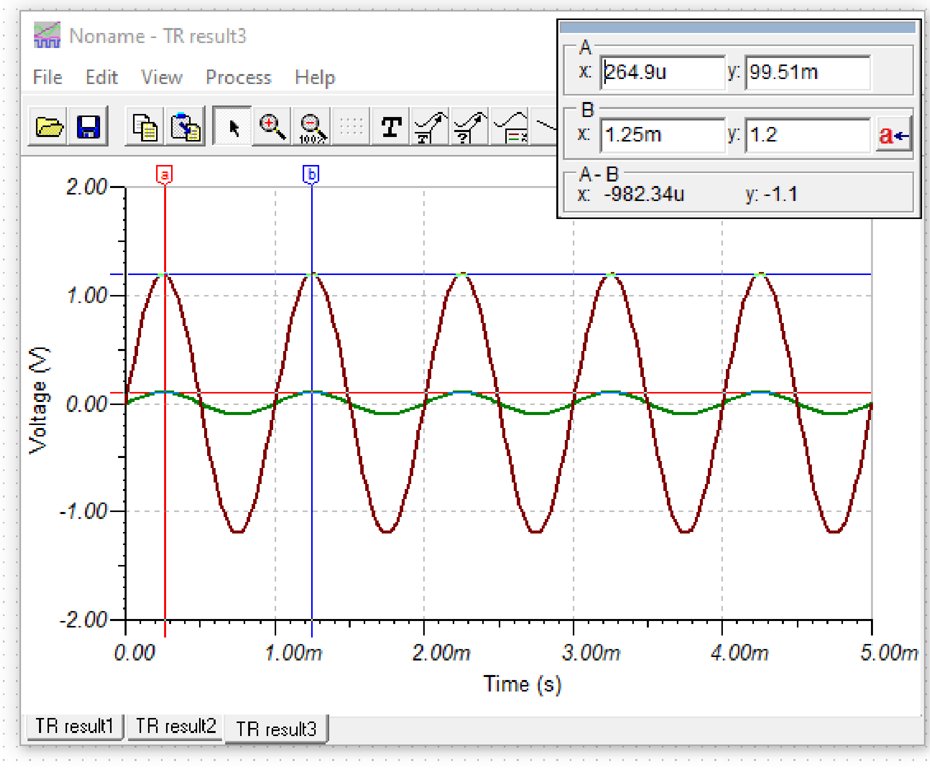
Assume $R_1 = 2k\Omega \Rightarrow \boxed{R_2 = 22k\Omega}$



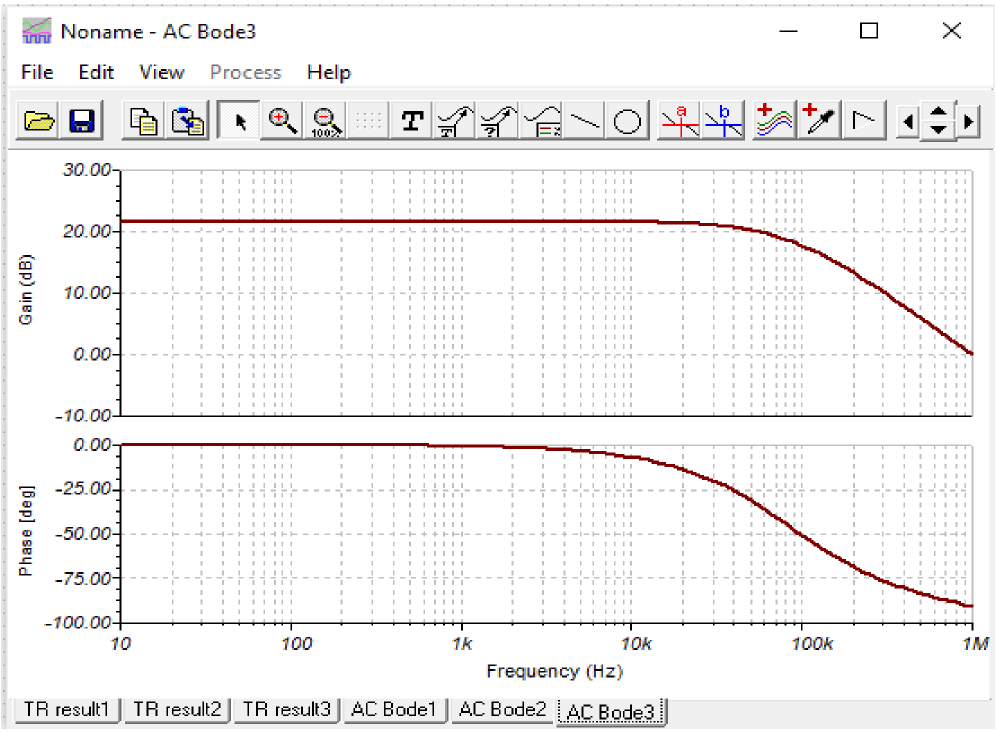
Vin=50mV



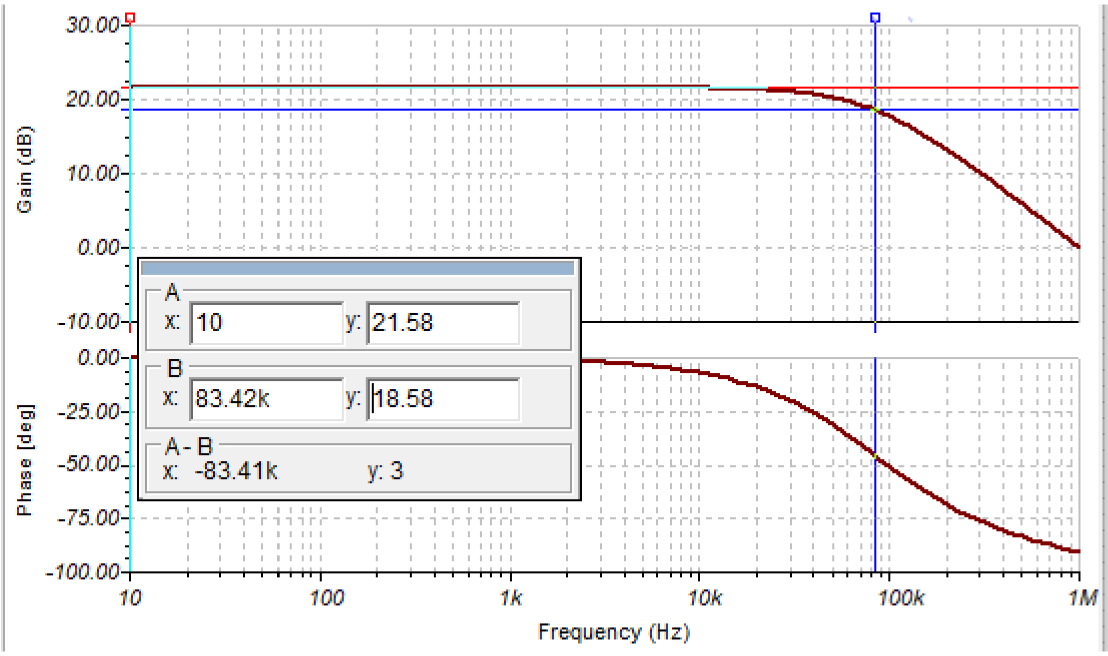
Vin=100mV



FREQUENCY RESPONSE



BANDWIDTH



Band width= 83.42k – 10 = **83.41k**

GAIN=6

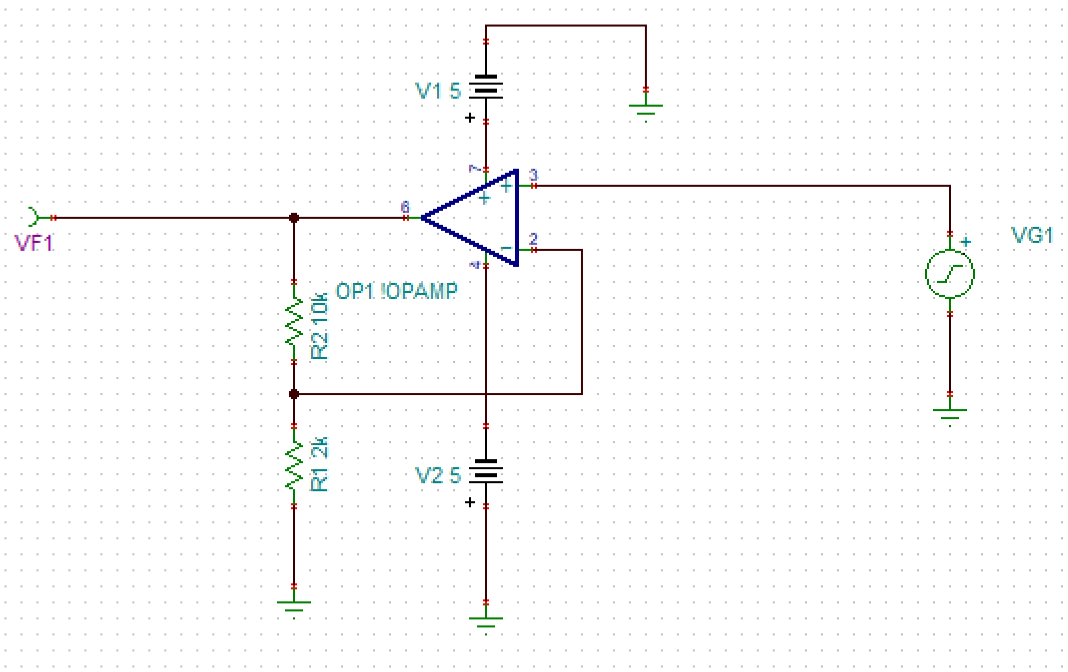
(3) Gain = 6

$$6 = \frac{R_2}{R_1} + 1$$

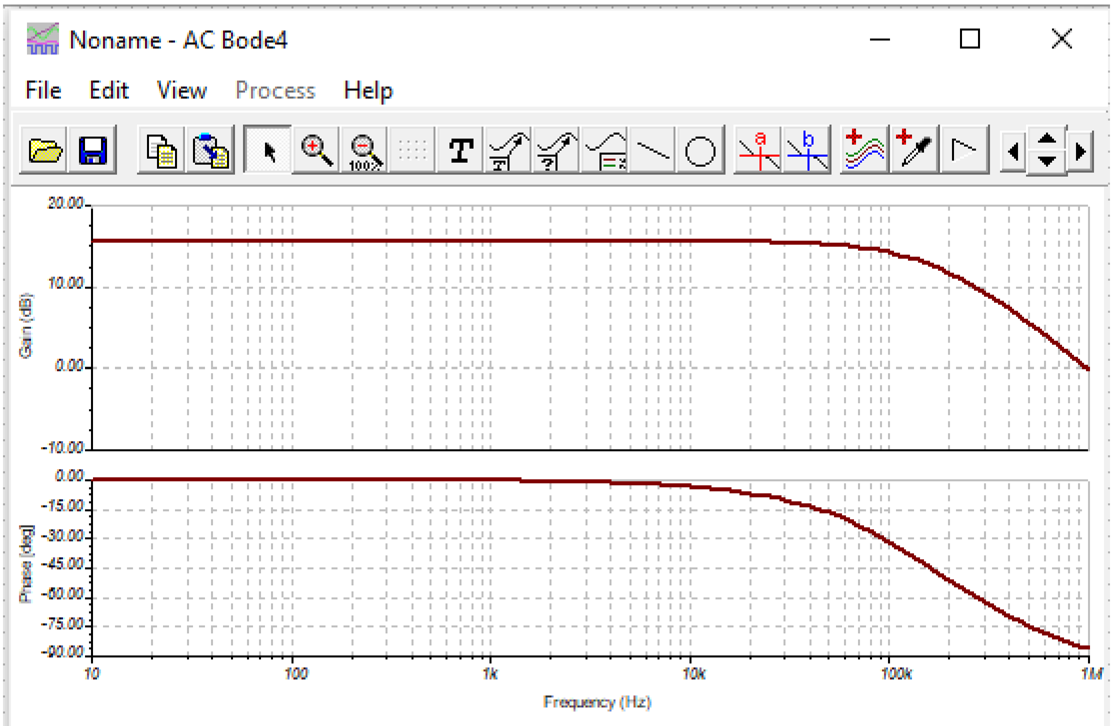
$$R_2 = 5R_1$$

Assume

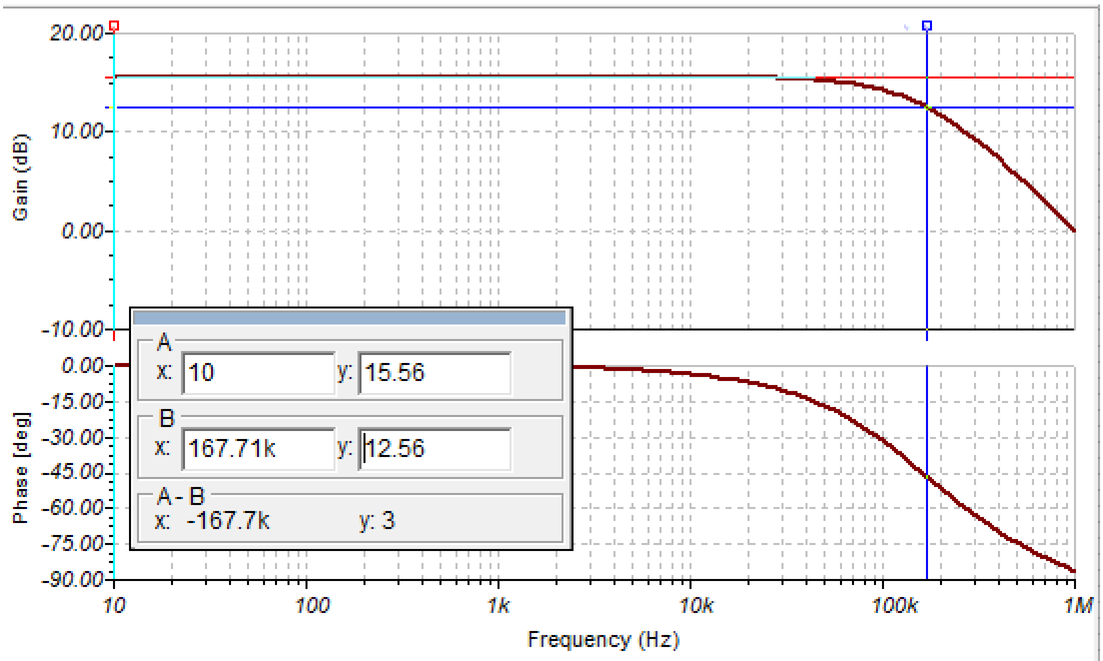
$R_1 = 2k\Omega \rightarrow \boxed{R_2 = 10k\Omega}$



FREQUENCY RESPONSE



BANDWIDTH



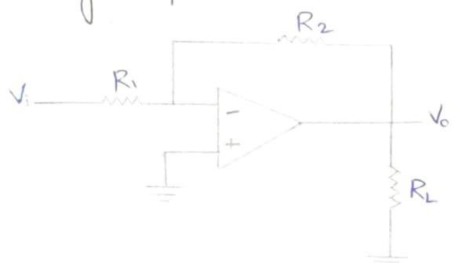
Band width= 167.71k – 10 = **160.7k**

INVERTING AMPLIFIER

GAIN=12

Analysis→

Inverting Amplifier



$$V_0 = -\left(\frac{R_2}{R_1}\right) V_i$$

as the phase shift is 180°. so it is an Inverting Amplifier.

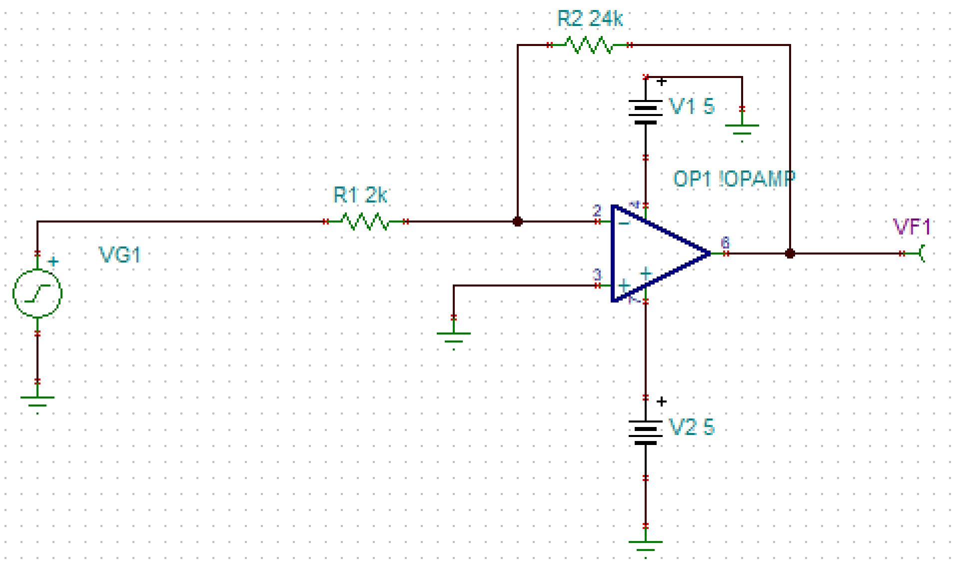
Gain=12

$$V_0 = -\frac{R_2}{R_1} V_i$$

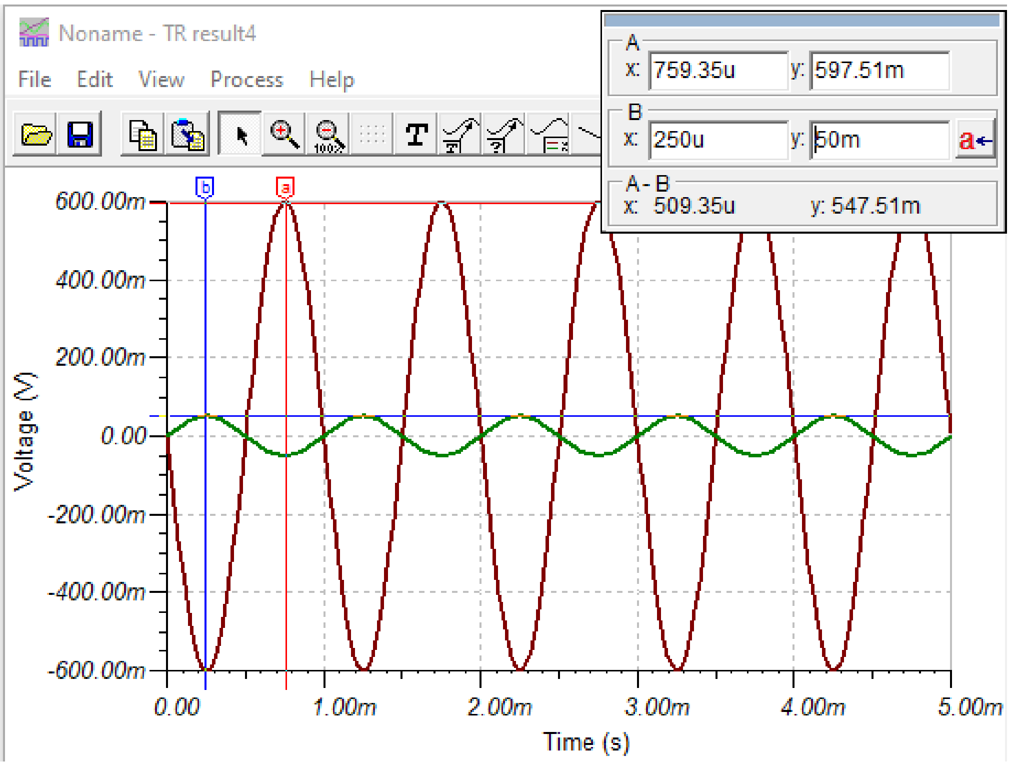
$$\Rightarrow \frac{V_0}{V_i} = -\frac{R_2}{R_1} \Rightarrow 12 = -\frac{R_2}{R_1} \Rightarrow \boxed{R_2 = 12R_1}$$

Assume

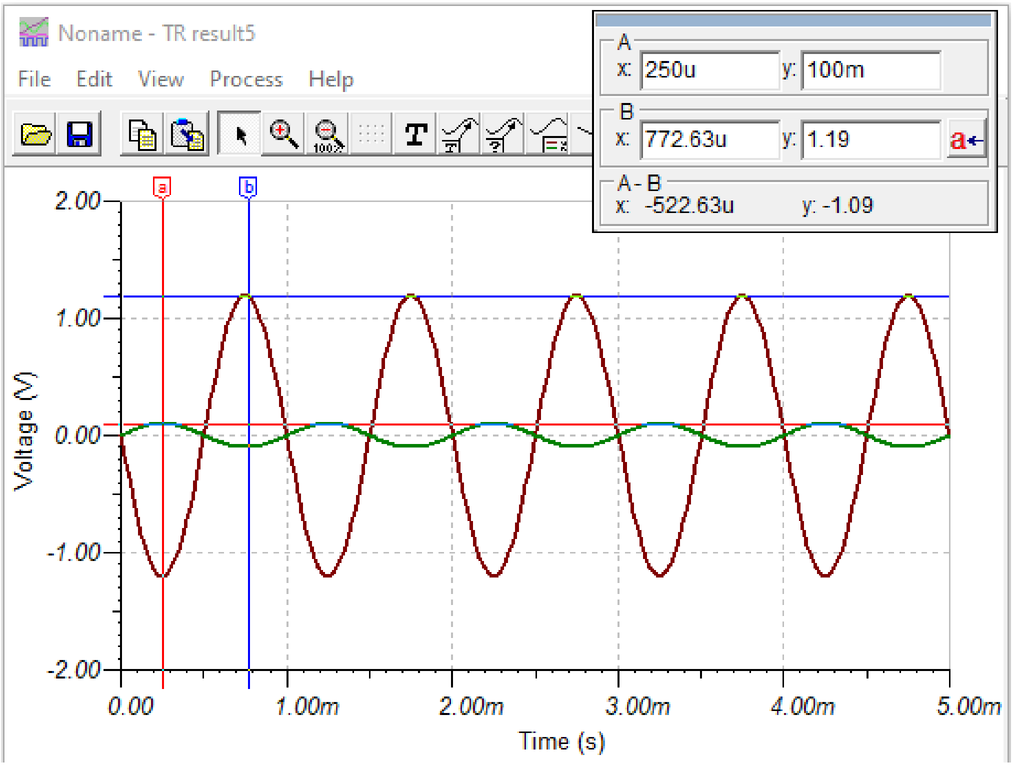
$$R_1 = 2k\Omega, \Rightarrow \boxed{R_2 = 24k\Omega}$$



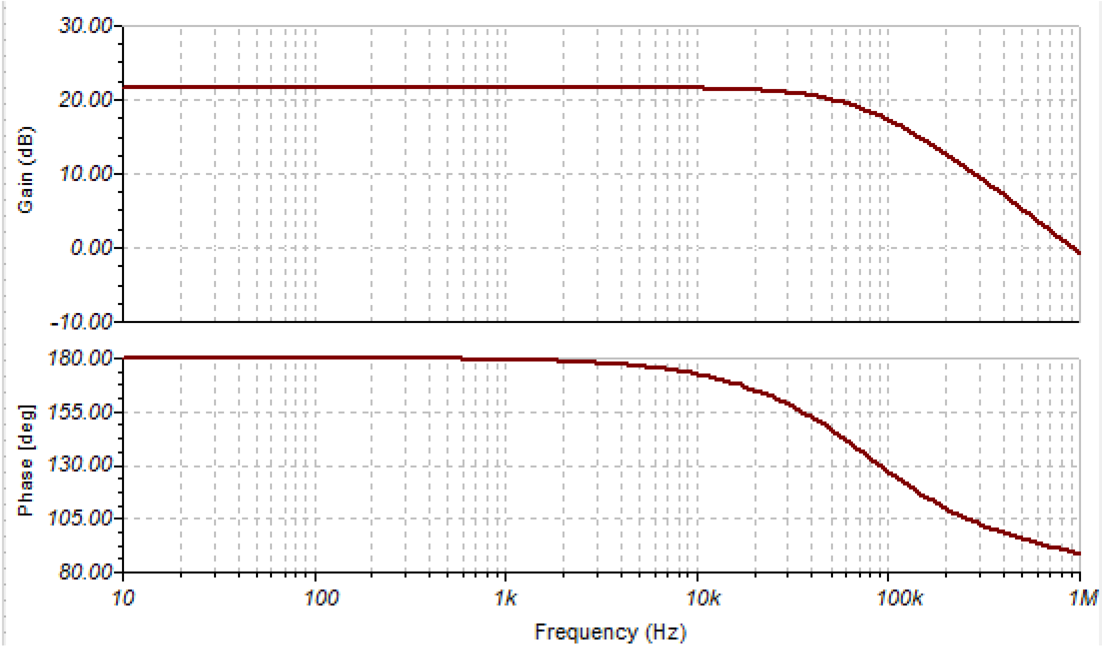
Vin=50mV



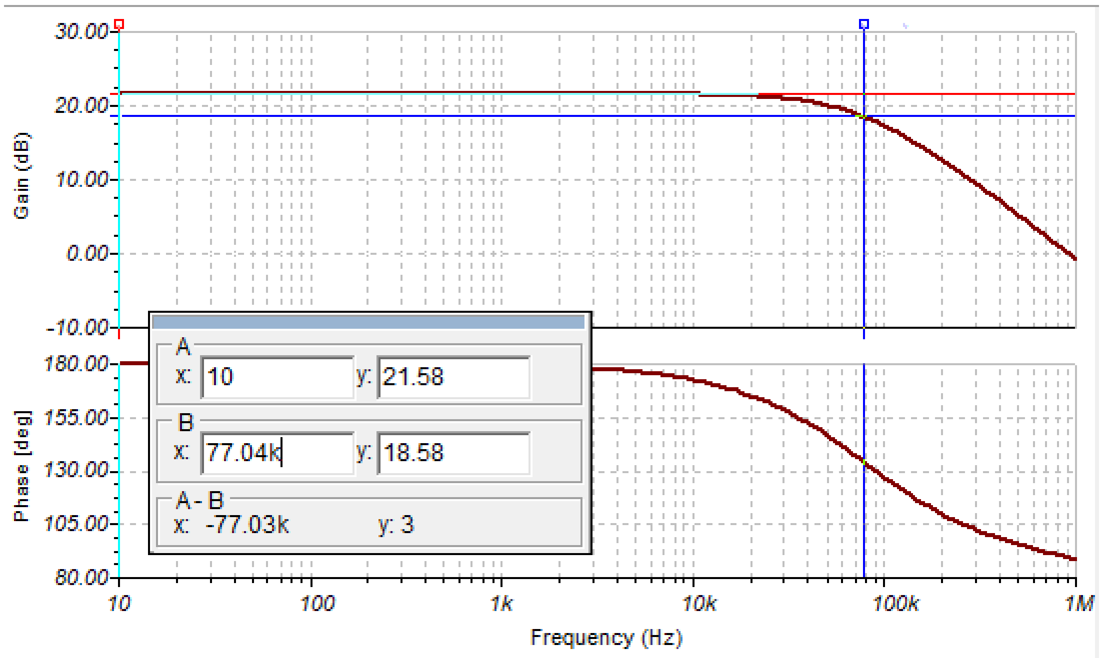
Vin=100mV



FREQUENCY RESPONSE



BAND WIDTH



Band width= 77.04k – 10 = **77.03k**

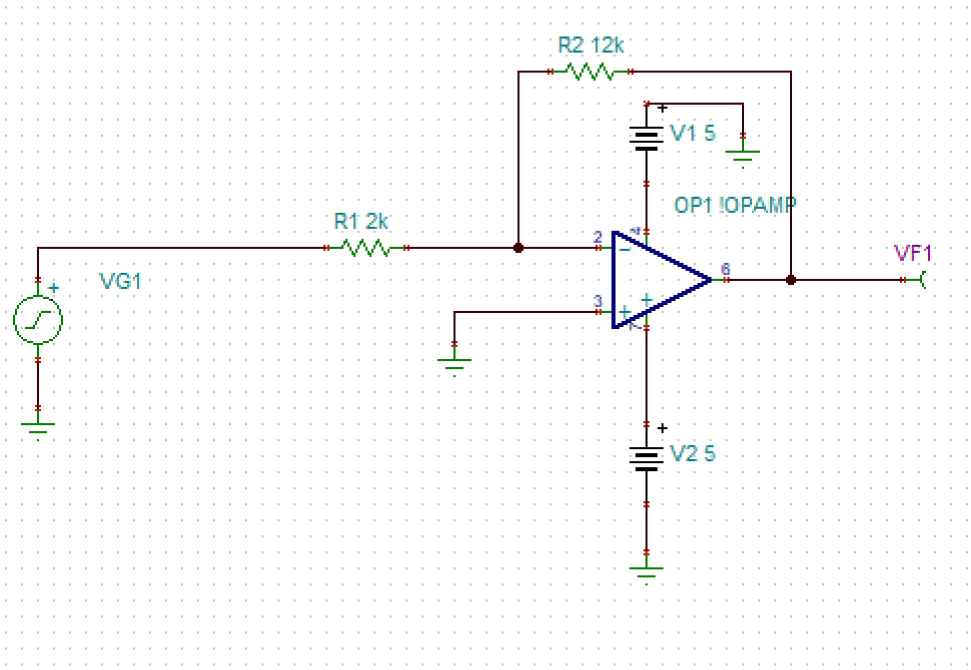
GAIN=6

Gain=6

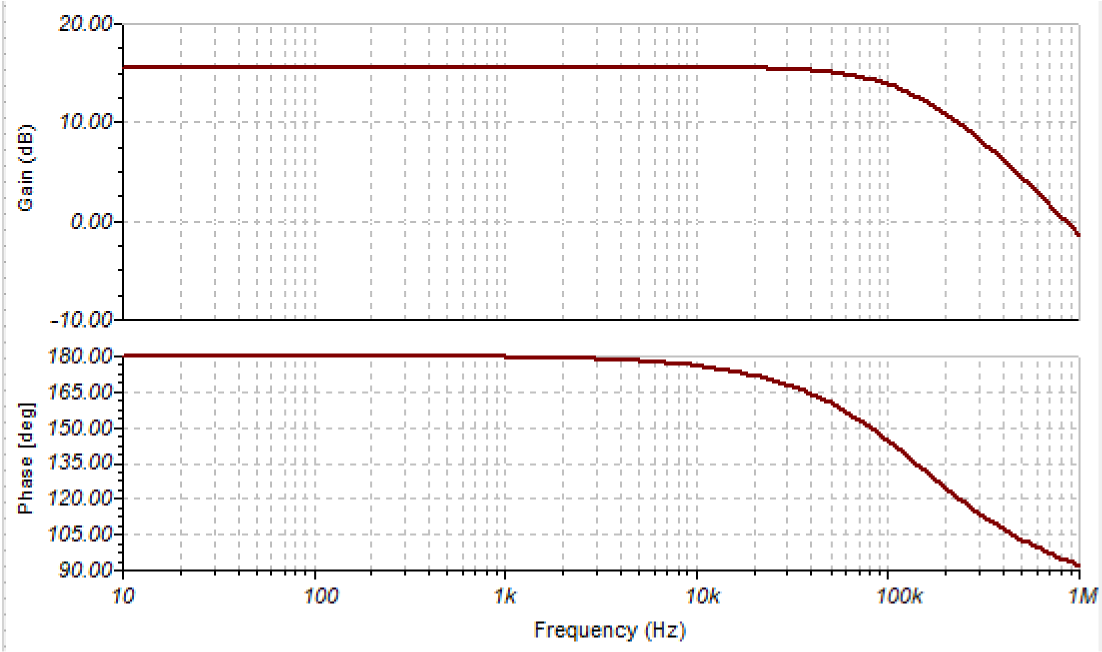
$$V_o = \frac{-R_2}{R_1} V_i \Rightarrow 6 = \frac{-R_2}{R_1} \Rightarrow \boxed{R_2 = 6R_1}$$

Assume

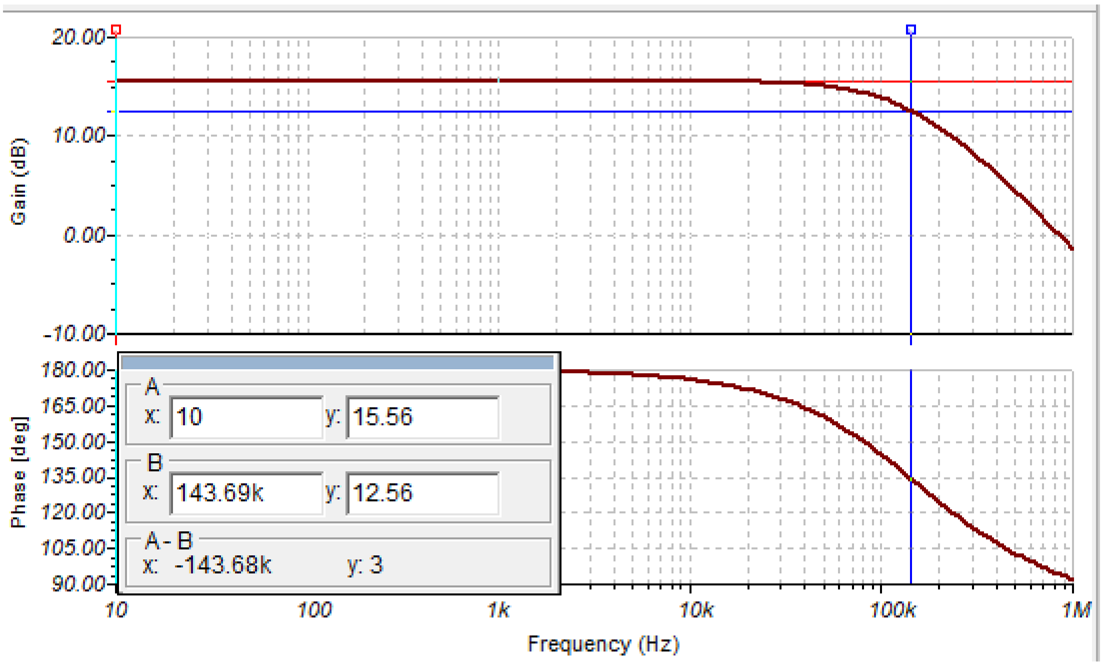
$$R_1 = 2k\Omega \Rightarrow \boxed{R_2 = 12k\Omega}$$



FREQUENCY RESPONSE



BAND WIDTH

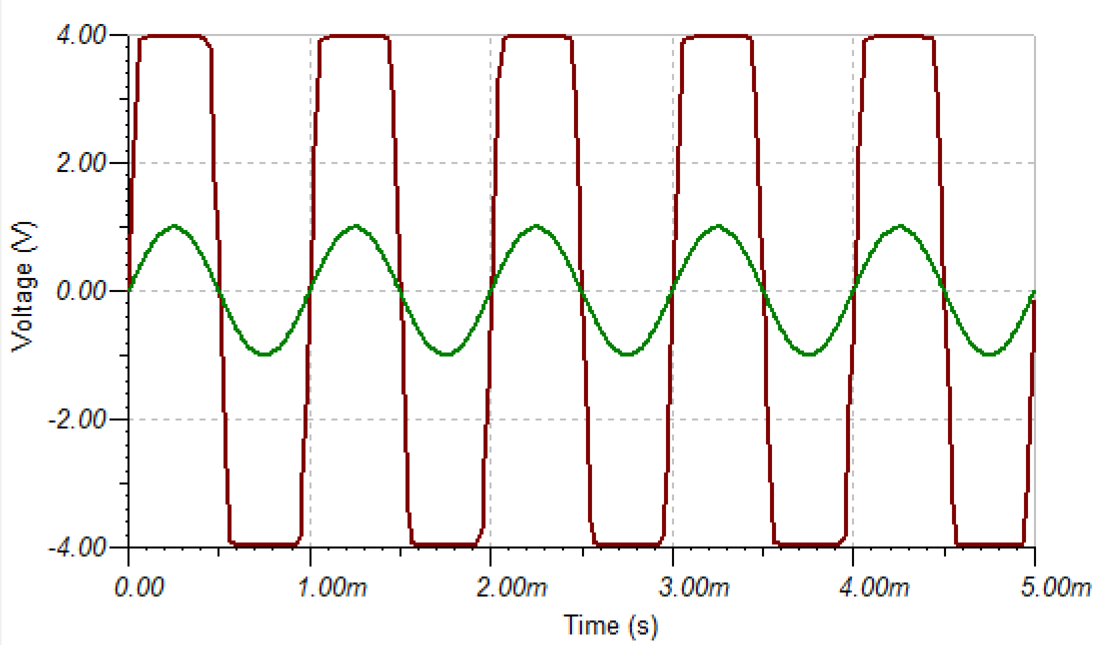


Band width= 143.69k – 10= **143.68k**

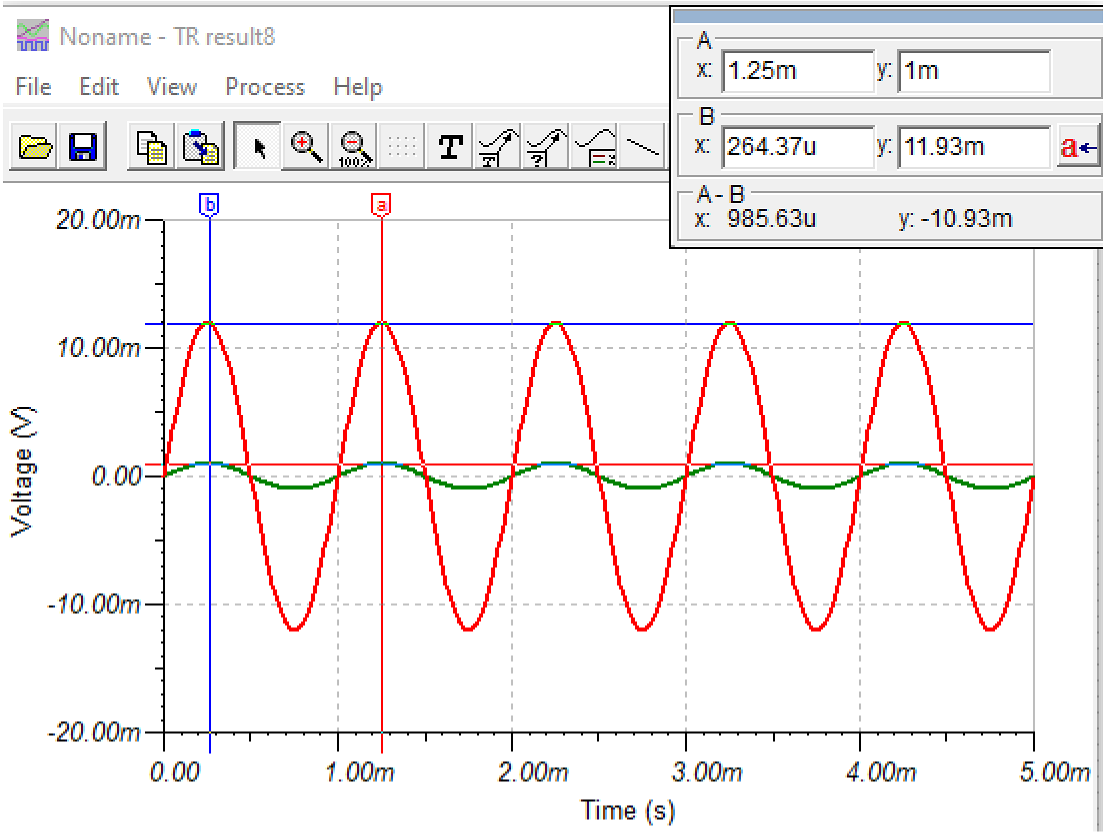
Inference

1. What is the expected and simulated output values of the amplifier in question 1, when the input signal is 1V and 1 mV?

(i) Vin=1v → Output Voltage=4V



(ii) Vin=1mV → Output Voltage=4V



Inference:-

1.)

$V_{in} = 1V$

Gain = 12

$\frac{V_o}{V_i} = 12 \Rightarrow V_o = 12(1)$

$\boxed{V_o = 12V}$

$V_{in} = 1mV$

Gain = 12

$\frac{V_o}{V_i} = 12 \Rightarrow V_o = 12(1mV)$

$\boxed{V_o = 12mV}$

	Expected		Simulated	
	Vi = 1V	Vi = 1mV	Vi = 1V	Vi = 1mV
Vout(V)	12	12m	4	12m

2. Is there a difference in the expected and simulated output values for the above input values. Why?

ANS:

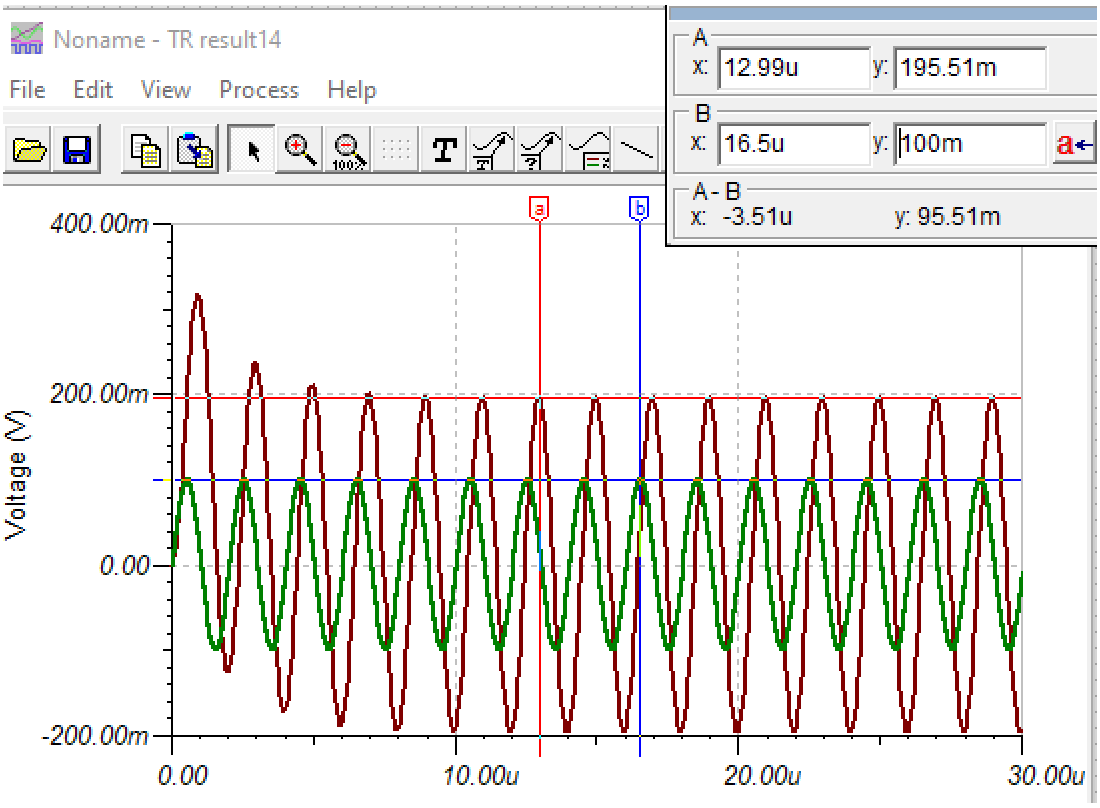
There is a difference , because the bias voltage was given 5volts so maximum output voltage will be 5volts .

3. What is the measured gain-bandwidth product (GBW) in designs of questions 1, 3 and 4. Is the GBW constant? Under what condition do you see the GBW being a constant.

ANS:

	NON-INVERTING		INVERTING	
Gain	12	6	12	6
Bandwidth (Hz)	83.41K	160.7K	77.0K	143.68K
GBW (Hz)	1M	0.96M	0.92M	0.86M

4. For the amplifier designed in Question 1, keep the amplitude of your input to 100 mV and set its frequency to 500 kHz. Determine the gain of your amplifier.



Simulated Gain is 1.95

5. Is the gain of the amplifier as calculated in step 4 different from expected value? Why?

ANS:

Each transistor has a limit to its high frequency current gain, and this is normally listed in transistor data sheets as the cut-off frequency fT. This is the frequency at which the small signal current gain hfe falls to 1. As gain begins to fall off at 6dB per octave (a doubling in frequency) well before fT is reached, the transistor needs to be operated at frequencies considerably lower than fT. Because of the relationship between frequency and gain in transistors, fT is also commonly listed as Gain Bandwidth Product.